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University Evolution, Entrepreneurial Activity and Regional Competitiveness

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University Evolution, Entrepreneurial Activity and Regional Competitiveness

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Origin of the Work

In today's globalized and knowledge-driven society, regions represent the key loci in the organization and governance of economic growth and, more generally, wealth creation. As they have been increasingly recognized as economic entities which base their growth on innovation, knowledge represents the major factor in achieving regional competitiveness (Huggins et al. 2008). The economic growth literature (Mankiw et al. 1992; Romer 1990; Lucas 1988) viewed knowledge embedded in human capital as the key element to foster the competitiveness between territories. However, knowledge, and particularly that able to foster innovation, is not free, but tacit, which cannot be easily bought via the market.

Universities represent privileged entities where to find human capital ready to transfer knowledge to the industry (Acs et al. 2002; Jaffe et al. 1993). This has mainly taken place since the last two decades, when universities have acquired more importance in regional innovation systems, from being only recognized as mere repository of knowledge and wisdom to centres of technology and knowledge transfer to the local environment. University spillovers shape the innovation behaviour of entrepreneurial firms (e.g. Audretsch and Lehmann 2005; Audretsch et al. 2005; Audretsch and Stephan 1996) and, in turn, the overall competitiveness of regions (Acs et al. 2002; Anselin et al. 1997).

Nevertheless, while scholars have particularly focused on the positive externalities that firms benefit in positioning close to a university (Abramovsky and Simpson 2011; Audretsch and Lehmann 2005), being affiliated with it (Meoli et al. 2013; Bonardo et al. 2011) or jointly collaborating in research projects (Fontana et al. 2006) as drivers of regional competitiveness, less attention was paid to the important changes that universities have faced during the last decades. The contributions included in this book aim to highlight how the recent changes that modify universities' activities have affected the role that academic institutions tend to have as "catalyst" of regional development. The pressure for universities to internationalize (Knight 2004) and crucially rely on third party funding (Bolli and Somogyi 2011) might indeed contribute to emphasize the existing differences

between successful and lagging regions, as occurred at a country level (e.g. South Europe).

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Structure of the Book

This book consists of seven parts which provide to the reader a complete overview of the different topics related to the impact of universities on the territories. First, in the spirit of the entrepreneurial orientation of academic institutions, recent trends in the academic entrepreneurship literature are addressed, from the creation of spin-offs in specific contexts to the effect of specific characteristics of academics on their entrepreneurial career. This is the topic addressed in the first two parts. Specifically, Part I takes an individual perspective and deals with the motivations that lead scientist to pursue an entrepreneurial venture. The papers by Huyghe and Knockaert, by Yasuda, and by Micozzi, Micozzi, and Pattitoni study academic entrepreneurship in relation to university culture and climate, scientists' mobility, and gender issues. Part II investigates academic spin-offs from an organizational perspective, with case and comparative studies. The papers by Hewitt-Dundas and Burns, by Finardi and Rolfo, and by Lindholm-Dahlstrand, Smith, and Baines study academic entrepreneurship in relation to incubators, national research institutions, and in comparison between Sweden and the UK.

The third mission of universities is not accomplished only via academic entrepreneurship. Three parts investigate the localized impact of universities at large. First, as the economic growth of regions is strongly associated to the interactions that firms are able to create with the academic sphere, contributions in Part III investigate the increasing value that such interactions have in gaining the regional competitiveness. Simmons, Levie, and Monsen address the competitive advantages that firms can gain from teaming up with universities. The papers by Remdisch, Otto, Just, Pötschke, and Klöppner and by Menter well investigate the roles of principal investigators and how universities can contribute to increase regional competitiveness by increasing employer attractiveness. Part IV is dedicated, instead, to the role of the regional context. Drawing upon the results of Audretsch et al. (2012), a set of studies focus on a quite neglected topic in the literature, that of the impact of regional context and competitiveness to the innovation of entrepreneurial firms and the technology transfer practices of universities. Barjak and Es-Sadki study the influences of regional economic environment on the technology

transfer performance of universities. With reference to industrial policy in aeronautics, Reis, Mendonça, Amaral, and Heitor investigate and identify policy and research implications of the changing nature of industrial production. Finally, Seitz's paper links corporate social responsibility to national competitiveness. Part V devotes attention to the role played by universities in metropolitan areas as organizational entities constantly perceiving reputation and legitimacy is considered. In order to draw insights, Wood and Lawton-Smith look at of London, while Lawson at Manchester. Cattaneo, Meoli, and Paleari study the role of the internationalization of universities, which is a growing phenomenon worldwide.

Lastly, since generating knowledge does not ensure that knowledge would spill over for commercialization driving innovation and economic growth, the last two parts of this book deal with the relationship between technology, finance, and innovation. These two parts depart from the strictly entrepreneurial focus to encompass innovation. Part VI relates innovation to specific technologies (i.e. ICT, software, and mechatronics). The papers collected in this part deal with resource management and spin-offs in the ICT sectors (Verbano, Wasser, Lincoln, and Venturini), with virtual products and physical resources of software companies (Werbik), and with technology foresight in mechatronics (Bassani, Minola, and Vismara). Finance is introduced in Part VII. Bachmann and Baumann discusses the effects of government R&D incentives on international R&D trade. Giudici presents equity crowdfunding as an entrepreneurial activity. Signori uses signaling to investigate how innovation is perceived by external investor in IPOs.

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This book represents the outcome of a very long collaboration and a continuous cooperation between the editors. On November 8–9, 2013, the Cisalpino Institute for Comparative Studies in Europe (CCSE) hosted the annual conference of the Technology Transfer Society. This conference was one of the numerous activities that we organize together. Among them, we would like to mention the joint summer school that we hold annually, while we invite to visit our website www.cisalpino.eu for more information about our initiatives. We are indebted to Al Link and Don Siegel who made it possible that the annual conference of the Technology Transfer Society could be hosted in 2013 in Bergamo. Their thoughtful advice and suggestions from planning the conference until the completion of this volume are gratefully acknowledged.

In the 2013 conference of the Technology Transfer Society, professionals from academia, research institutes, and the business world from 27 countries gathered in the i.lab scientific park in Bergamo, Italy. There were over 100 submissions to the conference, of which the best 64 papers were presented. These papers employed a variety of methodologies, including qualitative methods, interview-based techniques, regression analyses of survey data, and sophisticated econometric analyses of archival data. Different units of analysis were employed, such as the individual invention, the university, firms, or industries. One year and three rounds of review later, a collection of papers and thoughts presented at this conference is summarized in this edited book.

We would like to thank all those people who contributed in different ways to this great success. First of all, Stefano Paleari, President of the Cisalpino Institute for Comparative Studies in Europe (CCSE), who offered his guidance and enthusiasm since the very beginning of this journey. We also thank Mattia Cattaneo and Andrea Signori for their continuous support and for sharing a number of research projects. Finally, we acknowledge the friendly cooperation in finalizing this book by Prashanth Mahagaonkar at Springer.

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Part I
Academic Entrepreneurs

Chapter 1

The Relationship Between University Culture and Climate and Research Scientists' Spin-off Intentions

Annelore Huyghe and Mirjam Knockaert

Abstract Over the past decades, universities have increasingly become involved in entrepreneurial activities. Despite efforts to embrace their 'third mission', universities still demonstrate great heterogeneity in terms of their involvement in academic entrepreneurship. This chapter adopts an institutional perspective to understand how organizational characteristics affect research scientists' entrepreneurial intentions. We study the impact of university culture and climate on entrepreneurial intentions, thereby specifically focusing on intentions to spin off a company. Using a sample of 437 research scientists from Swedish and German universities, our results reveal that the extent to which universities articulate entrepreneurship as a fundamental element of their mission fosters research scientists' spin-off intentions. Furthermore, the presence of university role models positively affects research scientists' propensity to engage in entrepreneurial activities, both directly and indirectly through entrepreneurial self-efficacy. Finally, research scientists working at universities which explicitly reward people for 'third mission' related output show higher levels of spin-off intentions. This study has implications for both academics and practitioners, including university managers and policy makers.

Keywords Entrepreneurial intentions • Academic entrepreneurship • Organizational culture • Organizational climate

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1.1 Introduction

Universities do not only engage in research and teaching, but are increasingly active in the commercialization of research results, or their so-called ‘third mission’ related to entrepreneurship and economic development (Etzkowitz 2003; Rasmussen et al. 2006). This entrepreneurial tendency is inspired by decreasing university budgets and pressure from policy makers who view the commercialization of research as a key driver of national competitiveness (Ambos et al. 2008). ‘Third stream’ entrepreneurial activities go beyond the traditional, scientific dissemination mechanisms, such as publications (Van Looy et al. 2011), and include university spin-offs, patenting and licensing activities, contract research and consulting (Wright et al. 2008).

As a result of the institutional transformation and universities’ growing interest to fulfill their ‘third mission’, the academic literature has devoted considerable attention to academic entrepreneurship. We refer to Rothaermel et al. (2007), Markman et al. (2008) and Djokovic and Souitaris (2008) for excellent reviews of the literature. In summary, the academic entrepreneurship literature includes studies at macro-level (studying the role of government and industry), meso-level (focusing on the university and the technology transfer office) and micro-level (studying firms and individual entrepreneurs) (Djokovic and Souitaris 2008). Only recently, scholars have started to explore research scientists’ entrepreneurial intentions (e.g., Mosey et al. 2012; Prodan and Drnovsek 2010). Entrepreneurial intentions are considered the single best predictor of entrepreneurial behavior (Bird 1988; Fishbein and Ajzen 1975) and have been widely studied as outcome variable in diverse contexts (Krueger et al. 2000; Souitaris et al. 2007).

Studying entrepreneurial intentions in an academic context is important given the presence of entrepreneurial potential in scientific knowledge (Obschonka et al. 2012). Academic research has been a crucial ingredient for the development of new products and processes (Mansfield 1998) and about 70 % of inventions require further involvement by the research scientist in order to be successfully commercialized (Jensen and Thursby 2001). Academic entrepreneurship provides a critical contribution of research scientists to the national economy and society (Ping 1980) and is often considered crucial for competitive advantage (OECD 2003). Nevertheless, it is recognized that commercializing research results is difficult. At the heart of the problem is the inherent tension between academic and commercial demands (Hackett 2001; West 2008). Universities have tried to overcome this tension in a number of ways, for instance, by establishing technology transfer offices (TTOs) (Siegel et al. 2007). Consequently, it may be valuable for resource-constraint boundary spanners (such as technology transfer offices) to identify those research scientists who are most likely to engage in entrepreneurial activities in order to focus their attention on a specific target group.

So far, within the literature on entrepreneurial intentions, there is ample evidence on individual drivers of entrepreneurial intentions (e.g., Dohse and Walter 2012; Lüthje and Franke 2003; Souitaris et al. 2007). Surprisingly, only few

empirical studies have explored the role of organizational drivers for entrepreneurial intentions. Specifically, Lee et al. (2011) studied entrepreneurial intentions in a corporate setting and Walter et al. (2011) assessed the extent to which characteristics of university departments affect students' self-employment intentions. Similarly, the scarce research that has studied determinants of entrepreneurial intentions in academia has mainly focused on the individual level. Prodan and Drnovsek (2010) for instance found that entrepreneurial self-efficacy was the most important driver of entrepreneurial intentions and found smaller effects related to the type of research and the number of years the research scientist stayed at the institute. Goethner et al. (2012) showed that attitudes and perceived control were key determinants of entrepreneurial intentions in an academic context, whereas Obschonka et al. (2012) identified social identity as a central factor in explaining entrepreneurial intentions. Strikingly, while it is vital to understand the context in which the academic entrepreneur originates, to date, the organizational determinants of research scientists' entrepreneurial intentions remain an unexplored area.

Accordingly, this chapter aims at providing a better insight into the university characteristics that affect research scientists' propensity to engage in academic entrepreneurship. Specifically, we adopt an institutional perspective and focus on university culture and climate as factors shaping research scientists' intentions to create a university spin-off (hereafter: 'spin-off intentions'). Further, university spin-offs are defined as new ventures initiated within a university setting and based on technology derived from university research (Rasmussen and Borch 2010), and typically represent the central route to public research commercialization (Wright et al. 2008). We study our research question in a sample of 437 research scientists from six Swedish and German universities.

This article unfolds as follows. We first present our conceptual framework building on institutional theory, followed by a description of our research methodology. We subsequently present our results and discuss implications for academia, practice and future research.

1.2 Conceptual Framework

Institutional theory has been widely used as explanatory framework in diverse research domains, ranging from marketing (e.g., Grewal and Dharwadkar 2002) over strategic management (e.g., Peng et al. 2009) to entrepreneurship (e.g., Bruton et al. 2010). Nevertheless, even among organizational theorists and sociologists, considerable variation exists in the definition of the central concepts of institution and institutionalization (DiMaggio and Powell 1983; Scott 1987).

This study approaches the organization as institution and draws upon a recently emerging stream in institutional theory, called 'new institutionalism' (DiMaggio and Powell 1983, 1991; Scott 1987, 2001; Zucker 1987). Viewing the organization as an institution entails that implemented institutional elements generally arise from

within the organization itself or from imitation of similar organizations, not from power or coercive processes located in the state (Zucker 1987). The neo-institutional perspective rejects the rational-actor models of classical economics and utilizes cognitive and cultural explanations of social and organizational phenomena (DiMaggio and Powell 1991). Scott (2001, p. 49) subsequently defines institutions as “multifaceted, durable social structures, made up of symbolic elements, social activities, and material resources”, with the central components of institutions being rules (regulative), norms (normative) and values (cognitive). As institutions’ rules, norms and values stipulate what is appropriate behavior, they render some actions unacceptable or even beyond consideration (DiMaggio and Powell 1991). Institutions are instrumental in shaping actors’ goals and beliefs (Scott 1987) and in turn, affect motivational forces and behaviors (De Long and Fahey 2000; Szulanski 1996).

Accordingly, we argue that the organizational context in which research scientists are embedded might either trigger or restrain them from engaging in academic entrepreneurship, above and beyond individual-related characteristics. Despite a growing number of initiatives targeted at the ‘third mission’, universities still demonstrate large heterogeneity in their degree of institutional transformation (Tijssen 2006) and in their support for and involvement in entrepreneurial activities (Kenney and Goe 2004; Louis et al. 1989; Wright et al. 2008). Universities were traditionally developed to manage activities of research and teaching and, as such, these institutions have to be adapted to incorporate academic entrepreneurship. Universities hold distinct ideologies and trajectories towards their entrepreneurial role through which they exercise a strong influence on their members (Stankiewicz 1986).

Following the above arguments, we propose that university characteristics influence the extent to which research scientists intend to undertake entrepreneurial activities. In what follows, we focus on organizational culture and organizational climate and develop a conceptual framework linking these university characteristics to research scientists’ entrepreneurial intentions. Organizational culture and climate are closely related, but distinct constructs (Kuenzi and Schminke 2009; Schein 2000). Both constructs conceptualize the way people experience and describe their work environment (Schneider et al. 2013). However, on the one hand, organizational culture is defined as the beliefs and values that typify a setting and are taught to new members as the proper way to think, feel, and act within the organization (Schein 1985; Zohar and Hofmann 2012). On the other hand, the concept of organizational climate designates how organizational policies, practices and procedures embed beliefs and values, as such communicating the organization’s goals and the means through which employees can achieve those goals (Ostroff et al. 2003; Schneider et al. 1998). In other words, culture denotes assumptions, beliefs, meanings and values within an organization, whereas climate refers to the practices through which culture is manifested (Denison 1996).

1.2.1 The Relationship Between Organizational Culture and Spin-off Intentions

Adopting an institutional lens when examining culture is relevant (Zilber 2012), as it represents one important means by which normative and cognitive structures are transmitted (DiMaggio and Powell 1991). Organizational culture provides meaning and context (Schein 1985) and affects how organizational members consciously and subconsciously think and make decisions. Ultimately, organizational culture has an impact on the way in which people perceive, feel and act (Hansen and Wernerfelt 1989). Organizational culture shapes the way organizational members set personal and professional objectives, perform tasks and administer resources to achieve them. Within this study, we follow Schein (1985, p. 9)'s definition of organizational culture as "a pattern of basic assumptions invented, discovered or developed by a given group as it learns to cope with its problems of external adaptation and internal integrations that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems". Subsequently, organizational culture, acting through institutional belief systems and norms, can be a very effective means of directing the attitude and behavior of organizational members towards entrepreneurial activities.

Consequently, in order to increase research scientists' interest in spin-off creation, universities could create a culture which is supportive towards such activities, alongside investments in tangible organizational units such as technology transfer offices, incubators and science parks. In this respect, Clark (1998) has identified an integrated entrepreneurial culture as a core ingredient for successful institutional transformations into entrepreneurial universities. Along the same lines, O'Shea et al. (2005) argue that universities need to develop a culture supportive of commercialization in order for academic entrepreneurship to flourish.

While there are numerous dimensions of organizational culture (Detert et al. 2000), this study examines two visible components of culture through which universities might influence research scientists' intentions to engage in entrepreneurial activities. Focusing on visible elements is appropriate, because organizational culture is more likely to be transmitted to organizational members through visible elements (values and behavioral patterns) than through invisible elements (basic assumptions) (Hofstede 1998; Schein 1985). In particular, we focus on the presence of a university mission that incorporates academic entrepreneurship and role models that exemplify academic entrepreneurship.

1.2.1.1 Entrepreneurial University Mission

An organizational mission is a statement of the organization's reason for being, long term purpose and distinctiveness, reflecting the institutional belief systems and ideologies (Klemm et al. 1991; Swales and Rogers 1995). The development of

an organizational mission is widely acknowledged to be a popular management tool, which requires effective communication to both organizational members and external stakeholders (Cochran and David 1986; Williams 2008). A large body of research has indicated that an organizational mission guides the individual behavior of organizational members (Bart 1996; Smith et al. 2001).

Historically, universities' missions were primarily directed towards research and teaching, turning their entrepreneurial transformation into a challenging task (Ambos et al. 2008). Institutional change typically requires and implies a modification of the culture or the key institutional elements that shape culture, including the mission (Schein 1985). As indicated by Jacob et al. (2003), the reconciliation of universities' traditional and entrepreneurial activities does not only require changes in infrastructure but also, amongst others, the adaptation of the university mission. Ideally, an entrepreneurial university should focus on research, teaching and entrepreneurial activities simultaneously (Etkowitz 2004; Guerrero and Urbano 2012).

Following institutional theory and given the tendency of organizational members to conform to organizational norms regarding entrepreneurship (Lewis et al. 2003; Peters and Fufeld 1982), in particular in a university context (Friedman and Silberman 2003; Roberts 1991), it is likely that the university mission will affect research scientists' entrepreneurial intentions. Accordingly, we argue that the more universities highlight academic entrepreneurship as a fundamental part of their mission, the greater research scientists' intentions to engage in entrepreneurial endeavors will be. Thus,

Hypothesis 1 The extent to which a university mission emphasizes academic entrepreneurship compared to traditional activities is positively related to research scientists' spin-off intentions.

1.2.1.2 Entrepreneurial University Role Models

Role models constitute a second key element of organizational culture. The influence of role models on individuals has been highlighted in a number of contexts, including marketing and consumer behavior (Childers and Rao 1992; Martin and Bush 2000) and career development (Gibson 2003, 2004; Kram and Isabella 1985). Role modeling refers to a cognitive process in which individuals observe attributes of people in social roles similar to themselves and increase this perceived similarity by imitating these attributes (Erikson 1985; Gibson 2004). Individuals are affected by institutional norms, or behavioral patterns of peers within their organization, and tend to act like them (Bercovitz and Feldman 2008; Haas and Park 2010; Jain et al. 2009). Since research scientists are exposed to a peer-oriented culture (Samsom and Gurdon 1993), the internalization or imitation of institutional norms is expected to be strong (Lewis et al. 2003).

Specifically, it is well acknowledged that role models and peers play a crucial role in driving individuals' entrepreneurial activity (Falck et al. 2012; Nanda and Sorensen 2010; Thornton 1999). In a university context, the presence of

entrepreneurial role models creates an example for research scientists and provides them with a feeling of security. Peer examples signify that academic entrepreneurship is accepted as a legitimate activity within the university, which reduces concerns about the social repercussions of own entrepreneurial actions (Stuart and Ding 2006). The findings of Shane (2004) and Bercovitz and Feldman (2008) support the view that research scientists' commercialization decisions are socially influenced.

Typically, individuals will imitate the particular behavior of their role models (Bandura 1986). Indeed, Prodan and Drnovsek (2010) provided evidence on the positive link between perceived role models of spin-off creation and research scientists' intentions to found a company themselves. Hence,

Hypothesis 2a The presence of university role models involved in spin-off creation is positively related to research scientists' spin-off intentions.

Besides the direct impact of role models on entrepreneurial intentions through internalization or imitation, we expect the presence of role models to also indirectly affect entrepreneurial intentions, as a process of social comparison is likely to take place. Individuals judge their own abilities by comparing themselves to similar others (Festinger 1954). The presence of entrepreneurial role models will convince research scientists that they have what it takes to engage in entrepreneurial activities themselves. Consequently, role models may influence entrepreneurial self-efficacy, or an individual's confidence in his or her ability to successfully perform entrepreneurial roles and tasks (Chen et al. 1998). In turn, entrepreneurial self-efficacy may affect entrepreneurial intentions. Boyd and Vozikis (1994) developed a theoretical model in which self-efficacy was proposed as an important antecedent of entrepreneurial intentions. Empirical studies have provided strong support for the existence of such relationship (Chen et al. 1998; Krueger 1993; Zhao et al. 2005). Therefore, we assume that entrepreneurial role models will indirectly, i.e., through entrepreneurial self-efficacy, affect spin-off intentions. Thus,

Hypothesis 2b Entrepreneurial self-efficacy mediates the relation between university role models involved in spin-off creation and research scientists' spin-off intentions.

1.2.2 The Relationship Between Organizational Climate and Spin-off Intentions

Organizational climate is defined as the shared perceptions of and the meaning attached to policies, practices and procedures that organizational members experience, as well as the kinds of behaviors that are expected, rewarded and supported (Ostroff et al. 2003; Schneider et al. 1998). Climate reflects the tangible, culture-embedding mechanisms of organizations, through which they attempt to direct the energies of organizational members (Quinn and Rohrbaugh 1983; Schneider

et al. 2013). Consequently, organizational climate is not identical, but closely related to organizational culture. Climate represents how culture is manifested through organizational policies and procedures, and how the organizational environment is perceived through the eyes of the individuals operating in that environment (Denison 1996; Reichers and Schneider 1990). As part of the institutional context, organizational climate exerts a strong influence on organizational members' motivation and behaviors (Brown and Leigh 1996; Kuenzi and Schminke 2009). Therefore, organizational climate can also influence individuals' attitudes and actions towards entrepreneurial activities.

Reward systems have often been seen as a focal dimension of organizational climate (Schneider et al. 1998). Extant literature has shown how organizational reward systems affect individual outcomes including motivation (e.g., Tyagi 1982), creativity (e.g., Shalley et al. 2004; Tesluk et al. 1997), job performance and satisfaction (e.g., Downey et al. 1975), affective commitment (e.g., Rhoades et al. 2001), knowledge sharing (e.g., Bartol and Srivastava 2002) and entrepreneurial behavior (e.g., Hornsby et al. 2002).

1.2.2.1 Entrepreneurial University Reward System

Organizational rewards, be they monetary or non-monetary, reflect the organization's goals and objectives and encourage individual members to focus their attention on particular activities (Jensen 1993). Organizational members seek information concerning what activities are rewarded by their institution, and direct their behavior towards such activities while disregarding activities they are not rewarded for (Kerr 1975). Accordingly, through the implementation of specific reward systems, organizations can enhance the likelihood that desired behaviors occur.

In a university context, reward systems are typically based on research scientists' publication output (Franklin et al. 2001). Nevertheless, scholars have suggested that the establishment of rewards for entrepreneurial activities is needed in order to foster a climate of entrepreneurship within universities (Friedman and Silberman 2003; Shane 2004; Siegel et al. 2003). As such, if universities want to encourage their employees to engage in research commercialization, it will be desirable to adapt the incentive systems to the 'third mission' (Debackere and Veugelers 2005; Link et al. 2006; Markman et al. 2004). If reward systems are to stimulate research scientists to direct their efforts towards entrepreneurial activities, they should no longer be exclusively based on research and teaching excellence, but also reward entrepreneurial accomplishments (Henrekson and Rosenberg 2001; Jensen and Thursby 2001; Lockett and Wright 2005).

Following institutional theory and the literature on organizational reward systems, we can expect university rewards to affect research scientists' entrepreneurial intentions. Specifically, we argue that the more explicitly the university reward system incorporates entrepreneurial activities as a criterion compared to the

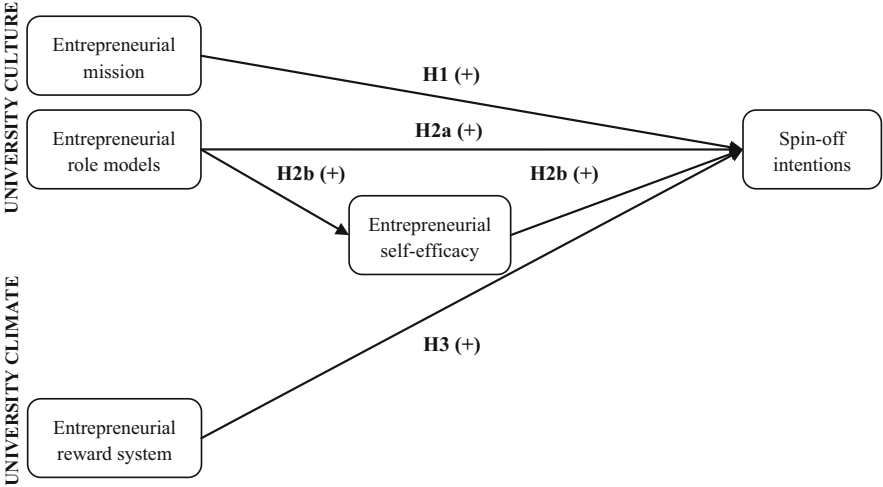


Fig. 1.1 Conceptual model

rewards for research and teaching, the greater the research scientist’s intentions to engage in spin-off creation. Thus,

Hypothesis 3 The extent to which a university reward system incorporates academic entrepreneurship compared to traditional activities is positively related to research scientists’ spin-off intentions.

Figure 1.1 summarizes our hypotheses.

1.3 Research Methodology

1.3.1 Data Collection and Sample

Our study is based upon unique cross-sectional data collected in 2012 at six universities in two European countries, Sweden and Germany. Both countries have similarly strong and mature infrastructural support for entrepreneurial activities initiated by both government and individual universities. Sweden and Germany are characterized by high levels of R&D intensity and a relatively high degree of academic entrepreneurship (Wright et al. 2008). An important difference lies in the academic exemption or professor’s privilege in Sweden, which asserts full ownership of intellectual property rights to faculty (Klofsten and Jones-Evans 2000). For both countries, we compiled a list of all universities using secondary data (including reports by ministries of education, university rankings, technology transfer networks and general internet searches). Next, we selected one or two geographical regions within each country (i.e., Gothenburg, Stockholm and

Munich region) and contacted all universities' TTO through email or phone, which resulted in full participation from 6 out of 15 TTOs contacted.

The data collection process included face-to-face interviews with technology transfer officers from each university, followed by an online survey for research scientists involved in different scientific disciplines. First, we contacted the technology transfer offices from the six universities (Chalmers University of Technology, Gothenburg University, Mälardalen University, Halmstad University, KTH Royal Institute of Technology and Technical University Munich). Through face-to-face interviews, we obtained information on university characteristics (e.g., human and financial resources, annual innovation output) and technology transfer practices (e.g., history and organizational structure). Primary data were verified and complemented with secondary data from annual reports, university and TTO websites. Furthermore, we asked permission and assistance to contact research scientists at each university. We specifically targeted research scientists (as opposed to, for instance, tenured professors) because research scientists (i.e., doctoral and post-doctoral positions) are more likely to develop their career capital due to uncertainty about which career track will be the most beneficial to them (Krabel and Mueller 2009). In contrast, professors are typically more focused on establishing their reputation in the scientific community.

The survey population consisted of 8857 research scientists, of which 5418 at the Swedish universities and 3439 at the German universities. Respondents received a request through email to complete an online questionnaire. We obtained 1103 failure messages indicating that email addresses were invalid or our message could not be sent, resulting in a usable population of 7754 research scientists. After 1 week, a reminder email was sent. In total, 850 responses were received (or 11 % of the usable population). After elimination of incomplete responses, our final sample consists of 437 research scientists who fully completed the questionnaire, or 5.6 % of the usable population. T-tests revealed no significant differences between respondents who filled in all questions and those who provided incomplete responses, or between early and late respondents, in terms of age, gender, education, position, academic experience or country ($p > 0.05$). As such, non-response bias was unlikely to be a problem in our dataset (Hair et al. 2006). Some procedural techniques were used to reduce the risk of common method bias. In our email, we guaranteed anonymity to reduce respondents' tendency to give socially desirable answers (Podsakoff et al. 2003). Moreover, careful attention was given to the wording of questions in order to avoid vague concepts and to reduce items' ambiguity (Tourangeau et al. 2000).

1.3.2 Measures

1.3.2.1 Dependent Variable

Spin-off intentions were measured by the following items: 'How likely is it that, in the foreseeable future, (1) You will engage in the founding of a university spin-off?, (2) You will engage in the establishment of a company based upon an idea and/or technology developed at the university? and (3) You will participate in the founding of a firm to commercialize your research?', on a scale ranging from 1 (very unlikely) to 7 (very likely). Scale reliability measured by Cronbach's alpha is 0.92.

1.3.2.2 Independent Variables

University Mission Drawing upon Guerrero and Urbano (2012), we created seven items to measure whether the university mission incorporates academic entrepreneurship. Respondents were asked to indicate their degree of agreement with the following statements on a scale ranging from 1 (strongly disagree) to 7 (strongly agree): 'The mission of my university focuses on (1) Publishing papers with practical implications, (2) Knowledge transfer (patents, licenses, spin-offs), (3) Promoting an entrepreneurial culture, (4) Generating entrepreneurs, (5) Publishing scientific, peer-reviewed papers, (6) Academic excellence (research and teaching) and (7) Consulting and contract research with industry.' Exploratory factor analysis pointed to the existence of two factors: 'focus on traditional activities' (items 5 and 6; Cronbach's alpha 0.78) and 'focus on entrepreneurial activities' (items 1, 2, 3, 4 and 7; Cronbach's alpha 0.84). Subsequently, we summarized these items in two constructs and divided the values obtained for the first construct by the latter construct. As such, our variable labeled 'Entrepreneurial mission' expresses the relative importance of 'third mission' within the university mission, as perceived by the research scientists.

University Role Models Participants were asked: 'Has anyone in your university, who you know personally, created a company based on university research?'. Responses were coded 1 (41 % of the sample) in case of perceived spin-off role models and 0 otherwise. As such, a dummy variable was generated, labeled 'Spin-off role models'.

University Reward System We created six items to reflect whether the university reward system values academic entrepreneurship, beyond the traditional, scientific activities of teaching and research. Using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), respondents were requested to answer the following statements: 'My rewards (e.g., salary, additional financial resources, recognition from scientific community, flexi-time...) are determined by (1) Research performance (e.g., number and quality of publications), (2) Involvement in consulting and contract research, (3) Involvement in administrative, service

or committee activities, (4) Involvement in patenting and licensing, (5) Teaching performance (e.g., student evaluations) and (6) Involvement in spin-off creation'. The exploratory factor analysis revealed two factors: 'emphasis on traditional rewards' (items 1, 3 and 5; Cronbach's alpha 0.70) and 'emphasis on entrepreneurial rewards' (items 2, 4 and 6; Cronbach's alpha 0.88). We again generated summarized measures for the two constructs and calculated the relative importance of entrepreneurial rewards compared to traditional rewards. The measure we obtained was labeled 'Entrepreneurial rewards'.

1.3.2.3 Other Variables

Following prior literature on academic entrepreneurship and entrepreneurial intentions, other characteristics could affect research scientists' entrepreneurial intentions. In what follows, we elaborate on our mediating and control variables.

Entrepreneurial self-efficacy was measured using the scale developed and validated by Zhao et al. (2005), including four items: 'How confident are you in successfully (1) Identifying new business opportunities?, (2) Creating new products?, (3) Thinking creatively? and (4) Commercializing an idea or new development?' (1 = no confidence, 7 = complete confidence). Scale reliability measured by Cronbach's alpha is 0.81.

Gender (0 = male, 1 = female) was controlled for as men are usually more entrepreneurial than women (Crant 1996; Zhao et al. 2005).

Position (0 = doctoral researcher, 1 = post-doctoral researcher) indicates whether the respondent has already obtained a PhD or not.

Technical degree (e.g., bio-science, physics, electronics, mechanics, robotics, ...) and non-technical degree (e.g., economics, law school, psychology, MBA, ...) assesses the degree research scientists obtained (0 = no, 1 = yes). Education is a key element of human capital which has been shown to affect the likelihood of becoming an entrepreneur (Mosey and Wright 2007; Shane 2000).

Academic experience indicates the number of years respondents have so far spent in academia. Research scientists' embeddedness in academia may lower the likelihood of producing commercial outputs (Ambos et al. 2008).

Medicine was included as a dummy variable (coded 1 if a research scientist performs research on clinical medicine or pharmacy, 0 otherwise), as medical inventions have greater marketability than inventions from other disciplines (Powers 2003). Further, research scientists at medical faculties are typically more familiar with working at the intersection of basic and applied research (Stuart and Ding 2006).

Country was controlled for, given the academic exemption or professor's privilege in Sweden (Klofsten and Jones-Evans 2000), by including a dummy variable (0 = Germany, 1 = Sweden).

1.3.2.4 Discriminant Validity and Common Method Variance

Before testing our hypotheses, we ran confirmatory factor analyses to check the distinctiveness of our measures and to rule out the impact of common method bias. Discriminant validity was assessed for pairs of constructs by constraining the estimated correlation parameter between constructs to 1 and then performing a chi-square difference test on the values obtained from the constrained and unconstrained models (Anderson and Gerbing 1988). For all 10 pairs of constructs, the chi-square values were significantly lower for the unconstrained models (i.e., $\Delta \chi^2_{df=1} > 3.84$), which indicates discriminant validity. Furthermore, we wanted to verify whether our results were affected by common method variance, which is a legitimate concern when all variables are gathered through a questionnaire (Podsakoff et al. 2003). Thus, we added a latent variable which was allowed to influence all items of our base model in which all items were allowed to load on their respective latent constructs. This additional latent variable represents the common method extracted from all items (Podsakoff et al. 2003). While CFI and SRMR fit indices indicate that this model is somewhat better than the model without common method variable, PNFI, which takes into account a model's parsimony and hence helps compare models (Hair et al. 2006), was higher for the model without the common method factor (0.75 versus 0.65), pointing to a better model fit. This indicates that common method variance was not a major concern in our study.

1.4 Results

Table 1.1 provides the means, standard deviations and correlations for all variables. Our sample consists of 281 (64 %) Swedish and 156 (36 %) German research scientists. 41 % of our respondents are women and 25 % occupy a post-doctoral position. In addition, 269 (62 %) research scientists in our sample possess a technical degree (science, technology or engineering) and 148 (34 %) a non-technical degree (business, social sciences or humanities). On average, respondents indicated having 7.59 years of experience in academia (SD 6.57 years). 93 respondents (21 %) are involved in clinical medicine or pharmaceutical research.

Hierarchical OLS regression analyses were performed to assess hypotheses 1, 2a and 3. In the first model, we entered only the control variables, while the independent variables were added in the second model. We checked for multicollinearity problems by calculating variance inflation factors (VIFs) for all models. The highest VIF was 1.1, which is substantially below the critical value of 5 (Hair et al. 2006) and indicates that multicollinearity is unlikely to be a concern in our study. Our results are presented in Table 1.2.

Model 1 is the baseline model consisting of control variables only. Results indicate that research scientists holding a technical degree (science, technology,

Table 1.1 Descriptive statistics and correlations

	Variable	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	Gender ^a	0.41	0.49											
(2)	Position ^a	0.25	0.43	0.05										
(3)	Technical degree ^a	0.62	0.49	-0.21**	-0.14**									
(4)	Non-technical degree ^a	0.34	0.47	0.18**	0.14**	-0.75**								
(5)	Academic experience	7.59	6.57	-0.06	0.36**	-0.17**	0.16**							
(6)	Medicine ^a	0.21	0.41	0.18**	0.12**	-0.31**	0.17**	0.19**						
(7)	Entrepreneurial self-efficacy	3.80	1.27	-0.23**	-0.08*	0.16**	-0.14**	0.04	-0.12**					
(8)	Country ^a	0.64	0.48	0.09*	0.12**	-0.22**	0.24**	0.23**	0.31**	-0.14**				
(9)	Entrepreneurial mission	0.83	0.33	-0.15**	-0.09*	0.12**	-0.12**	-0.03	-0.17**	0.18**	-0.11*			
(10)	Spin-off role models	0.41	0.49	-0.08	0.11**	0.10*	-0.11**	0.11**	0.01	0.19**	0.01	0.05		
(11)	Entrepreneurial rewards	0.74	0.51	-0.08	-0.08	0.11*	-0.17**	-0.09*	-0.03	0.21**	-0.07	0.18**	0.13**	
(12)	Spin-off intentions	2.89	1.61	-0.17**	-0.06	0.23**	-0.16**	-0.04	-0.08*	0.55**	-0.02	0.23**	0.23**	0.27**

Pearson correlation coefficient (1-tailed): *p < 0.05, **p < 0.01; n = 437

^aCorrelations of binary variables should be interpreted with care

Table 1.2 OLS regression model coefficients (standard errors in parentheses)

	Spin-off intentions	
	Model 1	Model 2
Constant	−0.206 (0.312)	−0.925** (0.343)
<i>Control variables</i>		
Gender	−0.103 (0.136)	−0.05 (0.133)
Position	0.057 (0.158)	0.043 (0.154)
Technical degree	0.609** (0.205)	0.627** (0.199)
Non-technical degree	0.132 (0.205)	0.267 (0.201)
Academic experience	−0.018 (0.011)	−0.018 (0.011)
Medicine	0.079 (0.173)	0.109 (0.169)
Entrepreneurial self-efficacy	0.687*** (0.052)	0.612*** (0.052)
Country	0.340* (0.144)	0.342* (0.140)
<i>Independent variables</i>		
Entrepreneurial mission		0.576** (0.195)
Spin-off role models		0.341** (0.130)
Entrepreneurial rewards		0.409*** (0.127)
F-statistic	27.350***	24.007***
R ²	0.34	0.38
Adjusted R ²	0.33	0.37
R ² change		0.04***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; $n = 437$

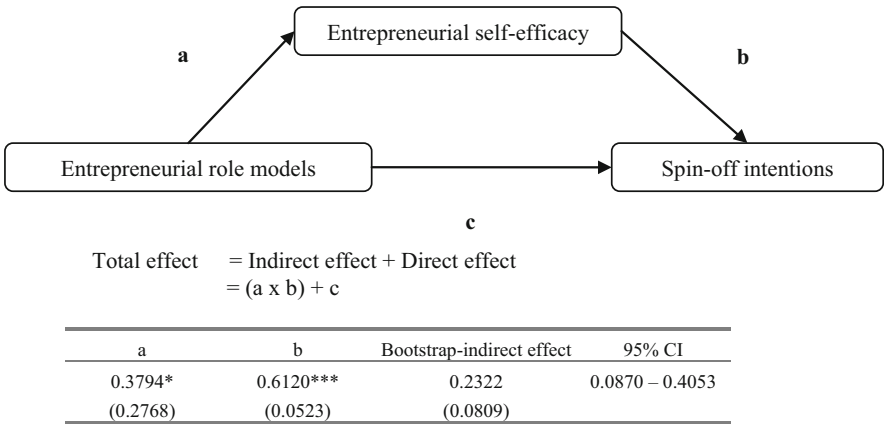
or engineering) have higher intentions to engage in spin-off creation ($p < 0.01$). Further, in line with prior research (Prodan and Drnovsek 2010; Zhao et al. 2005), entrepreneurial self-efficacy positively affects research scientists' entrepreneurial intentions ($p < 0.001$). Finally, a significant country effect ($p < 0.05$) exists, with Swedish research scientists showing higher intentions to found a company based on university research compared to their German colleagues.

Model 2 presents the results for the effects of culture and climate on entrepreneurial intentions, whilst controlling for individual characteristics and country effects. Adding independent variables to the baseline model leads to significant improvement of R^2 ($p < 0.001$). We find support for Hypothesis 1, which proposed that the degree to which a university mission highlights academic entrepreneurship relative to its traditional tasks is positively associated with research scientists'

spin-off intentions ($p < 0.01$). *Hypothesis 2a*, which looked at the relationship between university role models and research scientists’ entrepreneurial intentions, *is also supported*. The presence of spin-off role models is positively related to spin-off intentions ($p < 0.01$). Our findings *also support Hypothesis 3*, which states that the explicitness of academic entrepreneurship as criterion in the university reward system, compared to research and teaching, is positively related to research scientists’ entrepreneurial intentions. Entrepreneurial rewards has a significant positive influence on spin-off intentions ($p < 0.001$).

In order to test for the indirect relationship between university role models and intentions through entrepreneurial self-efficacy (Hypothesis 2b), we used a macro developed by Preacher and Hayes (2008). This allows us to disentangle the impact of direct and indirect (mediation) effects and relies on bootstrapping to test the mediation effect. The results are shown in Fig. 1.2.

Figure 1.2 displays the significance of the indirect effect, in particular the extent to which entrepreneurial self-efficacy mediates the relationship between university role models and entrepreneurial intentions. The indirect effect of spin-off role models on spin-off intentions via entrepreneurial self-efficacy is positive and significant (95 % CI = 0.087–0.405). This *provides support for Hypothesis 2b*.



* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; $n = 437$
F-statistic is significant at 0.1% level. Confidence interval (CI) is bias-corrected based on 10,000 bootstrap samples. Covariates included: gender, position, technical degree, non-technical degree, academic experience, medicine, country, entrepreneurial mission and entrepreneurial rewards. Standard errors in parentheses.

Fig. 1.2 Diagram of the mediation effect

1.4.1 Robustness Checks

We conducted post hoc analyses to assess the robustness of our results and to provide more fine-grained insights into the impact of organizational culture and climate on research scientists' entrepreneurial intentions. Specifically, while we deliberately assessed organizational culture and climate through the perceptions of research scientists, it is relevant to verify the degree to which people within an organization agree in their perceptions (Schneider et al. 2013). We subsequently calculated the (two-way random) intra-class correlation coefficients (ICCs) for the responses received on the items for mission and reward system for each university. ICC(2) is an index of the reliability of the group means and is commonly interpreted in line with other measures of reliability, with 0.70 or higher deemed adequate (Bliese 2000; LeBreton and Senter 2008). All ICCs were significantly above this generally accepted minimum value, with the lowest ICC equaling 0.89. This points to considerable convergence in the opinions of research scientists on the university mission and reward system.

1.5 Discussion and Conclusions

This chapter has sought to contribute to our understanding of how organizational culture and climate affect entrepreneurial intentions in academia, thereby adopting an institutional perspective. Our study provides evidence that universities can shape research scientists' intentions to engage in spin-off creation, by offering an institutional environment that promotes academic entrepreneurship. First, our analyses reveal interesting insights into the influence of *organizational culture* on entrepreneurial intentions. Particularly, the more universities emphasize academic entrepreneurship in their mission compared to research and teaching, the greater research scientists' intentions to engage in spin-off creation. Furthermore, a second element of university culture, the presence of spin-off role models leads to stronger intentions among research scientists to engage in spin-off creation. At the same time, entrepreneurial role models also exert an indirect influence on entrepreneurial intentions through an increase of research scientists' entrepreneurial self-efficacy. Specifically, research scientists who detect entrepreneurial role models in their university feel more confident that they could successfully engage in entrepreneurial activities themselves, and are therefore more likely to hold entrepreneurial intentions. Second, as for *organizational climate*, research scientists working at universities which explicitly allocate rewards for entrepreneurial endeavors were found to possess higher levels of entrepreneurial intentions.

This study contributes to the academic literature in a number of ways. First, this study contributes to the academic entrepreneurship literature, in which entrepreneurial intentions have only recently started to receive attention. Specifically, we use an institutional lens to study the impact of organizational context on

entrepreneurial intentions, while controlling for individual factors. Importantly, whereas university culture has been identified as a key driver for academic entrepreneurship (Clark 1998; Jacob et al. 2003; Martinelli et al. 2008; Siegel et al. 2004), to this point no research has provided a theoretical framework nor empirical evidence on the association between university culture and the development of entrepreneurial intentions. As such, this research responds to recent calls by Djokovic and Souitaris (2008) to untangle the impact of an entrepreneurial culture within the university and by O'Shea et al. (2005) to explain academic entrepreneurship in terms of university culture and rewards. Particularly, we show that elements of organizational culture, namely university mission and the presence of role models, just as organizational climate, including the extent to which the university reward system values entrepreneurial activities, have an important effect on research scientists' spin-off intentions. Second, this chapter enriches the entrepreneurial intentions literature which has predominantly focused on individual-level explanations of entrepreneurial intentions, but has to a large extent neglected organizational determinants. Given that individuals are embedded in institutional contexts, they cannot be studied in an isolated manner. Accordingly, we respond to a call by Dohse and Walter (2012) to contextualize entrepreneurial intentions.

Our research also has relevant implications for practitioners, including policy makers and university management. First, for policy makers, who base university funding upon evaluation criteria including a mix of research, teaching and entrepreneurial activities (Etzkowitz et al. 2000), it may be useful to understand how the universities they finance could enhance their commercialization output. Consequently, for instance, they could help to increase this output by stimulating universities to include entrepreneurial activities as part of the reward system. Second, for university management, this research shows that it is beneficial to incorporate academic entrepreneurship in the university mission and to make sure that research scientists are aware of existing role models. While examining the mechanisms through which university management could communicate that entrepreneurship is a fundamental part of the university mission was beyond the scope of our study, it is likely that any sort of communication (newsletters, speeches by university management) that increases the awareness among research scientists of the importance of entrepreneurial activities within their university will generate higher levels of entrepreneurial intentions. Furthermore, university management could ensure that role models make public appearances more frequently and as such, focus research scientists' attention on academic entrepreneurship as an ongoing and accepted organizational practice. Finally, university management could establish a reward system that does not only value scientific output, but also distributes rewards for research scientists' engagement in entrepreneurial activities.

Our study has a number of limitations which suggest fruitful areas for further research. First, data were collected at six universities in Germany and Sweden. While we find limited country differences based upon our analyses, there is little reason to assume that our results could not be generalized to other regions in Europe. Yet, further research could broaden the geographical scope and develop similar studies in other countries or study universities in a broader range of

contexts. Also, future studies could assess to which extent our results hold in samples of public research institutions or university colleges. Second, while our results indicate that raising awareness of an entrepreneurial mission or role models is conducive to entrepreneurial intentions, our study does not provide insights into how such awareness could be generated by universities and what communication mechanisms yield the better result. Consequently, future research could explore how to make research scientists optimally aware of the organizational culture in order to direct their behavior towards entrepreneurial activities. Third, our data collection is cross-sectional in nature. As such, we are unable to assess the impact of changes in the university mission or reward system on entrepreneurial intentions, nor to evaluate under which organizational conditions entrepreneurial intentions actually translate into entrepreneurial behavior. We encourage future studies to employ longitudinal research designs to shed light on these issues. Finally, this chapter deliberately focused on institutional characteristics at the level of the university. While we controlled for individual-level factors that have been found to affect entrepreneurial intentions, future research could purposefully assess which individual-level and organizational-level determinants reinforce each other, applying multilevel analysis techniques. Along the same lines, we call for research that further disentangles the impact of institutional context on entrepreneurial intentions, by including characteristics both at university and departmental level. Specifically, given that organizational culture may exist for a whole organization but also simultaneously in the form of subcultures (Schneider et al. 2013), a strong entrepreneurial spirit at the institutional level without support from local levels might have a less effective impact on research scientists' entrepreneurial intentions.

In spite of these limitations, to our knowledge, this chapter is the first to address the impact of organizational characteristics on entrepreneurial intentions in an academic context. Controlling for individual characteristics and considering academic entrepreneurship in a broad sense, we found that university culture and climate largely affect research scientists' spin-off intentions.

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Chapter 2

Mobility and Academic Entrepreneurship: An Empirical Analysis of Japanese Scientists

Satoko Yasuda

Abstract This study examines whether the mobility of university scientists enhances academic entrepreneurship at the individual level by examining scientists' career paths. It draws on a theoretical framework concerning the factors that enable entrepreneurs to recognize opportunities. A new set of data comprising credible and wide-ranging information facilitated the empirical analyses of more than 500 scientists holding full-time positions at the University of Tokyo. First, the study distinguishes between Japanese academic entrepreneurs (AEs), who recognized the opportunities offered in Japanese academia from 1998 to 2004, and non-AEs, who did not. It then compares the career paths of AEs and non-AEs, highlighting three kinds of mobility: job mobility, sector mobility, and international mobility. The result of the probit analysis clearly shows that both job mobility and international mobility are positively related to enhanced entrepreneurship among Japanese scientists, whereas sector mobility is not. A brief discussion of the results follows. This paper concludes that mobility—the experience of moving beyond boundaries—enables Japanese scientists to access the resources, learn the skills, and acquire the entrepreneurial traits that enhance their academic entrepreneurship.

Keywords Academic entrepreneurship • Mobility • Antecedent conditions • Opportunity recognition • University spinoff firm

2.1 Introduction

This study explores the factors shaping entrepreneurship among Japanese scientists who have created university spinoff firms and are transferring university inventions to the industrial sector and to society at large.

University inventions are being increasingly perceived as a source of innovation as developed economies become more knowledge-based. The depth and diversity of knowledge transferred from universities to society significantly impacts both

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firms' competitiveness and the social welfare of nations. Hence, both the managers of private companies and the policy makers of developed countries place significant emphasis on knowledge transfer from universities to industry.

However, this transfer always faces considerable difficulties. The prior research addresses the mismatch between the knowledge created in universities and what commercial exploitation of that knowledge requires (Wright et al. 2007a). Some view this mismatch as a knowledge filter that prevents knowledge invented in universities from becoming economically useful (Carlsson et al. 2009).

University entrepreneurship—"patenting, licensing, creating new firms, facilitating technology transfer through incubators and science parks, and facilitating regional economic development" (Rothaermel et al. 2007)—has been drawing significant attention from innovation scholars, many of whom have seen university entrepreneurship as an institution of national innovation system that induces universities and university scientists to attempt to overcome the knowledge filter (Zucker et al. 1998; Etzkowitz et al. 2000; Baba et al. 2009).

Among the various activities involved in university entrepreneurship, new firm creation by university scientists is one of major research agenda (Shane 2004; Wright et al. 2007b). The literature frequently focuses on academic entrepreneurs (AEs), university scientists creating university spinoff companies and developing their lab discoveries to meet industrial and social demands (Shane 2004). The previous research discovered several characteristics commonly shared by AEs. Some scholars found that AEs are likely to display high performance in patenting and publishing (Zucker et al. 1998; Powers and McDougall 2005). Others highlighted the intrinsic aspects of AEs, finding that psychological factors such as personal motivation (Sauermann et al. 2010), value orientation towards commercial activities (Lam 2011), and role identity (Libaers and Wang 2012) correlate well with entrepreneurship among AEs.

Existing studies "[share] a common theme: that spinoff behavior is a reflection of individual actions and therefore is largely due to the personality, ability or willingness of the individual to engage successfully in entrepreneurial behavior" (O'Shea et al. 2004). The studies confirmed that AEs' enhanced entrepreneurship stems from their individual characteristics, although their theoretical frameworks and methodologies vary.

While this paper does not challenge the existing literature that AEs share some characteristics, it argues that many studies have missed important insights about the conditions that have shaped them. The existing literature has not yet explored why AEs have these characteristics, nor sought to identify the factors that led university scientists to develop entrepreneurship that subsequently drove them to entrepreneurial activities such as firm-creation. This study explores these factors, which it refers to as *antecedent conditions*.

A few articles have discussed antecedent conditions. Some found that the *antecedent attributes* consist of excellence in scientific productivity, both of the scientists and of their organizations, and asserted that these attributes consequently encourage some scientists to do entrepreneurial work (D'este et al. 2009; Van Looy et al. 2011).

Several scholars suggested that mobility—the experience of moving beyond boundaries between organizations, sectors, and nations—is strongly related to the antecedent conditions that enhanced the entrepreneurship of some scientists and stimulated them to become AEs (Stephan and Levin 2001; Crespi et al. 2007; Edler et al. 2011; Krabel et al. 2012), although none of these scholars employed the term “antecedent conditions.”

Inspired by the literature, this paper examines whether mobility constitutes the antecedent condition for becoming an AE by assessing the mobility of Japanese scientists holding full-time positions at the University of Tokyo (UOT), Japan’s top-ranked university, through an analysis of their career paths.

The approach of this study is an effective way of accurately estimating the human mobility of university scientists. As Lenzi (2007) indicated, many studies on mobility analyze datasets extracted from patent data; however, the patent data do not always reflect human mobility. For example, inventing scientists can work for a university while affiliated with other organizations geographically distant from each other. As inventing scientists may apply for many patents while claiming multiple affiliations (i.e., job titles), their human mobility can be overestimated.

A dataset extracted from curriculum vitae (CV) information accurately indicates the human mobility of each scientist. It clearly traces the trajectory of the scientist’s physical movement from one organization to another. Few studies have analyzed CV data, however, mainly because collecting them often requires scholars to devote substantial time and research funds. In Japan, CV information on many scientists is clustered in certain websites, many maintained by credible organizations such as universities, governmental agencies, funding organizations, famous preparatory schools, and large booksellers. This analysis of Japanese scientists makes full use of these detailed and credible CV data, which facilitates the accurate identification of the human mobility of university scientists.

This study contributes to research by empirically demonstrating that mobility constitutes the antecedent condition that enhances entrepreneurship among Japanese scientists; it also shows policymakers that academic scientists with high mobility are likely to conduct knowledge transfer from university to industry through entrepreneurial activities, so that they may consider the relevant policy implications.

The rest of this paper is organized as follows. The next section reviews the existing literature, leading to the theoretical development and hypotheses, examined later. Section 2.3 introduces the research methods and key variables used in the empirical analysis. Section 2.4 presents the results of the analysis. Section 2.5 provides a brief discussion on the implications of the results. Section 2.6 summarizes the study.

2.2 Theoretical Framework and Hypotheses

2.2.1 *University Entrepreneurship and AEs*

The university is among advanced countries' oldest institutions. Since its development in medieval times, its main roles have been basic research and teaching, and therefore, universities have provided their societies with sophisticated knowledge and highly skilled people. As developed nations shifted towards knowledge-based economies, universities faced increasing demand to augment the supply of knowledge (Foray and Lissoni 2010).

Recently, and especially since WW2, the demand further escalated and has imposed a new request on universities. The governments and people of advanced countries have become interested in enriching their economic and social conditions by exploiting academic knowledge. They expect universities to transfer their research outcomes to the industrial sector and thus contribute directly to productivity increases in firms and to the growth of nations. In response to this expectation, universities and their scientists have engaged in knowledge transfer through patenting, licensing, and the creation of new firms (Foray and Lissoni 2010; Slaughter and Leslie 1997). Consequently, universities now serve a "third-mission" of contributing directly to the development of societies and countries (Etzkowitz et al. 2000).

The enactment of the Bayh-Dole (BD) Act (U.S. Law 96-517, Patent and Trademark Act Amendments of 1980) was both an outcome of and a response to the needs of that third mission. The legislation instituted a uniform patent policy across U.S. federal agencies and universities. Soon afterwards, Japan and many European countries adopted similar legislation (Grimaldi et al. 2011). Many studies on the legislation's impact on the innovation systems of various sectors, regions, and nations have been published.

American scholars frequently focus on university patents and patent-related activities conducted by academics. Among these, many studies argued that the BD Act has had little impact on the qualitative and quantitative growth in university patents (Henderson et al. 1998; Mowery et al. 2001; Mowery and Ziedonis 2002).

European scholars observed the impact of BD-like legislation in their countries from a wider perspective than that taken by their U.S. peers. They paid significant attention to entrepreneurship, known to be a driver of rapid and widespread knowledge transfer from universities to industry (Siegel et al. 2007; Wright et al. 2007b; Baldini 2009, 2010; Lam 2010). They often discussed whether the legislation strengthened the wealth-generating abilities of European universities, and analyzed whether the legislation enhanced their aptitude "to convert [their] scientific research into technologies and practical applications through the creation of high-tech start-ups" (Wright et al. 2007b, p. 6).

Although the results vary somewhat across authors and sample regions, many European studies concurred that the legislation has facilitated systemic change in Europe's university sector. Unlike the BD Act, which permitted federally funded

researchers to file for patents on their research outcomes and grant licenses for these patents to private companies, BD-like legislation in European countries was introduced to enable systemic change in European universities. The legislation was expected to fill the gap between the U.S. innovation system, in which university scientists frequently exhibit entrepreneurial attitudes, and the European system, which has suffered from the *European Innovation Paradox*.¹

Japan has had a similar experience. It introduced BD-like legislation expecting to catch up with the US system of innovation. Between 1998 and 2004, the Japanese government enacted four laws,² all of which were expected to encourage university scientists to transfer and commercialize their research outcomes (Baba et al. 2009; Collins and Wakoh 2000; Kneller 2007; Walsh et al. 2008; Harayama et al. 2009). During the same period, the government offered incentives to university researchers such as generous financial support in order to enhance their entrepreneurship.

However, some have been skeptical about the effectiveness of Japan's BD-like legislation in enhancing academic entrepreneurship (Harayama et al. 2009; Collins and Wakoh 2000). They argued that, for at least several years after the BD-like legislation was enacted, there was no robust evidence to show that innovation system in Japan had shifted towards U.S.-like system, in which university scientists are very eager to create spinoff firms by which to transfer university inventions (Kneller 2007). In the same vein, Harayama et al. (2009) asserted that some of the policy initiatives carried out in accordance with the legislation actually hindered academic entrepreneurship.

On closer inspection, Kneller (2007) found that Japanese professors did not change their traditional attitudes to knowledge transfer: both before and after the BD-like legislation was introduced, most transferred their research outcomes through exclusive ties to large and established companies rather than by creating their own spinoff firms.

Though both Europe and Japan attempted to introduce BD-like laws in order to adopt a U.S.-style innovation system that encourages university spinoffs, both (excluding the UK) still substantially lag behind the U.S. in the number of new spinoff firms and firm-founding AEs. Institutional differences between the U.S. on one side and Europe and Japan on the other are considered among the major factors responsible for the lag.

The individual characteristics of scientists were also closely studied by the scholars. Some have highlighted psychological aspects such as motivation

¹"In their seminal work, Carocostas and Muldur have shown that the productivity rate of [European] academics in term of scientific papers is higher than that of their US colleagues, when we take language-related into account. However, in terms of patents per capita, all European countries lag significantly behind the US" (Wright et al. 2007b, pp. 5–6).

²The Act on the Promotion of Technology Transfer from Universities to Private Business Operators, also known as the "TLO law" (Act No. 52 of May 6, 1998); the Act on Special Measures for Industrial Revitalization, also known as the "Japan Bayh-Dole Law" (Act No. 131 of 1999); the Industrial Technology Enhancement Act (Act No. 44 of April 19, 2000); and the National University Corporation Act (Act No. 112 of 2003).

(Sauermann et al. 2010), value orientation towards commercial activities (Lam 2011), and role identity (Libaers and Wang 2012). Others focused on scientists' mobility as reflected in their career paths. Most of the research in this stream confirmed that high mobility is significantly related to enhanced entrepreneurship among scientists (Stephan and Levin 2001; Hunt and Gauthier-Loiselle 2008; Edler et al. 2011; Krabel et al. 2012).

Though empirically robust, the findings might have underestimated the level of mobility of some of the scientists. Some articles proxy mobility using scientists' foreign-born backgrounds (Stephan and Levin 2001; Hunt and Gauthier-Loiselle 2008; Libaers and Wang 2012), which might have missed many native-born scientists who had stayed in foreign countries for a long time and then returned home. Articles that collected data from online surveys (Edler et al. 2011) may also not be free of underestimation since there is no guarantee that the scientists' career paths were disclosed in detail.

Though this study's use of CV information is not free of the underestimation risk, the CVs used are posted on websites maintained by organizations with the right to collect scientists' career-path information. Thus, this study can estimate mobility accurately while contributing to the literature through a detailed examination of whether mobility encourages university scientists to become AEs.

2.2.2 *Entrepreneurship and Opportunity Recognition*

The entrepreneurial activities of both business entrepreneurs and AEs begin with successful opportunity development. This process includes the recognition of an opportunity, its evaluation, and its development (Ardichvili et al. 2003). Recognizing, identifying, and selecting the right opportunities for innovation are among the most important abilities of a successful entrepreneur (Stevenson et al. 1985). One may thus infer that AEs are more likely to have what it takes to recognize opportunities than are non-AEs.

The literature on entrepreneurship theorized about the factors that enable entrepreneurs to recognize opportunities; these include social networks (Hills et al. 1997), prior knowledge (Shane 1999), personal traits such as optimism (Krueger and Dickson 1994), creativity (Schumpeter 1934; Kay 1986; Hills et al. 1997), motives (Sauermann et al. 2010; Lam 2011), preference structure (Lam 2011), and a scientist's inclination towards "outcome-based basic research" (Baba et al. 2011).

However, regardless of how well the theory explained the factors enabling AEs to recognize opportunities, few revealed how AEs came to gain access to those factors. Something must have induced them to access such *enabling factors*. For convenience, this study calls that "something" the "antecedent conditions." Logically, the antecedent condition precedes AEs' entrepreneurial activities and influences the onset of their entrepreneurial behavior.

D’este et al. (2009) and Van Looy et al. (2011) highlighted the scientific capabilities of both the AEs and their universities and discovered some of the antecedent attributes of AEs’ entrepreneurial skills. The notion of antecedent attributes is related to what this paper calls “antecedent conditions.”

This study attempts to indicate more unambiguously that antecedent conditions refer to events and statuses in a scientist’s past. They precede the point at which the AEs decided to create spinoff firms; they enhanced their entrepreneurship and allowed them to create firms. This study assumes that antecedent conditions can be found by examining individual scientists’ career paths. It therefore compares the career paths of AEs and non-AEs, presuming that the career differences between the two groups define the antecedent conditions. To facilitate its empirical analysis, the study estimates an individual’s career path by focusing on three kinds of mobility: job mobility, sector mobility, and international mobility.

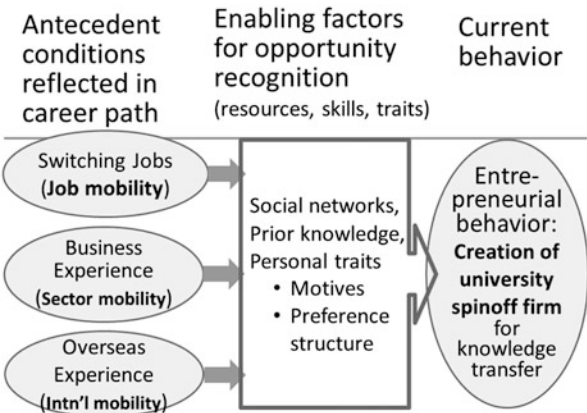
The next three subsections review the existing literature on scientist mobility,³ from which three hypotheses will be drawn.

Figure 2.1 summarizes the above discussion and illustrates the conceptual framework for the study.

2.2.3 Job Mobility and Opportunity Recognition

This study divides scientists into two groups: scientists who have moved to their current affiliation from other universities fall into the high-job mobility group,

Fig. 2.1 Conceptual framework



³ Some authors distinguish between human and technology mobility (Crespi et al. 2007; Lenzi 2007), the former mainly measured using individuals’ background information and the latter estimated based on data contained in patents. This study examines human mobility, estimated using the career path information of individual scientists.

while those who have stayed at their current affiliations since being hired full-time comprise the low-job mobility group.

Scholars who investigated the relationship between job mobility and academic entrepreneurship approached the topic from one of two perspectives: researchers' intrinsic factors, such as motives and preference for entrepreneurial behaviors, or AEs' access to both knowledge and human networks as joint supports for their entrepreneurial endeavors.

Richardson and McKenna (2003) and Thorn (2009) are among those who highlighted researchers' intrinsic factors, indicating that scientists' career motives, not financial incentives, drive them to be mobile. Similarly, Lam (2011) focused on intrinsic factors and revealed that heterogeneous motives drive academic scientists into commercial endeavors. She drew from social psychology theory to discuss how personal motivation affects scientists' commercial engagement. In the same vein, Sauermann et al. (2010) surveyed data on more than 2000 U.S. academic scientists and clearly showed the significant relationships between their motives and entrepreneurial activities.

Scholars who focused on AEs' access to both knowledge and networks often indicated that entrepreneurs seek innovation by recombining different types of knowledge. As the theory of "sticky knowledge" argues, place-specific or context-embedded knowledge is immobile (Asheim and Isaksen 2002). This theory implies that job mobility enables entrepreneurs to access fresh knowledge embedded in the organization to which they have just moved. It also implies that, when an entrepreneur envisions a *new combination* of the fresh knowledge with the familiar knowledge that he/she had learned at the previous affiliation, the entrepreneur clearly recognizes an opportunity for innovation.

Entrepreneurs are also able to build relationships with new colleagues, some of whom contribute ideas for innovation. As a quid pro quo, entrepreneurs may transfer knowledge from their previous affiliations which would be considered fresh by their new colleagues. This process of knowledge exchange facilitates mobile entrepreneurs' recognition of novel opportunities.

From the discussion above, this study postulates a proposition regarding job mobility: in academia, job mobility fosters entrepreneurial savvy, and thus job mobility and the likelihood of creating spinoff firms are positively correlated. This proposition leads to the first hypothesis:

H1 University scientists who have job mobility are more likely to be AEs than are their non-mobile peers.

2.2.4 Sector Mobility and Opportunity Recognition

University scientists with work experience in the industrial sector comprise the high-sector mobility group, while those who have stayed in the university sector for their entire professional lives comprise the low-sector mobility group.

The literature on knowledge transfer among universities and businesses frequently indicated the gap between these two sectors. Some scholars addressed the gap as a mismatch between the knowledge created in universities and the requirements for its commercial exploitation (Wright et al. 2007a); others viewed this gap as a knowledge filter that prevents knowledge from becoming economically useful (Carlsson et al. 2009).

The literature often indicates, however, that there are factors that help AEs fill the gap or overcome the filter. For example, direct communication among the persons involved—those participating in knowledge exchange from both universities and companies—has been extensively studied. Research in this stream often discovered that direct communication is supported by face-to-face interactions among academic scientists and company researchers (Balconi and Laboranti 2006), by consultancy and joint research conducted by both academics and business people (D’Este and Patel 2007), and by social networks of academics developed through prior business owner experience (Mosey and Wright 2007).

From the discussion above, this study postulates a proposition regarding sector mobility: sector mobility provides scientists with opportunities to have direct communication with businesspeople, which subsequently helps scientists fill the gap or overcome the filter between academia and industry. This proposition leads to the second hypothesis:

H2 University scientists with sector mobility are more likely to be AEs than are their non-mobile peers.

2.2.5 *International Mobility and Opportunity Recognition*

Research on international mobility often observed that scientists’ entrepreneurship is associated with their overseas experience or foreign backgrounds. These studies mainly drew on theories developed in three fields: labor migration, sociology, and innovation studies.

Studies employing the labor migration theory indicated that overseas experience improves migrants’ risk perception, making them less risk averse. Individuals who are less risk averse are more likely to engage in entrepreneurial activities such as firm creation (Hormiga and Bolívar-Cruz 2012).

Sociology scholars have also found a positive relationship between migration experience and entrepreneurial behavior. Tracing the diffusion of knowledge that follows the migration of highly skilled people, they found a new phenomenon called “brain circulation”—the process by which highly skilled immigrants take advantage of their ethnicity to enhance their entrepreneurial opportunities. These *circulating brains* serve as middlemen (or middle women) linking knowledge in their host countries to the distant regions from which they have come (Saxenian 2002; Chalamwong 2004; Davenport 2004; OECD 2008). Through a close analysis of migrant professionals in Silicon Valley, Saxenian (2007) argued that foreign-

born professionals skillfully recognize the opportunities in one country that are not available in others.

Innovation studies approached the topic from one of two different viewpoints: scientific productivity or entrepreneurship status. Some scholars have shown that overseas experience increases scientists' productivity, measured mainly by their publishing and patenting activities (Stephan and Levin 2001; Lee 2004; Hunt and Gauthier-Loiselle 2008). Drawing on the theory of "star scientists" (Zucker et al. 1998) and "Pasteur's quadrant" (Stokes 1997), scholars in this stream also showed that the higher scientists' productivity, the more entrepreneurial they are. Therefore, they concluded that scientists with international mobility are more entrepreneurial than are their less mobile peers.

Other innovation scholars investigated the direct relationship between international mobility and entrepreneurial traits. This strand of literature did not emphasize the importance of scientific productivity in stimulating entrepreneurship; rather, it underlined the intrinsic factors influenced by overseas experience or foreign birth and which eventually make them more entrepreneurial than their peers. These intrinsic factors include role identity (Libaers and Wang 2012), social and human capital (Edler et al. 2011; Krabel et al. 2012), and entrepreneurial propensity (Bercovitz and Feldman 2007).

The literature often indicated a positive relationship between international mobility and academic entrepreneurship, no matter the level of scientific productivity. Hence, this study postulates a third proposition: international mobility is positively related to academic entrepreneurship. This leads to the hypothesis below:

H3 University scientists who have international mobility are more likely to be AEs than are their non-mobile peers.

2.3 Data and Methodologies

2.3.1 Data Selection

This study collects data on Japanese⁴ scientists who had full-time positions at the UOT in (or near) 2012. It employs this timeframe because it marks a decade since the Japanese government initiated its organizational reform of national universities intended to enhance entrepreneurship among Japanese scientists; it is thus the best period for observing the state of entrepreneurship among scientists.

From 1998 to 2004, the Japanese government initiated an organizational reform of Japanese national universities to catch up to the U.S. model, in which many AEs are conducting knowledge transfer and therefore directly contributing to the

⁴ A couple of scientists whose names do not seem to be Japanese are included in the data. However, their nationality could not be confirmed.

competitiveness-building of both firms and the nation. The Japanese government provided various incentives to motivate university researchers to commence knowledge transfer, including substantial financial support for AEs. Thus, the 1998–2004 period was an era of opportunity.

However, the reform was followed by unintended consequences: most Japanese professors did not respond to the incentives, nor attempted to seize the opportunities.

Nevertheless, a small but constant number of scientists working for national universities successfully recognized the opportunity and created spinoff firms to gain from it.

Table 2.1 displays the number of AEs involved in the formation of university spinoff firms. The left one shows the number of AEs affiliated with the top 10 national universities in Japan. It shows data as of 2003, the earliest year for which figures are available and the mid-point of the reform that legitimated firm creation by national university staff for the first time. Meanwhile, the right one shows how many AEs were produced at the UOT during the 2003–2012 period.

Table 2.1 displays two features that jointly show the appropriateness of the data selection of this study. First, AEs are clustered in the top 10 universities, which produced 51 % of AEs in 2003. Among them, UOT is one of the most important

Table 2.1 Number of academic entrepreneurs (AEs) in Japan

Name of University	Number of faculty involved in spinoff firms (as of March, 2003)	fiscal year	number of UOT faculty involved in spinoff firms in each of the fiscal year	Total number of UOT professors, associate professors, lectures
Osaka University	22	2003	21	2,793
University of Tokyo (UT)	21	2004	24	2,808
Hokkaido University	21	2005	21	2,828
Kobe University	14	2006	38	2,429
Nagoya University	13	2007	33	2,424
University of Tokushima	11	2008	29	2,489
University of Tsukuba	9	2009	29	2,436
Tokyo Institute of Technology	8	2010	30	2,428
Kagawa University	8	2011	31	2,472
Kyushu Institute of Technology	7	2012	32	2,430
Total (top-ten universities)	134			
Total (all national universities)	265			

Source: MEXT (Ministry of Education, Culture, Sports, Science and Technology)

Source: University of Tokyo

sources of AEs. Therefore, researching AEs at the UOT should reveal the factors shaping the current system of innovation in Japan.

Second, the table on the right indicates that the number of AEs at the UOT has been constant since 2003. Every year since 2003, between 20 and 40 AEs have reported involvement in university spinoff firms. However, AEs at UOT are a minority within their organization. Each year, AEs constitute from 0.8 to 1.5 % of all UOT professors, associate professors, and lecturers. This number is slightly larger than that for all of Japan's national universities.⁵ As a whole, however, AEs form a fringe group among full-time researchers in all of Japan's national universities, including the UOT. This suggests that the research on UOT would, at a satisfactory level, elucidate the entrepreneurial status of many Japanese scientists working for national universities.

It is important to note that a small but constant number of AEs have been stimulated by the government-led reform and have successfully recognized the opportunity to create spinoff firms. Why did they view the reform positively and recognize the opportunity to begin entrepreneurial activities while their peers did not? The remaining part of this paper explores this question guided by the assumption that there are antecedent conditions that enhance entrepreneurship among the AEs.

2.3.2 Data Sample

As Table 2.1 clearly shows, the UOT is one of the main sources of Japanese AEs; accordingly, this study investigates scientists working there. As of May 2012, the UOT had 2430 professors, associate professors, and lecturers with full-time positions.⁶ This number includes not only scientists but also humanities and social science specialists. Of 2430 UOT researchers, this study selected a sample of 551 scientists specializing in one of the following disciplines: engineering, computer science, medicine, pharmaceutical science, and chemistry. This sample group accounts for approximately 23 % of all UOT faculty members.

To identify the three types of mobility in the sample, an original database was constructed by consulting various sources, including the official UOT website on which the CVs of many scientists are posted, databases run by Japanese governmental agencies, archived interviews conducted mainly by journalists and UOT students, and the websites of other credible organizations, such as established publishers, large online bookshops, and famous preparatory schools.

⁵The Ministry of Finance (MOF) estimated that there were as many as 67,594 full-time researchers in national universities in 2004. Around the same time, national universities produced only 265 AEs, who comprised only 0.4 % of all of full-time researchers at all national universities.

⁶From the UOT website (http://www.u-tokyo.ac.jp/per01/b02_03_h24_j.html).

Table 2.2 AEs and non-AEs at the UOT

AEs		60
Engineering/Computer Science (EC)	} 32	(27)
Bio Medical Engineering (EC)		(5)
Life Science (LS)	} 28	(28)
non-AEs		491
Engineering (EC)	} 389	(341)
Computer Science (EC)		(48)
Medicine (LS)	} 102	(63)
Pharmaceutical Science (LS)		(21)
Chemistry (LS)		(18)
Total		551
(Total number of profs., associate profs. and lecturers at UOT)		(2430)

EC specialists in engineering or computer science fields, *LS* specialists in life science field

Information disclosed in accordance with the Rules of the National Personnel Authority (NPA)⁷ enhances the quality of the database because it provides data regarding UOT researchers' involvement in commercial activities such as creating university spinoff firms or becoming involved in such firms as management board members.

Table 2.2 summarizes the data sample collected through these procedures; it shows that 60 out of the 551 UOT scientists are identified as AEs, who at the time of this research are university scientists, hold full-time positions at the UOT, and have created or joined the management board of university spinoff firms.⁸

2.3.3 Empirical Methodology

This study examines whether mobile scientists are more likely to become AEs than are non-AEs. Given the binary nature of both the dependent and independent

⁷ The Industrial Technology Enhancement Act, together with the National University Corporation Act, made it possible for full-time researchers at national universities to simultaneously hold positions in private businesses. In accordance with that, the NPA requested that national university scientists report their involvement in business to MEXT. The database of this study employs data collected and disclosed through this procedure.

⁸ This number includes AEs who had once been members of a management board of a spinoff firm but who resigned afterwards.

variables, this empirical study employs a probit analysis for the probability of becoming an AE:

$$AES_j^* = \begin{cases} 1 & \text{if } AES_j^* > 0 \\ 0 & \text{if } AES_j^* \leq 0 \end{cases} \quad (2.1)$$

$$AES_j^* = \alpha + \beta \text{ Jmobj} + \gamma \text{ Smobj} + \delta \text{ Int'l mobj} + \varepsilon_j \quad (2.2)$$

$$\varepsilon_j \sim N(0, \sigma) \quad (2.3)$$

where j indexes individual scientists and AES_j^* is a dummy variable for becoming an AE; Jmob, Smob, and Int'l mob are dummy variables representing job mobility, sector mobility, and international mobility respectively. A detailed description of each variable is given in the following subsection.

Probit regression analysis will be performed using (2.2).

2.3.4 Variables

2.3.4.1 Dependent Variable

This study adopts one dependent variable—the probability of becoming an AE—proxied by a dummy variable. The dummy variable takes the value 1 if the scientist has become an AE and 0 otherwise.

2.3.4.2 Independent Variables

This study adopts three independent variables: job mobility, sector mobility, and international mobility. Job mobility, referring to job-switching experience, is a dummy variable taking the value 1 if the scientist has moved from one organization to another after taking a full-time position either at a university or at a company, and 0 otherwise.

Sector mobility refers to the experience of working for a private company; this is a dummy variable and takes the value 1 if the scientist was hired by a private company on a *lifetime employment contract*⁹ before joining the UOT and 0 otherwise.

⁹This term refers to long-term employment rather than lifetime employment, which this study considers the Japanese equivalent of a *full-time position*. Employees who sign this type of contract rarely have incentives to switch jobs because of the pay system that offers favorable treatment for long-time members of an organization. Moreover, most large Japanese companies, which are the biggest source of sector-mobile UOT scientists, pay much higher wages than do national universities. Consequently, based on economic rationality, moving to the university sector is not considered an appropriate strategy for Japanese wage earners.

International mobility refers to the scientist’s past experience of living abroad; this is a dummy variable and takes the value 1 if the scientist worked for a foreign organization, or studied at foreign universities, for at least 3 years. Unlike the job mobility and sector mobility dummies that take the value 1 only if scientists change their affiliations *after* getting full-time positions, the international mobility dummy takes the value 1 if the scientists stayed in a foreign country for at least 3 years *whether or not they already had full-time positions*. This leads to the expectation that, all else being equal, international mobility may be the most popular of the three kinds of mobility.

2.4 Results

Table 2.3 provides the descriptive statistics. It shows the means, standard deviations, and minimum and maximum values. Table 2.4 contains the correlation matrix. None of the pair-wise correlation coefficients reach the threshold value of 0.7. To further assess the potential for multicollinearity, this study calculated the variance inflation factors (VIF). For all the models, the maximum VIF value is 1.23. Hence, the results do not suffer from multicollinearity.

Approximately 11 % of UOT scientists are AEs who have created at least one university spinoff firm or who are otherwise members of such a firm’s management board. Meanwhile, roughly half of UOT scientists (0.52) have experienced job switching, after obtaining a full-time position at an organization other than the UOT; the remaining half of the sample consists of stayers who have been at the UOT since securing their positions.

Table 2.3 Descriptive statistics

Variable	Observations	Mean	Standard deviation	Min	Max
<i>Dependent variable</i>					
Firm creation	551	0.11	0.31	0	1
<i>Independent variables</i>					
Job mobility	551	0.52	0.50	0	1
Sector mobility	551	0.17	0.37	0	1
International mobility	551	0.12	0.33	0	1

Table 2.4 Correlation matrix (Spearman)

	Firm creation	Job mobility	Sector mobility	Extended intrn'l mobility
Firm creation	1			
Job mobility	0.125	1		
Sector mobility	−0.016	0.429	1	
International mobility	0.205	0.062	−0.005	1

By contrast, sector mobility is quite low (0.17), as is international mobility (0.12): only 12 % of UOT scientists lived in foreign countries for at least 3 years. Contrary to expectations, international mobility is the lowest form of mobility among UOT scientists.

Table 2.5 presents the result of a probit analysis, the relationship between the probability of becoming an AE and the three kinds of mobility (job, sector, and international). In Model 1, job mobility has a significant and positive relationship with the probability of becoming an AE ($\beta = 0.4$, $P < 0.01$), confirming Hypothesis 1. The model also indicates a significant and positive relationship between AE activities and international mobility ($\delta = 0.76$, $P < 0.01$), confirming Hypothesis 3.

In Model 2, while the relationship between AE activities and international mobility is sustained, there is no significant relationship between the probability of becoming an AE and sector mobility; hence, Hypothesis 2 is not supported.

Model 3 links AE activities and the three kinds of mobility; it shows that the probability of becoming an AE is significantly and positively related to job mobility ($\beta = 0.48$, $P < 0.05$) and international mobility ($\delta = 0.74$, $P < 0.01$). Sector mobility, by contrast, has no significant effect on the probability of a scientist becoming an AE.

The three probit models in Table 2.5 jointly support Hypotheses 1 and 3, confirming that both job and international mobility influence UOT scientists to engage in knowledge transfer by creating university spinoff firms.

A limitation of this analysis should be noted. The empirical analysis did not employ control variables such as gender or age. The sample analyzed in this study is overwhelmingly dominated by male researchers (only 10 out of 551 researchers in the sample have female-like names); thus, the control variable for gender would not

Table 2.5 Results (Probit)

	Firm creation		
	Model 1	Model 2	Model 3
Independent variables			
Job mobility	0.4*** (0.15)		0.48** (0.16)
Sector mobility		−0.05 (0.20)	−0.29 (0.21)
International mobility	0.76*** (0.18)	0.79*** (0.18)	0.74*** (0.19)
Constant	−1.6*** (0.12)	−1.37*** (0.09)	−1.6*** (0.12)
LR chi2	25.05***	18.13***	26.96***
Pseudo R2	0.066	0.0478	0.0711
Observations	551	551	551

Results of probit estimation. Standard errors in parentheses

Significant at 5 %; *significant at 1 %

increase the explanatory power of the probit analysis. Very limited information about the year of birth of individuals in the sample was available, and, therefore, the study could not include a control variable for age. This might impose some limitation on the explanatory power of the model.

2.5 Discussion

The result of the empirical analysis suggests that, among UOT scientists, knowledge transferring activities through firm-creation are associated with job mobility and international mobility. This is corroborated by the existing literature, which (as discussed in Sect. 2.2) argues that mobility supports successful opportunity recognition by entrepreneurs. The literature frequently points out that moving beyond boundaries enables AEs to recognize entrepreneurial opportunities.

Mobile scientists are better positioned than their less mobile peers to recognize and obtain innovation opportunities because they have access to rich networks and have gained heterogeneous knowledge through their experience.

Furthermore, scientists with experience of doing research in foreign countries such as the U.S. or the UK, which have a wealth of best practices developed by pioneering AEs, may have positive motivations and preferences for entrepreneurial activities. Shane (2004) argued that the growth of spinoff activities is consistent with contagion effects, by which scientists are influenced by the pioneering AEs who have already founded spinoff companies. Pioneering AEs encourage their peers to devote themselves to entrepreneurial activities; as a consequence, several peer scientists decide to start their own spinoffs.

This contagion effect may spread not only among native-born peers but also among peers from other countries, including Japan. Japanese scientists who have visited pioneering AEs in foreign countries and shared research activities with them may have witnessed how well those pioneers had achieved knowledge transfer that helped solve social problems from which ordinary people had long suffered. They may also have learned how skillfully the pioneering AEs have managed the complicated tasks inherent to entrepreneurial activities. Thus, the Japanese scientists who have shared research activities with pioneering AEs in foreign countries were able to obtain a role model that would help them develop entrepreneurship.

The Japanese often say “you cannot do two things successfully at the same time:” pursuing two tasks—making scientific discoveries and managing spinoff firms that transfer the knowledge acquired through those discoveries—is not highly appreciated by Japanese scientists. However, those who have shared research activities with pioneering AEs in foreign countries and consequently witnessed effective spinoff-firm creation and knowledge transfer may have different proclivities. They may consider becoming an AE to be a satisfying career option. Accordingly, this study affirms that international mobility enhances entrepreneurship among Japanese scientists.

Nevertheless, in contrast to job and international mobility, sector mobility does not have a positive relationship with entrepreneurship. This implies that previous experience in the business sector does not incubate the capabilities contributing to successful opportunity recognition. This counterintuitive insight needs further investigation.

A comparative study of sector-mobile scientists and those with job and international mobility may provide a clue to this puzzle. Crespi et al. (2007) found differences in that which determines mobility towards universities or business (the former is equivalent to job mobility and the latter to sector mobility in this study). Their finding implies that sector mobility has a different impact on human capital formation than do job and international mobility.

Another possibility for solving the puzzle concerns the difficulty of combining knowledge. Both job and international mobility enable AEs to access fresh knowledge embedded in the organization to which they have just moved. Simultaneously, the AEs continue to utilize the familiar knowledge embedded in their previous affiliations, due to the openness of the university sector. Consequently, job and international mobility facilitate combining new knowledge with familiar knowledge, which comprises an opportunity AEs recognize and gain from.

By contrast, sector mobility may not allow mobile scientists to combine the two sources of knowledge due to the knowledge gap between universities and companies. Strict nondisclosure rules imposed on scientists who move to academia from private companies may also hamper combination. However, this study could not empirically demonstrate this causality. Further investigation is needed.

2.6 Conclusion

This study sought the factors encouraging Japanese academic scientists to engage in entrepreneurial activities that eventually result in knowledge transfer from university labs to industry. A new dataset composed of credible and varied information facilitated the analysis of more than 500 scientists currently holding full-time positions at the UOT.

Drawing on a theoretical framework for entrepreneurs' opportunity recognition, this study distinguished between Japanese AEs, who recognized the opportunities available in Japanese academia from 1998 to 2004, and non-AEs, who did not.

This study then compared the career paths of AEs to those of non-AEs. Three kinds of mobility—job mobility, sector mobility, and international mobility—were highlighted as antecedent conditions that incubate AEs' opportunity recognition abilities. The result of the probit analysis clearly showed that both job mobility and international mobility are positively related to enhanced entrepreneurship among scientists at significant levels, whereas sector mobility is not.

This result indicates that the experience of moving beyond boundaries enhances Japanese scientists' opportunity recognition ability and encourages them to behave

in ways that allow them to gain opportunities for knowledge transfer from universities to industry.

Finally, the methodological limits on this study should be mentioned. Since the research was focused on UOT scientists, the general applicability of the analysis is limited. It would be necessary to collect corresponding data from several other national universities to ensure that the result is consistent across Japan's academic institutions. Moreover, samples from different regions in Japan should be used in order to confirm that the result is robust and consistent across regions. Further research is needed to investigate how each type of mobility interrelates with the factors that enable AEs' successful opportunity recognition.

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Chapter 3

Fostering Female Entrepreneurship in Academic Spin-offs

Alessandra Micozzi, Francesca Micozzi, and Pierpaolo Pattitoni

Abstract We aim at analyzing female participation in Italian academic spin-offs using publically available data and a unique hand-collected database of all academic spin-offs set up in Italy from 2002 to 2007. We base our study on three complementary levels of analysis: macro, meso, and micro level. We show that the gender gap in academic spin-offs is relevant and that a certain degree of spatial heterogeneity—possibly reflecting cultural and environmental differences between Italian provinces—exists. Furthermore, our findings show a disadvantage of females in the startup funding phase: an unfavorable circumstance that reduces their chances of success and force them to create new businesses mainly in the service sector. Social relationships and empathy among females may help compensate their disadvantages and break down barriers to entrepreneurship.

Keywords Female entrepreneurship • Academic spin-offs • Gender bias • Gender gap

3.1 Introduction

Female-owned businesses are one of the fastest growing entrepreneurial populations in the world. They make significant contributions to innovation, employment and wealth creation in all economies (Brush et al. 2009; Hughes et al. 2012). Despite the growing importance of female entrepreneurship, this phenomenon is understudied (De Bruin et al. 2006; Hughes and Jennings 2012), particularly in specific contexts such as universities and research centers. To

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contribute to this strand of literature, we analyze the phenomenon of female entrepreneurship in academic spin-offs. According to Djokovic and Souitaris (2008) academic spin-offs are

companies which evolve from universities through commercialisation of intellectual property and transfer of technology developed within academic institutions. Djokovic and Souitaris (2008)

In general, the emergence of new ventures in knowledge-based sectors—and academic spin-offs belong to this category—is central to economic adaptation and change and, according to the endogenous growth theory (Romer 1986), favors the achievement of a long term economic development. These new ventures are important sources of market innovations (Audretsch 1995), as they replace less efficient existing firms with more efficient ones (Bosma et al. 2011), and sources of new job creation (Birch 1987), as they represent a job alternative for people with high levels of formal education.

Analyzing the new ventures scenarios from the last 20 years, the underrepresentation of female entrepreneurs—especially in knowledge-based new ventures—is common across countries (Davidsson and Honig 2003; Delmar et al. 2003; Reynolds et al. 2004; Wagner 2004; Arenius and Minniti 2005).

Our study builds on the two previous considerations: (1) new ventures in knowledge-based sectors are important drivers for economic growth; (2) females are underrepresented in these new ventures. Since the number of females who obtaining higher education in specific industrialized countries is higher than males (Hausmann et al. 2012) and females use different processes of opportunity identification and recognition with respect to males (DeTienne and Chandler 2007), fostering female entrepreneurship in academic spin-offs may be one way to contribute to economic growth through new venture creation in knowledge-based sectors. For this reason, understanding the complex interplay of factors that favor (prevent) females when (from) starting new academic spin-offs is crucial.

We analyze this complex interplay of factors using a unique database of academic spin-offs set up in Italy in the period 2002–2007 as well as other publically available data. We believe that Italy represents an ideal setting for our analysis. According to the GEM database, Italy reports the lowest index of entrepreneurial dynamics in the global ranking and the lowest share of new high-tech firms in comparison with the main EU countries (Bosma et al. 2011). This evidence contrasts with the aims of Horizon 2020 (i.e., the new funding program for research and innovation of the European Union) which focuses on knowledge-based innovations and promotion of a new entrepreneurial culture across Europe. Furthermore, in a recent study on the factors that affect nascent entrepreneurship in high-tech sectors in Italy, Micozzi (2013) finds that, for males the probability of starting firms in high-tech sectors is more than twice that of females, highlighting a relevant gender gap. Female entrepreneurship in academic spin-offs could therefore contribute to closing this gender-gap in entrepreneurial activities and foster new venture creation in knowledge-based sectors.

We base our study on three complementary levels of analysis: macro, meso, and micro level. At the macro level of analysis, we use publically available data, to

define the gender gap situation in Italy. At this stage, particular attention is paid to the female entrepreneurial phenomenon and the role of females in academic and research institutions. At the meso level, we first focus on the distribution of spin-offs by province and geographic area and then we link this information to the data on the number of female shareholders in these same academic spin-offs. At the micro level, we use a unique hand-collected database which comprises all academic spin-offs set up from 2000 to 2007 to investigate the determinants of the number of female shareholders in academic spin-offs at the firm level.

Our work contributes to existing literature on academic spin-offs in several respects. Despite the growing importance of female entrepreneurship, there is still a lack of research on the phenomenon of female academic spin-offs (Fuentes-Fuentes et al. 2012). Our paper is one of the first studies on the female entrepreneurship in Italy (few notable exceptions are Colli et al. 2003; Rosti and Chelli 2009; Brighetti and Lucarelli 2013) and, to the best of our knowledge, the first on female entrepreneurship in academic spin-offs. Besides publically available data, all our evidence is based on a unique database that we collected specifically to analyze the problem of female entrepreneurship in academic spin-offs. These data allow us to corroborate existing evidence from other studies in the literature concerning the under representation of females in firms (especially high-tech firms) and to offer new findings on this issue. Moreover, while the vast majority of the existing literature is based only on one level of analysis, we integrate the macro, meso, and micro levels in a unique framework.

The remainder of the paper is organized as follow. In Sect. 3.2, we present a brief literature review. In Sect. 3.3, we report the results of our empirical analysis. In Sect. 3.4, we summarize our main findings and discuss some policy implications.

3.2 Literature Review

Despite the growing importance of female entrepreneurship, there is still a lack of research on the phenomenon (Brush et al. 2009), especially in specific environments such as universities (Fuentes-Fuentes et al. 2012). A common result in almost all studies on female entrepreneurship is that the number of male entrepreneurs is much higher than the number of female entrepreneurs (Davidsson and Honig 2003; Wagner 2004; Arenius and Minniti 2005). Several studies focused on identifying which factors explain the propensity for males and females to become entrepreneurs and, thus, to indirectly explain the preponderance of male entrepreneurs. Some of these factors are general while others are more specific for spin-off creation (the topic of our study).

A primary factor in explaining the propensity for males and females to become entrepreneurs is the motivation to start new businesses. While, in general, researchers deem that the motivation to start new businesses is similar for both males and females, some studies suggest the opposite (Cañizares and García 2010). In addition to the desire for independence and control over one's own future (two

motivations that are common to females and males), Carter (2000) suggests that one female-specific motivating factor is the willingness to break through the “glass ceiling” (i.e., the invisible barrier preventing females from having the same opportunity as males). Thus, according to some literature concerning motivation, a preponderance of female over male entrepreneurs rather than the opposite could be expected. A similar line of thinking applies to risk tolerance. Even though there is disagreement in the literature on female and male risk-taking attitude differences (Minniti and Nardone 2007), recent studies show that the risk attitude of males and females is indeed quite similar when it comes to (simulated) real-life decisions and perceived differences are rather the result of misconceptions and stereotypes (Brighetti and Lucarelli 2013). Thus, also with respect to differences in risk taking attitudes between males and females, relevant differences in the number of male and female entrepreneurs should not be observed.

Conversely, the preponderance of male entrepreneurs can be explained considering another factor: the context. The entrepreneurial literature attributes an important role to the context: two females with the same set of motivational factors, but different demographic and contextual factors (e.g., presence/absence of children), might have a different propensity to start a new business. “Motherhood” is, indeed, the household/family context that might have the largest impact on female entrepreneurship (Jennings and McDougald 2007; Ahl and Nelson 2010; Eddleston and Powell 2012).

The preponderance of male entrepreneurs can be explained also in terms of opportunity recognition. Social networks and prior work/life experiences influence the process of opportunity recognition (Greve and Salaff 2003; DeTienne and Chandler 2007). Since, as found by Fischer et al. (1993), when starting up a new firm, males typically have larger social networks and previous experience in the field than females, they are more likely to recognize new potential businesses more easily than females. In this context, the development of male entrepreneurship at the expense of the female entrepreneurship is indeed a lost opportunity for growth and diversification. Since, as noted by DeTienne and Chandler (2007), males and females have unique stocks of human capital, fostering female entrepreneurship may be one way to contribute to economic growth and diversification through new venture creation. Some studies even show that in highly developed countries female entrepreneurs have a higher education level than male entrepreneurs (Cowling and Taylor 2001).

Another factor which explains the preponderance of male entrepreneurs is the problem of capital rationing. Research suggests that there are large differences between males and females when they ask for funds to finance their businesses. Compared to males, females obtain most of their funds through strong ties networks (family and friends) (Singh and Lucas 2005; Carter et al. 2007). With “traditional” financing channels (i.e., banks), females typically obtain less funds than males (Alsos et al. 2006). This difference arises because often bank workers perceive females as less entrepreneurial and creditable than males (Buttner and Rosen 1988). Thus, females are practically constrained to start businesses in lower capital intensive/growth industries (Coleman 2000; Orhan 2001; Singh and Lucas 2005).

As Buttner (1999) argues, starting with a smaller capital base may disadvantage female entrepreneurs, as a lack of cash is one of the biggest problems for startups, with direct consequences on survival rates and growth opportunities.

Having presented the main factors influencing the propensity for males and females to become entrepreneurs in general, we now focus on some specific factors which are likely to be particularly important with spin-off startups. All the barriers to female entrepreneurship identified above are even more relevant in the context of spin-offs, because spin-offs are developed in a highly competitive and ever changing context. In particular, technology-based startups are often regarded as a male domain (Nelson and Levesque 2007; Roan and Whitehouse 2007; Humbert et al. 2009) which means that female entrepreneurs might face social hostility and cultural biases when breaking into what is essentially a “male” world. In this respect, Dautzenberg (2012) presents an interesting literature review concerning high-tech entrepreneurship showing that female startups are smaller in terms of annual turnover (and growth) and exhibit lower employee productivity than male startups. The tendency for females to start up technology-oriented companies in the service sector and with substantially less capital than males is also confirmed. This tendency may depend on the propensity of female entrepreneurs to finance their startup projects primarily through private loans and on their lack of experience obtaining external equity funds.

One of the main causes of the gender gap in academic spin-offs is the gender gap in academics. Furthermore, despite the fact that the number of females working in universities has grown in recent years, their participation in academic spin-offs is still limited (Becheikh et al. 2006; Rosa and Dawson 2006). To understand this phenomenon more in depth, Ding et al. (2006) tracked the careers of more than 4000 life sciences research faculty members at U.S. universities over a 30-year period. Their study shows that females were less likely to have the type of relationships that can help scientists recognize the commercial potential of their research in the first place and then help them effectively commercialize it. Furthermore, even though the quality of female research seemed equal to (or even slightly better than) male research, females patented their research at about 40 % of the rate of males. As noted by Mitchell (2011)¹

...this (result) is a very significant narrowing of the field at one of the first major steps along the road to creating a startup company from one's research. Mitchell (2011)

In this spirit, understanding the factors that favor or prevent the involvement of females in spin-offs is crucial.

¹ According to the European Commission, in science, gender bias can occur (1) in the characterization of scientific excellence, (2) in the criteria used to assess it, (3) in the choice of the explicit and implicit indicators for scientific excellence, (4) in the way the criteria are applied to males and females, (5) in the failure to integrate females in scientific networks, and (6) in the procedures through which criteria are applied to people. This gender bias in scientific excellence is one of the elements that prevent equal representation of females at all levels of science, and is an important reason why some countries have elected to implement targets and quotas.

3.3 Empirical Analysis

3.3.1 Database Description and Descriptive Statistics

We base our empirical analysis on publically available data and on a unique hand-collected database comprising all academic spin-offs that took place in Italy between 2000 and 2007 (about 300). The total number of spin-offs with available data is 265 (about 88 % of the total).

In our empirical analysis, we integrate the macro, meso, and micro levels in a unique framework of analysis. As Fuentes-Fuentes et al. (2012) note, the individual level of analysis is not sufficient to characterize the entrepreneurial process of females in universities. Considering (or at least controlling for) the institutional perspective (i.e., the meso and macro levels) provides a more comprehensive framework/lens for the specific analysis of female entrepreneurship.

Our macro level analysis is based on data provided by MIUR (Italian Ministry of Education, University, and Research), Unioncamere (the office that registers new firms in Italy), GEM consortium, and World Economic Forum. Both meso and micro level analyses are based on our database of academic spin-offs. For this reason, we present a list of all variables that are included in our database. All variables (excluding time invariant variables) are registered at the time of spin-off startup and in the post-incubation period (about 3 years after the startup). Table 3.1 reports some descriptive statistics for each variable.

- **Number of female shareholders.** This variable is a count variable with a low average and median value (of about one), indicating that female shareholders are typically few in number (or absent).
- **Share of majority shareholder.** This variable exhibits high average and median values, denoting that typically a single shareholder controls academic spin-offs.
- **Average shareholders' share.** This variable assumes high average and median values, evidencing that the number of shareholders is generally low. Thus, the ownership structure of academic spin-offs tends to be quite concentrated.
- **Female majority shareholder.** This variable is a dummy equal to one when the majority shareholder is a female. In our sample, females are majority shareholders in less than 20 % of cases.
- **Shareholder funds.** This variable, which represents the amount of capital invested by shareholders, is included in the regression models to take any size effect into account. Average (median) shareholder funds are less than €30,000 (€15,000) at startup and less than €40,000 (€15,000) in the post-incubation period.
- **Province dummies.** This is a group of dummies indicating the province where the spin-off takes place. Milan is the province where most of the spin-offs occur.
- **Geographic area dummies.** This is a group of dummies indicating the geographic area where the spin-off is located. Most of the spin-offs take place in northern (north-east and north-west) regions.

Table 3.1 Descriptive statistics

Variables	At start up			In the post-incubation period		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Number of females	1.05	1	1.38	0.99	1	1.32
Share of majority shareholder	38.29	33.05	19.74	41.03	38	21.71
Average shareholders' share	21.13	16.67	12.81	24.69	19.64	17.96
Shareholder funds	28,376	15,000	36,387	39,461	15,000	71,138
Majority shareholder type		%			%	
	Female	17.36		Female	19.62	
	Non female	82.64		Non female	80.38	
Geographic area						
	North-east	33.96				
	North-west	23.77				
	Center	24.91				
	South/Islands	17.36				
Year	2000	3.77				
	2001	3.02				
	2002	4.53				
	2003	11.32				
	2004	19.62				
	2005	14.34				
	2006	20.38				
	2007	23.02				
Modal industry	Research & scientific develop.					
Modal province	Milan					
Modal university	Padua					

- **Industry dummies.** This is a group of dummies indicating the industry of the spin-off. The classification is based on the ATECO codes of economic activity by the Italian National Institute of Statistics (ISTAT). Most of our spin offs belong to the research and scientific development industry.
- **University dummies.** This is a group of dummies indicating the university in which the spin-off is generated. The University of Padua, in the north of Italy, is the university where most of the spin-offs are generated.²
- **Year dummies.** This is a group of dummies indicating the year when the spin-off occurred. Most of spin-offs took place in 2006 and 2007.

3.3.2 Macro Level

Using a macro level perspective, in this section we define the gender gap situation in Italy by reporting a selection of indicators on the female entrepreneurial phenomenon and the role of females in academic and research institutions. An overall picture of the macro level situation of females in Italy is presented in Table 3.2, which shows data from a survey of the World Economic Forum of 2011 (Hausmann et al. 2012).

Since 1947, the Italian Constitution (art. 37) has ensured parity between male and female workers. In 1991, law L. 125170 actively introduced measures to ensure equal opportunities for male and female workers. In 1997, law L. 903 defined the framework for equal treatment for male and female workers and the Ministry for Equal Opportunity was established. In 2006, all the existing laws on equal opportunity converged into one all-inclusive legislative decree (decree n. 171).

Despite all these laws to ensure equality between males and females (especially in the working environment), the last GEM global report shows a consistently negative trend in the number of new female entrepreneurs in Italy, even though there was a slight increase in 2012. The latest report by the Unioncamere seems to confirm the same trend: only 25 % of firms in Italy are set up by females, even though, again, the number increased in 2012. Notable geographic disparities exist: the female activity rate in the northern and central regions is more than twice that in southern regions. This disparity is likely linked to both formal (e.g., childcare facilities) and informal (e.g., traditional roles, religion, family values) institutional and cultural factors.

With respect to academic and research institutions, the Ministry for University and Research (MIUR) works in partnership with the Equal Opportunity Ministry to reduce the gender gap in academic and research institutions and as a result all major research centers have a Committee for Equal Opportunity. For example, the Commission for the Promotion of Female in Science (1999) housed in the CNR

²This result does not contrast with the evidence that the modal province for spin-offs is Milan, since Milan, unlike Padua, has more than one university.

Table 3.2 Gender gap indicators for Italy

Economic empowerment			
Female adult unemployment rate (% of female labor force)			10
Male adult unemployment rate (% of male labor force)			8
Share of female in wage employment in the non-agricultural sector (% of total non-agricultural employment)			44
Female's access to finance programs (%)			5
Ability of female to rise to positions of enterprise leadership (%)			3.2
Education		Social institutions and political rights	
Female teachers, primary education (%)	95	Year female received right to vote	1945
Female teachers, secondary education (%)	67	Quota type	Not legislated
Female teachers, tertiary education (%)	36	Length of maternity leave (months)	5
Female school life expectancy, primary to secondary (years)	13	Maternity leave benefits (% of wages paid in covered period)	80
Male school life expectancy, primary to secondary (years)	13	Provider of maternity coverage	Social insurance
Marriage and childbearing			
Mean age at marriage for female (years)			30
Fertility rate (births per female)			1.4
Adolescent fertility rate (births per 1000 girls aged 15–19)			7
Antenatal care coverage, at least one visit (%)			98
Births attended by skilled health personnel (%)			100
Maternal mortality ratio (per 100,000 live births)			4 (3–5)
Contraceptive prevalence, married female (% , any method)			63
Female HIV prevalence, aged 15–49 (%)			0.2
Male HIV prevalence, aged 15–49 (%)			0.3
Infant mortality rate (probability of dying between birth and age 1 per 1000 live births)			3
Overall population sex ratio (male/female)			0.96

Source: World Economic Forum

(Italian National Center of Research) where, remarkably, females represent 30 % of all CNR researchers. In 2003, the Association for Female and Science was founded.

Despite all these initiatives, the gender gap between males and females who pursue an academic career in Italy is still relevant: although 58 % of graduates are females, the most recently available data on the MIUR website shows only 45 % of females are assistant professors, 35 % associate professors, 20 % full professors, and only 1 dean is female (around 1 %).

Gender disparities in the entrepreneurial and academic (and research) context help explain the gender gap in academic spin-offs where, non-incidentally, the ownership structure of academic spin-offs reveals that females are majority shareholders in less than 20 % of the cases.

Since macro level effects correspond to structural changes at a national level, they are likely to influence all individuals in approximately the same way. For this reason, in the following micro level regression analysis, macro level variables can be accounted for through the inclusion of year fixed effects, which capture parallel shifts in the number of females over the years as a consequence of changed macro level conditions. Jointly significant year fixed effects indicate, thus, a changing environment for the female entrepreneurship situation in Italy. The opposite applies in the case of non-significant year fixed effects.

3.3.3 *Meso Level*

Using a meso level perspective, in this section we present specific observations on the spatial characteristics of our database of academic spin-offs. In the following micro level regression analysis, meso level variables are accounted for through the inclusion of province, geographic area, industry, and university fixed effects. All these effects have direct or indirect geographical connotations.³ The inclusion of these meso level fixed effects is based on the assumption that the heterogeneity of spin-offs belonging to the same group (province, geographic area, industry, and university) should be lower than the heterogeneity of spin-offs belonging to different groups. Understanding the spatial characteristics of our database is, thus, of particular interest, since spatial characteristics possibly reflect deep meso level structural differences among spin-offs.

The importance of the spatial dimension in high-tech entrepreneurship is also relevant according to the knowledge spillover theory of entrepreneurship. This theory emphasizes the role of new firm creation in exploiting knowledge created by university research (Audretsch and Lehmann 2005) and shows as proximity and agglomeration play an important role in R&D collaborations and knowledge exploitation, so considering the local context where the universities are located becomes important (Boschma 2005; Hewitt-Dundas and Roper 2011). Spin-offs are normally located very close to their parent institution (Audretsch and Lehmann 2005; Iacobucci and Micozzi 2015) due to the role played by incubators or Technology Transfer Offices, the direct involvement of academicians, and the collaboration between spin-offs and university departments.

In Fig. 3.1, we show the spatial distribution of the number of spin-offs by province and geographic area (the first pair of plots), the spatial distribution of the number of female shareholders at startup and in the post incubation period by province (the second pair of plots), and the spatial distribution of the average number of female shareholders per spin-off at startup and in the post incubation period by province (the third pair of plots).

³ This consideration is evident for province, geographic area and university dummies, but also holds for industry dummies, since specific industries tend to develop in specific geographic areas.

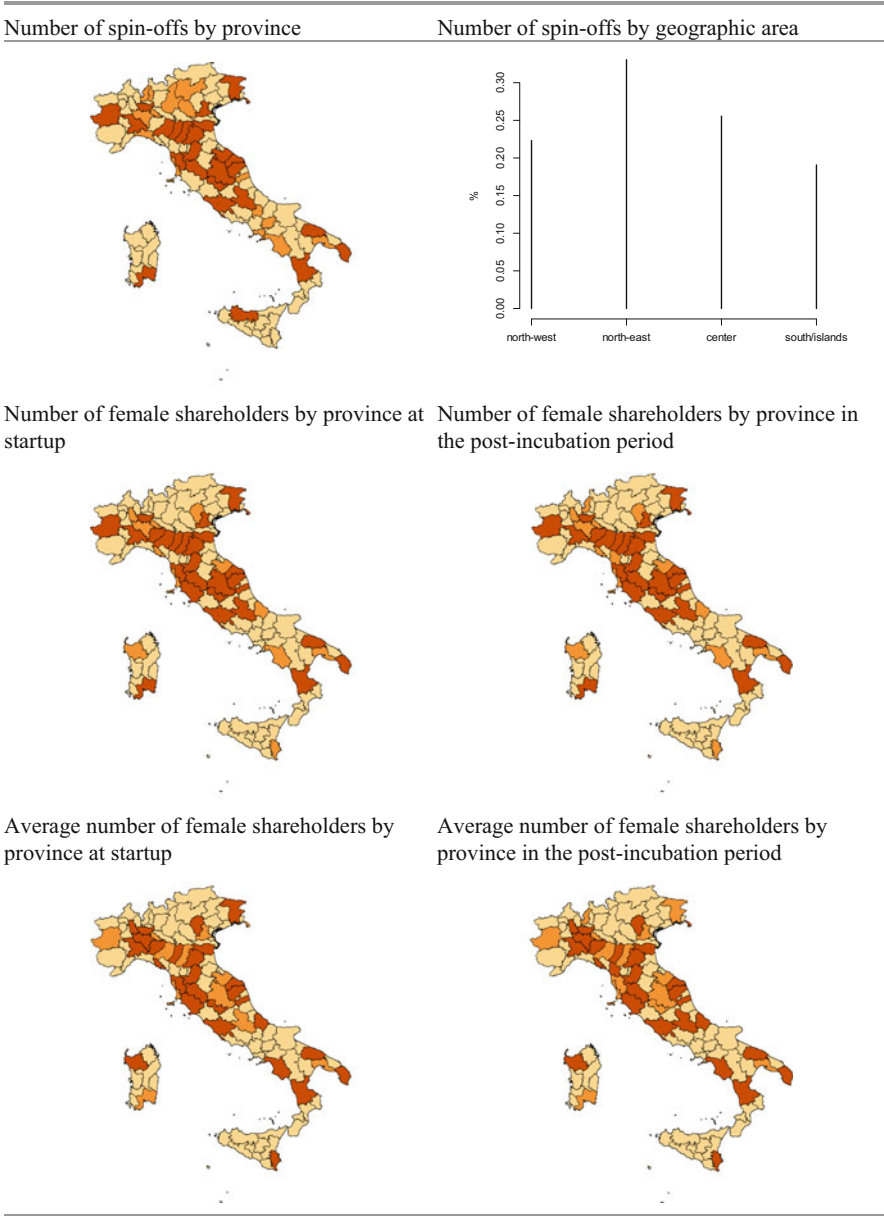


Fig. 3.1 Number of spin-offs and number of female shareholders spatial distribution

Figure 3.1 shows that the provinces with the highest number of spin-offs, number of female shareholders and average number of female shareholders per spin-off are concentrated in central and northern Italy. This broad classification

simplifies the actual spatial pattern in the map, but suggests the existence of a non-negligible spatial heterogeneity among province both for the number of spin-offs and for the number of female shareholders.

Two Moran's I tests for spatial autocorrelation seem to support the results of the visual inspection analysis: they suggest the presence of spatial correlation in the average number of female shareholders per spin-off both at startup (p-value = 0.049) and in the post incubation period (p-value = 0.063). This spatial autocorrelation may reflect latent meso level differences between provinces with respect to the analyzed variables. As noted by several authors (Baughn et al. 2006; Welter 2004; Welter and Smallbone 2008), these latent meso level differences may stem from cultural and environmental factors (that in our analysis are assumed to vary spatially) which increase the difficulties of females in entering entrepreneurship and growing their businesses.

3.3.4 *Micro Level*

In this section, we analyze the determinant for the number of female shareholders in academic spin-offs using a micro level perspective by first presenting our methodology and then the results of our regression analysis.

3.3.4.1 *Methodology*

Let y_i be the number of female shareholders for the spin-off i and $\mathbf{x}_i$ a vector of covariates which include the variables described in the previous section. We are interested in explaining the expected value of y_i given $\mathbf{x}_i$, i.e., $\mu_i \equiv E(y_i | \mathbf{x}_i)$.

Our response variable has some peculiar characteristics that need to be discussed. The number of female shareholders is a count variable in which each observation can take only non-negative integer values. Furthermore, for several spin-offs the number of female shareholders is low or zero. Thus, the distribution of the number of female shareholders exhibits a low modal value and a non-negligible number of zeros. The peculiarities of our response variable force us to deviate from a simple linear model estimated by Ordinary Least Squares (OLS), given that linear OLS models can predict negative values and are, in general, not well suited for highly non-normal data.

The most popular model for count data is the Poisson regression model (Wooldridge 2010; Verbeek 2012). In a Poisson regression model, the response variable is assumed to follow a Poisson distribution conditional on the covariates and the logarithm of μ_i is modeled as a linear combination of the covariates. The Poisson regression model takes the form

$$y_i | \mathbf{x}_i \sim \text{Poisson}(\mu_i), \log(\mu_i) = \mathbf{x}_i' \boldsymbol{\beta}$$

where $\boldsymbol{\beta}$ is a vector of parameters to be estimated. Estimation of $\boldsymbol{\beta}$ is generally obtained by maximum likelihood.

The main limit of the Poisson regression model is that it imposes the conditional variance of y_i to be equal to its conditional mean. In empirical applications, however, the conditional variance is often greater than the conditional mean, a situation known as over-dispersion (Cameron and Trivedi 2005). In the presence of over-dispersion, inference based on the plain Poisson regression model may be misleading. Therefore, the plain Poisson regression model needs to be adjusted to handle over-dispersion. Two common adjustments to account for over-dispersion consists in (1) basing inference on the sandwich estimators for standard errors (also known as robust standard errors), or (2) estimating an additional dispersion parameter in the model (quasi-Poisson regression model). Another way to account for over-dispersion is to use a negative binomial regression model, which is an alternative and more general model for count data (Zeileis et al. 2008).

Another concern with the Poisson regression model is that the number of zeros in our response variable may be larger than the number of zeros a Poisson regression model can handle (Cameron and Trivedi 2005). To account for this problem, we use a hurdle Poisson regression mode where a logit model governs the binary part of whether the count variable has a zero or a positive value and, if the value is positive, a truncated-at-zero Poisson regression model governs the conditional distribution of the positive counts (Mullahy 1986; Zeileis et al. 2008).

3.3.4.2 Estimation Results

The results of our regression analysis are presented in Table 3.3 in four Poisson regression models: two models for the number of females at startup (Model 1 and 2) and two models for the number of females in the post-incubation period (Model 3 and 4). The four models differ for the included covariates. In particular, all models include the share of majority shareholders, the average shareholders' share, the female majority shareholder dummy, and the logarithm of shareholder funds among the covariates. However, while Model 1 and 3 include province, industry and year dummies, Model 2 and 4 include geographic area and university dummies. The differences between each model pair serves to avoid an excessive number of dummy variables in the regression equations. As previously noted, including these groups of dummies (province, industry, year, geographic area, and university) allows us to control for macro and meso level effects and helps identify the effects of micro level variables on the number of females. Furthermore, the two models for the number of females in the post-incubation period (Model 3 and 4) also include the number of females at startup as an explanatory variable. This additional variable makes it possible to account for any memory effect in the number of female shareholders in the post-incubation period.

Table 3.3 Poisson regression models for the number of female shareholders

Dependent variable	Number of females at startup				Number of females in the post-incubation period			
	Model 1		Model 2		Model 3		Model 4	
Explanatory variables	Estimate	Std. error	Sign.	Estimate	Std. error	Sign.	Estimate	Std. error
Intercept	5.9452	1.1379	***	3.619	1.5984	**	-2.2358	0.7243
Number of females at startup	—						0.4967	0.0358
Share of major shareholder	0.0085	0.0069		0.0102	0.006	*	-0.0031	0.0041
Average shareholders' share	-0.0946	0.0142	***	-0.0845	0.0126	***	-0.0163	0.006
Female majority shareholder	0.8308	0.1678	***	0.76	0.1532	***	0.5642	0.1098
Log of shareholder funds	-0.2644	0.0876	***	-0.1708	0.0907	*	0.0671	0.0626
Province dummies χ^2	71.572		**	—			25.948	
Geographic area dummies χ^2	—			1.9651			—	
Industry dummies χ^2	51.998		***	—			19.796	
University dummies χ^2	—			97.915		***	—	
Year dummies χ^2	5.5509			—			4.0584	
Regression χ^2	275.47		***	236.01		***	329.68	
AIC	704.03			655.49			618.67	
Number of observations	265			265			265	

***, ** and * denote significance at the 1, 5 and 10 % levels. Robust standard errors

Coefficient estimates and standard errors for each covariate are reported, with the exception of the groups of dummy variables (province, geographic area, industry, university and year dummies) where we report Wald tests of joint significance instead. All our inference is based on robust standard errors,^{4, 5}

Looking at the coefficient estimates of Table 3.3, we note that the number of female shareholders at startup is larger when the majority shareholder is a female and lower for firms with a higher average shareholder's share (i.e., in case of concentrated ownership) (Model 1 and 2). These results extend also to the number of female shareholders in the post-incubation period (Model 3 and 4). The firm size seems to have a (negative) relationship with the number of females only at startup (Model 1 and 2) and not in the post-incubation period (Model 3 and 4). There is also weak evidence (Model 2) of a positive relationship between the share of the majority shareholder and the number of female shareholders at startup when we do not control for province, industry and year effects. Furthermore, at startup we observe province (Model 1), industry (Model 1) and university (Model 2) effects that are likely to reflect latent meso level factors. Time-varying latent macro-level factors, accounted for by year fixed effects, however, do not seem to significantly influence the number of female shareholders either at start-up or in the post-incubation period, suggesting a static situation in the condition of females in Italian spin-offs. Finally, the number of female shareholders at startup exerts a large influence on the number of female shareholders in the post-incubation period (Model 3 and 5), showing a certain degree of persistence in the number of female shareholders over time.

In Table 3.4, we report the results of two hurdle Poisson regression models: Model 5 for the number of females at startup and Model 6 for the number of females in the post-incubation period. The table is divided in two panels: in the lower panel (zero-hurdle part), we present zero-hurdle logit models for modeling zero vs. count observations; in the upper panel (count part), we report truncated-at-zero Poisson regression models for the count values.

The reported models include the same covariates in the zero-hurdle part as in the count part of the models.⁶ The covariates in the zero-hurdle part help in distinguishing between zero and larger counts, as demonstrated by their significance. With respect to the count part, the results in Table 3.4 are not qualitatively

⁴ Since over-dispersion tests provided mixed results, we decided to present robust standard errors in the table in order to mitigate the risk of basing our inference on underestimated standard errors due to over-dispersion. Basing inference on non-robust standard errors produced, however, similar results. We also estimated quasi-Poisson and negative binomial regression models. Results of these alternative models are qualitatively similar to those in the table and, thus, are not reported.

⁵ At the bottom of each model we report joint Wald tests for the overall significance of the estimated models to test for the hypothesis that all coefficients in the model apart from the intercept are equal to zero (Regression χ^2). All the test statistics strongly reject the hypothesis that the conditional mean is constant and independent of the explanatory variables.

⁶ To simplify the model to be estimated, we have excluded the groups of dummy variables from the regression equations and decided to focus only on micro level variables.

Table 3.4 Hurdle Poisson regression models for the number of female shareholders

Dependent variable	Number of females at startup			Number of females after the incubation period		
	Model 5			Model 6		
Explanatory variables	Estimate	Std. error	Sign.	Estimate	Std. error	Sign.
<i>Count model</i>						
Intercept	3.4898	0.9276	***	1.1414	0.8077	
Number of females at startup	—			0.3711	0.0406	***
Share of major shareholder	0.0027	0.0069		−0.0042	0.005	
Average shareholders' share	−0.1059	0.0186	***	−0.0572	0.0153	***
Female majority shareholder	0.1672	0.1911		0.2312	0.135	*
Log of shareholder funds	−0.1747	0.0892	*	−0.0976	0.0684	
<i>Zero-hurdle model</i>						
Intercept	3.0624	1.8409	*	−3.3018	2.9903	
Number of females at startup	—			3.984	0.6181	***
Share of majority shareholder	0.0132	0.0094		0.0392	0.014	***
Average shareholders' share	−0.0941	0.0237	***	−0.0826	0.0316	***
Female majority shareholder	19.3334	0.5008	***	17.7317	0.5984	***
Log of shareholder funds	−0.1959	0.1803		0.1069	0.2601	
Regression χ^2	163.19		***	397.26		***
AIC	622.71			371.84		
Number of observations	265			265		

***, ** and * denote significance at the 1, 5 and 10 % levels. Robust standard errors

different from those in Table 3.3.⁷ Given the coherence among the signs of the estimated coefficients in the models shown in Tables 3.4 and 3.3, we believe that we can rule out that excess zeros exert a large influence in our models. Therefore, it seems reasonable that this influence is not strong enough to invalidate our inference based on the simpler Poisson regression models of Table 3.3.

All results are largely supported by economic theory and previous findings in the literature. The negative relationship between the number of female shareholders and the capital invested by shareholders into the spin-off at startup may indicate a disadvantage of females in the startup (funding) phase.⁸ Several studies show that the capital invested by female entrepreneurs is indeed lower than the capital invested by male entrepreneurs and motivate this finding with the tendency of female entrepreneurs to finance their startup projects primarily through private loans and/or a (female) lack of expertise in obtaining external funds (Dautzenberg 2012). Lower capital invested at startup may lead females to create new businesses

⁷ The only exception is the insignificant coefficient of the female majority shareholder dummy in the count part of Model 5. However, this variable is still significant, as expected, in the zero-hurdle part of the model.

⁸ The negative relationship between the number of female shareholders and the capital invested by shareholders into the spin-off at startup should merely suggest an association rather than a real causal nexus.

mainly in the service sector (where fewer initial funds are needed) as is well-documented in the literature (see for example Sullivan and Meek 2012). This is in fact the case with our database, where the spin-offs with a particularly high number of female shareholders all belong to the service sectors (results are not reported in the table). The lack of initial capital may also explain why academic spin-offs, prevalently owned by females, produce fewer patents and licenses and/or are more failure-prone than academic spin-offs prevalently owned by males: in our database the relationship between the number of female shareholders and the number of patents and licenses is indeed negative and the average number of female shareholder in failed spin-offs is about 3.5 times the number of female shareholders in non-failed spin-offs (results are not reported in the table).

Two other important findings are that the number of female shareholders is higher for spin-offs where the majority shareholder is a female and that the number of female shareholders at startup positively influences the number of female shareholders in the post-incubation period. These findings could find an explanation in the importance of social relationships among females: the empathy among females may thus allow them to break through the barriers to entrepreneurship.

3.4 Conclusions

Since the diversity of economic agents in terms of motivation and opportunity recognition is essential for economic growth, the participation of females in entrepreneurial activities could favor faster development. In particular, fostering female entrepreneurship in academic spin-offs could represent an important way to add variety to the economic process, enhance country competitiveness, and fully realize country innovation potential.

Using publically available data and a unique hand-collected database of all the academic spin-offs set up in the period 2002–2007 in Italy, we analyze female participation in Italian academic spin-offs. Our study is based on three complementary levels of analysis: macro, meso, and micro level.

Our results show that despite policy measures thought to reduce the gender gap in Italy, this issue remains important and is especially found in high-tech industries. Furthermore, we find a relevant spatial heterogeneity in the number of spin-offs and female shareholders by province, where Northern provinces have both a higher number of spin-offs and female participation than Southern provinces. This spatial heterogeneity may reflect meso level differences in cultural and environmental factors at a provincial level. Finally, our econometric models show a negative relationship between the number of female shareholders and the capital invested into the spin-off at startup by shareholders, an unfavorable circumstance that shows a disadvantage for females in the startup funding phase, which may likely reduce their chances of success (in terms of number of patents and licenses and probability of failure) and force them to create new businesses mainly in the service sectors (where less initial capital is needed). Since the number of female shareholders is

higher for spin-offs where the majority shareholder is a female and the number of female shareholders at startup positively influences the number of female shareholder in the post-incubation, our analysis also suggests that social relationships and empathy among females may help compensate for their disadvantages breaking down the barriers to entrepreneurship.

Summarizing our results and the results of previous research we can identify several barriers that may impede the full development of female entrepreneurship in general and of female entrepreneurship in academic spin-offs in particular. Examples of these barriers include social, cultural and institutional barriers that influence the roles and responsibilities of females in society, structural barriers in the academic context, and individual barriers linked to the personal factors that affect the propensity to become an entrepreneur including the disadvantages in the funding stage.

Social intervention may have a positive impact on female entrepreneurship if it eliminates (or at least alleviates) institutional traits that restrict the opportunities (including economic opportunities) of females. In particular, in order to foster female entrepreneurship in academic spin-offs, policy makers should address these barriers promoting a cultural shift towards a more balanced recognition of female roles in the academic and entrepreneurial context (and more in general in society), favoring a venture capital supply for female-owned startups, introducing fiscal incentives for female entrepreneurs, and supporting the development of networks for female entrepreneurs.

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Part II

Academic Spin-offs

Chapter 4

Structural Capital of University Spin-Out Firms: The Moderating Role of University Incubators

Nola Hewitt-Dundas and Colm Burns

Abstract University incubators (UI) are generally believed to be important in the successful commercialisation of university spin-outs (USO) with over half of all UK Universities having established an on-campus UI. In this chapter we examine the value of UIs in the spin-out process, focusing on the structural networks of USOs located in a UI as compared to USOs in a University with no access to a UI. Our primary research question is therefore: *to what extent does the structural network of USOs with access to an on-campus UI differ from USOs without?* The research therefore contributes to a growing critique of the effectiveness of UIs in commercialising academic research and the recognition of positive direct and indirect externalities from participation in networks. Through network mapping of all USOs from two research intensive universities, we profile and analyse the formal and informal network ties of USOs to various partners internal and external to the host university. Through interviews we also consider how these networks enhance the resources and capabilities of USOs. Our findings highlight significant differences, with USOs located in a UI having more informal but fewer formal ties, both to other USOs as well as within the host University. In contrast, location in an incubator was not found to affect the extent and nature of ties with external organisations. Reasons for these differences are examined through interviews with the USOs and point to various factors including the proactive brokering role of incubator and university staff, university bureaucracy, the hidden networks of executive board members across USOs, university equity investment policy and complementary technologies.

Keywords Incubators • Universities • Networks • Spin-Outs

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4.1 Introduction

In the UK, government policy to promote a knowledge-based economy (Kitatgawa and Robertson 2012) has supported the promotion of university spin-outs (USOs) (HM Treasury 2003). While spin-out rates have continued to grow in the past decade (HESA 2012; Fini et al. 2011), there are concerns about the low growth rates of USOs, the cost-benefit to universities from supporting these firms (Colombo and Piva 2012), and the regional and national externalities they generate (Salvador 2011; Harrison and Leitch 2010; Targeting Innovation 2008). This situation raises two related questions which underpin the research in this chapter: how can the probability of USO growth be increased, and what support can or should be provided to these ventures?

One institutional approach to support the formation and growth of new ventures has been through incubators. Incubation has evolved significantly over the past 30 years from 'helping companies survive their formative years (decreasing downside risk) to one of adding value to companies (increasing upside advantage) (Miller and Bound 2011, 8). This emphasis on adding value is also evident across a range of high growth initiatives such as the 'accelerator programmes' which first emerged in the USA (e.g., the Y Combinator companies initiative in 2005 in California, and the Techstars programme in 2007 in Colorado) and later the UK (e.g., Seedcamp based in London and more recently in May 2012 a publicly funded Growth Accelerator programme across England) and across Europe (10 accelerator programmes existed across Europe in 2011) (Miller and Bound 2011). These accelerator programmes are seen as an evolution of the role played by incubators with the emphasis on adding value to businesses through time-limited coaching and mentoring support, a focus on groups of companies rather than individual businesses and integration with the local ecosystem (*ibid.*). As the incubation model continues to evolve with a growing emphasis on intensive business support and away from an emphasis on subsidised office space this raises questions about the contribution of incubator facilities to new venture growth. With the average capital investment cost of an incubator estimated to be €3.7 m and annual operating costs of €0.48 m (see Dee et al. 2011, 48) to what extent can the added value services provided to new ventures be realised in the absence of expensive infrastructural investments.

Research on the effect of incubators on the performance of tenants is extensive and inconclusive. Some studies find that incubators contribute positively to spin-out survival rates (O'Shea et al. 2008; Di Gregorio and Shane 2003), sales, employment and profit growth, finance raised and export growth.¹ In contrast, others find limited turnover or employment growth of spin-out firms (Salvador 2011; Harrison and Leitch 2010; Mustar et al. 2008), lower than anticipated financial returns to universities and regions (Colombo and Piva 2012) and, in some contexts, high

¹ See Dee et al. (2011) for an overview of the empirical studies on incubators and their tenant firms.

failure rates² (Targeting Innovation 2008). Further, not only is there mixed evidence on the effect of incubators on spin-out success, but other research has suggested that the probability of survival, business growth or innovation activity among incubated and non-incubated firms is not significantly different (Ahrweiler et al. 2011; Tamásy 2007). As a result, doubts have been raised over the economic potential of USOs and the large investments being made in promoting spin-out activity (Schwartz and Hornyh 2010; Mustar et al. 2008). Indeed, Gilsing et al. (2010, 12) suggest that government prioritisation of spin-out promotion has been based on “policy fashions rather than empirical evidence”.

Where positive effects of incubators on their tenants are identified, this is often attributed to the incubator acting as an “intermediary—or mediating—organisation (s), helping newly founded and young ventures to establish cooperative relationships with a broad range of economic actors” (Schwartz and Hornyh 2010, 485). Through these “cooperative relationships”, start-up firms gain access to resources and capabilities essential to survival and growth (Aernoudt 2004; Hansen et al. 2000). By implication therefore, for those spin-outs not located in an incubator the network of cooperative relationships will be constrained and there will be more limited access to complementary resources and capabilities.

For universities seeking to support USOs, these findings create uncertainty as to the anticipated benefits to be derived from establishing an incubator facility as opposed to merely providing entrepreneurial and business support to academics wishing to commercialise university-generated intellectual property (IP). While over half (58 %) of UK universities and specialist colleges in 2011 had an on-campus university incubator (UI)—largely supported through public funding in the late 1990s—30 % of UK universities with technology transfer offices had no involvement in any business incubators or science parks, whether on- or off-campus, and 22 % of UK universities reporting spin-out activity undertook this in the absence of a UI (HESA 2012). Given the high capital and operational investment in UIs and the emergence of alternative ways of supporting USOs (Cooper et al. 2012; Carayannis and Von Zedtwitz 2005; Durão et al. 2005), it is critically important to understand the additionality that UIs generate for USOs (Bruneel et al. 2012).

In this chapter our focus is on the networks that are developed by university spin-outs. Specifically we are concerned with the effect on a spin-out of being located in a university incubator in terms of the scale and scope of informal and formal relationships that they form and the effects of this on their competitiveness. This is achieved by mapping the cooperative relationships formed by USOs, comparing how these cooperative relationships (i.e., networks) differ for spin-outs with access to a University incubator compared to those with no incubator and we explore and compare the benefits of networks in the two contexts. The research therefore contributes to a growing critique of the effectiveness of UIs in supporting the

²Data for the current study showed that 28 % of all tenant/client USO across both case units (N = 73) had ceased trading.

successful spin-out of academic research, and reflects the recognition of positive direct and indirect externalities from participation in networks.

Two research-intensive universities are examined, one with a University owned incubator and one without. Interviews with the founders of all spin-out companies were conducted and applying social network analysis techniques we map the formal and informal network ties between the cohort of spin-out firms in each university, network ties to the host university schools as well as to external partners. USO founders also discussed their own experiences including, for different types of partners, obstacles and enablers to network formation and benefits accruing from network ties.

The remainder of the chapter is structured as follows. In the following section, we summarise the contextual literature around university business incubation and consider the relative strengths and weaknesses of alternative university approaches to supporting USOs i.e., through establishing or not establishing incubator facilities. From this we propose 3 hypotheses on how incubators might affect the network characteristics of university spin-out firms. Our empirical study, including sample, data collection and data analysis methods, is described in Sect. 4.3. In Sect. 4.4 we present our network findings along with qualitative data exploring the reported network benefits in terms of resources and capabilities. In Sect. 4.5 we consider the implication of these findings, acknowledge the limitations of the current study and make some suggestions for future research.

4.2 Literature Review

Much has been written about changing strategic priorities within the university sector as public sector investment in universities and in academic research has declined (Hewitt-Dundas 2012). Slaughter and Leslie (1997, 8) point to a growth in “academic capitalism” as a means of securing external revenue, with an on-going emphasis on commercially-oriented activity, metrics and outcomes (Grimaldi and Grandi 2005; O’Shea et al. 2005; Owen-Smith 2003). Universities are focusing more on the private ownership of IP and a more proactive IP development and exploitation strategy (Siegel et al. 2003; Lockett and Wright 2005).

One element of this “academic capitalism” has been an emphasis on university spin-outs (USOs), defined as “new ventures that are dependent upon licensing or assignment of [an] institution’s intellectual property for initiation” (Lockett and Wright 2005, 1044–1045). Spin-out rates are reported to have increased markedly since the late 1990s (Clarysse et al. 2005; Fini et al. 2011; Markman et al. 2005; Mustar et al. 2008) and recent data for UK universities suggests that this trend is being sustained, growing by 46 %, or an average annual increase of 15.3 %, between 2008 (160 USOs) and 2011 (233 USOs).³

³ Calculation based on data from the Higher Education Business and Community Interaction Survey, various years as accessible through the UK, Higher Education Statistics Agency (HESA).

4.2.1 Supporting University Spin-Out Firms

One mechanism proposed to enhance the survival rates, performance and economic contribution of USOs has been university incubators (UIs). An incubator is defined as “a property-based organization focused on accelerating the growth and success of entrepreneurial companies through the provision of business support, resources, and services” (Markman et al. 2008, 1406). UIs are incubators located on university campuses, specialising in the commercialisation of university technology (Allen and McCluskey 1990) and typically hosting high-tech USOs. Beyond offering tenant firms suitably equipped business premises at attractive rates, they also offer services such as “coaching, mentoring, consulting, general advice, motivation, business introductions, technical appraisal and business network access” (Ahmad and Ingle 2011, 629).

In contrast to the property-based dimension of UIs (Markman et al. 2008, 1406, Durão et al. 2005) a ‘non-university incubator’ (Non-UI) approach to the commercialisation of USOs exists (see Table 4.1). Here, “universities without a central incubator building supply incubation support to spin-offs located at distributed places on-campus and off-campus” (Van Geenhuizen and Soetanto 2009, 671). In this case university spin-out firms may or may not be located on campus, are unlikely to receive subsidised office facilities, do not have to apply for admission to the incubator or have a limited period of support prior to being required to leave the incubator. Evidence from the Netherlands and Italy suggests that UIs with “no building space and physical facilities” are common (Colombo and Delmastro 2002, 1107; see also Van Geenhuizen and Soetanto 2009), yet this model of university commercialisation support is discussed much less frequently. The validity of the non-incubator approach to supporting USOs is further evidenced by references to ‘virtual’ incubators (Carayannis and von Zedtwitz 2005; Durão et al. 2005; Hackett

Table 4.1 Characteristics of UI and non-UI USO support models

USO characteristics	University incubator (UI) model	Non-university incubator (Non-UI) model
Location of USO	USOs located on-campus in university-administered premises	USOs located in off-campus premises not administered by university or on-campus in academic offices/labs
USO facilities and equipment	Shared start-up infrastructure and services (phone, heating, reception, meeting rooms, etc.) included	USOs source, install and pay full rate for equipment, internet access, overheads, etc.
Links to university	USOs can use university address	USOs can use university address
Business support services	Business support services offered to USOs (e.g., mentoring, advice, business network access)	Business support services offered to USOs (e.g., mentoring, advice, business network access)
Development period	USOs have limited time period before ‘graduation’ (i.e., leaving UI) is required—typically 2–5 years	No formal ‘graduation’ policy for USOs

and Dilts 2004). For example, OuluTech, the commercialisation support unit at the University of Oulu, epitomises this non-UI model, spinning out 10–20 firms per year and being a main contributor to the ‘Oulu phenomenon’ (an exemplar of regional development in Finland), but without a physical incubator (Rasmussen et al. 2006).

Incubators offer significant infrastructural and administrative benefits to tenants through reduced set-up cost and effort. Typically, USOs and other start-up firms must source and arrange basic resources such as reception services, phone, internet, etc. For incubatees, these resources are available, often at below-market rates, so time and money can instead be invested in much needed product or business development (Bruneel et al. 2012). This is of particular benefit to USOs given that lack of resources is one of the most cited obstacles to spin-out success (Van Geenhuizen and Soetanto 2009). Yet it is argued that USOs may become over-accustomed to the artificially favourable, subsidised business environment of a UI, leaving them blind to the strategies and capabilities of their competitors and unprepared for the highly competitive conditions of ‘real’ external markets (Bøllingtoft 2012; Inkpen and Tsang 2005).

Support from UI management and proximity to other companies may have unintentional and/or intentional benefits for USOs. For example, co-location may result in unintentional informal network ties among tenant firms; this may be particularly important for academic entrepreneurs in terms of avoiding isolation, gaining reassurance and a “sense of common struggle” (McAdam and Marlow 2007, 363, see also Cooper et al. 2012). Intentional benefits may arise where firms openly partner (formally or informally) with other firms and engage “in deliberate relationships ... in order to gather either technical knowledge or market understanding” (ibid.).

Where informal ties develop in a UI between USOs (Cooper et al. 2012; Schwartz and Hornych 2010), the development of social capital has been found to contribute to the development of *formal* relationships (Bøllingtoft 2012; Debackere and Veugelers 2005). This may be particularly important for academic entrepreneurs, where time constraints make formal networking difficult (McAdam and Marlow 2008). In contrast to this Lindelöf and Löfsten (2004) argue that informal ties to co-tenants rarely lead to formal transactions or collaborations, instead constituting opportunities which are rarely taken. McAdam and Marlow (2007) attribute this to a ‘guarded’ atmosphere in the UI, with tenants reluctant to cooperate with one another for fear that knowledge or investment prospects may be stolen. Alternatively, it is possible that the development of social capital may cloud the commercial judgement of incubator tenants, as they make decisions in the interests of their co-tenants to their own detriment: “because you have to think of the other entrepreneurs’ businesses also” (Bøllingtoft 2012, 312). In either case, the evidence suggests that informal links between USOs in a UI are likely to be stronger due to economies of agglomeration and social capital. This leads to our first hypothesis:

Hypothesis 1a USOs located in a UI will have denser informal network ties to one another than USOs without a UI.

Although the evidence on the correlation and causality between informal and formal network ties is mixed, organisational studies tend to emphasize the development of informal relationships arising from physical proximity and this providing the basis for more formal relationships, what Kingsley and Maleki (2004, 75) refer to as “friendships [as] a common starting point for the networks of businesses”. In the context of the UI, the expectation of denser informal network ties leads to the expectation of denser formal network ties, hence our second hypothesis:

Hypothesis 1b USOs located in a UI will have denser formal network ties to one another than USOs without a UI.

Beyond the benefits associated with UI support and co-location with other firms at a similar stage of development, USOs in a UI may also benefit from knowledge spillovers from university research. USOs in knowledge-intensive sectors which are located closer to universities are better positioned to access, commercialise and benefit from future scientific research (Rothaermel and Thursby 2005; Colombo and Delmastro 2002), as proximity fosters trust and collaboration between firms and universities (He and Wong 2012). This idea that proximity to universities increases firms’ tendency to access and benefit from university research and knowledge suggests that:

Hypothesis 2a USOs located in a UI will have denser informal network ties to host university schools than USOs without a UI.

Hypothesis 2b USOs located in a UI will have denser formal network ties to host university schools than USOs without a UI.

Beyond the networks with other university USOs or schools, as businesses, USOs need to form links with external organisations. Evidence on the effect of being located in an incubator suggests that this might affect the formation of external ties in different ways. First, in the UI environment, there is a danger that the inter-organisational links that USOs form, either informally or formally, will be inward-looking “remain[ing] too much oriented on the academic world”, to the neglect of commercial efforts (Gilsing et al. 2010, 16; see also Bekkers et al. 2006). Alternatively, UI location may be beneficial to USOs in forming external links. For example, positive credibility effects may arise for UI tenants from their university affiliation (McAdam and McAdam 2008; Leitch and Harrison 2005; Rothschild and Darr 2005). Although there is also some evidence that for USOs, a university address may hamper their ability to be taken seriously particularly when seeking venture capital investment (Harrison and Leitch 2010; Vohora et al. 2004). An explanation is that the university association boosts firm credibility initially but as the relationship matures the university association becomes a detriment to credibility, signalling that firms “are still in diapers” (McAdam and Marlow 2007, 368).

Reflecting the findings of Gilsing et al. (2010) one of the most cited risks of being located in a UI is ‘insularity’ (McAdam and Marlow 2008; Bekkers

et al. 2006). Where links to external organisations are lacking, the inter-organisational network of the USO will comprise an homogenous group of similar firms that will constrain USOs' development activities. Specifically, such lack of diversity may, for USOs based within UIs, reduce "the chance of unforeseen novel combinations of knowledge which can lead to discovery" (Pittaway et al. 2004, 44). This expectation of greater insularity of USOs in an incubator environment leads to the final hypothesis:

Hypothesis 3 USOs located in a UI will have fewer external network ties than USOs not located in a UI.

4.3 Data and Methods

Our empirical study was based on a comparative case analysis of two research intensive universities on the island of Ireland: one with an on-campus UI and the other providing business support for USOs but without a UI. Exploring such a limited number of cases in detail is warranted by the absence of extant research comparing these two models (Dul and Hak 2007) and by the complexity of collecting, mapping, analysing and comparing both network data and qualitative data within one research study. Further, given the heterogeneity of knowledge and technology transfer activity across the higher education sector (Hewitt-Dundas 2012) it was important to ensure that the comparative cases were similar in terms of the size of the university and the quantity and quality of research output.

The first case was a university (University 1) that established a wholly-owned incubator (UI) in 2003, located on the university campus. This university incubator comprises business units, desk space and bio-incubation units, as well as a reception service, equipped meeting rooms and a café. Generally, the incubator does not invest in tenants but does take an equity holding of 15 % in USOs in exchange for university-owned IP being assigned to the firm. As of February 2013, the incubator had 34 tenants (Table 4.2, Figs. 4.1 and 4.2).

The second case (University 2) that we analyzed was a university with a longer history than University 1 of formally supporting the commercialization of university research. This University established a company with limited liability (Non-UI⁴) in the mid-1980s with the objective of commercializing university research by supporting spin-out activity. Non-UI invests in each USO and upon receiving equity in the firm, IP is assigned from the University to the USO. USOs can also access, through Non-UI professional services, IP advice and venture capital networks but, crucially, not university-owned office or lab space. As of February 2013, Non-UI had supported 59 firms since its formation with 25 of these being active as USOs at the time of our survey (Table 4.2, Figs. 4.3 and 4.4).

⁴ Non-UI is a fictitious name for the commercialisation company.

Table 4.2 Characteristics of university spin-outs in University 1 (UI: with incubator) and University 2 (Non-UI: commercialisation company without an incubator)

	University 1 (UI)				University 2 (Non-UI)		
	On-campus	USOs	Spin-Ins	Total	USOs	Shareholding	Total
Incubator USOs							
Population N	9		6	25	40	22	3
% Surveyed	67.0		83.0	64.0	68.0	82.0	100.0
Age and size							
Age (years): Mean (median)	7.0 (7.3)		2.5 (2.1)	5.2 (5.2)	5.1 (4.7)	10.5 (9.2)	15.8 (14.3)
USO size (no. FTEs): Mean (median)	8.7 (4.0)		4.4 (0.0)	4.9 (2.5)	5.7 (2.0)	46.1 (2.3)	9.7 (6.0)
Sector (% of firms)							
Human health and social work	16.7		0.0	0.0	3.7	5.6	0.0
Information and communication	33.3		0.0	56.4	40.7	27.8	33.3
Pharmaceuticals	33.3**		20.0	6.2	14.8*	0.0**	0.0
Materials	0.0		20.0	6.2	7.4	5.6	0.0
Equipment	0.0		20.0	6.2	7.4**	33.3	33.3**
Professional, scientific and technical activities	16.7		40.0	25.0	25.9	27.8	33.3

Note: Data relates to February 2013 when survey work was undertaken
Significance levels: *p < 0.10; **p < 0.05

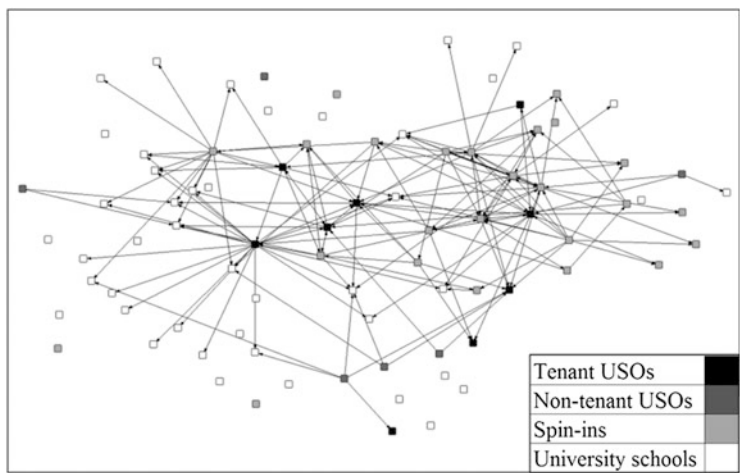


Fig. 4.1 UI informal network map (University 1 with Incubator)

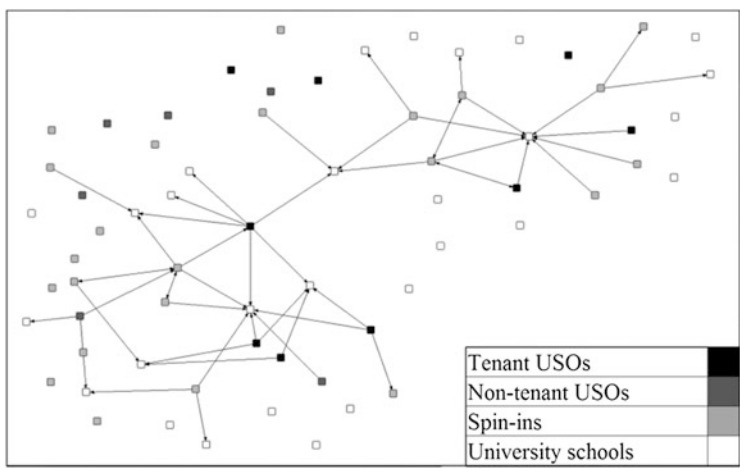


Fig. 4.2 UI formal network map (University 1 with Incubator)

Clients of Non-UI were typically older than clients of UI—this was unsurprising given the considerable difference in the units’ ages and the absence of ‘graduation’ (short of acquisition/liquidation) in Non-UI. Despite this, the average (median) number of employees in the USOs was similar for Non-UI and UI. Further, the pattern of USOs by sectoral grouping was broadly similar in the two contexts, although UI had a significantly higher proportion of pharmaceutical manufacturing firms while, in Non-UI, equipment manufacturing was significantly more prevalent (Table 4.2).

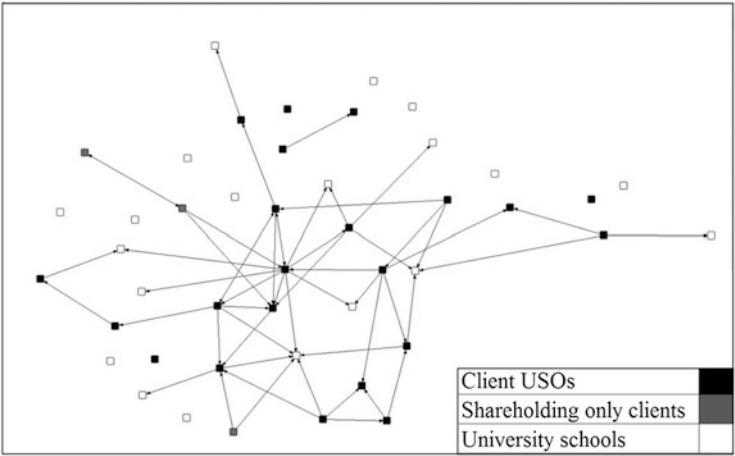


Fig. 4.3 Non-UI informal network map (University 2 without incubator)

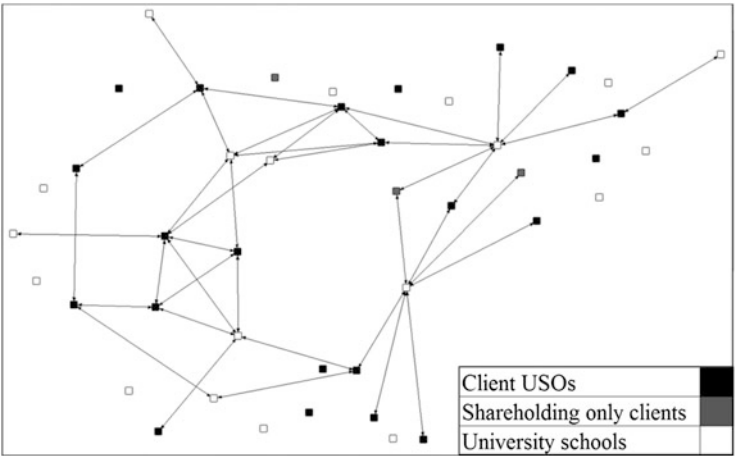


Fig. 4.4 Non-UI formal network map (University 2 without incubator)

Our approach involved interviewing a founding member of each firm—including USOs and spin-in firms located in UI, on-campus USOs not located in UI, Non-UI USOs and the three non-USO firms in which Non-UI had taken a shareholding. Of the population of 65 firms, overall 68 % of UI client firms and 84 % of Non-UI client firms were interviewed. Data collection occurred between November 2012 and February 2013, with interviews occurring at the firms’ premises or a similarly suitable location and lasting for between 45 and 90 min. All interviews were recorded (with the exception of two where interviewees did not consent to recording).

4.3.1 *Network Data*

Our interest in this paper is in the structural networks of USOs and in how and why access to a UI affects such networks and the benefits derived from them. A first step was to apply social network analysis (SNA). Methodologically, this approach was selected because network analysis of USOs is limited and the application of SNA has not been widely applied to profile the scale and scope of these network relationships. Cooper et al.'s (2012) study represents an exception to this, while Sherman and Chappell (1998) documented different types of ties among incubator tenants but without applying SNA techniques. In collecting data to address our hypotheses through SNA, both categorical and ordinal data were collected:

Network Ties All firms were asked to identify all (i) other USOs (ii) host university schools (iii) external private firms (iv) external universities and (v) external publicly funded research centres/labs with which the USO had formal and/or informal ties.⁵ Respondents were given a list of *all* current and former USOs from their university and a list of all host university schools. For other partner categories, the template was blank and they were asked to list companies,⁶ universities, etc. themselves.

Intensity of Ties For each reported formal or informal network partner, respondents were required to indicate how frequently they (or anyone from their firm) interacted with them.

Network analysis was carried out using UCINET SNA software. After documenting all respondent firms' attributes (e.g., firm type, age, host university) their informal and formal ties to different partner types, and the attributes of each of these ties (direction, frequency of interaction), this data was imported to UCINET in the form of DL language text files. The software was then used to calculate network densities within and between various node groups across the two university contexts. Network density measures how connected a group of nodes are to one another or to another group of nodes. For networks where ties have values (i.e., intensity)—as in frequency of interaction in our data—density is calculated using:

⁵ A formal network tie was considered to exist where a contractual agreement had been entered into or money had changed hands between the firm and the partner in question. An informal tie was defined as any interaction which involved neither a contract nor a financial transaction.

⁶ External private partner firms were too numerous to list in some cases. These respondents were asked to provide, via email, complete lists of client, supplier and collaborator firms or, where this was not possible or appropriate, an accurate count of partner firms in each of these categories. Usable data was collected from the vast majority of respondents in this way, with 43 of 48 (89.6 %) providing full data on external private firm partners.

$$D = \frac{\text{Sum of intensity of all actual ties}}{\text{Total number of possible ties}}$$

Network density can be calculated using asymmetric or symmetric data.⁷ We elected to use symmetric data on the bases that (a) business ties, and in particular formal business ties, are inherently bi-directional; (b) for unreciprocated informal ties, there was a possibility that the founder of Firm A simply was not the point of contact for the founder of Firm B, leaving them unaware that a tie existed between the firms.

SNA requires access to all nodal actors and assumes that every node has the potential to be linked to any other, so it could not be applied to data collected on USO network ties to external partners. This data was instead analysed by building a dataset of each respondent firm's reported counts for each external partner category. Mean counts of external ties (to private firm clients/suppliers/collaborators, universities and research centres/labs) for the UI and non-UI contexts, and for sub-groups within each, were calculated and compared statistically.⁸

4.3.2 Qualitative Data

In addition to collecting network data, we attempted to interview the population of active USOs in both universities (40) as well as the 25 spin-in companies based in the UI. Of these 65 firms, we successfully interviewed 74 %, i.e., 48 firms. The purpose of the interviews was to explore emergent differences or similarities in network characteristics between the UI and Non-UI settings (i.e., where an incubator and professional support was present and where no incubator facility was present but professional support was offered). Interviews were conducted with the firm's founders exploring their perceived obstacles and enablers to network formation, details of cooperative partnerships, benefits accruing to firms from network ties, and the impact of being located (or not) in a university incubator on these various factors.

Interviews were recorded, transcribed and analysed with MaxQDA (qualitative analysis software). The data was 'open coded': each transcript was systematically studied and relevant words and phrases were categorised under themed headings and sub-headings, created and restructured dynamically during analysis. The

⁷ Asymmetric data takes account of the recorded direction of a tie: where one actor reports a tie to another but this is not reciprocated, only one tie is included in the analysis. Symmetric data assumes that a tie reported in one direction is reciprocated even if the reciprocal tie is not actually reported, so that every connected pair of nodes constitutes a pair of ties.

⁸ The Mann-Whitney test involves combining values or scores from two independent samples into a single ordered list, assigning a rank to each score within this list and generating a statistic indicating whether either sample has a significantly greater number of highly ranked scores than would be expected.

resulting code system (cross-referenced by respondent and group) allowed identification of recurrent themes and comparison of the experiences and opinions of UI and non-UI founders, and of sub-groups within each context. Finally, network data was revisited in light of the interview data.

4.4 Findings

4.4.1 *Structural Networks Among USOs*

By analysing the presence of informal and formal ties that USOs reported with (i) other USOs from the same University (excluding spin-ins and shareholdings), (ii) all other firms (including spin-ins located in the UI and shareholdings of Non-UI) and (iii) academic schools or centres within the host university, density measures were calculated (Table 4.3⁹). As anticipated the density of informal ties was higher than for formal ties. The density of informal UI and Non-UI full networks (i.e., among client firms and between client firms and host university schools) did not differ significantly at 8.23 % and 8.99 % respectively. However, the density of informal ties among USOs was significantly greater in the UI context (41.67 %) compared to the Non-UI context where there was no incubator (18.18 %).¹⁰

In terms of formal network ties, the density of these was very low in both the UI and Non-UI contexts (Table 4.3). Although the density of inter-organisational formal ties in Non-UI was significantly higher across all of the groups studied, these values were low. For example, formal ties between USOs in University 2 were 6.06 % while no formal ties were found in UI. Further, including spin-in companies and spin-outs for which the University had a shareholding, the density was again significantly higher in University 2 (Non-UI) at 7.27 % compared to 2.15 % in UI.

Taken alongside the denser informal network in UI, this fails to support the earlier finding of Bøllingtoft (2012) and Debackere and Veugelers (2005) that social capital developed through informal ties would develop and translate into formal business relationships. In contrast, in the case of Non-UI, informal ties were less common but where links between USOs did exist, these were based on more formal contractual arrangements.

As well as the greater incidence of formal business relationships between USOs in University 2, there also emerged a strong commonality in board members across the USOs. 76 % of Non-UI USOs had at least one board member in common with

⁹ These network ties are graphically presented in Appendix.

¹⁰ This difference was latent in the full network analysis due to the inclusion of university schools as nodes: the higher number of schools (44 compared with 20 for the Non-UI) ‘diluted’ the UI informal network and gave a misleadingly low density figure.

Table 4.3 Density of UI and Non-UI informal and formal networks

	UI	Non-UI	Pearson Chi square	p-value
<i>Informal network</i>				
USO-USO network	41.67	18.18	20.461	0.000**
Full network	8.23	8.99	1.148	0.284
USO-school network	12.37	8.86	5.453	0.020*
<i>Formal network</i>				
USO-USO network	0.00	6.06	4.605	0.032**
Full network	2.15	7.27	127.330	0.000***
USO-school network	5.81	12.50	22.066	0.000***

Note: Full Network includes spin-in firms in the case of UI and firms for which Non-UI have a shareholding

Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

another USO; this figure was only 15 % for UI USOs.¹¹ This is an important finding and may help to explain the lower density of informal (social) ties but the higher incidence of formal (contractual business) ties among Non-UI USOs.

Our findings therefore lead us to accept Hypothesis 1a that USOs located in a university incubator (UI) will have denser *informal (social) network ties* to one another than USOs without a university incubator (Non-UI). However, we reject Hypothesis 1b proposing that USOs located in a UI will have denser formal network ties to one another. Instead we find a very weak relationship between informal and formal ties.

4.4.2 USO-School Structural Networks

USOs in the UI were more likely to have informal ties to their university schools than USOs in the Non-UI context (12.37 % and 8.86 % respectively) (Table 4.3). Formal business ties between USOs and university schools were significantly denser in University 2 (Non-UI) (12.50 %) than in the UI context (5.81 %). As found previously for ties between USOs, the correlation between informal (social) ties and formal (relational) ties was weak.

The strong commercial focus of the University 2 went some way towards explaining this difference in formal ties to academic schools. University 2 has a range of established institutes and centres which are affiliated to specific schools but which focus solely on commercial/research activities. For USOs, these represent channels and opportunities for engaging commercially with the university which

¹¹ We used network fragmentation as a more formal means of comparing board of director networks. Fragmentation measures pairs of nodes in a network which are not connected to one another (directly or via other nodes) as a proportion of all possible node pairs. The symmetrised UI director network was much more fragmented (96.5 %) than that in the non-UI context (23.1 %).

were less evident in University 1.¹² For example, 61 % of Non-UI USO respondents had formal business ties to at least one host university institute/centre; the figure for UI USOs was only 18 %. Proportions of Non-UI and UI USOs with *any* formal school ties differed much less (89 % and 73 % respectively), suggesting a positive link between the existence of commercially-focussed institutes/centres and the density of USO-school formal ties.

These findings lead us to accept Hypothesis 2a that USOs located in a university incubator will have denser informal network ties to schools in their host university than USOs without a university incubator. As with Hypothesis 1b we also reject Hypothesis 2b finding instead that USOs located in a non-incubator context (University 2) have denser formal network ties to host university schools. Again there is no positive correlation between the density of informal ties and formal ties with university schools. Where formal ties are found these tend to be stimulated by the presence of centres/institutes with a commercial focus which are more receptive to formal links with USOs. As such, formal ties between the University schools and USOs are influenced by the character of the schools rather than the USOs.

4.4.3 *USO External Network Ties*

External network ties that each spin-out was engaged in was examined in terms of private firm clients, suppliers, collaborators, universities and publically funded research centers/labs. None of the counts were normally distributed and usable data was returned from 25 incubator respondents and 18 Non-UI respondents (i.e., $N < 30$). As a result, the non-parametric Mann-Whitney test was applied to determine if significant differences existed between the external network ties of spin-outs located in an incubator (UI) and those with no incubator (Non-UI) (Table 4.4).

USO tenants (including spin-out and spin-in firms) in UI reported, on average, more external network ties than USO clients of Non-UI with mean counts of 37.00 and 28.20 respectively (Table 4.4). Excluding spin-in firms from the analysis and comparing only spin-out firms in UI and Non-UI we see no significant difference in the extent of external network ties (average of 27.1 ties per USO in UI compared to 28.2 ties in Non-UI). This suggests that the context of being located in an incubator, or not, has little effect on the scale and scope of external partnerships formed. However, the findings also highlight that spin-in firms are more developed commercially than university spin-outs. While it might have been anticipated that proximity of USOs with spin-in firms would assist in developing the external network ties of USOs, this is not found. On the other hand, as suggested in the hypotheses that USOs not located in an incubator may have greater commercial ties, this is not supported.

¹² The UI host university had an average of 1.85 institutes/centres for every university school while the non-UI average was 3.85.

Table 4.4 Frequency of external network ties

	UI tenants (incl. spin-ins)	UI USOs only	Non-UI USOs only
Customers/clients	25.20	17.60	18.93**
Suppliers	8.40	7.20	5.40
Private collaborators	0.00	0.00	0.73
Total Private	33.60	24.80	25.07
Other universities	3.00	2.00	2.07
Publicly funded research centres/labs	0.40	0.30	1.07
Total public	3.40	2.30	3.13
All	37.00	27.10	28.20

Note: Significance levels: ** $p < 0.05$

Exploring this through the interviews we found that UI spin-out tenants valued their university affiliation, believing that this helped to stimulate interest among prospective clients, however it was not central to the formation of ties with clients:

I don't think it's direct in 'Oh, you're a [University 1] company, we want to deal with you' – it's more 'We want to learn about you'. The fact that you're associated with a reputable university – and as they then learn more about [UI] it becomes an advantage (ISO5).

Infrastructural factors went some way towards explaining this contrast. The “impressive facility” of UI was deemed a significant selling point for USOs, allowing firms to present themselves as legitimate and stable “going concern[s]”. Several UI respondents referred to the specific value of this in establishing credibility and overcoming USO stigma:

We would have site visits here. You can bring [prospective clients] to [UI] and they go 'Ok, there's four walls – that's a start'. Then you bring them to the labs and they go 'Yes, this is real', and they're convinced that this is not some cowboy operation (ISO3).

Assuring credibility was more difficult for Non-UI firms who frequently identified problems of assuring clients that being a USO did not preclude them from being a “proper company”. Many saw USO status as a deterrent to larger companies seeking sustainable business partners—and not “small companies which could be gone in 2 years' time” (CSO4). Others identified a stigma around ‘campus companies’, whereby industry may avoid partnering with USOs on the basis that “if you give them a job to do, they take a long time and don't meet deadlines” (CSO9).

This “professional façade” and its role in attracting and reassuring clients was an inherent benefit of being a UI tenant, but was obviously lacking for non-UI client USOs. In the absence of UI facilities, some were premised in “shabby” facilities (CSO12) or had been forced to move “out here to the *** sticks” (CSO6), damaging their reputation in clients' eyes. Other Non-UI firms had not secured office premises for their business, with a significant minority (28 %) running their USOs from their academic offices and, in one case operating an early-stage USO from home:

I sold the first machine off my kitchen table. [University 2] didn't have an incubation space and they wouldn't give me a desk in the department, so I had no desk to work at and I had to make commercially sensitive calls to customers (CSO5).

Although physical location was seen to have some effect in assuring clients and other external partners of credibility, of greater importance was the financial investment by the universities in the spin-outs. The willingness by the university to invest directly or take an equity stake in the business was seen as a powerful and positive signal to potential investors:

There's an endorsement there. When other people look at it they're thinking 'Well, these other guys saw fit to invest in this company' so there's definitely a worth in having it (CSO1).

Based on these findings we reject Hypothesis 3 that USOs without an incubator will have more external network ties than USOs located in a UI.

4.4.4 UI and Non-UI Network Benefits

Taking the analysis one step further, the density and scope of network ties is only important in terms of the resources or capabilities that can be accessed and contribute to the growth or development of the spin-out (Barney 1991). Through interviews with the USO founders we explored these issues in more detail. Adopting a resource-based perspective we considered the formal and informal network ties of USOs in the two university contexts along the four dimensions of financial resources, physical resources, human resources and knowledge resources.¹³

Overall, there was little evidence that network ties to university schools or other USOs had direct financial benefits. In terms of revenue, the vast majority of respondents (80 % and 95 % in UI and Non-UI contexts respectively) attributed less than 5 % of their revenues to their UI/university affiliation whether directly (e.g., sales to USOs/schools) or indirectly (e.g., client introductions). In terms of investment, commercialisation support personnel were deemed useful in getting USOs "in front of potential investors". However, such network facilitation efforts did not increase the likelihood of securing investment: of all founders who, while seeking private investment, had been introduced to potential investors by commercialisation support personnel, only 54 % had ultimately secured investment; *all* of those seeking investment in the absence of UI/Non-UI introductions had been successful. There was no significant variation between contexts or sub-groups on this statistic.

¹³ Barney's (1991) firm resources also include organisational resources. However, network ties, in and of themselves, constitute organisational resources—i.e., "informal relations...between a firm and those in its environment" (Barney 1991, 101)—so we exclude organisational resources from our categorisation so as to avoid duplicating our discussion.

Some UI firms perceived indirect financial benefits from informal interaction with other incubator tenants. One observed that “water cooler talk can save you a significant amount of time and money” (ISI14), by giving the opportunity to learn—free of charge—from the experiences of peer companies rather than paying for the advice of IP solicitors, accountants, etc.

In relation to physical resources, many UI firms (55 %) reported using school-owned equipment on a *pro bono* basis. This provided a significant network benefit and in some cases was central to their business. A biotech USO explained that without access to highly specialised university-owned equipment, “it actually would probably be easier to move out of the country” (ISO3), given the financial and regulatory challenges of setting up a comparable lab. Similarly, a number of USOs in UI noted how they had used technology belonging to other tenant firms (e.g., conferencing systems, client extranet). This created a culture whereby “most of [the UI tenants] would go out of our way to help each other if we could” (ISI1). In contrast to this for Non-UI, ‘open access’ to school lab and equipment was less common, however the potential contribution of these facilities to the businesses was reflected in the number of formal network ties with host university schools. Further, given that firms were typically isolated from other spin-offs, this culture of a ‘shared struggle’ and associated network benefits were much less apparent with the emphasis on formal ties.

Evidence of human resource benefits from inter-spin-out networks was lacking, with little discussion of staff movement between USOs. However, many interviewees reported that proximity to university schools was important in recruiting high quality graduates. Non-UI firms were less likely to access university human capital, but those who did tended to do so in a more formal way through paid contracts or knowledge transfer partnerships (KTPs). One early-stage USO displayed a particularly innovative way of addressing its own ‘liability of newness’ from a human resource perspective:

[When] you go to pitch business to a company, it’s kind of chicken and egg: until you’ve got the staff, you can’t get the contract but until you get the contract you can’t afford to recruit the staff. So what we’ve done is we’ve actually gone out and said ‘Look, get the contract [and] we can actually sub-contract some of that back to the university’, which allows [us] to get an external contract (CSO16).

In other words, the USO leveraged highly skilled university research staff on a casual, *ad hoc* basis, providing the human resources to compete for substantial contracts, but without the expense of formal recruitment and long-term salaries, etc. Several other Non-UI USOs described a similar model, and saw this as a key tangible business benefit of having university ties, particularly under challenging economic conditions:

We pull in a team of experts as opposed to having them all sitting here with nothing to do. . . That’s just the way we have to work – staff are the most expensive part of the business (CSO11).

This suggests that the social capital associated between spin-out founders and their original academic schools remains important in providing skills for the

business. While geographical proximity may assist with this, particularly in the recruitment of graduates, it is not a pre-requisite suggesting that the incubator context has limited effect on attraction and recruitment of staff for USOs.

As outlined in Table 4.3, UI spin-out firms had significantly denser informal ties with other spin-out firms than USOs in Non-UI (41.67 and 18.18 respectively). When talking to the USOs about acquiring business knowledge, UI USOs emphasised repeatedly the knowledge they accessed from one another. Some provided unpaid technical consultancy (e.g., technology test/review) to co-tenants, but most shared knowledge was more general in nature. Specifically, although individual USOs differed markedly in their sector and stage of development, all ultimately faced very similar problems—"accounting, research, IP", etc.—so the idea of drawing on the diverse experiences of co-tenants as a resource for overcoming common challenges was raised repeatedly:

You're surrounded by sources of knowledge and experience on all the common factors companies like us have to deal with. And everybody is good at something different [but] everyone is facing the same challenges (ISI9).

These knowledge benefits were identified less frequently by Non-UI USOs, however these businesses were conscious of—and aspired to—the same informal knowledge sharing cited by UI tenants:

It would be fantastic to have a whole group of different people that you could dip in and out of when you needed to (CSO10).

Similar knowledge benefits emerged in relation to school ties. For UI clients, network ties to university schools were typically based on free and open exchange of knowledge, involving "collaborations [and] the general exchange of advice between experienced people [with] no formal agreement" (ISO3). However, the firms deriving most knowledge resources from school interactions seemed to be UI spin-ins. A prime example was a manufacturing spin-in which, when asked to solve a problem by a major European scientific agency, was unable to arrive at a solution. An engineering PhD was approached and, in collaboration with the firm, delivered a technology which surpassed the expectations of the agency. What is more, the case represented an archetype of industry-academia interaction, in that the spin-in retained commercial rights to the technology but the PhD was free to publish the science behind it, i.e., "they got their currency out of it [and] we got ours". In Non-UI, it was significantly different, with the basis for USO-school interaction being formal business transactions and not free knowledge exchange. However, there was limited recognition of the potential knowledge benefits of USO-school networks and regret about not fully exploiting school knowledge resources:

All the departments who might be able to answer questions for [Non-UI] companies and nobody even thinks of using the skills that exist there. Those people could be tremendous help as I see it, with ideas or a bit of advice (CSO1).

4.5 Discussion and Conclusions

4.5.1 *USO-USO Network Ties*

The significantly higher density of USO-USO informal ties in the incubator context confirms previous research findings (Cooper et al. 2012; Schwartz and Hornych 2010), suggesting that co-located USOs develop more and stronger social ties with one another than those dispersed in private premises outside the university campus. An obvious explanation for this being the physical infrastructure of the incubation facility in nurturing the social interactions between USO founders.

The correlation between informal (social) and formal (relational) ties was not found and instead formal ties between USOs in Non-UI were significantly denser. This is contrary to other research (Bøllingtoft 2012; Debackere and Veugelers 2005), and suggests firstly, that informal ties do not necessarily lead to formal ties (Lindelöf and Löfsten 2004) and, secondly, that formal USO business relationships can emerge in the absence of informal ties. In addition, we find evidence that where informal ties lead to more formal, relational ties, proximity may be playing a very strong role.

Being located in a mutually supportive culture and sharing of technology (e.g., videoconferencing etc.) are clear benefits of being located in an incubator. The main benefit however was advice around IP, investment, accounting, etc. which as identified previously by Clarysse et al. (2005) and Vohora et al. (2004) are issues of particular importance to academic entrepreneurs given their lack of entrepreneurial or commercial experience. On the other hand, with co-tenants seen more as friends or sources of generic advice than as potential business partners, it was arguable that this more intense informal interaction precluded UI USO tenants from identifying mutual opportunities for formal business, while Non-UI USOs showed awareness of other USOs businesses and made conscious efforts to identify synergies.

In any case, formal USO-USO network ties were extremely sparse in both contexts, so we conclude that USO support units, whether physical or otherwise, apparently do not stimulate business between clients/tenants. Instead, the key message here is that the advice and support which early-stage academic entrepreneurs can draw from one another is the key benefit and this is best accessed through informal network ties (Cooper et al. 2012; McAdam and Marlow 2008).

The extent to which USOs were engaged in external ties to organisations outside the university was remarkably similar for both USOs located on an incubator and those with no incubator. This suggests that USOs located in an incubator are as aware of and connected to external organisations as spin-outs with no incubator. This therefore challenges assumptions that incubator tenancy breeds insularity, an overly-academic focus and impedes knowledge of external markets (Bøllingtoft 2012; Gilsing et al. 2010; McAdam and Marlow 2008; Bekkers et al. 2006; Inkpen and Tsang 2005). At the same time, comparing this to our data on external networks of spin-in businesses, USOs irrespective of incubator context have a significantly weaker profile of commercial contacts. This suggests two possible explanations:

first, USOs have inferior commercial ties than spin-in firms; second, the incubator context works in one of two ways (a) it either creates a commercial upgrading effect as spin-in firms share their information/knowledge relating to customers/clients with spin-outs and brings them to a level, on-par with USOs who are not in an incubator environment and as a result are more exposed to customers/clients, or (b) there is no learning effect from spin-in firms on the customer profile of USO spin-outs in an incubator and that the commercial ties of USOs are naturally lower.

Previous research has emphasised that incubator/university affiliation boosted USOs' credibility (McAdam and McAdam 2008; Leitch and Harrison 2005; Rothschild and Darr 2005). In our research we find that while there are advantages to being located in incubation facilities these are largely superficial with the priority being on the USO's ability to demonstrate technical and commercial viability. In the context of this chapter, the incubator environment is useful to USOs in presenting a professional façade, however it is neither sufficient nor critical to the development of formal commercial ties.

The practical implication here is that, where possible, a UI is desirable but that it will not necessarily transform campuses into 'hotbeds' of commercial activity, something which should be understood by university policy/decision-makers when considering investment in incubator facilities. To stimulate formal on-campus business for USOs, UI support personnel should go beyond facilitating informal USO-USO interaction, and make efforts to raise mutual commercial awareness (e.g., presentations to co-tenants on current business activities). Establishing commercially focused school-affiliated institute/centres would also be beneficial in this respect.

Where the resources for a university incubator are unavailable, conscious and sustained effort is required on the part of commercialisation support personnel to encourage informal interaction among client USOs, maximising informal USO-USO network ties—and their associated benefits—in the absence of co-location; this may take the form of regular coffee mornings, 'away days', workshops, seminars, etc.

The study was subject to a number of limitations. Sample size was an issue and, in particular, more USO respondents on the UI side would have made our network analysis and comparison more meaningful. However, this simply reflected the spin-out rate from the host university and, ultimately, over 73 % of active USO clients of Non-UI responded. These findings are one of the first attempts to critically reassess the value of university incubators through a comparative case approach. As technology evolves, business models adapt and new models of support to promote high growth businesses are considered, traditionally accepted models such as incubators must be re-examined. This study makes a tentative step in that direction with significant opportunities to expand this inquiry through future research. For example, while in this chapter we have mapped the formal and informal network of USOs in two contexts we have not examined through qualitative analysis the reasons why such patterns exist and the consequences of them. Further, given the emphasis in the incubation literature on how these environment assist USOs in overcoming the 'liability of newness', it would also be interesting to compare and

contrast the business formation process in these two contexts. Associated with this would be studies of the human-capital dimension of an on-campus incubator: to what extent does geographical and institutional proximity enhance access to skills and expertise of academics and graduate students, or is the founders' social capital sufficient to overcome this lack of co-location? Ultimately, although considerable evidence supports the benefits of incubation, academic researchers should continue to question the underlying assumptions associated with incubation support models.

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Chapter 5

Spin-off Creation in a National Research Institution: Technological and Industrial Implications

U. Finardi and S. Rolfo

Abstract The present work takes into account the creation of Spin-off companies in CNR, Italian National Research Council, up to 2012. The aim is to analyze the relations of Spin-offs with CNR, their technological sector and their industrial performance. Several types of data are exploited and analyzed. Studied topics encompass relations with CNR Departments, geographical distribution, local research and industrial context. The main analysis relies on budgetary and industrial sector data, in order to measure the performance of CNR Spin-offs. Their performance is also compared with suitable benchmarks of firms and academic Spin-offs. The evolution of the context is also considered in the study. The study of the activity of CNR in fostering the creation of knowledge-intensive firms offers an insight on the role of National Research Institutions, and in particular of the specific case.

Keywords Spin-off creation • National Research Council of Italy • Firm performance • National Research Institutions • Technology Transfer

5.1 Introduction

The research systems of many European countries is based, besides Universities, also on Research Institutions of national relevance, devoted solely to fundamental or applied research. Examples of such Institutions are for instance the Max Planck Gesellschaft and the Fraunhofer Gesellschaft in Germany, the CNRS (Centre National de la Recherche Scientifique) in France, the CSIC (Consejo Superior de Investigaciones Científicas) in Spain and the CNR (Consiglio Nazionale delle Ricerche) in Italy. Such institutions—each having its relevant peculiarities—differ from both UK Research Councils (which are agencies coordinating and funding

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research) and the American National Academy of Sciences, where the research personnel serves *pro bono* being hired by Universities or other research institutions. In such National Research Institutions, instead, tenured research personnel performs research activities in various fields. The main difference with Universities is obviously the fact that, in principle, researchers do not perform teaching activities.

This obviously does not hinder the chance of being engaged in “Third Mission” and Technology Transfer activities. In particular, in the present situation of worldwide economic crisis, performing such activities has a twofold important role. By one side it can be a way to support research and research personnel. By the other side it is an instrument able to foster the economy of the Nation exploiting for practical purposes relevant research results.

In the present situation of CNR, National Research Council of Italy, “Third Mission” is even more relevant. In fact in the last 15 years CNR research activities have moved towards more applied research topics, partly abandoning target-free research. This is due both to National and internal research policies and to the chronic Government under-financing. The lack of financing has thus generated the need for money deriving from research projects with strong practical orientation and narrower scope. In consequence of these facts, the level (quality and quantity) of publishing in highly regarded international journals has forcedly witnessed a decrease (Coccia and Rolfo 2008). Also the rate of success in competitive financing is hindered by these trends. Thus the practical exploitation of research results is a further chance of supporting research activities of any kind.

This framework makes it relevant the study of the performance of “Third mission” activities in Italian CNR. The present work aims at analyzing one of the specific outcomes of “Third Mission” activities performed inside CNR. It tackles in fact the topic of creation of Spin-off companies in CNR Institutes. It does so contextualizing CNR Spin-off creation inside both industrial and research environments. The creation and the performance of Spin-offs is studied with the use of several sets of indicators (in particular balance-sheet data) and of benchmarks able to set them in the context they operate in. In this way we aim at studying the contribution of CNR to the creation of new companies, to the Italian industrial context, and to National development.

Besides the above described policy implications, two further motivations lie behind this study. The first one is the extant knowledge on Spin-off creation in Italy: the topic, though touched in the past, still deserves attention. In fact, notwithstanding the publication of a yearly report by Netval (a network between Italian universities and some research organizations), this topic has not been analyzed often in recent years.¹ The second one, also shown in the theoretical framework, is a generalized lack of knowledge on the creation of Spin-offs in National Research Organizations. This topic—with some slight exception regarding German Max-Planck Gesellschaft—has never been touched to our knowledge by previous research efforts.

¹ The participation of public research organizations to the yearly enquiry of Netval is very recent.

Due the exploratory aim of our work we will not enter one of the specific approaches described by Mustar et al. (2006) even if the data collected allow us to better understand both the institutional links and the business models.

The present work is organized in the following way. Section 5.2 contains a literature overview and research framework, revising literature on CNR and its Technology Transfer and Third Mission activities, on Spin-off creation in Italy and on Spin-off creation inside European National Research Institutions. Section 5.3 describes the dataset and the methodology, whereas Sect. 5.4 presents the case study: data, metrics and analysis. Finally, Sect. 5.5 presents the discussion of results, the conclusions, as well as learned lessons and policy advice.

5.2 Literature Overview and Framework of Research

The present section contains a literature overview, framing present research effort, on the most relevant topics for this work: National Research Council of Italy, academic Spin-off creation in Italy and Spin-off creation in National Research Institutions in Europe.

5.2.1 *The National Research Council of Italy and Its Technology Transfer Activities*

National Research Council of Italy was established in 1923 by Italian Government to perform scientific research in any field of knowledge. Its first President has been the mathematician and physicist Vito Volterra, and the second (from 1927) the Nobel Prize Guglielmo Marconi, inventor of radiotelegraphy. Since its foundation its research activities have witnessed worldwide diffusion (see for instance Science 1928, 1929).

In more recent years research activities of CNR have been marked by the creation of the so-called “Progetti Finalizzati” (“Oriented projects”) (see De Paoli 1987). But, on policy side, the most important facts are two subsequent reformations (1999 and 2003) which have strongly changed its nature and the way it is financed (see Biggin 1997). Besides other issues, reformations also established Departments inside CNR. CNR is traditionally organized in Institutes, each tackling a more or less specific topic of research in sciences, social sciences, engineering. Departments have been conceived as grouping of Institutes performing research activities in the same (or in similar) research areas. They have each a Director with staff, and the Institutes of each Department are partly financed with common funding.

Some works study features and organization of CNR.² Coccia (2004a) tests on CNR Institutes a model (the relev model) for measuring scientific performance. His findings allow discerning between high performance (the majority) and low performance Institutes, and show that high performance Institutes self-finance much more than low performance ones.

CNR Institutes are also exploited, in the analysis of Coccia (2005), as the basis for building a taxonomy of public research bodies. Findings show the relation existing between the input of resources and the output in terms of scientific production. This is not true in cases (such as Astronomy or Genetics Institutes) that require a very high input producing only long term results.

The topic of the relations between target-free scientific production and applied activities in CNR is instead tackled by Coccia and Rolfo (2008) on 2000–2003 data. Strategic changes between the two activities are highlighted in an analysis performed over different research areas. Applied activities are measured using revenues deriving from contracts (activities such as tests and analysis, or technological, quality and environmental services). Data analysis shows a crowding out effect of such (low-level and strictly practical) activities on scientific productivity.

The organizational behavior, the bureaucracy and the human resources of CNR have been studied instead by Coccia and Rolfo (2007, 2010, 2013). Coccia and Rolfo (2007) tackle the theme of the effects of organizational changes on a wide research structure, using CNR Institutes as a case study. Productivity before and after 1999 and 2003 reformations is studied. The analysis shows that “this policy reform has increased problems of governance and reduced research productivity” (p. 226). Similar results are obtained by Coccia and Rolfo (2010), tackling more specifically the topic of how reforms did foster scientists’ entrepreneurial behavior. Also under this point of view results tend to support a “negative judgment of this restructuring” (p. 146). A further effort (Coccia and Rolfo 2013) analyzes the organizational behavior of CNR from a demographic point of view. Results highlight the effects of low investments, lack of career path and incentives, and bureaucratization of research policy management.

Coming to the more specific topic of the study of Third mission and Technology Transfer inside CNR, a first attempt has been made by Coccia and Rolfo (2002) in the study of a local set of CNR Institutes, based in the Piedmont region. A taxonomy of activities is presented in the work. Subsequently, Coccia (2004b) measures spatial activity of Technology Transfer. Technology transfer is treated as the flow of information from source to users. Metrics, applied to the case of CNR, show “the strong influence of the space variable in the activities of Technological transfer” (p. 33).

A specific case of “Technology Transfer virtual network” (set up by CNR in the 1990s) is instead studied in Cariola and Coccia (2004). The social network analysis of CNR data shows that the main interest in Technology collaborations is from small firms. Territorial proximity is a positive driver of collaboration.

²The below reviewed articles may serve also as a reference for a description of the features of CNR.

Another insight on CNR determinants of technology production is offered by Tuzi (2005). Author sets up “a possible CNR technological production function” (p. 508), showing the positive correlation between patent production and two determinants of Institutes: stock of technological knowledge and scientific production. Economic and human resources, instead, do not influence production.

Finally Abramo (2006) performs a study on patenting and licensing of CNR, in comparison with MIT. Findings show a much lesser impact of CNR in domestic competitiveness, and a high fraction of CNR patents that are never licensed.

5.2.2 *Creation of Academic Spin-offs in Italy*

The seminal work of Chiesa and Piccaluga (2000) was probably the first to tackle the topic of the creation of academic Spin-offs in Italy. Their empirical study did encompass only 48 academic Spin-offs, concluding the existence of “an Italian (and perhaps partly European) model for research Spin-off companies, which is different from the American (and perhaps Anglo-Saxon) one. The Italian model seems to be characterized by low risk levels, together with modest growth rates” (p. 338). The results of the present study partly confirm, at the distance of more than a decade, those of Chiesa and Piccaluga.

Creation of Spin-offs is also discussed by Balderi et al. (2007) in a wider perspective on valorization of research results in Italy. Their data show the relation existing between the years of experience of the University’s Technology Transfer Office (TTO) and the number of existing (surviving) Spin-off companies. Commitment is considered critical in determining the performance. Results “suggest that the creation of new technology-based firms is a critical component of the strategy of research valorization pursued by Italian universities” (p. 28).

In more recent times also Algieri et al. (2011) deepen the role of TTOs in the creation of Spin-offs. After a quantitative analysis of the number of Spin-offs per Region and University, authors perform a logistic regression to explain the growth or decrease of the number of Spin-offs per university. Results show the dependence of the growth in the number of Spin-offs by financial resources and by the presence of full-time and highly-skilled personnel of TTOs. Moreover the probability of success is much higher in northern Italy than in central and—mainly—southern Italy. Colombo et al. (2010) study instead the relations between university research characters and the growth of university Spin-offs. The results of their finely structured regression model are mixed, and show non linear relations between university characters and firm outcome.

Salvador and Rolfo (2011) perform an analysis of Italian university Spin-offs, working on a sample of firms. Their linear regression model shows that the number of Spin-offs in an Italian Region depends on the number of structures such as incubators and science parks. The scenario presented by exploited data is “complex, confused and difficult to qualify” (p. 179). The most relevant fact is probably that “most attention has been focusing on spin-off creation and not on increasing the

probability that these firms are sustainable in the long term” (p. 181). Salvador (2011) comparing university Spin-offs with a sample of start-up companies operating in the same industries highlights worst performances for the academic Spin-offs than for the start-ups.

Finally, one of the most recent and relevant contributions on this topic is that of Iacobucci et al. (2013). Authors analyze the complete database of Italian Spin-offs created inside Public Research Institutions between 2000 and 2012. Several of their findings are close to those of the present analysis.

Other works tackle instead specific sub-topics of academic Spin-off creation. For instance Nosella and Grimaldi (2009) discuss the role of policies at university level in Spin-off creation. Authors work on a sample of 37 universities, with data obtained via a questionnaire sent in 2005 to University Technology Transfer Units. Results show the dependence of the number of generated Spin-offs on the characters of TT Units: “the generation of academic start-ups is positively affected by university intervention. [...] universities, through specific support mechanisms, may have an important role in overcoming some types of market failures” (p. 694). A similar topic, that of university regulations, is tackled by Salvador (2009): in particular the author explores the imitative behavior of universities in issuing Spin-off regulations. The cluster analysis performed—clustering university rules according to specific determinants—shows that there is no significant difference in the content of the various sets of regulations (p. 456).

Also Abramo and D’Angelo (2009) perform an analysis on the supply of technology from public sector to firms, in order to highlight possible mismatches. Their analysis, based on scientific productivity matched with a survey, shows—among other findings—the “misalignment between research policies and industrial policies in Italy” (p. 12).

The barriers towards collaboration between industry and academia are also explored by Villani (2013), analyzing two specific cases. Results show that the presence of a third party, though not sufficient by itself, might enhance the chances of success in collaboration.

Again Abramo et al. (2012) perform a study that considers a wide database of university Spin-offs. Their aim is to enlighten the relations existing between performance in research and Spin-off creation. Results show that, generally, “entrepreneurial” professors present a high academic performance, while Spin-off creation does not conflict with quality in research.

Finì et al. (2009), on their side, study instead the motivation of university researchers in setting up a new firm. The analysis is performed over a sample of 88 academics-entrepreneurs and 45 Spin-offs. The study shows the importance of the external context and of the involved technology in enhancing the chances of Spin-off creation. Nevertheless

“academics’ decision to start-up a new company is strongly influenced by academic related expected outcomes, such as: the generation of further stimuli for research activities, the gain of prestige and reputation as leading academics, the creation of funding opportunities (grants) for students or research assistants, or the possibility to get new infrastructure and facilities for academic research activities. These findings suggest that Italian academics’

decision to found a new company is not driven by ‘entrepreneurial attitude’ (e.g., personal earning, etc.), but rather by the expectation of some positive outcomes/benefits for them as academics” (p. 398).

These results must be taken in account discussing the findings of the present work.

5.2.3 Spin-off Creation in National Research Institutions in Europe

To the best of our knowledge, as far as now no analysis has been performed on the creation of Spin-offs in National (non-university) Research Bodies. Nevertheless some studies have tackled surreptitiously the case of Spin-off creation at Max-Planck Society (MPG) in Germany. Data on MPG Spin-offs are considered by Buenstorf (2009) in his analysis of the relations existing between scientific performance and academic inventing/commercialization. Also a subsequent analysis on the relations between distance and licensing activities (Buenstorf and Schacht 2013) considers MPG Spin-offs; so do Buenstorf and Geissler (2012) in a further analysis on licensing.

Slightly more related with the topic of the present work are the articles of Krabel and Mueller (2009) and of Fritsch and Krabel (2012). Krabel and Mueller (2009) investigate the motivations driving scientists to start a new company, exploiting data on MPG Spin-offs. Results “suggest that close ties to industry established through joint research projects with private firms, patenting activity, and prior founding experience are the most important factors enhancing activities towards starting a business”. (p. 954). Data on MPG scientists are analyzed also by Fritsch and Krabel (2012), who perform a further study on scientists’ attitudes towards entrepreneurial engagement. Again, prior experience with private sector, together with scientific discipline and career stage, are the main determinants towards the choice.

5.3 Data and Methodology

The case study performed in the present work considers Spin-off companies created inside CNR. Names, addresses and websites of CNR Spin-offs have been retrieved exploiting two sources. The first one is the official CNR website, which contains a specific section dedicated to the creation of Spin-offs.³ The second one is a list of

³ <http://www.cnr.it/sitocnr/IICNR/Innovazione/Spinoff.html> and <http://www.cnr.it/sitocnr/IICNR/Innovazione/SocietaSpinoffCNR.html>, accessed July, 2013 (in Italian).

Spin-offs (with related data) provided directly from the Central Administration (CNR Director's Office), relative to Spin-offs created from 2007 onwards.

Starting from names and address, as well as from other information, budgetary data have been retrieved on the AIDA Database.⁴ In order to obtain a complete picture of Spin-offs, and thus of CNR Spin-off creation, several types of data have been retrieved and used: balance sheet data, industrial sector classification, and other relevant data.⁵

Together with data relative to Spin-off companies, also benchmark samples' data have been extracted from AIDA. In particular for each Spin-off a sample of enterprises from the same Province and 4-digits ATECO sector has been extracted.⁶ 4-digits codes have been chosen as those able to provide the most suitable samples in terms of dimensions.

Finally, data on employees have been extracted from the database ASIA.⁷

Methodology implies the use of above described data to calculate indicators able to elucidate the characters of CNR Spin-offs in terms of industrial performance, connections with the local environment, role inside CNR.

5.4 Case Study Analysis

The definition of "CNR Spin-off company" depends on official documents published by CNR itself. In particular it is defined in the "Disciplinare per la partecipazione del personale CNR ad imprese Spin-off" (Procedural guidelines for the participation of CNR personnel to Spin-off enterprises). Guidelines foresee two different types of CNR Spin-offs: actual partnership of CNR in the society ("Spin-off partecipati") or mere contribution in terms of knowledge or other similar intangibles ("Spin-off sostenuti").

⁴ AIDA (see <http://www.bvdinfo.com/Products/Company-Information/National/Aida.aspx>, accessed July 2013) is an Italian company information and business intelligence database, produced by Bureau Van Dijk. It contains data on all Italian companies: balance sheet data, as well as address, employees, industrial sector, partners, *etc.*

⁵ Italian Industrial classification is called ATECO. ATECO (Classificazione delle Attività Economiche, Economic Activities' Classification) is the classification adopted by Italian National Statistics Institute ISTAT for national statistics on economic and productive activities. In its most recent edition (2007) its structure follows NACE rev. 2. It is commonly exploited in all works concerning industrial economics in Italy.

⁶ ATECO classification has different levels of refinement. It starts from 2-digits classification (88 general categories) to 4-digits to 6-digits (the most selective classification).

⁷ ASIA database contains data on employees of all Italian firms and sectors, and is provided by INPS-Istituto Nazionale Previdenza Sociale (Italian National Social Insurance Institute).

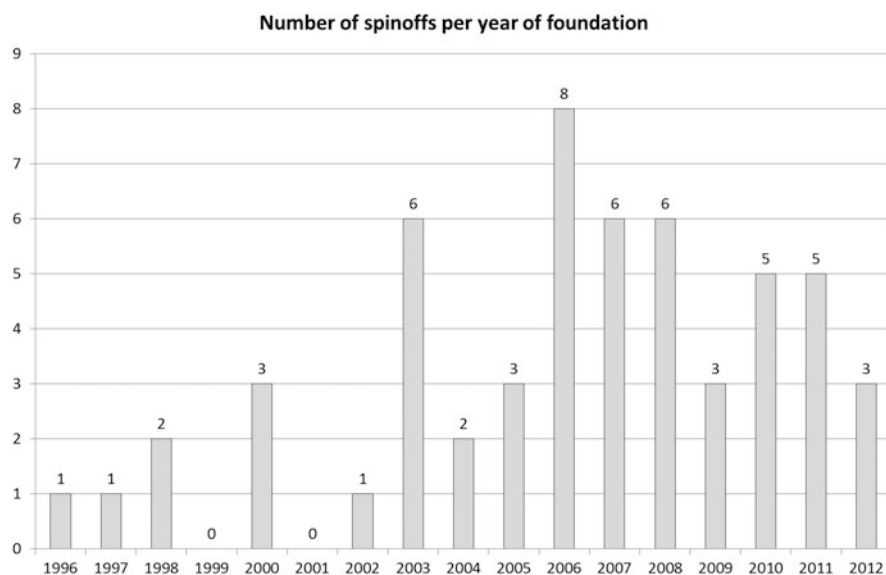


Fig. 5.1 Distribution of spin-offs according to the year of foundation

The sample contains a total of 55 Spin-off companies, created from 1996 onwards.⁸ Figure 5.1 presents the number of Spin-offs per year of foundation.⁹ Out of these 55 Spin-offs, CNR is partner in only 4 cases. In 7 cases Universities or National Research-Technology Consortia are partners in the society (one Spin-off belongs to both groups).

5.4.1 Geography and Industrial Sectors of Spin-offs; Relations with CNR Structure

A first relevant issue to be addressed is the geographical distribution of Spin-offs. Figure 5.2 contains a map of Italy presenting (with some approximation) the location of the Spin-offs, retrieved according to their address (ZIP code): each point represents a Spin-off. The map shows a strongly uneven geographical distribution, feasibly influenced by the geographic position of originating CNR Institutes (some Spin-offs have the same road address of the Institute) and/or by the presence of incubators or science parks.

⁸ Netval (2013) report counts 97 Spin offs. It must be noted that this number encompasses also Spin-offs created by INFM (National Institute of Materials' Physics). Nevertheless Netval does not provide any list of such Spin-offs, and instead refers in its website to the list from CNR which was exploited in the present work.

⁹ It must be noted that a further Spin-off, operating in the field of speech technologies, has been created in July 2013.



Fig. 5.2 Map of the geographic distribution of Spin-offs

Tables 5.1 and 5.2 present instead the distribution of Spin-offs according to the usual classification of Italian regions in North-Center-South and to two other determinants: respectively the originating Department (Table 5.1), thus partly showing the interaction with the structure of CNR, and the 2-digits ATECO classification (Table 5.2).¹⁰ Names of Departments and activity describing ATECO codes are translated in English for the readers' sake.

¹⁰Departments are those existing before April 4th, 2012. The 11 departments have been reorganized after that date into 7 departments.

Table 5.1 Distribution of spin-offs: geography vs. originating department

	North	Center	South	Total
Medicine	2	4	3	9
ICT	3	1	3	7
Materials & Devices	9	3	7	19
Land & Environment	3	1	3	7
Cultural Identity	1	1	0	2
Agriculture & Food	0	0	1	1
Molecular Design	5	0	5	10
Total	23	10	22	55

Table 5.2 Distribution of spin-offs: geography vs. 2-digits ATECO code

ATECO 2007 2-digits code and classification	N	C	S	Total
20—Manufacture of chemicals and chem. products	0	0	1	1
21—Manuf. of basic pharmaceutical products	0	1	0	1
23—Manuf. of other non-metallic mineral products	1	0	0	1
26—Manuf. of computer, electronic and optical prod	1	2	3	6
27—Manufacture of electrical equipment	1	0	0	1
32—Other manufacturing	0	1	0	1
33—Repair and install. of machinery & equipment	1	0	0	1
46—Wholesale trade	0	1	0	1
62—Computer programming, consultancy & rel. act.	4	1	5	10
70—Act. of head offices; management consultancy	0	1	0	1
71—Architect. and engineering activities; technical testing and analysis	1	0	2	3
72—Scientific research and development	14	4	9	27
Data unavailable	0	0	1	1
Total	23	11	21	55

Data show that Spin-off creation is not polarized in one of the three traditional divisions of Italy. At the same time these two tables also present data on the scientific-technological and industrial distribution of Spin-offs.

From Table 5.1 we can infer that, while there is not significant relation of geography with the originating Department, there is strong polarization under this last profile. First of all, out of the 11 CNR Departments, 4 do not have any Spin-off relating to them: Life Sciences, Production Systems, Energy and Transports, Cultural Heritage. More than half of the Spin-offs derive from 2 Departments: Materials & Devices (19) and Molecular Design (10).

A tentative analysis of the relations existing between Spin-off creation and the geographical distribution of CNR has been performed. In Fig. 5.3 two graphs present the relation between the number of Spin-offs and the number of Institutes/Branches of CNR per Italian Region. The number of CNR seats has been extracted from CNR Website.¹¹ In the second graph the Regions where no Spin-offs

¹¹ <http://www.cnr.it/istituti/Perareegeografiche.html> (in Italian), accessed July 2013.

4 firms deal with consulting and engineering offices. The most relevant figure in the table is perhaps the number of “R&D” Spin-offs present in Northern Italy: 14, that is, more than half of the total “R&D” Spin-offs and more than half of the total Northern Italy Spin-offs.

Results show the strong polarization of Spin-offs in the area of consulting and R&D, rather than in the production of goods.

5.4.2 *Budgetary Data*

The most relevant insight is probably that offered by budgetary and employment data for the Spin-off companies in the sample. Data are resumed in Tables 5.3, 5.4, 5.5, 5.6 and 5.7. Table 5.3 presents a classification in classes of Spin-offs according to stock/budgetary capital. It is easily seen that most values are very low, and have in many cases been chosen in order to meet the minimum values imposed by Italian law for the creation of a society of capitals.

Table 5.5 reports the values of the average Turnover, Total value of production and EBITDA for years 2010, 2011 and 2012. For sake of better clarity Spin-offs have been divided into four groups, according to their ATECO codes: “Production” (ATECO 20, 21, 23, 26, 27, 32, 33 and 46), “Editing” (ATECO 62), “Consulting” (ATECO 70 and 71) and “R&D” (ATECO 72). In Table 5.6 instead Spin-offs are divided into budgetary classes according to a pseudo-logarithmic scale. Data show in general an average small dimension and low performance of Spin-offs. Average EBITDA values are in many cases negative or around 0. Nevertheless, a deeper analysis of the data shows the presence of four outliers (two in “Production” and two in “R&D”). These are Spin-offs with a performance strongly below the average, in particular regarding their EBITDA. This fact obviously biases the value of the average of the two sectors. Table 5.7 reports the data of the four classes without the four outliers. While the values for “Editing” and “Consulting” obviously do not change, values of EBITDA for “Production” and “R&D” are sensibly higher.

Finally, it must be noted that in some cases “R&D” Spin-offs present, in the Standard profit/loss account, a high value of “Other revenues” item. It is possible that under this item are listed revenues deriving from the participation to competitive research projects. Table 5.4 contains a comparison of the average values of Turnover and “Other revenues” for the years 2010–2012 for “R&D” Spin-offs.

5.4.3 *Employment Data*

Data on the number of employees (updated at 2010) have been retrieved to show the creation of work places in CNR Spin-offs. The sum of employees (there comprising board members actively participating in the work activities of the Spin-off) is of

Table 5.3 Dimensional analysis: value of stock/societal capital in Euros

Classes of stock/societal capital (€)	Number of spin-offs
0–10,000	15
10,001–20,000	19
20,001–50,000	8
50,001–100,000	6
100,001–500,000	6
>500,000	1
Total	55

Table 5.4 Turnover vs. “other revenues”, R&D spinoffs

Year	2010	2011	2012
Turnover	171,910.88	132,660.78	163,695.95
Other revenues	83,415.24	23,034.09	46,620.88

141.5 for the 39 Spin-offs present in ASIA database. The average is 3.6 employees per Spin-off. It must nevertheless be noted that 32 Spin-offs out of 39 have less than 5 employees. Table 5.8 resumes data on employees, calculated for the above described macro classes. Data show a slightly higher average number of employees for “Production” Spin-offs, followed by “R&D” and “Editing”. The three “Consulting” Spin-offs have only one employee (a member of the board) and thus appear not to be different from any other consulting office. Finally, it must be considered that each Spin-off has at least one member of the board registered as a worker/employee: this diminishes considerably the number of created work positions.

5.4.4 Relations with the Local Research Environment

The research context in which Spin-offs are created and operate may have an important role. In order to explore the relation existing between Spin-off creation and the local research environment a simple exercise has been performed. Data on the number of researchers per 1000 inhabitants, as well as data on population, have been retrieved on ISTAT databases.¹² Then the number of Spin-offs per each Italian Region has been plotted against the number of Researchers (both as absolute value and as percentage of population). Results are reported in Figs. 5.4 and 5.5. In Fig. 5.5 the Regions with no Spin-offs are withdrawn. For each plot a best fit has been calculated. Results (equation of the regression line and R^2 value) are superimposed to the graph. Pearson’s correlation coefficients have also been calculated and are respectively: 0.3990; 0.1041; −0.0203; −0.1259.

¹²Source for data on population is http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPORESBIL1&Lang=, accessed July 2013; source for data on researchers is <http://www.istat.it/it/archivio/77342>, accessed July 2013.

Table 5.5 Evolution of average budgetary data: turnover, total value of production, EBITDA (4 macro sectors)

	No of spin-offs	Turnover 2010	Turnover 2011	Turnover 2012	TVP 2010	TVP 2011	TVP 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
"Production"	13	298,672.00	161,080.58	270,474.55	413,282.91	433,974.42	467,927.55	-49,043.55	-137,057.08	-167,111.36
"Editing"	10	165,484.13	220,360.88	192,140.70	190,265.63	234,548.50	260,076.30	20,565.88	3452.75	-2996.30
"Consulting"	4	52,302.00	33,900.25	62,239.50	54,197.67	35,720.25	64,881.75	5238.33	18,199.25	22,164.00
"R&D"	27	171,910.88	132,660.78	163,695.95	279,231.64	173,223.04	229,485.43	-86,698.36	-119,738.30	-11,392.00

Table 5.6 Evolution of budgetary data: turnover, total value of production, EBITDA (spin-offs joined in budget classes, pseudo-log scale)

Class (in Euros)	Turnover 2010	Turnover 2011	Turnover 2012	TVP 2010	TVP 2011	TVP 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
0–50,000	18	18	19	14	15	14	39	41	36
50,001–100,000	10	8	7	5	5	6	3	5	6
100,001–200,000	6	9	9	10	15	8	3	2	3
200,001–500,000	8	11	7	10	7	11	2	0	2
500,001–1,000,000	3	2	3	5	5	4	0	0	0
>1,000,000	2	0	2	3	2	3	0	0	0
No data available	8	7	8	8	6	9	8	7	8

Note: 0–50,000 Euros class contains also negative EBITDA values (14 in 2010, 11 in 2011, 12 in 2012)

Table 5.7 Evolution of average budgetary data: turnover, total value of production, EBITDA (4 macro sectors, no outliers)

	No of spin-offs	Turnover 2010	Turnover 2011	Turnover 2012	TVP 2010	TVP 2011	TVP 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
"Production"	11	342,110.11	165,658.20	295,991.11	391,641.56	365,777.00	371,748.00	68,482.78	51,482.70	46,374.67
"Editing"	10	165,484.13	220,360.88	192,140.70	190,265.63	234,548.50	260,076.30	20,565.88	3452.75	-2996.30
"Consulting"	4	523,02.00	33,900.25	62,239.50	54,197.67	35,720.25	64,881.75	5238.33	18,199.25	22,164.00
"R&D"	25	177,814.52	133,415.10	159,234.62	290,333.96	174,491.18	222,275.00	31,370.91	18,316.14	47,710.52

Table 5.8 Number of employees, FTE (4 macro sectors)

	Number of spin-offs	Sum of employees	Average
“Production”	8	42.2	5.3
“Editing”	8	26.4	3.3
“Consulting”	3	3.0	1.0
“R&D”	23	69.8	3.5

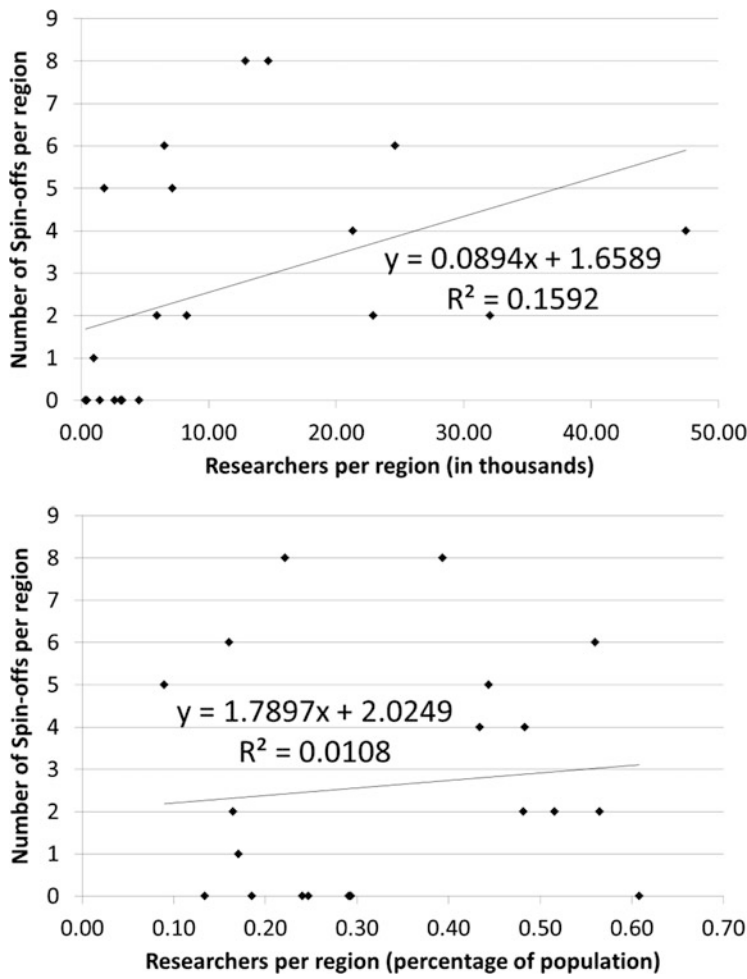


Fig. 5.4 Number of spin-offs per Italian region vs. researchers per Italian region (in thousands and as percentage of population)

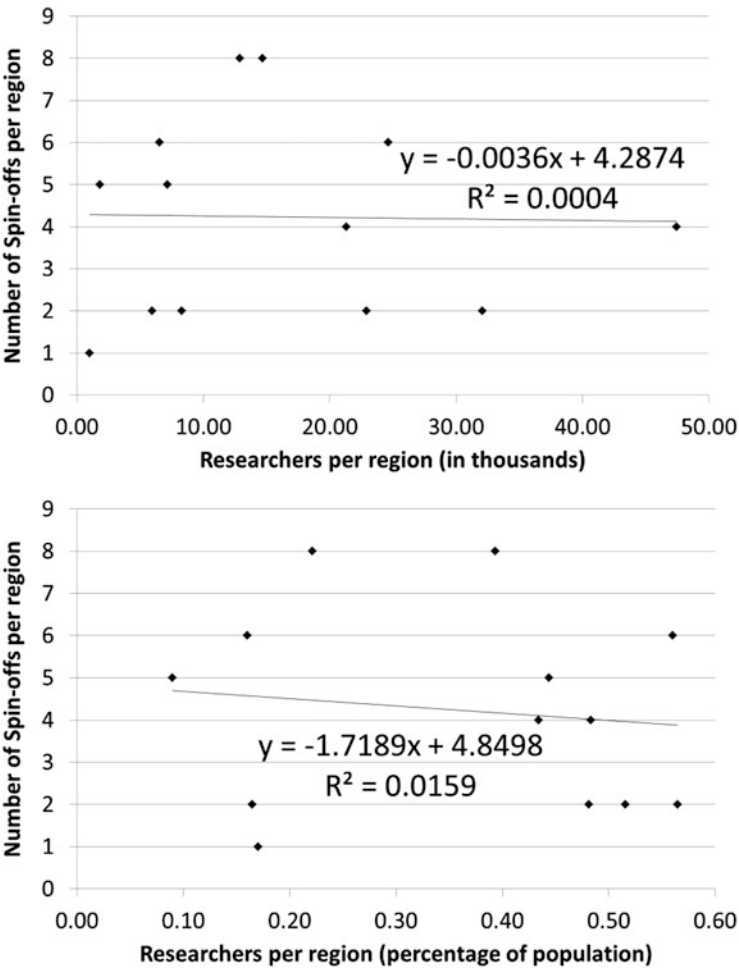


Fig. 5.5 Number of spin-offs per Italian region vs. researchers per Italian region (in thousands and as percentage of population)—regions with 0 Spin-offs withdrawn

Data should be considered cautiously, given the small number of points considered in the linear regressions and in the Pearson’s correlation coefficient. Nevertheless all data are consistent in showing that, once the Italian Regions where no CNR Spin-offs exist are withdrawn, there is no correlation between the number of local Researchers and the number of Spin-offs.

5.4.5 Benchmark Performance Analysis: Firms

CNR Spin-offs have been contextualized within the surrounding industrial environment in order to better study their performance. For each Spin-off a comparative sample has been extracted from the above described AIDA database. Samples are composed by firms operating in the same Province and in the same ATECO 4-digits code of the Spin-off. Such firms are in principle their closest competitors, and their performance is thus a suitable benchmark.

Benchmark samples have been retrieved for 47 out of 55 Spin-offs. The sum of enterprises in the 47 benchmark samples is 10,949. Nevertheless the distribution of samples is strongly skewed: minimum is 2, maximum is 2575, median is 27, mean 233 but standard deviation is 583. Thus, again, results should be handled with caution. The considered time span goes from 2008 to 2011; the number of cases for each year varies from 36 to 45, according to the availability of AIDA data for the exploited magnitudes.

Performance has been studied as follows. For both Turnover and EBITDA the ratio between Spin-off and mean and median of relative sample have been calculated. Then the results have been classified into four categories: performance of Spin-off less than half of the sample's performance; more than half to equal; more than equal to double; more than double. In the case of EBITDA also a category for negative values has been considered. Median has been considered because in most cases samples are rather skewed. Results are presented in Tables 5.9 and 5.10, reporting absolute value and percentages for each year and each group of performance for both Turnover and EBITDA. Data show that most of the spinoff perform below or much below the benchmark. This is more evident if mean benchmark values are considered. Time evolution does not shows a positive trend in the performance.

5.4.6 Benchmark Performance Analysis: Academic Spin-offs

A further performance analysis has been made measuring the performance of the Academic Spin-offs of two Italian Engineering technical Universities: Politecnico of Torino (northern Italy) and Politecnico of Bari (southern Italy). The two Universities have been chosen mainly due to the relevance of Engineering topics for industrialization. Moreover, the incubator of Politecnico di Torino is regarded as of the best ones in Italy and Europe. Politecnico di Bari has instead been chosen as it is the only Engineering technical University in southern Italy.

Table 5.9 Performance of spin-off: comparison with the medians of the comparative samples

	Spin-off/median 2008 ratio	Spin-off/median 2009 ratio	Spin-off/median 2010 ratio	Spin-off/median 2011 ratio
Turnover				
0–0.50	13	11	15	18
0.51–1.00	9	12	9	6
1.01–2.00	4	6	6	7
>2.00	8	8	11	9
Total	34	37	41	40
%				
0–0.50	38.2	29.7	36.6	45.0
0.51–1.00	26.5	32.4	22.0	15.0
1.01–2.00	11.8	16.2	14.6	17.5
>2.00	23.5	21.6	26.8	22.5
Total	100.0	100.0	100.0	100.0
EBITDA				
<0	6	8	12	8
0–0.50	6	6	5	8
0.51–1.00	9	4	8	6
1.01–2.00	4	6	3	4
>2.00	9	11	11	14
Total	34	35	39	40
%				
<0	17.6	22.9	30.8	20.0
0–0.50	17.6	17.1	12.8	20.0
0.50–1.00	26.5	11.4	20.5	15.0
1.01–2.00	11.8	17.1	7.7	10.0
>2.00	26.5	31.4	28.2	35.0
Total	100.0	100.0	100.0	100.0

Results are presented in Tables 5.11, 5.12 and 5.13. In Politecnico di Torino data for 32 Spin-offs have been retrieved, starting from a list provided by Incubator I3P. Polarization in the number of Spin-offs in this case is rather unbalanced towards “Production” and “Consulting” than towards “R&D”. For Politecnico di Bari data of 14 Spin-offs have been retrieved, starting from the official website of the University. In this case the number of Spin-offs is lower, and the most represented categories are “R&D” (6 Spin-offs) and “Consulting” (5 Spin-offs).

Also in the case of Politecnico di Torino data show the presence of two outliers (both in “Production”) affecting the average performance of the sector. Data presented in Table 5.12 show the average data without the two outliers.

Table 5.10 Performance of spin-off: comparison with the mean of the comparative samples

	Spin-off/mean 2008 ratio	Spin-off/mean 2009 ratio	Spin-off/mean 2010 ratio	Spin-off/mean 2011 ratio
Turnover				
0–0.50	26	29	34	35
0.51–1.00	4	7	5	5
1.01–2.00	5	3	6	2
>2.00	1	1	0	2
Total	36	40	45	44
%				
0–0.50	72.2	72.5	75.6	79.5
0.51–1.00	11.1	17.5	11.1	11.4
1.01–2.00	13.9	7.5	13.3	4.5
>2.00	2.8	2.5	0.0	4.5
Total	100.0	100.0	100.0	100.0
EBITDA				
<0	7	14	15	11
0–0.50	18	17	15	17
0.51–1.00	2	3	4	8
1.01–2.00	7	4	6	4
>2.00	3	2	5	4
Total	37	40	45	44
%				
<0	18.9	35.0	33.3	25.0
0–0.50	48.6	42.5	33.3	38.6
0.50–1.00	5.4	7.5	8.9	18.2
1.01–2.00	18.9	10.0	13.3	9.1
>2.00	8.1	5.0	11.1	9.1
Total	100.0	100.0	100.0	100.0

The performance of Spin-offs for both Universities are, in general, aligned with those of CNR. While the Spin-offs from Politecnico di Bari tend to be in average smaller, those from Politecnico of Torino present higher Turnovers, in particular for “Production” and “Consulting” while are lower in “R&D”. Nevertheless the values of EBITDA are aligned with those of CNR, thus showing also in this case the difficulties of creating new knowledge-intensive firms in the Italian industrial context. Once outliers are removed, the difference of the Turnovers in “Production” increases, while the values of EBITDA substantially do not.

Table 5.11 Evolution of average budgetary data, Politecnico di Torino: turnover, total production value, EBITDA (4 macro sectors)

	No of spin-offs	Turnover 2010	Turnover 2011	Turnover 2012	Gross rev. 2010	Gross rev. 2011	Gross rev. 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
"Production"	13	459,918.00	649,606.42	757,843.44	819,466.17	933,201.17	985,927.11	-72,016.08	-195,980.42	26,247.00
"Editing"	7	222,475.29	176,364.43	186,340.50	294,772.29	270,968.00	256,430.17	22,298.29	23,714.00	16,788.33
"Consulting"	10	355,070.80	395,438.60	439,989.44	389,770.90	442,275.10	425,719.13	39,252.10	52,635.90	46,099.56
"R&D"	2	77,900.00	48,297.50	91,041.00	86,620.50	325,80.47	110,872.50	-1475.50	9276.50	3511.00

Table 5.12 Evolution of average budgetary data, Politecnico di Torino: turnover, total production value, EBITDA (4 macro sectors, outliers withdrawn)

	No of spin-offs	Turnover 2010	Turnover 2011	Turnover 2012	Gross rev. 2010	Gross rev. 2011	Gross rev. 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
"Production"	11	348,336.30	500,460.30	852,573.88	567,381.10	621,523.50	1,075,048.25	17,659.80	-9500.50	48,091.75
"Editing"	7	222,475.29	176,364.43	186,340.50	294,772.29	270,968.00	256,430.17	22,298.29	23,714.00	16,788.33
"Consulting"	10	355,070.80	395,438.60	439,989.44	389,770.90	442,275.10	425,719.13	39,252.10	52,635.90	46,099.56
"R&D"	2	77,900.00	48,297.50	91,041.00	86,620.50	325,80.47	110,872.50	-1475.50	9276.50	3511.00

Table 5.13 Evolution of average budgetary data, Politecnico di Bari: turnover, total production value, EBITDA (4 macro sectors)

	No of spin-offs	Turnover 2010	Turnover 2011	Turnover 2012	Gross rev. 2010	Gross rev. 2011	Gross rev. 2012	EBITDA 2010	EBITDA 2011	EBITDA 2012
"Production"	1	16,000.00	8000.00	26,293.00	16,000.00	8000.00	92,386.00	3297.00	1478.00	11,116.00
"Editing"	2	164,857.50	105,773.00	58,387.50	187,628.50	133,242.50	110,908.50	40,565.50	12,577.50	23,849.50
"Consulting"	5	21,450.50	3911.00	27,670.50	21,450.50	3911.00	27,713.25	4942.50	-599.50	1346.25
"R&D"	6	89,448.00	115,007.50	104,004.20	130,319.25	132,166.33	121,978.00	-6942.00	14,426.17	20,685.60

5.5 Discussion of Results, Conclusions and Learned Lessons

This study aims at the analysis of the specific case of Spin-off creation inside CNR, National Research Council of Italy. Balance sheet data, as well as data on employees and on location of Spin-offs, have been analyzed in this study. Benchmarks of firms have been used to further deepen the characters of the studied samples. Several conclusions can be drawn from the joint analysis of data.

Data on geographic distribution and on the relation with the Regional research environment suggest the absence of a systematic plan. Spin-off creation seems rather driven by different reasons: institutional (the presence of supporting institutions such as incubators or science park), technological (the presence of a suitable technology in the originating Institute), or merely depending on the entrepreneurial skills of the researcher(s).

Under the more restricted point of view of Industrial Economics analysis, if Spin-off creation has been intended as an instrument to help growing high-technology, knowledge-intensive production activities, it can be said that the goal has substantially not been reached. First of all it must be noted that the number of Spin-offs strictly oriented towards productive activities is the minority. To the contrary, most Spin-offs deal with research activities. Then, industrial performance is rather low in terms of turnover and generated income. The number of working position generated in the process is also rather low. Around 100 working places in more than 10 years can't be considered in fact a good performance. Also benchmarking shows that, under a general point of view, economic performance of Spin-offs tends to be lower than that of the benchmark samples.

Heirman and Clarysse (2004) classify Spin-offs in four classes according to their business stage: Venture-capital-backed, Prospectors (those at an early stage of product development at founding), Product Start-ups (those close to market) and Transitional Start-ups: those that "started as technical consultants without a concrete product idea" (p. 258). This seems the case of most CNR Spin-off companies. Again according to Heirman and Clarysse (2004), "We found that one out of five companies that today bring a new product to the market or develop one originally started as a consulting company. These firms changed their business model during their early growth and we label them as transitional starters. They outnumber the amount of companies that start with venture capital. The consulting mode is less risky than the other starting profiles. Transitional starters do not need external capital and the companies are mostly founded by one or maximum two persons" (p. 265). Nevertheless what may raise some concern in the present case study is the presence of Spin-offs presenting a relatively long historical path. 19 Spin-offs on the 29 in the two groups "Consulting" and "R&D" have been created in or before 2007 (a couple of them in the late 1990s). This could mean that some "Transitional starters" might remain lifelong in their "Transition" state. This in turn might be caused also by the fact that Spin-off creation in some cases could be exploited as a

way to perform research activities without the (many) bureaucratic “red-tapes” imposed by Italian public administration to its employees.

These facts can at least partly explain the performance of CNR Spin-offs. Another relevant fact is the strong specialization in consulting and research activities. This, in a country such as Italy (characterized by a large presence of traditional industries), represents a serious obstacle to growth. The lack of a qualified demand on the market side and the availability of (modest) research contracts on the public side act as powerful lock-in tools for these firms.

Nevertheless the comparative analysis of the two Italian Universities (Politecnico di Torino and Politecnico di Bari) shows that Spin-off creation in CNR must be considered inside a more generalized situation. For instance, apart from economic performance, it is relevant the fact that in Politecnico di Torino Spin-off creation is polarized—beside production activities—towards consulting. In this a phenomenon similar to that envisaged in CNR could be in act.

These facts support the idea that the findings of Chiesa and Piccaluga (2000), though obtained more than a decade ago, still partly hold. Also the more recent work of Iacobucci et al. (2013) reports several findings close to those presented here. In fact their analysis of all the Spin-offs created by Public Research Institutions between 2000 and 2012 show—in general—small societal capitals, low levels of growth, low performance in sales, low investments in innovation and a strong polarization towards consulting and R&D. In their conclusions authors ascribe the general low level of performance to the absence in Italy of a favorable environment for hi-tech enterprise, as well as to the specific characters of ownership and governance of the Spin-offs. Nevertheless they also consider as positive outcome the fact that several researchers have engaged in hi-tech, knowledge-intensive entrepreneurial activities outside the strict academic environment. These concepts might apply also to the subject of the present work.

Regarding possible policy advice, the first suggestion, obvious and mainly dictated by common sense, is to study a better planning of Spin-off creation inside CNR starting from a more severe selection and a stronger support also by the mean of incubators managed directly by CNR personnel or in association with other bodies. In any case without a general turnaround of the Italian economy towards a growing importance of high tech industries the role of research spin-off will stay at a marginal level.

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Chapter 6

Academic Entrepreneurship: Spin-offs in Sweden and the UK

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Abstract Discussions of academic entrepreneurship often focus on efforts to commercialize inventions appropriated within the intellectual property (IP) system. However, studies in the U.S. have shown that a substantial amount of entrepreneurship happens outside of the formal IP system.

In the UK each university sets its own rules on ownership of IP. In a few European countries, like Sweden, an inventor ownership model is dominating. There is a lack of studies of European academic entrepreneurship outside of the formal IP system; and accordingly there have been few possibilities to analyze the effects of different institutional set ups.

To help fill this gap, this chapter analyses how different institutional settings affect academic entrepreneurship in Europe. By analyzing both patents and spin-offs (from Oxford University, UK and Chalmers University, Sweden) we will shed light on two processes for commercialization of university research. We empirically investigate university technology transfer at two different universities in two countries with a different inventor ownership regulation.

Keywords Academic Entrepreneurship • Commercialization • University spin-offs • Patents • Institutional setting

6.1 Introduction

It has been argued that Europe's research and industrial base has a comparatively limited capacity to convert scientific breakthroughs and technological achievements into commercial successes (e.g., the EU White Paper 1993). The perception

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of a strong European science base which is not translated into economic growth is often labelled the “European Paradox” (EU 1995). Over time, the focus has turned to the commercialization of publicly financed R&D. Even though some reports (Arundel and Bordoy 2008; Bergman 2010) have pointed to positive trends in, for example, efforts to encourage the creation of university spin-offs, there is a strong belief that the EU under-performs in the commercialization of publicly funded science.

The discussion of academic entrepreneurship often concentrates on faculty efforts to commercialize inventions appropriated within the intellectual property (IP) system organized by university administrators, e.g., Technology Transfer Office (TTOs). There has also been an assumption that academic entrepreneurial activities are reflected through the disclosure of patents via TTOs. However, studies in the U.S. have shown that a substantial amount of academic entrepreneurship happens outside of the formal IP system (Fini et al. 2010; Markman et al. 2008). Possibly then, similar processes may exist also in Europe. This has clear implications for normative assumptions about the seamless linear processes of research to commercialization within the context of now worldwide societal objectives on capitalizing on knowledge (see Etzkowitz and Klofsten 2005).

The specifics of the political context are, however, crucial. For example, while in the UK, since the mid-1980s, each university has been able to set its own rules on ownership of IP, in a few other European countries, like Sweden and Italy, an inventor ownership model is dominating. There is a lack of studies of European academic entrepreneurship that happens outside of the formal IP system; and accordingly there have been few possibilities to analyze the effects of different institutional set ups.

To fill this gap, this chapter asks the question, how do different institutional settings affect the commercialization/exploitation of university research in Europe? In order to answer the question, we empirically investigate university technology transfer at two universities in two countries with a different inventor ownership regulation. The two cases are Oxford University in the UK and Chalmers University in Sweden. The Oxford case will be used to illustrate the university ownership model, while the Chalmers case represents the inventor ownership model. The two cases are selected because both universities have well-established commercialization systems. Both universities are also creating a high number of university spin-off companies. In the UK, only Cambridge University has created a higher number of spin-offs than Oxford. In Sweden, however, Chalmers University is only ranked eighth in university spin-off creation. The largest Swedish universities create even more university spin-offs. Thus, in relation to its size Chalmers is performing like an average Swedish university.

Our empirical data allow us to compare the formation and performance of academic spin-offs at the two universities. We investigate and analyze how Oxford academics involved in spin-off companies disclose or exploit patents inside or outside the formal university IP system. In the Chalmers case we have identified a high number of spin-offs, both by faculty leaving the university and by faculty keeping their university positions. Our comparisons add further insights of the impact of different intellectual property ownership by highlighting these issues in

the European context. By analyzing both patents and university spin-offs we are able to shed light on two processes through which the commercialization of university research occurs.

The chapter begins with explanations of the university spin-off phenomena. It focuses particularly on institutional conditions which influence the formation of university spin-offs. Next the methodology and results are presented. The results provide new insights and perspectives on technology transfer processes through university spin-off firms. In the last section, some conclusions are drawn and some limitations and recommendations for further research are discussed.

6.2 University Spin-offs and Technology Transfer

The effort to create a knowledge-based economy has significantly emphasized the role of universities in commercializing new innovations including scientific and technological discoveries from the research laboratories (O'Shea et al. 2004). In addition, the importance of technology and knowledge transfer from university to industry including the necessity to build closer association between science/technology and its application and exploitation have driven the development of numerous entrepreneurial initiatives inside universities (Allen 1995). The term, "the entrepreneurial university" (Etzkowitz 1983), was an early recognition of universities acting entrepreneurial, including a growing number of academic scientists in the US who were forming their own companies.

Numerous explanations of factors contributing to the formation of university spin-offs as well as other forms of commercialization through such as patents and licenses have followed. Four are highlighted. Firstly, legislative initiatives are widely regarded as contributing to an acceleration of the formation of spin-off ventures. For example in the UK, from 1985, universities were given autonomy to arrange their own rules and policies on IP ownership (Lawton Smith and Ho 2006). Secondly, universities with cultures that embrace entrepreneurial activity not only have better rates of commercialization through patenting but also have high numbers of academic spin-offs than those which do not (O'Shea et al. 2004). Earlier Roberts (1991) proposed that a university's social norms and expectations are key factors in encouraging commercial activity. Thirdly, reputations including research prominence of universities are strongly linked to the rate of spin-off creation (Di Gregorio and Shane 2003). Fourth, the regional knowledge infrastructure plays a vital role in supporting university spin-offs activity. Saxenian (1994), for example, illustrated that the formation of university spin-offs are more likely to happen in high-technology clusters because of easy access to local expertise, networks and knowledge. However, other evidence suggests that even when these are in place, they are not necessarily used by the spin-off firms (see for example Harrison and Leitch 2010).

The potential monetary, political and social pay-offs from such activities have motivated policy makers and university administrators to support these entrepreneurial activities. Of particular importance is the Bayh-Dole Act of 1980, which

granted US universities ownership rights of academic intellectual property. In the UK, the government has provided financial and political incentive structures to support R&D based entrepreneurial activity. By the year 2000, the number of spinoffs began to rise substantially in the UK. This was associated with an increase in the number of personnel working on technology transfer at UK's universities (Lawton Smith and Ho 2006). In 2007/08, spin off companies from higher education institutions (HEIs) employed almost 4500 people, had a turnover of more than £73 million and had acquired over £52 million in external investments (BIS 2009).

While many European nations have now abandoned the "Professor's privilege" (Geuna and Rossi 2011), some US researchers, for example Kenney and Patton (2009), have criticized the university-ownership model, and suggest instead an "Alternative model" with inventor ownership. Indeed, comparing the inventor ownership model with the university ownership model, they conclude that this:

... showed that the inventor ownership regime strikingly dominates the better funded, more highly rated, and much larger university ownership universities. (Kenny and Patton 2011, p. 1109)

The argument that inventor ownership has a positive effect on entrepreneurship is part of a growing literature that critically addresses institutional ownership. It is not necessarily the case that a Bayh-Dole-type institutional change will have a positive effect on technology transfer and economic growth. Kenney and Patton (2011) provided three examples where adopting a Bayh-Dole-type model has not been successful: Cambridge, UK (Breznitz 2011), Japan (Carraz 2008; Takahashi and Carraz 2011) and Denmark (Valentin and Jensen 2007). Of these, the University of Cambridge is the clearest case for showing that an inventor ownership model can be successful for transferring technology and encouraging entrepreneurship (Breznitz 2011). Abandoning this model, to mimic the US Bayh-Dole model, in this case did not lead to increased technology transfer or entrepreneurship. Instead, there are indications that entrepreneurship, particularly in biotechnology declined.

In addition, most often, the academic entrepreneurial activities revealed by official statistics agencies are those that arguably take place inside the formal IP system such as industrial collaborations or consulting (Jensen and Thursby 2001; Mansfield 1995, 1998). The process of academic entrepreneurship is most often envisioned as a practice that begins with a disclosure of a new invention to a TTO, which then turns into a patented discovery that is either licensed out to companies or exploited to create a new company (Fini et al. 2010). This process has received attention from scholars, including studies of invention disclosure (Thursby and Thursby 2005), patenting (Henderson et al. 1998; Mowery et al. 2002; Mowery and Ziedonis 2002; Sampat et al. 2003), licensing (Jensen and Thursby 2001; Jensen et al. 2003), and the exploitation of university-assigned IP to form new companies (Markman et al. 2004; Mustar et al. 2006; Nerkar and Shane 2003, Shane 2004). The multi-dimensional characteristics of university-industry linkages (Agrawal 2001; Bonaccorsi and Piccaluga 1994), which can also be considered as entrepreneurial activity, include a range of avenues (Cohen et al. 2002; D'Este and Patel 2007; Faulkner 1994) or 'mechanisms' (Meyer-Krahmer and Schmoch 1998) in

which knowledge and resources are exchanged and co-created between universities and industry without any occurrence of IP disclosure through formal systems.

There has been a distinct move away from the Professor's privilege in Europe towards various systems of institutional ownership in the belief that the commercialization of research results will be facilitated (EU 2007, 2008; Geuna and Rossi 2011). Sweden is now one of few European countries who have not abandoned the Professor's Privilege. This is so despite several national government investigations and repeated arguments by e.g., the OECD that Sweden should change this institutional setting. In a recent paper, Jacobsson et al. (2013) discussed this "dominant belief" and the commercialization of academic research in Sweden. They found strong indications that Sweden was performing quite well, both in terms of the number of university spin-offs created and the amounts of patenting originating in Swedish Universities. They argue that in the Swedish case, where about 80 % of the academic patents were found to be assigned to industry, abandoning the Professor's privilege for a University ownership model could well have negative effects since it would risk disrupting the strong knowledge sharing networks. As Geuna and Rossi (2011, p. 1075) argue:

In countries where university enforcement of IPR has traditionally been weak...because of the professor's privilege...academic inventors have...patented their inventions individually or assigned IPR ownership to collaborating firms. In these contexts, regulations...enforcing university ownership may increase university-owned patents at the expense of university-invented patents. Care must be taken...not to disrupt pre-existing functioning knowledge transfer relationships between academic inventors and firms.

Jacobsson et al. (2013) concluded that there is strong evidence that (a) substantial academic patenting activity takes place in Sweden, although 'invisible' without detailed scrutiny of patent data bases, and (b) the IPR rests within the business community to a greater extent than in other countries—and that the transfer mechanism obviously works. They base this conclusion on a few earlier studies of academic patenting, e.g., Lissoni et al. (2009) which set out to specify this magnitude in several countries, including Sweden. They capture patents held by individual researchers as well as by firms collaborating with an academic researcher who is the inventor, but not the owner. The share of academic patents, defined in that way, of total patents was found to be at the same level in Sweden as in the U.S. (6 %) and higher than that of France and Italy.¹ The significance of this relatively high figure is magnified by the extensive patenting activity for Sweden as a whole. Hence, Swedish academics account for a high share of an internationally very high number of patent applications.

As mentioned, most of these Swedish patents are, however, not owned by the academics but by firms collaborating with Universities. Geuna and Rossi (2011, Table 5) point to a very high Swedish share of business ownership (81 %), higher

¹ The US share of 6 % is calculated by Lissoni et al. (2009), based on Thursby et al. (2009). For Sweden, Ejermo (2011) arrives at a figure of 4–5 %, but using the same method of Lissoni et al. (2009) he adjusts the figure to 6 % (Ejermo 2012).

Fig. 6.1 Categories of spin-offs founded on Swedish university research. (Source: Jacobsson et al. 2013)

Entrepreneur affiliated with the university, at the time of founding the firm	NO	(II) external entrepreneur firm c. 100	(I) indirect university spin-off firm c. 400
	YES	(III) side-line firm c. 175	(IV) direct university spin-off firm c. 200
		Yes	No
		Academic researcher staying at university, after the founding of the firm	

than other European countries. Moreover, these European shares are much higher than that of the USA. In the Swedish case, the top companies owning academic patents include large multinational companies which interact to a great extent with universities and obviously very often come out of that collaboration with the IPR.

In addition to patenting and university-industry networking, Jacobsson et al. (2013) also analyzed different categories of university spin-offs. In earlier studies there is a great variety in definitions and measurement of university spin-offs. One main issue has to do with whether it is research/technology that is spun-off or if it is the individual researcher who leaves his/her employment to set up a new firm. In their definition of university spin-offs, Jacobsson et al. (2013) included both direct university spin-offs and two categories of firms that involve spinning off knowledge from University research, see Fig. 6.1. Direct university-spin-offs are established by university researchers themselves, both by researchers leaving the university and those staying and creating a side-line firm.

Among the indirect spin-offs, Jacobsson et al. (2013) include firms established by previously employed university researchers (alumni) but not until the founder has worked an additional time in industry. In addition are firms founded by an “external entrepreneur” who is not the university researcher. In these firms, the university researcher stays with the university and keeps his/her university employment. Taken jointly, they estimated that about 875 new firms were started every year based on university research in Sweden.

Unfortunately, Jacobsson et al. found no available international data that were directly comparable with the Swedish. One reason for this is that in countries with a university ownership model, it is normally the IP and the disclosures that are measured, for example by university TTOs and associations like AUTM in the US. This means that in available spin-off data, information is not usually given

about whether the university researchers have kept their university employment or not. Even so, they presented a rough comparison with UK and US spin-off data. The UK data were drawn from HE-BCI survey² and US data by AUTM.³ Their finding was that the figures for both UK and US were of the same magnitude as the direct university spin-offs in Sweden (only quadrant IV in Fig. 6.1). The AUTM reports some 400–650 university spin-offs each year, while the British HE-BCI survey reports between 150 and almost 300, i.e., within the range of the figures for Sweden.

Moreover, since the US and the UK data only report spin-offs based on disclosures registered at participating universities, that is, within the IP system, this would suggest that the figures seriously underestimate the total spin-off frequency (Åstebro et al. 2012). This problem was discussed by Fini et al. (2010) who found that only 35 % of new firms started by university researchers in the US were based on patented inventions within the IP system. Correcting for this would mean that the US figure should be increased to about 1 600 spin-offs per year.

To inform and provide faculties, universities and policy makers with more accurate picture on academic entrepreneurial activities and parameter than the only mechanism of patents disclosure via formal IP channel is one important aim with this chapter. Here we ask how different institutional settings affect academic entrepreneurship and the commercialization of university research in Europe.

6.3 Method

This chapter uses two case studies—Oxford University in the UK and Chalmers University in Sweden—to analyze and compare technology transfer and university entrepreneurship in two different institutional contexts.

6.3.1 *The Oxford Case*

The University of Oxford is one of the world's top universities. Oxford offers more than 320 different graduate degree programmes and has over 9800 graduate students from more than 140 countries and territories, over 5500 graduate research students and nearly 12,000 undergraduates. Oxford's research activity involves more than 70 departments with over 10,000 employees, including 1600 academic

² Funding of British HEIs (Higher Education Institutes) partly depends on spin-off creation, and, thus, the data reporting is not likely to be an underestimation. See <http://www.hefce.ac.uk/econsoc/buscom/hebci/>. This data is collected annually from British HEIs since 2003.

³ The AUTM data only report spin-offs based on disclosures registered at participating universities. It should be noted that the AUTM studies only include data from less than 200 US Universities. These universities are, however, the most research intensive ones. AUTM data for 2004–2010 is available at <http://www.autm.net/home.htm>

staff and 3000 research staff. In 2011–2012, total University income was £1016.1 million, out of which about half was research. External research grants and contracts is the University's largest source of income. In 2011–2012, 40 % (£409 million) of income came from external research sponsors.

In a world university rankings published by Times Higher Education in 2012/13, Oxford University is ranked 2nd. Its place in this ranking is owing to unique qualities, i.e., high concentration of “world-class scientists”, the world's second best university in medical and the fifth best university in biological science disciplines (QS World University Ranking 2012a, b), as well as a number of interdisciplinary research centers, which some have links with international academic and industrial partners (Lawton Smith and Ho 2006).

Oxford University has an elite and very well-established commercialization system; it also creates three times as many spin-offs as UK universities on average. Only Cambridge University has created more spin-offs than Oxford has. The key mechanism for creating university spin-offs is through Isis Innovation, the university's technology transfer company, established in 1988. Commercialization activities, however, only started to take off and expand in 1997 following the appointment of a successful entrepreneur and business angel as CEO (Lawton Smith and Ho 2006). Since then, Isis Innovation has been in charge of generating spin-off firms based on academic research produced within and owned by the University. So far it has supported the formation of more than 75 companies. It has created a new spin-off company every 2 months on average (Isis Innovation 2013). Since 2000, external investment of over £266 million has been raised by spin-off companies, and 5 Oxford spin-off firms have been listed on London's AIM market. Besides, in 2012, Isis Innovation filed 100 patent applications on behalf of the University; it also manages over 470 patent application families as well as 700 license agreements (Isis Innovation 2013). It is claimed that licensees and commercial partners are solicited from both national and international technology and business sectors. In the Oxford case we use a sample of university spin-offs which is drawn from the existing database of 75 companies spun out from the University of Oxford and published on the Isis Innovation website.

In the data collection process, first we use the ICC Directory of UK Companies provided by Lexis Nexis and Companies House (lexisnexis.com/uk/nexis/search and companieshouse.gov.uk) which contained detailed profiles of the companies including the company's registered address, date of incorporation, board of directors, any subsidiaries which the company may own, key facts about the companies, and financial data. In this study, we identified and listed names of directors of all 75 Oxford spin-off companies. Second, we cross-checked all director names with the University of Oxford's contact search database to find out who is an academic and in which departments or colleges he/she is currently working. However, the database does not provide the period(s) of employment with the University of Oxford. Third, to investigate the patents' profile of the Oxford university academics, patent searches were done via the Espacenet of the European Patent Office. ESP@CENET on the European Patent Office website includes records of the patents filed by companies which can be accessed and searched by a range of

criteria such as applicant name, inventor name, and so on. We conducted the search by inputting the name of an academic as an “inventor” and put in different applicants beginning with (i) “name of academic”, (ii) “Isis Innovation”, and (iii) “company name”. This patents search process is repeated for all academics in the database.

We recorded the following details: (i) number of patents, (ii) publication date (the date when the patent is filed) (iii) applicants or assignees, (iv) European classification number. In addition, we noted down whether the patents were assigned to Isis Innovation or the University of Oxford, or, otherwise, were filed under other names. This is used to determine if the patents filed stay within the University IP system or have bypass potential. We also report on the size of university spin-offs (employees and turnover) within the university system and with a potential bypass.

6.3.2 *The Chalmers Case*

Chalmers University of Technology, in Gothenburg, Sweden, is one of the oldest and largest institutes of technology in Sweden. It offers Master of Science degrees, Bachelor degrees and doctoral degrees. Research is carried out in the main engineering sciences as well as in technology-related mathematical and natural sciences. Some 2300 employees work at Chalmers’ 17 departments. Of these some 1600 are teachers and researchers. The turnover is around £0.25 billion a year (2011); two-thirds of this sum relates to research. Thus, Chalmers amount of research is around a third of Oxford’s (i.e., 30 % of research income, 34 % of research staff).

Since 2000 Chalmers has a vice-president who is responsible for external relations. A strategic decision is that the processes of knowledge transfer and commercialization should be fully integrated with Chalmers research and education activities. Approximately 60 full-time equivalents work with knowledge transfer and commercialization at Chalmers. In addition several hundreds of persons from business work pro-bono as advisors, board members, industrial faculty, etc., thereby supporting Chalmers’ knowledge transfer and commercialization activities. On behalf of the Ministry of Education, Chalmers established the Innovation Office West, in 2011. This Office has a role as an innovation advisor to Chalmers as well as seven other regional HEIs. In 2011, the Innovation Office established a support role for research-verification, where 37 validation projects were started which include analyzing the commercial potential of research results.

Venture creation is another important process for Chalmers’ commercialization of new knowledge. Through the combination of the entrepreneurial school, incubators and seed investments, with an emphasis on active ownership, Chalmers has achieved great success with respect to this value creation process. In 2010, the portfolio companies in the Chalmers venture creation process had a turnover of over £43 million.

By the creation of strong links between education and exploitation of knowledge, Chalmers School of Entrepreneurship has developed a unique venture creation model that has been recognized both nationally and internationally. The idea with this action-based school is to educate people, not about entrepreneurship, but through entrepreneurship. Through this Chalmers contributes with entrepreneurial graduates to the regional/national innovation system. In 2011, Chalmersinvest, Encubator Holding (linked to the School of Entrepreneurship) and Chalmers Innovation Seed Fund invested around £2 million in new ventures.

In the Chalmers case the university has provided a list of the names and home addresses of every faculty employee as of spring 2012. Out of the identified 1191 researchers we excluded visiting professors and others with a temporary employment, ending up with a list of 921 professors, docents, lecturers, and post docs. We used the database Retriever to identify all kinds of private company activities of these researchers. We found 276 persons with some kind of company engagement. After excluding for example sole proprietorship and engagements as director of the board in other kinds of organizations, we finally identified 207 incorporated firms created by Chalmers faculty. We used the Espacenet to do a patent search for all the identified university spin-offs as well as for the individual researcher who had created the spin-off.

To complement the data on spin-offs in the Chalmers case we also used the MONA database of Statistics Sweden to find university spin-offs created by faculty who has left the employment at the university. This data consist of Swedish matched employer-employee panel data where we can find information on all new university spin-offs set up by researchers leaving the university between 1997 and 2009. In doing so we found 62 firms created by former Chalmers employees. Unfortunately the use of this database didn't allow us to identify the firms or the patents held.

In addition, the use of the MONA database allowed us to compare Chalmers with other Swedish universities. Despite a high number of university spin-offs, we found that Chalmers was only ranked eighth of all Swedish universities in spin-off creation. Larger universities, like Lund University, created many more university spin-offs each year. Also, in Sweden, Chalmers is ranked tenth in size (number of full time researchers). Thus, we found that, in relation to size, the frequency of Chalmers' university spin-offs is similar to an average Swedish university.

6.4 Findings

In this section we are presenting facts about the spin-off firms from each of the two universities. This includes data on the firm's patenting and performance, and on the university affiliation of the academic directors.

6.4.1 The University Spin-off Firms

First, for the 75 spin-offs from Oxford University, we found that one company is a non-trading company and 9 companies are dissolved or in liquidation. Also, one company is registered in Belgium, hence there is no information registered in the UK Companies House. More than 50 companies have operated between 1 and 10 years, 18 companies have been in operation between 11 and 15 years, while only 5 companies have been in business longer than 16 years (Fig. 6.2).

For Chalmers we identified a considerably higher number of university spin-offs, a total of 207 incorporated firms created by researchers still employed at the university in spring 2012. Out of these eight are no longer active, and we lack data of founding year. Thus, out of the 921 academic researchers employed at Chalmers in 2012, there were 129 researchers (14 %) who had created an incorporated firm. This means that researchers active in company formation on average started 1.67 incorporated firms. The oldest four firms were established in the 1960s, and the average age of all 199 firms (where we know the founding year) was 11.26 years (Fig. 6.3).

In addition to analyze spin-offs set up by researchers employed at Chalmers University we also used the Swedish MONA database of Statistics Sweden to find out the total number of spin-offs created from Chalmers University. The MONA database consist of Swedish matched employer-employee panel data where we can find information on all new university spin-offs set up by researchers leaving the university. The database provides information on spin-offs created between 1997 and 2009. In this period, there were a total of 164 new firms created by Chalmers researchers (excluding post-docs, PhDs and visiting researchers). Out of these we found 62 spin-offs where the researcher, in the first year after start-up, had gained a higher income from his/her own firm than from a university employment. These 62 firms are then—most likely—direct university spin-offs where the researcher has left his/her university employment. Thus, these firms are in general not included

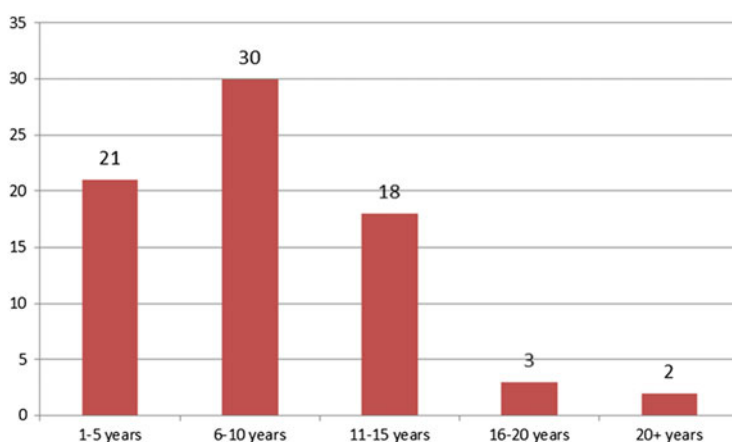


Fig. 6.2 Number of years in operations—Oxford spin-offs

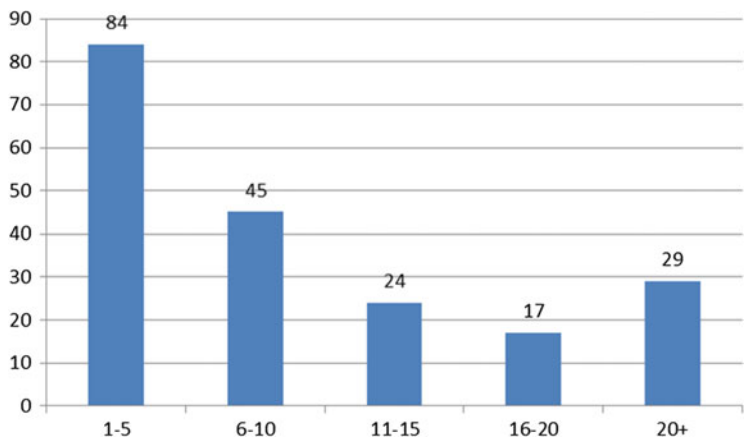


Fig. 6.3 Number of years in operation: Chalmers spin-offs

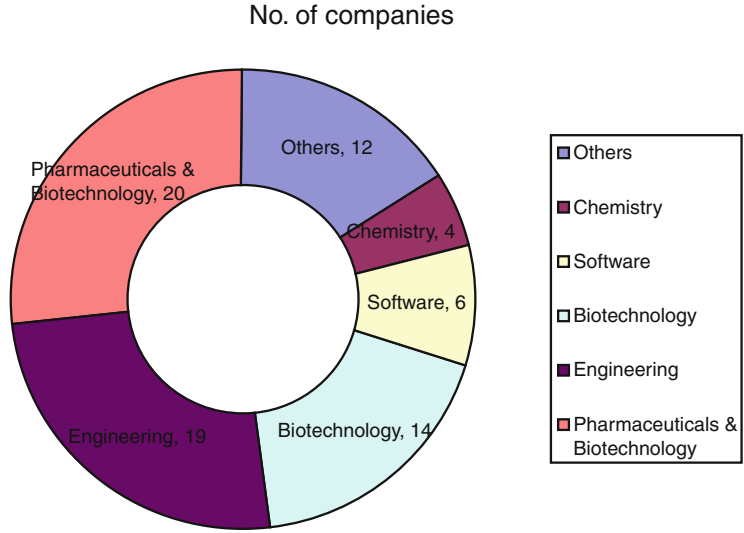


Fig. 6.4 Sector- Oxford spin-offs

among the 207 firms identified among the researchers still employed at Chalmers. We can therefore conclude that Chalmers’s academic researchers generate far more spin-offs than is the case in Oxford. Moreover, that this is not a recent phenomenon. Figures 6.4 and 6.5 show the sectors where the university spin-offs are established. Figure 6.4 shows the diversity of the Oxford companies; the largest group within the sampling firms is in pharmaceutical and biotechnological sector, followed by engineering, software and chemistry sector respectively. The Chalmers spin-offs, Fig. 6.5, are dominated by engineering firms (out of which “research and consulting” is the largest group). Medtech and biotechnology spin-offs are not very

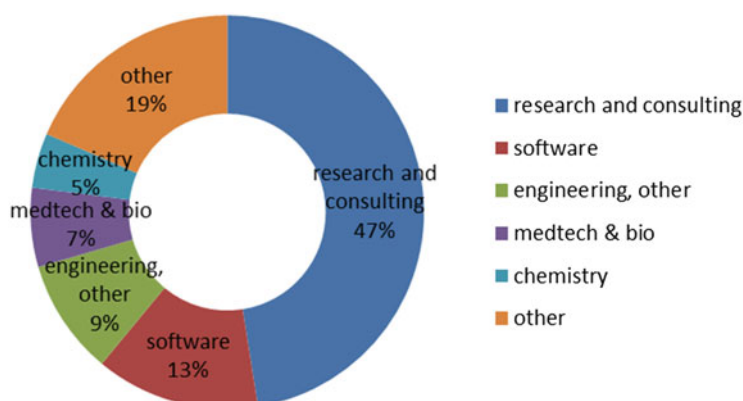


Fig. 6.5 Sector- Chalmers spin-offs

frequent, something which is of course related to the fact that Chalmers is a technical university without any medical research. We do not find many “research and consulting” spin-offs in the Oxford case. Probably such firms exist, but are not recorded and owned by Isis Innovation. However, if we exclude the “research and consulting” spin-offs from Chalmers, we still find 105 university spin-offs from Chalmers. With respect to Oxford University’s research being three times the size of Chalmers, this is a very high figure.

We used a binary logistic regression to analyze the differences between Oxford and Chalmers spin-off formation, Table 6.1. First, the chi-square tests of the logistic regression model were significant for both groups of spin-offs and indicates that a significant relationship exists between the entire set of independent variables and the dependent variable (i.e., being an Oxford spin-off).

Table 6.1 confirms that there are significant differences in spin-off formation at the two universities. The Oxford spin-offs are characterized by having more patents ($p < 0.001$), and being established in the biopharma ($p < 0.000$) or engineering sectors ($p < 0.02$). Chalmers spin-offs are more often found in the research and consultancy sector ($p < 0.001$).

6.4.2 Academic Characteristics and Patents Ownership

There are 122 academics from the University of Oxford involved in spin-off companies: 114 are male and 8 female. The average age for male academics is 56 years old, while 51 years old for female academics. Despite being a technical university with relatively few female researchers, the share of women directors is higher in the Chalmers case. While only 6.6 % of the academic directors in the Oxford spin-offs were women, the corresponding figure in the Chalmers spin-offs is 15 %. Also in the Chalmers spin-offs the male founders are slightly older than the

Table 6.1 Probability of Oxford/Chalmers spin-off creation (binary logistic regression)

	B	S.E.	Wald	Sig.	Exp(B)
age	-,029	,024	1,430	,232	,972
company patents	,325	,097	11,149	,001	1,384
biopharma	1,713	,453	14,329	,000	5,546
engineering	1,084	,452	5,752	,016	2,956
consultancy	-2,672	,800	11,162	,001	,069
Constant	-1,333	,349	14,544	,000	,264
-2 log-likelihood	192,34				
Cox & Snell R2	,371				
Nagelkerke R2	,538				
Chi2 (df)	126,06(5) ***				
% correct predictions	72,8				

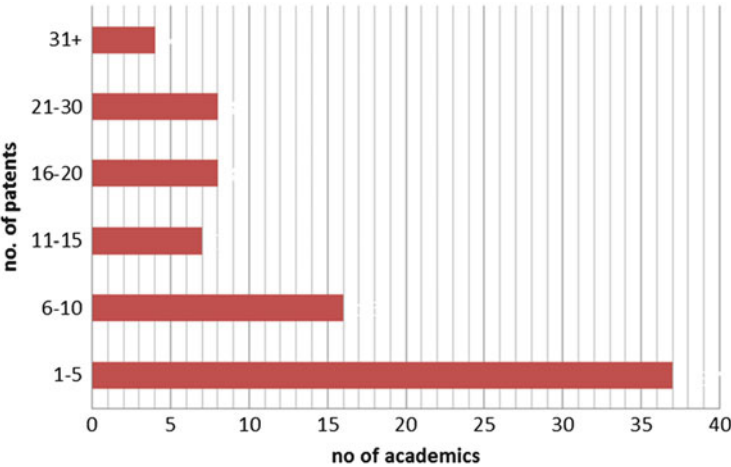


Fig. 6.6 Number of patents owned by academics in Oxford spin-offs

females; 53.7 years vs 52.2 years. In the Chalmers spin-offs the average age of the founder is 53.42 years.

There are very large differences between the two cases when we compare the frequency of patenting in the spin-offs (Figs. 6.6 and 6.7). Figure 6.6 shows that

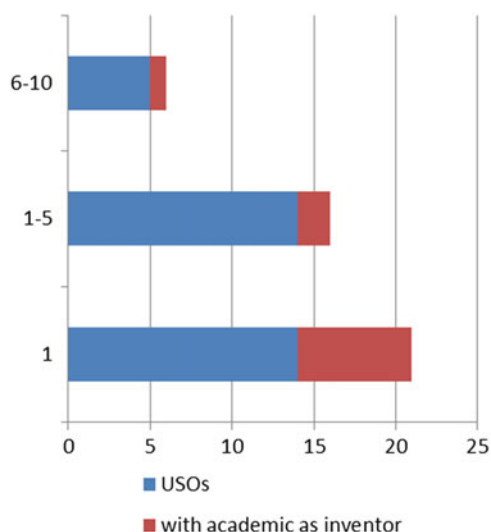


Fig. 6.7 Number of patents in Chalmers spin-offs

more than half of the academic directors from Oxford own 1–10 patents, while as many as 27 of them possess more than 11 patents. In addition, we discovered that 47 % of the Oxford spin-offs' patents were filed within the University IP system, whereas 53 % of patents have filed outside the University IP system.

Most of the academics in the Chalmers spin-offs do not own any patents (Fig. 6.7). Together all the 199 spin-offs own 94 patents. Only 33 of the spin-offs have any patents at all. No firm holds 10 patents or more. Moreover, it is not always the academic him/herself who is registered as the inventor. In fact, only 17 of the 129 academic directors have invented patents owned by their own firms. Together these individuals have 39 patents.

Since the Swedish law gives the IP rights to the individual academic researcher, there cannot be any bypassing within the Swedish system. But, as was found by Lissoni et al. (2009) and Geuna and Rossi (2011), in the Swedish case academic patents are most often applied by existing firms. Elaborating a bit with the KEINS data⁴ for Chalmers we find that between 1980 and 2001 the database includes 102 Chalmers-invented patents and 39 academic inventors. However, the assignees of the Chalmers patents are mainly (68.6 %) large existing firms, over 50 % of the patents are assigned to five large companies (Ericsson 22.6 %, Kvaerner 8.8 %, Pharmacia&UpJohn 7.8 %, EKA 5.9 %, Berol 5.9 %). Only 21.6 % are assigned to

⁴The KEINS database on academic inventors contains detailed information on university professors from France, Italy, and Sweden, who appear as designated inventors on one or more patent application registered at the European Patent Office (EPO), 1978–2004. It was produced for the EU-sponsored project on Knowledge-based Entrepreneurship: Innovation, Networks and Systems, and is made available to all interested researchers through the CESPRI website. <http://www.cespri.unibocconi.it>

university spin-offs (15 start-up firms). Using the Espacenet to do a patent search for these 15 university spin-offs we found that they own 104 patents, (out of which 22 included in KEINS data). 36 of these were granted between 1980 and 2001 and 68 between 2001 and 2011. This means that the average spin-off firm held 6.93 patents. Thus, in the Chalmers case, where the IP rests with the academic inventor, this leads to a high share of patents being assigned to large existing firms. Few of the university-spin-offs are patent-based, but there is a fraction of spin-offs that are assigned a relatively high number of patents.

6.4.3 Size of the University Spin-offs

The size distribution of spin-off companies in the Oxford sample by employees and turnover is shown in Table 6.2. Taken together the 75 Oxford spin-offs employ almost 4000 persons, and have a turnover of 430 million pounds. Thus, in the Oxford case the 4600 academic and research staff has generated an additional 4000 new jobs in the spin-offs (a ratio of $3959/4600 = 0.86$).

The majority of firms are however small (nearly three quarters). The exception being that there was one large company that did not go through Isis Innovation (1834 employees and a turnover of £337 million).

Table 6.2 Number of employees and turnover in Oxford spin-offs, inside and outside the Isis Innovation system

No. of employees of companies	Outside Isis system (n = 41)	Within Isis system (n = 34)	Turnover of companies	Outside Isis system (£, n = 41)	Within Isis system (£, n = 34)
N/A	6	0	N/A	9	3
0 (dissolved)	4	3	–0	3	4
			1–25 k	6	4
			25 k–50 k	0	1
1–10 (micro)	11	13	50 k–100 k	3	1
			100 k–250 k	1	5
11–50 (small)	9	9	250 k–500 k	4	3
			500 k–1 m	3	4
50–250 (medium)	10	9	1 m–10 m	10	8
250+ (large)	1 ^a	0	10 m+	2 ^a	1
Total employment	3079	880	Total turnover (k£)	401,865	28,758
Mean employment	75.1	26.0	Mean turnover (k£)	9802	846

^aOne Oxford spin-off formed outside Isis system is a large outlier (1834 employees and a turnover of 337 300 k£). Excluding this firm reduces the total employment into 1614 employees (average 31.1 employees) and the turnover into 64,565 k£ (average 1614 k£)

Table 6.3 Number of employees and turnover in Chalmers spin-offs (with and without patents)

No. of employees of companies	With patents (n = 33)	Without patents (n = 166)	Turnover of companies	With patents (£, n = 33)	Without patents (£, n = 166)
N/A	3	26	N/A	3	26
0	7	59	–0	5	31
			1–25 k	8	23
			25 k–50 k	2	18
1–10 (micro)	20	68	50 k–100 k	1	17
			100 k–250 k	5	16
11–50 (small)	3	10	250 k–500 k	2	12
			500 k–1 m	2	9
50–250 (medium)	0	3	1 m–10 m	5	12
250+ (large)	0	0	10 m+	0	2
Total employment	126	683	Total turnover (k£)	17,016	80,596
Mean employment	4.2	4.9	Mean turnover (k£)	583	633

The pattern for turnover is rather varied. On the whole, more of those which have bypass potential have a higher turnover, which might suggest an association between the ownership regime and performance.

Only very few of the Chalmers spin-offs are patent-based firms. To see if this affects the performance of the Chalmers spin-offs we choose to separate spin-offs with and without patents. Table 6.3 presents the number of employees and the turnover (in pounds) of the Chalmers spin-offs.

Taken together the Chalmers spin-offs employ approximately 800 persons, and have a turnover of 97.6 million pounds. On the average each firm had 4.8 employees and a turnover of £623 k, figures considerably lower than for the Oxford spin-offs. Also, the ratio between generated spin-off employment and academic and research staff is lower in the Chalmers case ($809/1600 = 0.506$). However, if the Oxford outlier is excluded (a ratio of $(3959-1834)/4600 = 0.27$) the Chalmers ratio is in fact higher.

T-tests of different measures of spin-off size and growth are presented in Table 6.4. Here it is confirmed that the Oxford spin-offs are significantly larger and have demonstrated higher growth than the Chalmers spin-offs. Moreover, if the Oxford outlier is excluded from the analysis all measures of differences in size and growth are statistically significant at $p < 0.05$.

Also noteworthy (in Table 6.3) is that the spin-offs without patents outperform the 33 Chalmers spin-offs with patents. Moreover, checking figures of profitability among the Chalmers spin-offs show that the patent-based ones in fact generates a loss (on average a loss of £100 k in 2011) while the non-patent-based spin-offs instead are more profitable (on average £27 k in 2011). Thus, the majority of the Chalmers spin-offs are small non-patent-based firms with a small profitability.

Further we performed linear regressions of size and growth to better understand what can explain the performance of the spin-offs. Table 6.5 presents the results of

Table 6.4 Spin-off performance

	Oxford/Chalmers	N	Mean	Std. deviation	Levene's test for equality of variances	t-test sig (2-tailed)
Growthturnover	ox	71	332,091	1,282,620	0.000	0.063
	ch	192	43,907	105,045		
Turnover	ox	71	6,065,120	40,080,008	0.001	0.247
	ch	193	515,740	1,681,002		
Intumover	ox	71	10.03	5.73	0.540	0.011
	ch	193	8.01	5.60		
Employees	ox	69	57.38	221.04	0.000	0.052
	cth	170	4.76	15.05		
Ingrowthturnover	ox	71	8.51	5.06	0.722	0.004
	ch	191	6.60	4.67		

Table 6.5 Spin-off performance, regression log turnover and average growth

	Model 1 size	Model 2a growth	Model 2b growth, outlier excluded
Constant			
Age	0.198***	0.049	−0.28
Patents	0.080	0.557***	0.020
Oxford/Chalmers	0.215**	0.118*	0.282***
Biopharma	−0.123+	−0.201***	−0.222**
Engineering	0.120+	0.129*	0.129*
Consultancy	0.091	−0.003	−0.005
R2	0.116	0.388	0.117
Adj R2	0.095	0.374	0.096
F (F-sign)	5.627***	27102***	5.606***

Significance level: * <0.05, and ** <0.01, *** <0.001 and + <0.10

the two regression models; Model 1 with the logarithmic value for turnover representing the Size of the firm, and Model 2 with the average annual growth in turnover representing Growth. Model 2 has been separated into Model 2a and 2b. Model 2a includes the growth of all firms, while Model 2b excludes the one Oxford outlier with extreme high growth.

The regressions confirm that Oxford spin-offs outperform Chalmers spin-offs, and that this is the case even if the Oxford outlier is excluded from the analysis. Quite naturally, the age of the spin-off is important for the size, but not for the average growth of the firm. Also being in engineering has a positive effect on size and growth, while spin-offs in biopharma instead enjoy a limited growth and smaller size. Taken together this suggests that especially Oxford spin-offs in engineering are likely to be high-performing firms. In addition, Table 6.5 also tells that a high number of patents have positive effect on average growth, but it should be noted that this effect disappears when the Oxford outlier is excluded. This firm not only holds a lot of patents, it is also demonstrating a considerable growth.

6.4.4 University Affiliation of Academic Directors

Academics, who are involved in Oxford spin-off activities, are from 40 (out of 70) Oxford departments and Colleges. More than half of the departments and Colleges in the sample only produced 1–2 spin-off companies. However, 16 spin-off companies are created from the Department of Engineering Science, followed by 7 companies spun out from the Physical and Theoretical Chemistry Laboratory, and 6 companies from Department of Chemistry, Department of Biochemistry and Magdalen College respectively.

The consolidated picture of data for Oxford (e.g., number of patents, number of academics, number of patents filed within the University IP system, and number of patents with potential academic bypass) shows that academics from the department

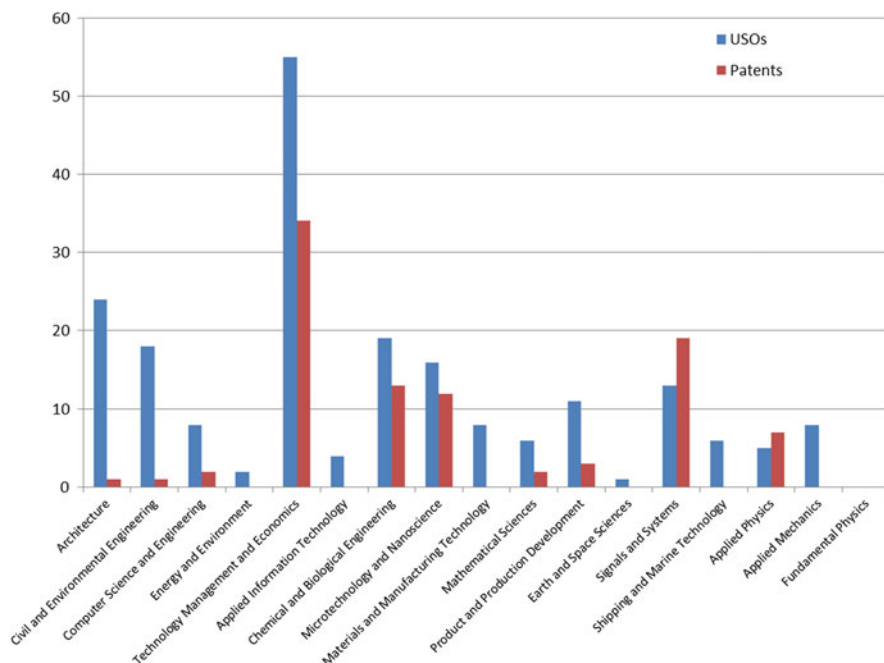


Fig. 6.8 Number of patents and spin-offs by Chalmers departments

of Engineering Science owned a high number of patents, in which the number of patents disclosed within the University IP system is slightly more than the number of patents filed outside the formal IP system. Conversely, a different pattern has been observed for academics from the department of Biochemistry. They are more prone to filing patents outside the IP system. This can possibly be explained by the potentially higher commercial value of the patents.

In the Chalmers case the university does not own the IP, and thus, bypassing is not possible. Instead Fig. 6.8 is used to illustrate the frequencies of both spin-offs and patenting from the 17 Chalmers departments.

As can be seen in the figure the highest number of spin-offs and patents has originated from the department of Technology Management and Economics. At first this might seem odd, but is easily explained by the fact that researchers at this department are active in the Chalmers School of Entrepreneurship with its unique venture creation model. In addition, the departments of Chemical and Biological Engineering, Microtechnology and Nanoscience, and Signals and Systems, also generate a relatively high share of spin-offs and patents. The departments of Architecture and Civil and Environmental Engineering also generate many spin-offs, even though these in general do not hold any patents.

6.5 Discussion and Conclusions

In this chapter we asked how different institutional settings affect the commercialization and exploitation of university research in Europe? By comparing two universities with well-established commercialization systems, we found that institutional settings matter in the rate and type of entrepreneurial activities (spin-off companies and patents). In relation to its size, the spin-off creation at Chalmers University is on par with other Swedish universities. Instead, Oxford University is an outlier among UK universities, only Cambridge University has created more spin-offs. Despite of this, our empirical data show that Chalmers University, with an inventor ownership model, generates a higher number of spin-off firms. At the University of Oxford, with a university ownership model, the frequency of university spin-offs was found to be lower, but instead the firms performed better.

Our findings are consistent with previous studies, which show that a significant percentage of academics do not engage in the entrepreneurial activities through formal IP channels. The idea of an entrepreneurial university rests on the idea that universities can and may act entrepreneurial themselves, for example by exploiting and commercializing academic research. This is often done through the formation of technology transfer offices with a specific task to commercialize university IP, both through licensing knowledge and set up of university spin-offs. In this way, entrepreneurial universities are often assumed to contribute and encourage university entrepreneurship. In other institutional settings where universities themselves do not own the research results and IP, one of the basic conditions for an entrepreneurial university simply does not exist. Even so, as demonstrated in this chapter, this does not hinder university entrepreneurship. In fact, as found in the Chalmers case, university entrepreneurship can be very frequent even in cases where the rights to commercialize research results rest with the academic researcher.

Thus, the most important finding in this chapter is that universities can contribute to entrepreneurship and act entrepreneurial even when the IP rests with the university inventor, a function of decisions made within the prevailing system of government. Moreover, a considerable amount of university entrepreneurship does take place outside the formal IP system. This is not necessarily a problem that universities should try to stop - to encourage university entrepreneurship an entrepreneurial university could also try to encourage the kind of entrepreneurship that is not necessarily based on university IP.

Furthermore, our results indicate that even though there is a high frequency of university spin-offs in the Chalmers case, these are small and usually not based on patents. Compared to the Oxford case, the Chalmers spin-offs are considerably smaller, often acting as consultants. Interesting, the patent-based Chalmers spin-offs are not performing as well as the non-patent-based ones; they are both smaller and less profitable. Having spin-offs acting as consultants can of course be important when the spin-offs functions as research boutiques and transfer research results to other companies and organizations which use the IP to create growth and

renewal. To further analyze such effects of technology transfer from university spin-offs is an important task for future research.

One limitation in this study is that due to the lack of data on period(s) of employment with the University of Oxford, this study cannot conclude authoritatively on the academic bypassing of Isis Innovation/University of Oxford for the disclosure or exploitation of their inventions. Even though the case provided in this study is drawn from a single institution and the data is rather descriptive, our findings appear to be consistent with previous studies, which showed that a significant percentage of academics do not engage in the entrepreneurial activities through formal IP channels. In line with this further research on university spin-off bypassing should be encouraged for a better understanding of European university entrepreneurship outside of the formal IP system. The research on university spin-offs outside the IP system has been undertaken extensively in the U.S., while there, to the best of our knowledge, are yet no such studies carried out in European context.

Our findings thus have some suggestions to the *modus operandi* of academic entrepreneurship. An attempt from policy makers or university administrators to highlight the importance of intellectual property rights towards academic entrepreneurial activities seems to be focusing only on a fraction of academic entrepreneurial activities, whereas omitting some vital portions of them. In addition, the existing Oxford system that the entrepreneurial activities are expedited through Technology Transfer Office falls short in supporting a substantial segment of academic entrepreneurial activities, which take place outside of the formal university IP system. Thus, the aim and attempt of universities to employ academic entrepreneurship for the creation and contribution to regional economic development might be undermined versus its prospect.

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Part III
University–Industry Interactions

Chapter 7

Perceptions of Firm Competitive Advantages from Teaming Up with Universities: An Exploratory Study

Sharon Simmons, Jonathan Levie, and Erik Monsen

Abstract In the context of university collaborations, we know very little about why some firms perceive that teaming up with universities provide them with competitive advantages. One reason why we know so little is that university collaborations can take different forms and vary in terms of the nature of relationships, the motivation of parties and the outcomes that are expected from the collaboration. Another reason why is the lack of panel data that can be used to empirically study the competitive advantages that firms obtain from collaborating with universities. That said, the Kauffman Firm Survey (KFS) is a large dataset that asks firm owners about the competitive advantages of their firms and the reasons why they exist. In this paper, we use the KFS perceptual variables to explore the perception of firm owners about the competitive advantages of teaming up with universities. While there are limitations to the empirical conclusions that can be drawn, the research questions we explore using the KFS sample provide interesting avenues for future research.

Keywords Competitive advantage • Universities • Collaboration • Kauffman firm survey

7.1 Introduction

Empirical studies of university–industry collaborations in the UK and US show that both small and large firms can obtain competitive advantages from interacting with universities. Not all firms, however, have been successful in their attempts to obtain competitive advantages from teaming up with universities. Why this is the case is not well understood. We do know that firm efficiencies or inefficiencies in the

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integration of the outputs from university collaborative efforts play an important role (Oliver 1997). We also know that there are many ways in which firms can collaborate with universities (Bishop et al. 2011). Some firms obtain competitive advantages from the acquisition of new ideas and explorative learning capabilities (Arvanitis et al. 2008; Meyer 2006). Some firms also achieve competitive advantages from increases in innovation speed (Markman et al. 2005; Shane and Stuart 2002). Lastly, other firms obtain competitive advantages from the power and reputation effects of being affiliated with universities and a host of other reasons that we have not specified (Alvarez and Barney 2001).

This paper explores the perceptions of entrepreneurs about their competitive advantages and the reasons for them. To date, we do not know if an entrepreneur's perception that they gain competitive advantage from teaming up with a university is correct, i.e. if it is associated with subsequent objective measures of performance or with other factors. We address this question in our paper, by exploring significant correlations between the perception of the KFS firm owners about having a competitive advantage over competitors.

Specifically, we examine the competitive advantages from working with a university, with both subject and objective measures of resource inputs and superior performance. We draw upon samples of firms in their fourth, fifth and sixth year of operation from the Kauffman Firm Survey (KFS) to conduct the exploratory analysis. The KFS asks these firm owners whether they have competitive advantages and, if so, the reasons why the competitive advantages exist—including whether teaming up with a university was one of the reasons.

We explore the KFS data in two stages. First, we use t-tests to explore whether the entrepreneurs with perceptions of having a competitive advantage actually exhibit financial performance superior to other firms in the KFS sample. Second, we use regression models to explore correlations between perceptions of competitive advantage from working with universities and selected industry and firm variables in the KFS data. It is important to emphasize that there are limitations to the empirical conclusions that can be drawn from our exploratory analysis of the perceptions of the KFS firm owners and the correlations of these perceptions to competitive advantages and superior performance.—Nonetheless, the questions we explore in this paper using the KFS sample of firms do uncover interesting avenues for future research on university-industry collaborations.

One interesting avenue that has been observed by prior research is that successful university-industry collaborations require the connectivity of resources (Huggins et al. 2008). Without connectedness, it would be difficult for firms to appropriate the full value or exploit cost or productivity synergies from teaming up with universities (Cockburn and Henderson 1998; Caloghirou et al. 2001).

To explore some of the connections that probably should exist for firms to obtain competitive advantages from teaming up with universities, we ask the following questions in the next sections of this paper:

- Do KFS firm owner perceptions of their competitive advantage over competitors correlate to objective measures of superior performance?

Table 7.1 Two-sample t-test results for KFS firm revenues (2008–2010)

Group Statistics					
	Competitive Advantage (2008 Year)	N	Mean	Std. Dev.	Std. Error Mean
2008 Revenue	Yes	1044	6.22	2.967	.092
	No	717	5.35	3.283	.123
2009 Revenue	Yes	1044	6.70	2.419	.075
	No	717	5.81	2.915	.109
2010 Revenue	Yes	1044	6.56	2.578	.080
	No	717	5.85	2.900	.108

Independent Samples Test										
	Equal Variances	Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Lower Upper	
2008 Revenue	Assumed	38.699	.000	5.797	1759	.000	.872	.150	.577	1.166
	Not Assumed			5.690	1434.835	.000	.872	.153	.571	1.172
2009 Revenue	Assumed	61.077	.000	6.930	1759	.000	.885	.128	.634	1.135
	Not Assumed			6.696	1346.643	.000	.885	.132	.626	1.144
2010 Revenue	Assumed	30.128	.000	5.441	1759	.000	.716	.132	.458	.974
	Not Assumed			5.324	1417.462	.000	.716	.135	.452	.980

- Do internal firm resources such R&D capacity and competitive patents correlate to the perceptions of competitive advantage from teaming up with universities?
- Do the capabilities of firms to collaborate with other firms and government agencies correlate to the perceptions of competitive advantage from teaming up with universities?
- Do firm size or industry attributes correlate to the perceptions of competitive advantage from teaming up with universities?

For each of the above questions, the next sections of the paper discuss what we know from the extant literature and our exploratory findings using the KFS data. The t-test and regression models of the KFS data that we use to explore the research questions are then presented in Tables 7.1 and 7.2, respectively. We next discuss limitations in the conclusions that can be drawn from this study and provide potential avenues for future research.

7.2 Perceptions of Firm Competitive Advantage

Firms obtain competitive advantages from the orchestration of resources and capabilities that lead to superior performance over current or potential competitors when current or potential competitors are unable to duplicate the resource orchestration (Barney 1991; Ndofor et al. 2011; Penrose 1959; Sirmon et al. 2011). A resource is a “tangible or intangible asset that the firm owns, controls, or has access to and from which it potentially derives rents” (Danneels 2012, p. 43). Valuable,

Table 7.2 Model predicting university as a reason for firm competitive advantage

	Model		
β	SE		
<i>IVs</i>			
Patent competitive advantage	1.56	***	0.37
Company competitive advantage	1.09	***	0.26
Government lab competitive advantage	2.77	***	0.51
Firm revenues	−0.17	***	0.04
Total R&D	0.11	*	0.05
Manufacturing (31) ^a	0.03		1.78
Manufacturing (32) ^b	2.09	*	0.86
Manufacturing (33) ^c	1.75	*	0.68
Wholesale trade	0.16		1.01
Retail trade	1.46	†	0.87
Transport and warehouse	1.17		1.19
Information	1.65	†	0.88
Finance and insurance	0.33		1.07
Real estate	1.09		1.02
Professional services	1.52	*	0.62
Administrative	1.44	†	0.77
Education services	4.10	**	1.37
Health care	1.44		1.07
Arts and entertainment	1.34		1.17
Accommodation and food	2.44	*	1.07
Other services	−0.02		0.95
Firm offers services	0.66		0.43
Firm offers products	−0.33		0.32
Venture capital	0.56		1.08
Year—2008	−0.56	*	0.25
Year—2009	0.13		0.61
Region—Midwest	−0.18		0.43
Region—South	−0.53		0.43
Region—West	−0.30		0.44
Location—rented space	0.16		0.33
Location—purchased space	0.29		0.59
Location—client site	−0.19		0.77
−2 log likelihood	−611.03***		

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, $N = 1499$

^aFood; Beverage and tobacco; Textile mills; Textile product mills; Apparel; Leather and allied; Wood

^bPaper; Printing and related support; Petroleum and coal; Chemical; Plastics and rubber; Nonmetallic Mineral

^cPrimary metal; Fabricated metal; Machinery manufacturing; Computer and electronic product; Electrical equipment, appliance, and component; Transportation equipment; Furniture and related; Miscellaneous

rare, inimitable and non-substitutable resources provide opportunities for sustained competitive advantages when the resources are supported by complimentary financial, human and organizational assets or routines (Barney 1991; Christmann 2000; Penrose 1959).

This resource based view (RBV) of firm competitive advantages has informed many scholarly studies of firm performance. RBV however has some challenges and limitation. For one thing, competitive advantages are temporal and firm rivals eventually erode competitive advantages over time (Wiggins and Ruefli 2002; Sirmon et al. 2010). Factors such as this temporality and others noted in prior studies make it difficult to objectively isolate and measure individual firm resources that provide competitive advantages which lead to superior performance (Hall et al. 2001; Tether 2002; Porter 1980).

Recognizing these challenges, the perceptual variables in the KFS provides a unique opportunity to ask interesting questions about the correlations between firm resources, competitive advantages and superior performance. Perceptual variables provide important insights into the mechanisms beyond “traditional measures” of performance such as profit or royalty (Coff 1999, p. 121) that contribute to the success or failure of start-up and early stage firms (Arenius and Minniti 2005). The hurdle that has to be surpassed however is whether the subjective perceptions of firm owners about their competitive advantages have any correlation to the actual superior performance of their firms relative to competitors. As such, we raise our first research question.

Research Question 1 Do KFS firm owner perceptions of their competitive advantage over competitors correlate to objective measures of superior performance?

7.3 Internal Firm Resources and University Collaboration

Collaborations between private firms and universities are made distinct from other forms of collaborations by the public good character of the resource inputs and outputs of universities (Argyres and Liebeskind 1998; Todorovic et al. 2011). Because of the strategic advantages of trading knowledge with universities, firms that develop, license or purchase university intellectual property can obtain competitive advantages that lead to higher survival rates, growth potential and performance (Dahlstrand 1997; Zhang 2009). For both small and large firms, university collaborations may enhance the dynamic capability to simultaneously explore and exploit markets for ideas (Grindley and Teece 1997); and the technological capability to obtain first mover advantages and establish complimentary expertise (Franco et al. 2009; Mosey and Wright 2007).

University collaborations can provide large firms like Microsoft and Cisco with the R&D capabilities to timeously introduce innovative products into high technology markets (Ransbotham and Mitra 2010 citing Financial Times 2006). University collaborations can also provide small start-up firms with otherwise

unavailable resources such as patents that increase their market bargaining power (Köhler 2011; Gambardella 2005). Moreover, university collaborations are particularly valuable in markets where the predominant mode of commercialization by innovative entrants is via cooperation rather than competition (Gans and Stern 2003). One explanation for this is that it makes it easier to enter the value chain without having to carry out all the value-adding functions necessary to deliver a product or service to the customer. The aforementioned benefits of teaming up with universities, however, can only be effectively embedded in those firms with the appropriate resource bundles and capabilities (Salter and Martin 2001).

The empirical evidence from prior studies show that resource configurations influence the commercialization of university technology (Vohora et al. 2004; Powers and McDougall 2005; O'Shea et al. 2005; Landry et al. 2006; Rasmussen and Borch 2010; Heirman and Clarysse 2004); the formation of alliances and university-industry collaborations (Mowery and Ziedonis 2002; Santoro and Chakrabarti 2002; Wright et al. 2004; Perkmann and Walsh 2008); and firm performance (Arvanitis et al. 2008; Walter et al. 2006; Shane and Stuart 2002; Markman et al. 2005). For example, in a longitudinal panel of 487 Italian 'new technology based firms' (NTBFs), Colombo et al. (2010) show that a university spin-off origin can be beneficial to the growth of high-tech start-ups only to the extent that the high-tech start-up can detect and absorb the technological capability that is being transferred. In other words, the firm incidence and sustainability of competitive advantages from university collaborations are likely to differ based on whether firms have their own internal resources to draw upon; and, also upon how dependent firms are upon their teaming up with the university for superior performance (Feller and Feldman 2010).

Building upon the literature discussed above, we explore the correlations between specific resources and attributes of the KFS firms in our sample and their perceptions of having obtained competitive advantages from collaborating with universities. Our research questions that follow set the stage for future empirical studies of the in-house resources, cooperative capabilities and industry attributes that influence whether firms can successfully leverage the intellectual property, knowledge and other benefits that can be obtained from collaborating with universities.

7.3.1 *Internal R&D Expenditures*

Some firms are very productive at internal R&D activities and are therefore more inclined to engage in them. Other firms, while not necessarily as productive, engage in internal R&D because of the specialization of their assets or products (Ceccagnoli et al. 2010). Irrespective of productivity, the accrual of rents from innovations requires firms to combine R&D capabilities with the capability to appropriate market returns from those R&D capabilities (Franco et al. 2009; Gans and Stern 2003). Stated plainly, if a firm has the capability to market a useful

technology, then it has an incentive to access useful technology not just from its in-house R&D capability but also from external sources.

If a firm has no internal R&D capability, it may not be as likely to achieve superior financial performance from the deployment of an externally-sourced potentially useful technology, even if it has the capability to market the useful technology. This is because the firm does not have as fine-tuned an ability to detect and refine the technology for marketability.

Yet, for firms with this R&D capability, we may incorrectly assume that it would not make sense to both do their own R&D and license in the output of external R&D because they have the filtering, refining and marketing capability. This assumption may be flawed because innovation speed and the timing of market entry matters. As such, even the most R&D-productive firms have an incentive to acquire external technology from sources such as universities because of constraints on human and financial capital and other internal weaknesses (Ceccagnoli et al. 2010; Keupp and Gassmann 2009).

For researchers, the challenge is that relationships between R&D capabilities and competitive advantages are intangible and difficult to observe (Terlaak and King 2006). These challenges arise particularly since firms strategically keep their R&D activities secret to protect their innovations (Cohen et al. 2002). Nonetheless, R&D plays a significant role in the sustainability of competitive advantages. As Reed and DeFillippi (1990) suggests, tacitness and complexity in a firms skills and capabilities that increases with R&D investments can generate the causal ambiguity that is needed to create barriers to imitation and to sustain competitive advantages.

In other words, “firms that are able to create new technological resources by virtue of their higher R&D competence will prosper relative to other firms that are not able to do so” (Danneels 2012, p. 47). Further, dynamic capabilities and ultimately performance increases when there is an integration of external technology acquisitions with internal technological resource accumulations from R&D (Mathews 2003). Of course, these relationships are probably curvilinear, controlling for organizational size (i.e., employees) and the proportion of R&D personnel. If the firm is too top-heavy with R&D people, for example, then there is likely to be insufficient investment in other functions like marketing and financial control, which will have a negative impact on firm performance. This brings us to the second research question:

Research Question 2 Among those firms that team up with universities, do greater R&D expenditures increase the likelihood of perceptions that competitive advantages were obtained from the collaboration?

7.3.2 *Patents that Provide Competitive Advantages*

There are mixed findings on whether patents help or hurt firm cooperative behaviors and outcomes with universities (Greenhalgh and Rogers 2007). Patents create an

intellectual property rights barrier around transferred knowledge (Murray and Stern 2007). As such, patents can be effective at reducing transaction costs and this benefit is often emphasized in the literature (Shane and Stuart 2002). Patents as a resource, however, have also been shown to provide long-term value to some firms and not others and in some markets but not others. Patent licensing agreements can increase transaction costs in markets where private firms engage in patent races to exclude other firms from appropriating returns from technological advances (Shapiro 1985). For instance, where an invention can be substituted by an alternate good, broad university patents that discourage substitution may become more valuable (Klemperer 1990). On the other hand, where the commercial environment is one of incremental innovations of less novelty, narrow university patents that are subject to less challenge may be of a higher quality (Scotchmer and Green 1990).

Further, while patents can increase the bargaining position of startup firms, the ownership of patents is associated with hefty litigation and social costs that reduce the patent value for early stage startups (Gambardella 2005). Nonetheless, Cockburn et al. (2010) show that the size of the patent portfolio does positively affect firm performance in markets with fragmented intellectual property protection. Coupe (Coupe 2003) also suggests that the size and quality of patent portfolios provide competitive advantages by increasing the elasticity of returns from R&D expenditures. These findings in the prior literature suggest that firms with valuable patent stocks should have the capability to efficiently integrate resources that are acquired from teaming up with universities. This leads to the third research question.

Research Question 3 Among those firms that team up with universities, do more valuable patent stocks increase the likelihood of perceptions that competitive advantages were obtained from the collaboration?

7.3.3 *Cooperative Capabilities*

Inter-firm collaborations have been the focus of a number of conceptual articles addressing competitive advantages in markets for technologies but have been subject to very little empirical testing (Ransbotham and Mitra 2010). Firms will often times attempt to compensate for deficiencies in their internal resources with external acquisition strategies (Gans and Stern 2003). An understanding of the competitive advantages that arise from external acquisition strategies call for non-efficiency based analyses that go beyond traditional considerations of transaction costs (Yoo 2010). Generally, the motivators of inter-firm cooperative behaviors are competitive threats (Bianchi et al. 2009) and internal firm weaknesses (Keupp and Gassmann 2009). For instance, a survey of 355 firms participating in NSF engineering university-industry-government research centers found that firms participated in the research centers to gain access to upstream modes of knowledge and not necessarily access to specific products or services (Feller and Feldman 2010).

Inter-firm cooperative behaviors bestow legitimacy on startup entrepreneurs (Lichtenthaler 2011) and provide positive reputational effects for established firms (Alvarez and Barney 2001; Stuart et al. 1999). Further, Walter et al. (2006) found that inter-firm network capabilities moderate the relationship between entrepreneurial orientations that foster competitive advantages and organizational performance. In the context of university collaborations, to the extent that firms are more competent at external acquisition strategies, they should be more capable of leveraging university resources to achieve both monetary (Chesbrough 2003) and non-monetary (Van De Vrande et al. 2009) gains in market position (Lichtenthaler 2011). Stated more simply, our suggestion is that the more firms collaborate with one organizational form, the more they should be able to collaborate with other organizational forms, irrespective of the type of collaborator. This is knowledge spillover effect of collaborative activity which leads to the fourth research question in the paper.

Research Question 4 Among those firms that team up with universities, do the collaboration with other firms and government labs increase the likelihood of perceptions that competitive advantages were obtained from the collaboration?

7.3.4 *Firm Size*

Given the difference in organizational size and power between startups and universities, and the variance in size within startups themselves, we may expect there to be a relationship between firm size and the impact of university collaboration on the innovation efficiencies that lead to competitive advantages. For instance, the probability of university collaborating with a university increases with firm size in general; however, small firms who collaborate with universities may be better able to avoid the bureaucratic inefficiencies encountered by large firms (Link and Rees 1990). Nonetheless, because of the resource constraints of small firms, it is likely that large firms have greater expenditures toward university collaborations. Such expenditures, however, are more likely aimed towards research that is more tacit or experimental.

Larger firms have more resources that can be deployed to experiment with workarounds to innovation and process problems without drawing upon external collaborative resources (Cohen et al. 2002; Köhler 2011; Perkmann and Walsh 2008). As such, smaller firms tend to use knowledge transfers from university collaborations to solve problems in core technological areas, while larger incumbent firms tend to use the knowledge transfers to build competencies in non-core technological areas (Caloghirou et al. 2001; Santoro and Chakrabarti 2002). For small firms, therefore, collaborating with universities as opposed to conducting internal R&D can provide a more efficient path to achieving competitive advantages from either cost advantages or product differentiation or both (Markman et al. 2005).

Further, because startup firms are at a resource disadvantage in comparison to market incumbents, the teaming up of small firms with universities may increase the rate of return from the innovation resources (Cockburn and Henderson 1998; Link and Scott 2001). This is because collaborating with universities should increase the chances of success of an individual R&D program by a small firm. That said, it is important to stress that we are not inferring that small firms expend greater resources on university collaborations than large firms. Rather, our suggestion that the attributes of the collaboration (i.e., relationship between the core products and services) will more likely differ based on firm size.

Lastly, another way to look at firm size is from the perspective of the relative benefits of university collaboration. The greater the differential in organizational size and therefore power in protecting intellectual property, the more likely that firm owners will perceive a competitive advantage. Since all startups are smaller than universities, it follows that the smaller the collaborating firm, the more likely that the firm owner will perceive a benefit from collaborating with the larger entity—the university. This leads to our fifth research question.

Research Question 5 Among those firms that team up with universities, does smaller firm size increase the likelihood of perceptions that competitive advantages were obtained from the collaboration?

7.3.5 Industry Configuration

Although some firms have the resources and capabilities to leverage outputs from university collaborations, in certain industries doing so may not sufficiently contribute to the firm's superior performance (Coff 1999). There are a number of factors that contribute to the challenges firms face in different industries when it comes to collaborating with universities. Some of the challenges include the nature of the technology (radical, incremental), relationships with market participants (breadth and depth) and the strengths and weaknesses of intellectual property rights (Bahemia and Squire 2010). The research of Lavie (2006), for example, draws attention to the notion of inimitable and rare network resources that are not owned by a single firm and that are made valuable by the nature of the network relationship between interconnected firms. There is also the notion of the fragmentation of upstream property rights in an industry that results in firms having to license from multiple incumbents to enter the market. This fragmentation has been shown in prior studies to encourage incumbent firms to ramp up their patent portfolios using cooperative commercialization arrangements with universities (Cockburn and Stern 2010).

Given the above challenges, different industries call for different resources to be deployed in configurations and time stages that are pertinent to the industry (Mustar et al. 2006). In particular, cooperative commercialization strategies (i.e., licensing agreements and sponsored research) between universities and incumbent industrial

firms with the slack resources to invest in university spin-offs (Agrawal 2005; Zahra et al. 2006) are more likely to occur if there is less uncertainty about the effectiveness of the underlying intellectual property at appropriating the returns.

This lower uncertainty is likely to exist in manufacturing and electronics industries where the incumbent firms hold specialized complementary assets (Macho-Stadler and Pérez-Castrillo 2010). Link and Bauer (1989), for example, found in their sample of 92 manufacturing firms that cooperative research programs provided the competitive advantage of favorably increasing the rate of return to R&D by approximately 3 to 1. As certain industries should have greater appeal or advantages over others when it comes to university collaborations (Porter 1980), our sixth and last research question asks:

Research Question 6 Among those firms that team up with universities, do certain industries increase the likelihood of perceptions that competitive advantages were obtained from the collaboration?

7.4 Methodology

The data for our study is drawn from the Kauffman Firm Survey (KFS). The KFS target population was all new businesses included in the Dunn & Bradstreet database having started in 2004. A random sample of 32,469 U.S. businesses was sampled. Kauffman received 4928 complete surveys of eligible firms founded in 2004. Subsequently, Kauffman surveyed the same founders each year in waves. The questionnaires include data on the founders, financing, products and services, characteristics and other factors that influence entrepreneurial outcomes (Robb et al. 2009).

7.4.1 Dataset

While much of the KFS remained the same through the duration of the study, several questions were intermittently added as time progressed. Starting at the baseline year, the KFS firms were asked about their perception of having a competitive advantage. In particular, the following question was asked:

Businesses often have to compete with other businesses. A competitive advantage is something unique or distinctive a business provides that gives it an advantage compared to competitors. In calendar year [year], did [name of business] have a competitive advantage over its competitors?

Of relevance to our analysis, the following question was added in wave 4 (in the year 2008) to the KFS: *“Was the competitive advantage [name of business] had in calendar year [year] related in any way to [a.] teaming up with a college or university?”*

Each of these questions remained in the KFS for waves 4–6 (2008–2010). Our sample for the panel logit models used to investigate Research Questions 2–6 is composed of all firms in the KFS which answered ‘yes’ to question (1) above in the years 2008–2010, and provided an answer to question (2); missing data on either of these variables in any given firm-year were omitted from analyses. This resulted in a sample of 1499 firms and 2892 firm-year observations. Our sample for the t-tests that is used to investigate Research Question 1 is comprised of 1761 firms that reported having a competitive advantage in wave 4 (2008) and with reported total revenues for 2008, 2009 and 2010. This sample of firms is larger for Research Question 1 because some firms could have reported other reasons for their competitive advantage that did not include teaming up with universities.

We recognize that it would have been more robust to split the KFS sample into those firms that reported a perceived competitive advantage because of collaboration with a university and those that did not and then testing for equality of mean performance across the three groups: no competitive advantage, competitive advantage from universities and competitive advantage without universities. Limitations such as this one, reinforces the exploratory nature of the present study and provides opportunities for future research studies to empirically examine the research questions presented in this paper.

7.4.2 Study Variables

The t-Test for Research Question 1 is performed using data on *Firm Revenues* for two samples of firms—firms that in 2008 responded ‘yes’ to having a competitive advantage over competitors and those firms that responded ‘no.’ The dependent variable for Research Questions 2–6 is *University Reason for Competitive Advantage*. This variable is comprised of the ‘yes’ or ‘no’ answer provided for question (2) above. The response ‘yes’ was coded as ‘1’ and ‘no’ was coded as ‘0’.

To explore our research questions, we use six independent variables. The first variable is *Firm Revenues*, which we measure by the total revenue reported for the firm in a given year in the KFS. This is a calculated variable with a range from 0 to 9 representing revenue ranges. The second variable—*Total R&D*—is measured as the total research and development expenditures by the firm in a given year. The third binary independent variable is *Patent Competitive Advantage*. Respondents in the KFS were asked: “Was the competitive advantage [name of business] had in calendar year [year] related in any way to patents that [name of business] owns, has applied for, or licensed?” A response of ‘yes’ was coded as ‘1’ and ‘no’ was coded as ‘0’. The fourth binary independent variable, *Company Competitive Advantage* was coded in the same way for a response to the question: “Was the competitive advantage [name of business] had in calendar year [year] related in any way to teaming up with another company?” The fifth independent variable, *Government Lab Competitive Advantage* was coded in the same way for a response to the question: “Was the competitive advantage [name of business] had in calendar

year [year] related in any way to teaming up with a government lab or research center?" The sixth and final independent variable is *Firm Industry*. The KFS documents the two-digit NAICS code for each firm, each of which is assigned a dummy variable in our models. The omitted category is Agriculture, Forestry, Fishing and Hunting.

We also included several control variables. We control for whether the firm offered *Products or Services*. As venture capital-backed firms may have a significant competitive advantage we control for whether or not (binary) the firm received *Venture Capital* (Sapienza 1992). To control for macroeconomic conditions we included dummy variables for each Year in the sample (2008–2010). To control for more local conditions, we included dummy variables for the *Region* of the US—Northeast, Midwest, South, and West; the Northeast represents the omitted category. Lastly, we included a series of *Location* dummy variables which represented whether the primary location of the business was a residence, a rented space, a purchased space, or the site of a client.

7.4.3 Analyses

A preliminary Levene's test for equality of variances indicated that the variances of the two groups of KFS firms that reported 'yes' or 'no' to having a competitive advantage in 2008 were significantly different. For Research Question 1, therefore, a two-sample t-test was performed that does not assume equal variances. Next, given the structure of the KFS data, we utilized cross-sectional time series logistic regressions (panel logit models) to examine research questions 2–5. Our observation unit in each model is firm-wave.

Due to the presence of both cross-sectional and time series (waves 4–6) elements within our model, standard logistic regression runs the risk of violating both non-independence and homoscedasticity assumptions. That is, estimations based on standard regression analysis have understated standard errors, correlated error terms and inflated t-statistics. Fixed- or random-effects models are frequently employed to alleviate these issues.

In an effort to account for potential changes over time in our panel-level disturbances, we utilized random effects models for all of our analyses. We used Stata (version 11) and set a respondent ID assigned to each firm as the panel variable and the wave as the time variable. A full model was subsequently estimated using the *xtlogit* function along with the random effects (re) option to examine the research questions.

7.5 Results

Table 7.1 shows the result of performing the two sample t-test for *Firm Revenues*. Table 7.2 presents the results of the model testing Research Question 2–6, with *University Reason for Competitive Advantage* as the dependent variable. The descriptive statistics the variables used in our empirical models are omitted from the paper because of space constraints.

Research Question 1 anticipates that the KFS firm owner perceptions of their competitive advantage over competitors correlate to objective measures of superior performance. There is evidence that the group of KFS firms with subjective perceptions of having a competitive advantage in 2008 on average had superior financial performance to other KFS firms. The average 2008 revenue for the KFS firms that reported having a competitive advantage ($M = 6.22$, $SD = 2.967$, $N = 1044$) was significantly greater than the average 2008 revenue for the KFS firms that did not report having a competitive advantage ($M = 5.35$, $SD = 3.283$, $N = 717$), $t(1435) = 5.69$, $p = 0.00$. The average 2009 revenue for the KFS firms that reported having a competitive advantage in 2008 ($M = 6.70$, $SD = 2.419$, $N = 1044$) was significantly greater than the average 2009 revenue for the KFS firms that did not report having a competitive advantage ($M = 5.81$, $SD = 2.915$, $N = 717$), $t(1347) = 6.70$, $p = 0.00$. The average 2010 revenue for the KFS firms that reported having a competitive advantage in 2008 ($M = 6.56$, $SD = 2.578$, $N = 1044$) was significantly greater than the average 2010 revenue for the KFS firms that did not report having a competitive advantage ($M = 5.85$, $SD = 2.900$, $N = 717$), $t(1417) = 5.32$, $p = 0.00$. Note also that although the t-Test is two-tailed, the confidence interval contains only positive values for the differences in the means, indicating that the average is greater for the firms reporting a competitive advantage.

Research Question 2 anticipates that among those firms that team up with universities, greater R&D expenditures would increase the likelihood of perceptions that competitive advantages were obtained from the collaboration. As shown in Table 7.2, the coefficient for total research and development is positive and significant ($\beta = 0.11$; $p < 0.05$). Thus, we find support for our expectations regarding Research Question 2. Research Question 3 anticipates that among those firms that team up with universities, valuable patent stocks should increase the likelihood of perceptions that competitive advantages were obtained from the collaboration. As shown in Table 7.2, the coefficient for *Patent Competitive Advantage* is both positive and significant ($\beta = 1.56$; $p < 0.001$). Thus we find expected answers for Research Question 3.

Research Question 4 anticipates that among those firms that team up with universities, the collaboration with other firms and government labs increase the likelihood of perceptions that competitive advantages were obtained from the collaboration. As shown in Table 7.2, the coefficients for both *Company Competitive Advantage* ($\beta = 1.09$; $p < 0.001$) and *Government Lab Competitive Advantage*

($\beta = 2.77$; $p < 0.001$) are positive and significant. We therefore find expected answers to Research Question 4.

Research Question 5 anticipates that among those firms that team up with universities, the smaller firm sizes increase the likelihood of perceptions that competitive advantages were obtained from the collaboration. As predicted, the coefficient for *Firm revenues* ($\beta = -0.17$; $p < 0.001$) in Table 7.2 is both negative and significant. This result supports our expectations regarding Research Question 5.

Lastly, Research Question 6 anticipates that among those firms that team up with universities, certain industries increase the likelihood of perceptions that competitive advantages were obtained from the collaboration. Our expectations based on prior research were observed. We find that firms operating in two of the three manufacturing NAIC Codes had positive and significant coefficients ($\beta = -2.09$; $p < 0.05$) and ($\beta = -1.75$; $p < 0.05$). The non-significant NAICS code captured tobacco, textiles, mills and wood for examples. Other significant positive effects were found for the service, accommodation and food industries. For retail trade, information services and administrative industries, the perception was also positive but the coefficients were marginally significant. The other NAICS industry codes were not found to be significant.

7.6 Discussion

Our question of ‘why some firms team up with universities for competitive advantages and others do not’ is an important one. The exploratory analyses in this paper of the KFS data suggest that there may correlations between the competitive advantages that firms obtain from teaming up universities and internal R&D spending, valuable patent stocks, and inter-organizational cooperative capabilities. Additional suggestions of the exploratory analyses are that competitive advantages from teaming up universities may more likely be obtained by smaller firms; and also by firms operating in industries such as manufacturing and electronics.

Future and more robust inquiries into the research questions presented in this paper will be timely due to the increasing number of programs that have emerged in the United States and other countries which team up firms and universities for competitive advantages. The precept of these programs is that knowledge is a production input with increasing rather than diminishing returns (Coberly and Gray 2010; Romer 1986). On the firm level, competitive advantages from university collaborations can manifest into increased R&D output, superior firm performance or both (Zucker et al. 2001, 2002). On the economy level, the teaming up of firms and universities facilitate the diffusion of knowledge in commercial markets (Bonardo et al. 2010).

An assumption of the government and university policy that promotes the competitive advantages from collaboration between universities and industrial firms that can be nuanced in future studies is the assumption that industrial firms

have the capability to efficiently assimilate and exploit the knowledge that is developed within a university setting (Salter and Martin 2001). By focusing on the perception of firm founders as to the sources of their competitive advantages as opposed to the formal characteristics of the knowledge transferred from university to firms, our exploratory analysis raises the question of whether this assumption is more likely to be true for firms that have complimentary internal and external attributes.

Further, it could also be the case that while university collaborations provide a competitive advantage as a resource input; they can be non-impactful and even harmful to the extent that knowledge outputs are not absorbed by the sponsoring firm or if the sponsoring firm cannot control output flows to rival firms (Cassiman et al. 2002). In other words, the sponsoring firm should have the absorptive capacity to recognize, evaluate and commercially apply externally available knowledge to appropriate economic rents (Cohen and Levinthal 1989, 1990). Empirical studies of university–industry collaborations in the UK and US suggest that firms can, however, enhance their absorptive capacity through interactions with universities that build explorative learning capabilities (Bishop et al. 2011; Arvanitis et al. 2008; Feller et al. 2002; Meyer 2006).

Lastly, the collaboration of firms and universities arguably can maximize the social rate of return from technological innovations (Cockburn and Henderson 1998; Link and Scott 2001) through higher stocks of useful knowledge and scientific instrumentation; and also through higher stocks of skilled workers who have increased problem solving capacity (Salter and Martin 2001). Yet, the growth and efficiency of university–industry collaborations to commercialize technology that was observed immediately following Bayh Dole and other legislation has been diminishing in recent years (Cardozo et al. 2011; Young et al. 2008).

A possible explanation for this decrease is the perception of industrial firms that minor or nonexistent competitive advantages are obtained from collaborating with universities or that the collaborations do not compensate for the loss of control over flexibility and market returns (Rao et al. 2008); and for the increase in coordination costs (Christensen et al. 2005). In particular, collaborations with universities can create conflicts about the appropriation of university technology. The less appropriate the created technology, the less likely that firms can obtain competitive advantages from teaming up with universities (Chesbrough 2003). Future research can provide additional insights.

7.7 Limitations

The questions asked in the Kauffman Firm Survey provides a unique opportunity to explore the attributes of firms that have the perception of obtaining competitive advantages from teaming up with universities. There are, however, limitations to the empirical conclusions that can be drawn from the data. First, the KFS data is self-reported. However, there is support for the validity of the KFS evidence found

in the technology and innovation literature (Barge-Gil and Modrego 2011). Second, because we could not distinguish between those firms who teamed up with universities and those who did not—there may be a survivor bias.

For example, in some cases we actually test the likelihood that perceived competitive advantage from other variables (patents, collaboration with firms, collaborations with government labs) is associated with the perceived advantage from university collaborations. We use these variables because the KFS data does not indicate which firms collaborated with these entities and which firms did not—just the incidence of competitive advantage. This creates a selection bias in the model whereby firm owners who perceive that they get benefits from collaborations may be likely to collaborate more. This is an interesting but still different explanation from the one presented in this paper (i.e., that collaboration with other firms or government labs increases the cooperative capabilities of the firms in the KFS sample who team up with universities).

Additionally, entrepreneurs elect to collaborate with universities, and then, if they collaborate, they may be more or less successful. The criteria that affect whether they are successful in an endeavor (in this case, teaming up with universities) may be different to the criteria that were important in choosing whether to elect to collaborate in the first place. In other words, universities do not collaborate with entrepreneurs who choose not to collaborate with them. Lastly, we do not know how the KFS firms teamed up with the universities. There are several ways that firms can team up with universities—i.e., technology transfers, cooperative research, incubation, supply chains and others. They should each be explored.

7.8 Additional Future Research and Conclusions

Although selection biases and omitted KFS variables discussed above limit the empirical conclusions that can be drawn from the findings, they also draw attention to the richness of the research questions that can be crafted to explore why some firms obtain competitive advantages from teaming up with universities and others do not. While prior research has been informative as to incentives and disincentives of universities engaging industry in commercial activities, little attention has been paid to the attributes of the firms that stand to benefit most from such activities.

Opportunities exist for future research with robust variables and empirical methods that explicate how, when and why teaming up with universities prove firms with competitive advantages that lead to superior performance. Competitive advantages are likely to be obtained by those firms that have dynamic internal resources or aggressive strategies for accessing external resources (Dew et al. 2006; Giarratana and Fosfuri 2007). Future inquiries into the question of why some firms report that teaming up with a university was a reason for their competitive advantage can provide important insights into how internally developed and externally acquired resources can be bundled and leveraged for superior firm performance. For example, teaming up with universities through research partnerships can share the

costs and risks of accessing new technologies, either for sustaining existing market share or entering new markets (Bessy and Brousseau 1998; Grant 1996; Rosenberg 1992).

As a final concluding remark, we emphasize that a condition for successful innovation is that the technology underlying the innovation works in the field (Feller and Feldman 2010). Yet not all firms have the internal resources to invest in the development of working technology that is not directly linked to their core products and services. And, even those firms with the internal resources often limit their investment in new technology to avoid reputational effects (Agrawal 2005; Zahra et al. 2006) and knowledge diffusion from failed market experiments (Durand et al. 2008; Hagedoorn et al. 2000; Leyden and Link 1999; Shapiro 1985). In the context of university collaborations, the more we understand about why some firms perceive that teaming up with universities provides them with competitive advantages and others do not; the better we can become at predicting why university collaborations take certain forms, which outcomes are expected and what cooperative or coercive pressures motivate firms to teaming up with universities in the first place.

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Chapter 8

Gaining Regional Competitiveness by Increasing Employer Attractiveness in Small and Medium-Sized Enterprises: New Approach for Knowledge Transfer Between Academia and Business

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and Matthias Klöppner

Abstract Knowledge and innovation are the key factors for sustainable business development. Therefore, new models of cooperation have to be launched that intensify the knowledge flow between business and academia. The Innovation Incubator at Leuphana University of Lüneburg in Germany is an excellent example for such a strategic partnership between university and regional economy. This approach of knowledge transfer is funded by the European Regional Development Fund (ERDF) and focusses on strengthening the competitiveness of regional SMEs. As part of the Innovation Incubator the network for innovation and transfer “Performance Management in Medium-Sized Businesses” represents a concrete example of effective long-term cooperation between academia and business. This alliance aims at the constructive exchange of experience and knowledge between regional SMEs and academic experts in human resources and business development. One of the central questions for regional SMEs within this network is how to attract and recruit highly qualified employees. Within research-based working groups academic experts closely cooperate with business representatives in order to increase the employer attractiveness of SMEs.

Keywords Regional development • Business-academia cooperation • Knowledge transfer • Employer attractiveness

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8.1 Linking the Competencies of Academia and Business

New knowledge and innovation is the key to staying competitive and to business growth. For modern companies, strategic and continuous development of the entire organisational ‘know-how’ is vital to ensure and promote their own business development and, not less importantly, for Germany’s long-term economic development. Cooperation and exchange between businesses and universities is an important driving force for such development. “When companies and universities work in tandem to push the frontiers of knowledge, they become a powerful engine for innovation and economic growth. Silicon Valley is a dramatic example. For over five decades, a dense web of rich and long-running collaborations in the region have given rise to new technologies at a breakneck pace, and transformed industries while modernising the role of the university.” (Edmondson et al. 2012, p. 6). Sustainable cooperation offers companies as well as universities advantages and represents a decisive factor in the potential for innovation in a region. In order to guarantee and feed innovation for the future, and so that Germany’s increasingly knowledge-based economy can remain competitive, effective research cooperation between academic institutions and business are of central importance (Bundesverband der Deutschen Industrie et al. 2007, p. 2).

There are a wide variety of formats possible for cooperation between academia and business, ranging from very loose collaboration, to organising in-company graduate projects or consultancy tasks, and extending to strategic partnerships, for example, within the dual-studies framework (the German combined vocational training and degree programmes), or even establishing mutual research centres. Whatever the cooperation looks like, the fact is that all sides will profit. That was confirmed in 2007 by a study with 232 German companies, universities and public authorities in which almost all participants rated their experiences ‘very positive’ or ‘positive’ (Frank et al., p. 91). The important thing for all forms of knowledge transfer is a reliable basis of trust and clear agreement on the rules of the partnership, and all sustainable forms of cooperation between business and academia must be supported purposefully from all sides. Cooperation is a factor in creating innovation, and profits both sides. Companies can obtain valuable inspiration for innovative products and solutions to problems out of the latest academic findings. Through cooperation with universities and research institutes, they gain new perspectives and access to new methods (ibid., p. 6). Research work is also the more successful the better the exchange between business and academia functions. The research organisations especially profit through extra income from industry funding, professional prospects for staff and students and by the practical lessons from applying the findings of their work in businesses (ibid.).

The research cooperation between companies and universities in recent years reveals a trend: unlike past experience, it is now common to find long-term strategic partnerships. Even though ‘classic’ forms of cooperation—for example temporary consultancy and research contracts for single academic experts or institutes—as always play a big role, experience shows that these short-term forms of cooperation

which are usually between few people or departments, very often lack mutual understanding for each other's working methods and cultures (ibid., p. 6).

Clearly, long-term and strategic partnerships are more suitable for modern innovation processes. "They make an important contribution to building competencies on both sides and prove to be a stable organisational framework within which to develop and work on research questions, share investment risks and make the best use of the complementary strengths of both systems" (Bundesverband der Deutschen Industrie et al. 2007, p. 3, own translation). One example of such a long-term and strategic collaboration is the network 'Performance Management in Medium-Sized Businesses' at Leuphana University of Lüneburg, a multi-year programme within the framework of Leuphana's Innovation Incubator.

8.2 Project for Regional Development: The Innovation Incubator

With the Innovation Incubator, Leuphana University of Lüneburg has carried out the plan to create a large-scale cooperation between academia and business to support the development of the regional economy.

8.2.1 Main Objectives and Background

The Innovation Incubator represents a major EU regional business development project to strengthen regional economic development in the former governmental area of Lüneburg. With an investment volume of almost 100 million Euros the project was designed by Leuphana University of Lüneburg in cooperation with the German Federal State of Lower Saxony. After a period of preparation the project was officially approved in August 2009 by the European Commission. Until July 2015 various projects are carried out to support business innovation and development in the German Federal State of Lower Saxony (Leuphana Universität Lüneburg 2010). Three general objectives were set: to improve research, development and employment qualifications, to promote the potential for innovation and to develop regional cooperative structures (Kagel et al. 2010, p. 18).

The Innovation Incubator is mainly funded by one of the structural funds of the European Union, the European Regional Development Fund (ERDF), which aims to strengthen economic and social cohesion throughout the European Union by reducing existing disparities between the regions. This project follows the logic of the European Lisbon Strategy which was implemented by the European Council to improve research and development policy and to strengthen regional business development. Given this target, the European structural funds were redesigned for the funding period 2007 until 2013 and "convergence" in terms of economic

homogeneity has been defined as the top priority (so called objective 1). The region of Lüneburg has been declared an “objective 1 area” and is the only area which fits the definition of a convergence region within the western states of Germany (Bundesministerium für Wirtschaft und Technologie 2007, p. 5).

8.2.2 The Development Area: Convergence Region

The assisted region, defined as the convergence region, includes 11 administrative districts with about 1.7 million residents. This area has a gross domestic product per capita below 75 % of the EU15 average, which is the determining criterion for public funding. The region of Lüneburg is exactly characteristic of an “objective 1 region”. A SWOT analysis conducted by the Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr (2007) illustrated the economic underdevelopment of this area in comparison to average German and European economic growth. The capacities for innovation of its SMEs, the educational level and also the employment rate have been pointed out as further areas for development.

Generally, the convergence region is characterized by a heterogeneous sectorial structure; however the health care sector has a large proportion. It is a rural area which is comparatively thinly populated with a declining population. This is especially true in the rural districts verging on the former East Germany, which also have high unemployment rates compared to the average in other states of former West Germany. In addition, the region lacks an existing network and infrastructure of research institutions which is why Leuphana University of Lüneburg is taking a central role in regional development.

8.2.3 The Economic Structure: Small and Medium-Sized Enterprises

The official EU definition of small and medium-sized enterprises (SMEs) includes companies with up to 249 employees and an annual turnover of up to 50 million Euros. Within this range, companies are differentiated by their number of employees, so that, for example, microenterprises with below ten employees make up a separate category (European Commission 2006).

In Germany, SMEs with from 10 to 249 employees are the most common size for enterprises, with a total number of 2 million in the year 2010 (cf. Fig. 8.1). Employing 60 % of the working population, SMEs achieve one third of the annual sales in Germany (Statistisches Bundesamt 2013a).

Regardless of these quantitative criteria, SMEs share certain characteristics: in many cases one person is both owner and CEO of the company, the level of employee fluctuation is lower than in large-scale enterprises, the company focus

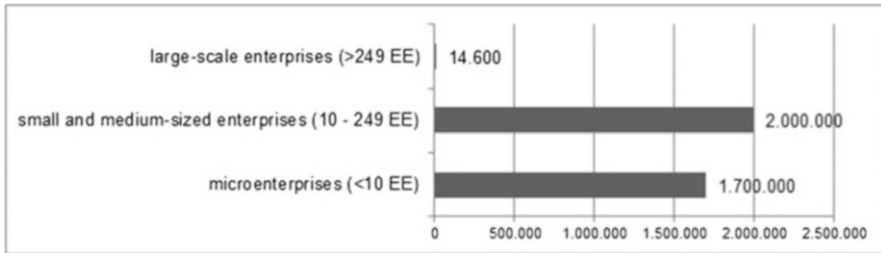


Fig. 8.1 Rounded number of enterprises in Germany in the year 2010 by size (own figure based on Statistisches Bundesamt 2013a)

is more on regional activities and commitment and they emphasize self-responsibility in their corporate culture (Hennerkes and Pleister 1999).

The labor market in the convergence region mainly consists of small and medium sized—in many cases family-owned—enterprises. The number of companies with less than ten employees here is well above the German average. Overall, more than half of all employees (54 %) in regional companies are working in companies with less than 50 employees (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2007, p. 23). Due to its location, it is an important challenge for this area to compete with the metropolis of Hamburg in the north, Bremen in the west and Hannover in the south.

8.2.4 Models of Cooperation Between Academia and Business

The Innovation Incubator represents a model project for regional development. The project finances investments in knowledge and innovation and enhances the knowledge transfer from the university to the regional economy. Its unique characteristic is the intensive interlocking of academic research and business. This investment in research is considered an innovative approach in European structural policy. The project pursues the goals of offering the latest research results to local companies and helping them put these results into practice. In addition, the different forms of cooperation offered by the Innovation Incubator provide a platform for regional entrepreneurs to share their experiences and their ideas, thereby promoting sustainable networking. Besides the objective of promoting knowledge transfer, the Innovation Incubator is committed to a strategy for training and education. This includes creating new job opportunities in the assisted region. For the medium to long term, the Innovation Incubator is pursuing the goal of creating and securing jobs in the region, enhancing the innovation potential of SMEs and increasing the number of qualified graduates to meet the needs of the regional labor market.

The key aspect of this concept is the integration of science and business. In its role as ‘booster’ of knowledge-based regional development, the university is

launching a variety of coordinated and integrated projects which represent a new model of regional cooperation (Kagel et al. 2010, p. 19). Furthermore, as well as offering traditional students and working professionals a unique and specially designed study program which is interdisciplinary and possesses many opportunities for specialization, Leuphana University of Lüneburg strongly focusses on knowledge transfer to local business. In order to strengthen this knowledge transfer, various cooperation models have been established.

8.3 Academia-Business Cooperation: The Network for Innovation and Transfer ‘Performance Management in Medium-Sized Businesses’

What a concrete cooperation model between university and a regional economy may look like will be outlined by the following example of the corporate network ‘Performance Management in Medium-Sized Businesses’. It is one of two networking projects within the context of the Innovation Incubator with a thematical focus on retention management, staff development and corporate/business succession.

8.3.1 *Characteristics of the Network*

The network for innovation and transfer ‘Performance Management in Medium-Sized Businesses’ aims to promote small and medium enterprises (SMEs) by equipping regional businesses with the latest research findings and practice-oriented knowledge (Just and Remdisch 2011, p. 60). The alliance was formed in 2010 and is still growing. The network is open to SMEs from all sectors of industry. To the present day, around 30 enterprises—most of them with less than 250 employees—from different branches of industry have worked together within the alliance. The range of sectors that are represented includes among others geriatric care, wholesale trade, logistics, food production, the pharmaceutical industry and engineering.

Aside from their functional specifics and different needs with regard to skilled personnel, all SMEs feature structural similarities (cf. Sect. 8.2.3). General tasks in human resource management are not specific to any individual sector either. The innovation and transfer network offers a platform for intensive exchange, so network members may share experience-based knowledge and professional expertise. Therefore, the business alliance seems an appropriate format within which SMEs can use mutual support to develop new ideas and compensate for a possible lack of financial as well as personnel resources (Helbich 2001, p. 123).

Besides providing a framework for exchange, another important feature of the network for innovation and transfer ‘Performance Management in Medium-Sized

Businesses' is its connection to Leuphana University of Lüneburg. This means that in contrast to other corporate networks and due to the EU funding, all administrative tasks, as well as a substantial proportion of the planning and organization for the network's activities is done by a central project team at the university. Company participation is without charge but regular involvement in the network's activities, including taking part in surveys, is expected in order to create a close and lasting spirit of membership. Furthermore, and even more importantly, through this project the university is forming long-term research partnerships within the local economy and promoting practice-oriented knowledge transfer. Through cooperation with universities companies benefit from research findings at first hand and bring their questions directly to the attention of academics (Frank et al. 2007, p. 6).

8.3.2 Formats of Collaboration: Workshop Series and Research-Based Working Groups

The central elements of the network's activities are regular workshops and research-based intensive working groups that focus on various subjects from the field of human resource management. Four times a year members of the network, usually chief executive officers or human resource managers, meet in all-day workshops to profit from lectures by academic and non-academic human resource experts and exchange experience and knowledge with colleagues from different enterprises. Recent findings are presented in an application-oriented form. The events are conceptualized as a thematic series, allowing the attendees to gain a deep insight into each topic and discuss it from several points of view.

In order to deepen their knowledge and enable direct transfer of the newly gained insights into professional practice, small working groups are set up additionally to the workshops. Accompanied by Leuphana researchers, practitioners collaborate for a period up to 15 months to develop solutions and concrete measures appropriate for human resource management in SMEs. The two research-based working groups described below follow the same approach based on this common process (cf. Fig. 8.2).

As a first step, a project sketch is drawn up by the researchers which contains information about the aims, work and time schedule as well as the functions of all partners. Then a survey is conducted to gather data about the status quo in a company. Subsequently the results are analysed by the researchers and written and presented in plain terms for the companies. A benchmark is generated and each company receives an individual report. On the basis of these findings, companies define firm-specific fields of action. The internal implementation process is accompanied by regular meetings of the working group which offer a framework of cross-company exchange and mutual support. The number and times of these get-togethers are determined by vote. In addition, these meetings are enriched by short lectures by the academics, who themselves profit from these events by getting

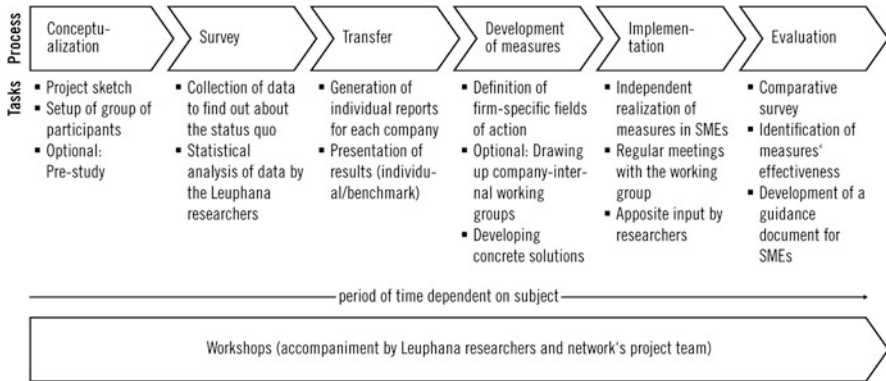


Fig. 8.2 Typical process of working groups in the network for innovation and transfer 'Performance Management in Medium-Sized Businesses' (own figure)

insights into the companies' progress. At the end of the working group, a comparative survey is conducted in order to identify which measures were the most effective. The findings are published in a guidance document for SMEs. So as to create a close and confidential working atmosphere, it was decided that not more than ten enterprises should participate in a working group. Furthermore all companies participating in the working group sign a cooperation agreement which regulates rights and obligations of the project partners, regarding, for example, intellectual property or cooperation with third parties.

8.3.3 *The Central Challenge: Shortage of Skilled Professionals*

All the topics covered by the network's transfer activities are chosen with due consideration to the needs of the local SMEs and the challenges of regional and trans-regional competitiveness. Apart from the characteristics of the convergence region mentioned in Sect. 8.2.2, the much discussed shortage of skilled professionals in Germany is also crucial for the choice of themes. This shortage should be distinguished from a general lack of available workforce, which is not currently a problem in Germany. The current shortage of skilled professionals is characterized by the shortfall of workers with specific professional qualifications and is often limited to certain regions. In particular, there are currently not enough qualified applicants available for jobs requiring expertise in mathematics, informatics, science and engineering resulting in an average of 2.5 vacancies available to each highly-qualified unemployed professional or academic with corresponding qualification (Anger et al. 2012, p. 37). There are also staffing shortages in other fields. In a survey of more than 20,000 business managers from medium-sized businesses, 35 % stated that their biggest problem is to fill vacant positions (DIHK 2013). Due

to the lack of skilled professionals in Germany and the particular difficulties in the region of the project, the theme chosen for the project's priority in 2013 is 'The employer attractiveness of SMEs'.

The following section introduces the examples of two research-based working groups from the network: 'Employer attractiveness in SMEs' and 'The attractive employer in geriatric care'. Both deal with the theme 'employer attractiveness' because it is a central element for staying and becoming more competitive by winning and retaining qualified specialists and management personnel, and generally for increasing productivity.

8.4 Working Group 'Employer Attractiveness in SMEs'

Since May 2013, representatives from academia and small and medium-sized enterprises (SMEs) have been working on the topics of increasing employer attractiveness and successful employer branding seeking research-based solutions.

8.4.1 Main Objectives and Background

Inspired by the success of the working group 'The attractive employer in geriatric care' (cf. Chap. 5) the additional working group 'Employer attractiveness in SMEs' was founded in order to work on the same topic but within the new context of regional SMEs from different branches. Therefore the topic needed an individual approach and own methods.

The main goal is to apply relevant scientific findings and derive practical recommendations for sustainable development in human resource management and enterprise leadership. Therefore the following questions are being asked:

1. What factors mark an SME as an attractive employer?
2. Is the employer attractiveness perceived differently by different groups of employees?
3. Do family enterprises have special characteristics which make them attractive to employees?
4. What measures are useful to raise the employer attractiveness in SMEs sustainably?

8.4.1.1 Members of the Working Group

Besides the representatives of Leuphana University of Lüneburg, the working group consists of nine small and medium-sized enterprises with an average of

154 employees. They are from diverse branches of the economy like drive and control technology, pharmaceutical services and logistics.

8.4.1.2 Employer Attractiveness and Employer Branding

Within recent years, business marketing has begun to focus on companies' own employees as a target group, since the image as an employer is seen as part of an enterprise's image as a whole. Creating an attractive 'employer brand' is intended to encourage high-performing staff to stay, to attract new talents and to raise the level of efficiency of all employees and thus bring a competitive advantage. But what makes an employer attractive? The working situation itself is complex and multi-levelled. Additionally each employee has individual demands according to his or her age, gender, life situation and personality. Following Berthon et al. (2005) employer attractiveness can be measured by the benefits or values the current and potential employees associate with working for an enterprise or organization. In a validated study, Berthon et al. (ibid.) identify five factors for an Employer Attractiveness scale (EmpAt): (1) Interest value, (2) Social value, (3) Economic value, (4) Development value and (5) Application value. With those definable features, a structured and differentiated analysis and evaluation of employer attractiveness becomes possible in order to reveal the strengths and weaknesses and to find overall attributes for an employer brand.

8.4.1.3 Family Enterprises

Following a definition from the 'Institut für Mittelstandsforschung Bonn', one of the most important national research groups in the field of SMEs in Germany, an enterprise is family-run if one or two natural persons or families hold more than 50 % of the voting stock and at the same time are members of the management board (Haunschild and Wolter 2010). In Germany about 95 % of all businesses fit into that definition. They employ about 57 % of the working population and achieve 41.5 % of the annual sales (ibid.). Despite many similarities and a huge overlap, family enterprises and SMEs are not the same, since some of the top-selling large-scale enterprises in Germany are family businesses, including Volkswagen, BMW or Aldi. However there is very little scientific research on family enterprises to date. The Family Influence on Power, Experience, and Culture Scale (F-PEC) offers for the first time a validated instrument to measure and distinguish family enterprises (Astrachan et al. 2002). Thereby it can be used as an initial point for systematic research on the specific attributes special to family enterprises, and is used by the working group 'Employer attractiveness in SMEs'.

Table 8.1 Supposed factors of employer attractiveness

Influencing factors	Indicating factors
Career prospects	Commitment to the job
Working situation	Commitment to the employer
Working atmosphere	Identification with the employer
Superior's leadership style	Job satisfaction
Achieved values from employment	Wish for continuing employment
Work-life balance	Recommendation of the employer
Training programs	

8.4.2 Method and Course of Action

The central element of the working group's task is an empirical study with two survey time-points. The employees are being surveyed using a standardized written questionnaire. The research focusses on factors which are supposed to influence the employer's attractiveness and those which indicate it (cf. Table 8.1).

The first survey took place at the very beginning of the cooperation of the working group revealing the initial status of the SMEs' individual employer attractiveness and their potentials for development. Subsequently, the SMEs are supposed to develop and implement measures for the preservation and enhancement of their employer attractiveness, at which they will be accompanied and advised by the working group. About half a year after the implementation of measures, the second survey will be carried out to analyse the effects on the employees. Comparing both survey time-points, the study can show what measures can be effectively used to raise employer attractiveness in SMEs.

8.4.3 First Results from the Study

The analysis of the study data is currently in progress. However first findings indicate that factors like location and flexible working hours are important components of a SME's attractiveness to employees. Other important aspects are a positive financial situation and high quality products. Focusing on the younger generation Y (born between 1981 and 2002), special attributes and expectations become visible. Personal development and work-life balance are revealed to be more important than economic benefits for many of them. Therefore future employer branding has to be planned and realized with a much more individualised approach to fit the needs of more employees.

8.5 Working Group ‘The Attractive Employer in Geriatric Care’

The working group ‘The attractive employer in geriatric care’ was founded in the context of the corporate network ‘Performance Management in Medium-Sized Businesses’. In this working group, ten facilities of inpatient nursing all across the convergence region (public sector, non-profit and commercial providers) with about 900 employees and Leuphana University of Lüneburg are working together to discover the essential characteristics of employer attractiveness in elderly care and to develop different strategies to improve their employer attractiveness.

8.5.1 *Background: The Demographic Shift and Shortage of Geriatric Nurses*

This working group is currently extremely relevant since the estimated need for qualified geriatric nurses is rising. The main driving influence is the demographic shift: very low birth rates and a rising life expectancy are causing an increasing percentage of elderly people in the German population, resulting in a rising number of elderly people in need of care. Demographics estimate an increase in the number of people in need of care from 2.5 million today to 3.4 million by the year 2030 (Rothgang et al. 2012; Bundesministerium für Gesundheit 2013) (Table 8.2).

Today, the largest percentage of persons in need of care is cared for at home with women as the main stakeholders in the provision of care. But the demographic shift is also being accompanied by changing social patterns, including smaller families, different residential patterns and increased female labor force participation (Dumeier 2012, p. 42).

These factors contribute to an increased need for professional geriatric nurses. In Germany, geriatric care is a profession with high requirements and high professional standards. To be a geriatric nurse, one needs full vocational training of up to 3 years. But few people decide to become professional geriatric nurses and many of them leave the job very quickly. The main causes are bad pay, a poor image of the profession and very difficult working conditions with shift work as well as physical and psychological stress.

As a result, we can already see a shortage of qualified geriatric nurses throughout Germany. This shortage will become worse: the gap between the supply and the demand for those professionals is estimated to be 500,000 full-time jobs by the year 2030 (Rothgang et al. 2012, p. 54; Enste and Pimpertz 2008; Pohl 2011). This problem can also be seen throughout Europe: shortages of care workers are expected or are anticipated in the care sector of many European countries (Bettio and Verashchagina 2010, p. 54). As Germany already has this problem today, other European countries will be able to learn from the German experience.

Table 8.2 (Estimated) number of people in need of care in Germany (in million) (own calculation based on Rothgang et al. 2012; Bundesministerium für Gesundheit 2013)

	Total number	Male	Female
2012	2.4	0.8	1.6
2020	2.9	1	1.9
2030	3.4	1.2	2.2

8.5.2 Objectives of the Working Group

As a consequence, the competition for qualified geriatric nurses among employers will be increasingly fierce. Where do specialists work when they have a choice? They will work for the most attractive employer (cf. Sect. 8.4.1.2). The question now is: What are the essential characteristics of employer attractiveness in geriatric care?

To answer this question, an initial employee survey was carried out, based on quantitative questionnaires. This survey included topics such as family friendliness, leadership, business culture, teams, work satisfaction and commitment to the employer. The questionnaire included among others the theory of organizational commitment (Meyer and Allen 1991) and was enriched by several specific questions on the work as a geriatric nurse. The main question to measure the employees' commitment to the employer was: Would you recommend your facility as an employer to other people?

Each facility received an individual report based on the analysis of the survey, and got a comparable benchmark based on all the facilities overall. The aim was to develop individual profiles of individual strengths and weaknesses of employer attractiveness.

8.5.3 Main Findings

In connection with the rate of recommendability as a work place, two main findings seem to contribute to the commitment to and the attractiveness of an employer.

Workplace health promotion: Professional care work is characterized by high physical and psychological stress. This leads to a high sickness rate/absenteeism due to illness. The improvement of physical and psychological health results in better stress management, coping with work load and in this manner to a lower sickness rate and higher job satisfaction—one of the main aspects of employer attractiveness.

Family-friendliness: Women represent around 85 % of German care workers (Statistisches Bundesamt 2013b, p. 9) and informal care givers for children and elderly are mostly female. Results of the working group such confirm that a good family-work balance with family-friendly working hours and/or possibilities for childcare in the workplace are very important.

8.5.4 *Different Approaches to Improve Employer Attractiveness*

The next step was the communication of the results to employees and the discussion of which topics should be addressed first or are most important. Each facility has an emphasis on particular topics, so it was clear that each facility needed an individual strategy to improve its attractiveness as an employer. Under the assumption that employees know best what they want and what they need, employees worked in different working groups independently from the management on several strategies to improve working situations and to create an attractive working place. These strategies have now been reviewed by the management of the facilities and put into practice.

One way to increase the family-friendliness of a care facility is to change its shift system. When the morning shift starts at 6 am (which is normal), it is impossible or difficult to care for children in the morning. When the shift starts at 8 am, a mother has the opportunity to bring her children to a day-care facility and is able to work from this time. Another aspect the working group is trying to improve is employee health through the introduction of a regular course of progressive muscle relaxation techniques and by incentives for using a bike instead of a car for the daily commute to work.

The facilities are following these strategies because of the results from the survey, their individual reports and several recommendations from Leuphana researchers and other members of the working group.

8.5.5 *Subsumption*

The working group is the basis for further work and the starting point for an organizational change process in care facilities. Although there are main trends in the findings for all the facilities overall, it can already be concluded that each facility needs its own specific strategy, i.e. individual solutions are required. Some managers of the working group's care facilities have already noted first improvements in the job satisfaction of employees due to changes, or at least due to a new dynamic at their workplace. It has already become clear that the direct exchange of knowledge and experience between care facilities and academia has a high benefit.

The final results of this process will be evaluated in November 2013 and published to be accessible for a broad audience. This will help other facilities and employers become attractive employers in geriatric care and solve the emerging problem of a wide shortage of highly qualified geriatric nurses. Further research has to be done on questions such as how to facilitate a permanent adoption of this change process.

8.6 Success Factors for Workable Cooperation Between Academia and Business

When academia and business work together, this provides the basic prerequisite for innovation, for a functioning business sector and for an efficient educational system—but it also presents the biggest challenge, for barriers continually obstruct the exchange between business and university. Research results, resources and personnel capacities are not sufficiently networked. It is the meeting of two cultures with distinct differences in communication, values and tasks. In Germany, the differences in mentality between the two sectors are still very considerable. In order to promote mutual understanding, academia and business must come closer to each other and establish a permanent interchange. This is what has been promoted and implemented over several years within the framework of the network ‘Performance Management in Medium-Sized Businesses’. We have tried to create a modern interface between business and academia and to build sustainable structures for the bi-directional transfer of knowledge. Our goal was to bring together the research-oriented culture of a university with the innovation-oriented environment of businesses. Out of our experience from the first half of the project it has been possible to derive the following action recommendations for setting up a workable cooperation between business and academia.

Key lessons for partnerships:

- University-business cooperation requires a strategic orientation; the leadership level of the university and company must stand behind them and propagate them.
- University-business cooperation must be set up to be as long-term as possible and always bi-directional.
- The right people are necessary, those who will act as bridge builders and who know both cultures. Trust is the central variable, and spatial nearness is also important.
- What is necessary is readiness and openness towards the cooperation, the right mind-set, but also competency on both sides (the university must come to terms with the needs of business; companies must show the ability to learn and absorb in order to apply the stimulation from research).

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Chapter 9

Principal Investigators and the Commercialization of Knowledge

Matthias Menter

Abstract The commercialization of scientific knowledge is playing an increasingly important role within the scientific community and especially for universities worldwide. Since policy makers expect an economic payoff from academic research and universities are faced with declining spending from the public sector, taking on technology transfer constitutes a new major objective of academia. As principal investigators (PIs) embody a key role within this process, scholars develop a growing interest in the unique skill and task set of these scientists. Therefore, this chapter highlights the process of commercialization of scientific knowledge as well as the role and concept of PIs by summarizing the existing strand of literature. Those researchers simultaneously act as project managers, negotiators as well as boundary spanners who bridge the gap between academia and industry. Getting a deeper understanding of the motives of PIs is crucial to provide an efficient infrastructure and facilitate the creation of research avenues fostering industrial innovation.

Keywords Principal investigators • Technology transfer • Technology transfer offices

9.1 Introduction

Universities increasingly face a paradigm shift concerning their traditional role in society as their tasks are expanded beyond teaching and research (Audretsch et al. 2014a). Known as the “third mission” of universities, taking on technology transfer and commercialization has become an emerging responsibility among academic institutions (Rasmussen et al. 2006). The answer toward the new challenges is a new policy, an academic entrepreneurship policy. Instead of managing and governing the status quo, universities have to change their missions and visions to cope with the new challenges. Like entrepreneurs, they have to seek

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opportunities to move towards the market and meet the needs of their stakeholders. A large and diverse literature analyzes the importance of universities within the regional and national innovation system highlighting the necessity of separate and specialized organizational units to manage university-industry collaborations (Hülsbeck et al. 2013; Schön et al. 2014).

This chapter summarizes concepts of knowledge-based innovation and the commercialization of knowledge and introduces the concept of principal investigators within this process. To stimulate the commercialization of faculty research, an adequate infrastructure has to be set up within universities to cope with these new challenges. Therefore, technology transfer offices (TTOs) have been established to strengthen the university-industry relationship (González-Pernía et al. 2013). Within the process of commercialization, TTOs are seen as the institutionalized way to transport and convey the ideas, inventions and innovations of academic researchers into the (regional) industry and society. However, the expected proactive role of TTOs within the technology transfer process is often not fulfilled (Hülsbeck et al. 2013). Despite growing interest in university-to-industry technology transfer, there are very few studies on the governance of universities' technology transfer offices. The few existing ones tend to focus on US universities and generally tackle one dimension of governance. One exception is Schön et al. (2014). They take into account the diversity of organizational models with a theoretical perspective and present a discussion on which combinations of structural dimensions should yield viable configurations. They conclude that measuring performance of TTOs without taking into account the governance characteristics, their degree of specialization and in particular the identification of the key players, such as principal investigators, may result in incorrect implications for management and policy makers. The awareness that key scientists increasingly coordinate and initiate entrepreneurial (research) activities and collaborations themselves and are the perhaps most valuable members of project teams leads to the concept of principal investigators as a role model in modern scientific research and knowledge transfer. This concept attracts scholars investigating how these scientists bridge the gap between academia, government, and industry (Casati and Genet 2014).

9.2 The Triple Helix and the Emergence of Principal Investigators

Knowledge and innovation are seen as one of the most important driving factors shaping economic growth and wealth, with universities being the main source of producing knowledge. A few decades ago, universities were recognized as a main source of knowledge spillovers and a means to serve as suppliers of scientific and technological knowledge. Since then, the relationship between academia and industry has been investigated intensively (Etzkowitz 1998; Gibbons et al. 1994;

Lee 1996). Firms try to benefit from close collaborations with universities as the originator of knowledge and innovation to gain competitive advantages. Several models have been set up to characterize the process of diffusion of knowledge, innovations and techniques (Acs et al. 2013; Ghio et al. 2014). Scholars in innovation economics have argued whether technological development (technology push) or demand factors (market pull) constitute the main cause for technological innovation (Rennings 2000). While these models only focus on distinct parts and aspects, Leydesdorff and Etzkowitz (1996) developed a model they called “Triple Helix” to capture the relationships and interrelations between the higher education sector (universities and research institutions), the private sector (new and established firms) and the public sector (government) more comprehensively. The traditional institutional differentiation is taken as a starting point for this concept. Due to the expanding role of the higher education and knowledge sector, this former separation has been softened over the time. Accordingly, this multi-stakeholder model focuses on the interactions of all institutions and the emergence of new structures such as research centers in universities or strategic alliances. In this context, the authors use the term hybrid organizations which tries to describe this constantly evolving complex system with its inherent dependencies (Etzkowitz and Leydesdorff 1999).

On the one hand, universities are directly affected by the government. Since financial resources are scarce, policy makers reduce the monetary support for faculty research and simultaneously aim to increase the economic payoff from academic research (Mansfield and Lee 1996). On the other hand, universities play an essential role in industrial innovation and are often seen as the engines of R&D-based economic growth (Feller 1990). Etzkowitz (2003) refers to this transformation from a research-oriented university to the entrepreneurial university by assigning entrepreneurial attributes to research teams and activities. Those “quasi-firms” within universities develop an inner dynamic with a clear focus on the commercial application of knowledge.

Etzkowitz et al. (2000) confirm that this pattern moving towards an entrepreneurial university exists. Since universities more and more become part of the knowledge infrastructure, academic knowledge plays an increasing role in industrial innovation. Policy makers expect universities to respond to the demand of industry and contribute to society by effectively using and transferring academic research (Buenstorf 2009). Universities are faced with declining spending from the public and governmental sector worldwide. This leads to university managers to increase the incentives for academics and scientists to collaborate with the industrial sector to close this financial gap. Worldwide, the private sector plays an ever more critical and important role in funding academic research (Gulbrandsen and Smeby 2005).

The commercialization of scientific knowledge has thus become a crucial task within academic research. The already mentioned paradigm shift of universities is very tangible in this field. Etzkowitz et al. (2000) metaphorically describe this transition as an evolution of ivory towers to an entrepreneurial paradigm. The establishment of technology transfer offices within universities to boost the commercialization of knowledge is a visible indication for this trend. The main idea of

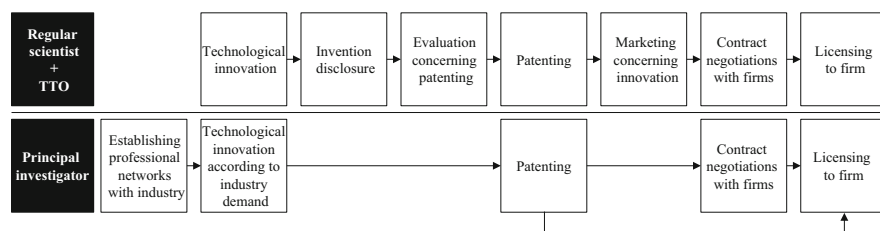


Fig. 9.1 TTO and PI involvement in the technology transfer process

TTOs was the support for scientists to come up with academic research which could be transferred into marketable products and services. Those intermediary institutions between university and industry should reduce transaction costs and simultaneously facilitate the sole focus of scientists on their actual research.

Nevertheless, the success of TTOs concerning the commercialization of knowledge has been discussed controversially (Siegel et al. 2003a). Hülsbeck et al. (2013) empirically investigated the performance of TTOs in Germany and concluded that the desired proactive role within the process of commercialization is often displaced by bureaucracy. Those institutions often lack the understanding of the formal and informal determinants of an effective technology transfer. Consequently, principal investigators themselves engage with industry in order to get to know the specific demands to produce and commercialize the required knowledge. Moreover, the creation of personal and professional networks is essential for those researchers to be known as an innovation incubator concerning a specific industry or topic.

The functional implications of those differences between TTOs and PIs are shown in Fig. 9.1. While the upper half of Fig. 9.1 expresses the role of scientists and TTOs (see Siegel et al. 2003b), the bottom half illustrates the different role of PIs within the process of commercialization. Whereas a regular scientist is dependent on commercial activities of TTOs, PIs are able to directly interact with industry partners. Since PIs are aware of future demands and needs, a more focused way of knowledge production can be pursued. Regular scientists have to disclose and let TTOs evaluate their inventions. In contrast, PIs can base their research activities on distinct industry demands and therefore shorten the patenting process. Subsequently, TTOs have to promote the patented inventions and find adequate firms to negotiate with. Due to the fact that PIs actively engage in their professional networks, PIs know future licensees prior to their actual research and thus do not need special marketing for their research. Concerning consultancy, PIs are even able to skip contract negotiations since a clear mandate and focus exists while starting research. Consequently, the time interval for technological inventions becoming marketable as well as transaction costs between the different actors within the commercialization process is reduced. Hence, the efficiency and performance of PIs concerning the commercialization tends to outweigh those of TTOs.

Besides the (academic) recognition within the scientific community as well as the industry, monetary bonuses play an essential role in commercial activities for

universities and scientists. Becoming a PI can be seen as an important milestone in the scientific career advancement concerning the creation of an international profile (O'Reilly et al. 2010). Due to the fact that those research programs are always linked to the scientists in charge, new career opportunities for such researchers are likely to evolve.

In order to obtain and be responsible for such third-party funding and to promote innovation, not only does the administrative premises concerning academic institutions have to be fulfilled, but also researchers with specific characteristics have to exist. Rasmussen et al. (2006) confirm this necessity as they state that most commercial activities are initiated and run by dedicated and highly motivated scientists. This adequate level of motivation has to be ensured by properly designed incentive systems within academic institutions (Henrekson and Rosenberg 2001). More generally, a policy has to be established which encourages science-based entrepreneurship and incentivizes commercial output.

The necessity of a high level of motivation has been investigated by Audretsch et al. (2010). Thus, the success of knowledge transfer is highly dependent on the willingness of scientists to commercialize their research findings. The commercialization of knowledge itself implies an intense collaboration with private firms or industry in general and embodies benefits as well as costs for the individual scientists. Therefore, principal investigators need to weigh the advantages and disadvantages of sharing their scientific results and promoting commercial usage of the created knowledge. For PIs, monetary as well as reputational rewards exist and have to compensate the associated drawbacks such as time-consuming, exhausting negotiations with industry partners concerning future trends.

Although, the general trend towards an entrepreneurial university exists, critics also consider the downsides of this development. Feller (1990) argues that the formerly “neutral” source of expertise could be lost by an increased interest of universities in monetary rewards. Moreover, scientists see the free flow of scientific knowledge to industry jeopardized through the commercialization of knowledge and the corresponding patenting (Etzkowitz and Leydesdorff 2000). In their opinion, this encapsulation of knowledge unnecessarily creates transaction costs and should be avoided. Due to that evolution, basic research with a long-term orientation is more and more replaced by applied research which focuses on the utilization of basic research. In this context, Bush (1945) talks about basic research as the “endless frontier” with an end in itself. Nowadays, this “endless frontier” is transformed—due to the above explained developments concerning the scientific environment—to an “endless transition” of knowledge through intermediate processes (Callon 1998).

Despite these potential drawbacks of commercialization concerning knowledge itself, policy makers mainly focus on the economic impact of the commercialization of scientific knowledge. Klofsten and Jones-Evans (2000) describe universities as catalysts for the improvement of employment opportunities for local industry. The authors characterize higher education as a significant force in regional economics and a supporter of the economic development. Consequently, regional and national governments are highly interested in knowledge-based industries and the

accompanying effects. Since universities serve as innovative think tanks, the regions around universities profit from the diffusion of new knowledge and technologies. These significantly positive effects on regions are known as university spillovers and describe the relationship between university research and innovative activities of entrepreneurial firms (Anselin et al. 1997). Therefore, fostering the commercialization of scientific knowledge is a governmental goal not for its own sake but to shape the competitiveness of regions (Audretsch et al. 2012a). Due to the fact that providing an adequate infrastructure and setting up an incentive system which enables not only the diffusion but also the adaption of new knowledge is difficult to institutionalize, scientists themselves engage in this complex process of commercialization. Principal investigators take on that challenge and try to bridge the gap between academia, government, and industry and create necessary networks which enable them to successfully promote their research.

9.3 Requirement Profile of Principal Investigators

The scientific landscape along with the traditional academic institution is changing, and thus actors of that transformation are faced with new challenges and tasks. Principal investigators are entering the academic landscape as actors, actively participating and shaping the new organization of science and thus simultaneously shaping the governance of research (Mangematin et al. 2014). As policy makers influence academia and industry by regulations and the institutionalization of (scientific) targets, those researchers interpret the given framework and build research avenues based on this set of rules (Casati and Genet 2014). Obviously, the tasks of PIs are beyond teaching and research as they actively engage and network with industry and government in order to be able to create a dialogue between all relevant players concerning the commercialization of knowledge.

Although there exists an extensive literature on the concept of technology transfer (Audretsch et al. 2012b, 2014b; Hülsbeck et al. 2013), a poor understanding concerning the actual role of principal investigators within this process exists at a micro level (Kidwell 2014). Since the research environment is constantly evolving, tasks related to research projects and the commercialization of knowledge are altering, too. Due to the globalization of research, multiple stakeholders are engaged in such projects and therefore require a distinct type of project leader who succeeds in achieving the desired targets. In this context, principal investigators act as the key agents and coordinate such (international) research programs. Boehm and Hogan (2014) consequently talk about PIs as “a jack of all trades” which exactly describes the diversity of tasks and duties those scientists have to face. Thus, successful principal investigators do not only engage in their specific area of research but also take on the role as project managers, negotiators, and resource acquirers.

O'Reilly et al. (2010) examined the task set as well as the specific role of PIs. Accordingly, the coordination of a research team as well as the planning and

scheduling of all research activities are essential obligations of PIs. Due to the multi-stakeholder environment, sometimes conflicting goals have to be streamlined. To minimize project risks and failure, often diverse projects are initiated simultaneously to spread risks and build up a project portfolio. However, budget and time restrictions counteract this approach. Consequently, PIs have to early place the focus on a distinct project set and act as the linchpin of every research program and be the primary contact point concerning institutional or project issues. In order to fulfill these tasks, an adequate research autonomy is required. Nevertheless, PIs are subject to distinct inhibiting factors concerning political, institutional, and project based factors which have to be overcome (Cunningham et al. 2014). Those challenges, PIs have to consider while conducting research projects, are manifold. Besides the administrative duties such as the report writing, the coordination of partners as well as the focus on project finances, especially the project work itself can be very demanding. Due to the existence of multi-stakeholder relationships, diverse opinions and expectations as well as different cultures clash and potentially provoke conflicts. Therefore, the tasks of PIs do not only consist of communicating and maintaining the project focus but also of adapting the project's direction if necessary. Since industry partners are often involved in such research programs and are interested in the rapid access to results, PIs additionally occupy the role of conciliators.

In this context, Casati and Genet (2014) identified the four main role models of PIs which enable them to perform the way they do: scientists, mediators, project leaders, and boundary spanners. As scientists they could rely on their specific human capital to evaluate scientific projects. They also should be a respected part in the scientific community to get the necessary expertise and advice from the scientific network. As mediators they should be able to motivate and coordinate the different stakeholders and their conflicting interests within the projects on a horizontal level. In contrast, as a project leader it is their ability to coordinate and motivate the participants on a vertical axes using incentives to shape the project in a positive way. As boundary spanners, PIs have to make use of their distinct networks to get to know the motives of the different actors within the process of commercialization. Only by understanding those driving factors, they can efficiently collaborate with all relevant stakeholders. All facets of PIs are important to successfully transfer and commercialize knowledge. Since those researchers have to produce applicable knowledge which can be used by industry, scientific know-how is required in a certain area of research. But not enough, PIs have to conceptualize tailor-made research programs to attract third-party supporters and get the required financial support. Since the research environment involves multiple stakeholders, PIs have to streamline different opinions to lead the project to success. Some scholars even designate the attribute of market shapers to PIs since those technology transfer agents serve as innovative sources for the industry and focus on the applicability of produced knowledge. Interdisciplinary networks of PIs facilitate the understanding of industry-specific demands and hence enable PIs to envision future market trends.

As it becomes obvious, fostering innovation and commercializing knowledge requires much more than just scientific know-how. Principal investigators are aware of future needs due to their deep understanding of the corresponding industry as well as their distinct networks within industry, academia, and government. This implies that principal investigators are team-players which actively look for the professional exchange with other scientists as well as practitioners. The establishment and management of stakeholder networks is essential since the actual support for such scientists as exemplified by TTOs is often limited. As a result, PIs are on the one hand responsible to build those collaborative networks and on the other hand reconcile mutual interests (Boehm and Hogan 2014). Some scholars even claim that those networks are the most crucial driver for scientific knowledge commercialization which implies the importance of PIs in relation to TTOs.

Besides the actual knowledge transfer, PIs are particularly critical concerning the knowledge application. The simple existence of literature concerning a specific new technology is not always sufficient enough for firms to make use of the produced scientific research. Thursby and Thursby (2004) talk about embryonic knowledge which critically depends on the participation of faculty to further develop ideas and thoughts. Due to the fact that firms steadily decrease their investments in R&D, the so-called absorptive capacities of those companies are limited. The goal of these firms is to understand the basic idea of faculty research and be able to monitor the collaborative development and application of early stage technologies. PIs therefore play an essential part not only in the creation but also in the adaption of produced knowledge.

Due to this influential role of PIs who constitute more than just sole scientists, Casati and Genet (2014) refer to PIs being scientific entrepreneurs. The main reason for this is that academic entrepreneurship fosters the technological development and contributes to the economic growth by getting deeply involved with industry partners. Many scholars equate academic entrepreneurship with the establishment of spin-off companies. However, as Klofsten and Jones-Evans (2000) explain, scientific entrepreneurship can have many more facets than just founding a new company apart from university. Besides the establishment of campus companies, undertaking specific research projects or getting involved in consultancy also belong to academic entrepreneurship activities. As PIs are expected to anticipate the future, those scientists have to have entrepreneurial spirit to understand the market and its actors. Additionally, such research programs are often tied to huge amounts of money, especially in natural science. Not having the ability to handle money responsibly might strongly contribute to project failure. Being an entrepreneur in science forms the basis for all commercial (research) activities.

The entrepreneurial role of principal investigators within personal and professional networks lies in the leading role of PIs concerning research projects. PIs incorporate scientific as well as managerial skills which are simultaneously required in scientific projects which aim to come up with marketable products or inventions. Consequently, the role of PIs includes many different facets which together make up such star scientists. However, beyond the actual research, common scientific obligations at the university such as mentoring, supervision, and the

traditional role as a professor engaged in teaching have to be disposed as well. Hence, principal investigators serve as a role model concerning the future trends of an evolving scientific environment (Mangematin et al. 2014).

Despite this scientific and entrepreneurial role, PIs have to stick to the core principles concerning science—the so-called “ethos of science”. This means nothing else other than remaining faithful to the own principals concerning fairness, transparency, integrity, responsibility, and discretion. Especially with regard to networks, this truthfulness forms the basis for all research activities. As reputation is critical in any type of business, ethical values have to be followed in order to fulfill the intended role associated with principal investigators.

9.4 Future Areas of Research

This chapter serves as a flashlight considering the aspect of the commercialization of knowledge and the involved scientist in this process, the so-called principal investigator. Although topics concerning technology transfer as well as the relationship between industry and university have been intensively investigated by scholars, the micro level of these processes has hitherto not attracted that much attention within the scientific community. Nevertheless, it is crucial to know about the motives of PIs as well as the actual activities and how those scientists succeed in their applied research projects. This insight is crucial for policy makers as well as for universities themselves to develop and implement adequate incentive systems as well as an efficient infrastructure concerning the commercialization of knowledge.

Since essential parameters concerning an efficient diffusion of scientific knowledge have already been examined (Feller 1990), scholars should now focus on getting a deeper understanding of the evolution of such scientists. Future research should answer the question how principal investigators evolve and differ from other or regular scientists in terms of character traits, social and scientific background. Are PIs with their inherent capabilities made or born? Furthermore, inferences have to be drawn from those potential differences concerning how PIs interact with their environment to be able to bridge the gap between the different institutions and act as boundary spanners. The investigated attributes which scholars designated on PIs, e.g. being a project manager, resource acquirer and star scientist could hereof serve as a starting point.

Another interesting area of research would be the examination of influences of PI activities on universities and encompassing regions. Since policy makers expect an economic payoff concerning research and PIs are seen as market shapers, the empirical investigation of the economic implications of PIs on regions constitutes a worthwhile scientific field. As the scientific as well as the social environment is rapidly changing, special consideration should be given to influencing factors such as PIs. Those researchers have the potential to shape the future of regions and economies. Consequently, more should be known about PIs and their direct and indirect implications on society. In order to be able to draw meaningful conclusions

from those investigations, the body of literature concerning PIs should prospectively focus mainly on empirical studies. Especially performance analyses of PIs in comparison to TTOs should be based on profound datasets.

To conclude, visions of PIs might significantly influence the future of society and therefore, more focus should be placed on the emergence of this new type of role model within scientific research. If policy makers are aware of the motives and needs of PIs, the necessary establishment of an adequate and fertile environment for PIs is likely to be successful.

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Part IV
The Role of the Regional Context

Chapter 10

Influences of the Regional and National Economic Environment on the Technology Transfer Performance of Academic Institutions in Europe

Franz Barjak and Nordine Es-Sadki

Abstract The paper looks how the national and regional environment influence the knowledge and technology transfer (KTT) performance of universities and public research institutes. We regress a number of institutional control variables, country dummies and variables for region size and economic structure, per capita income, technology intensity, and R&D intensity on four different tech transfer performance measures (R&D agreements with companies, patent applications, start-ups, licence agreements). Drawing on data from a survey of more than 200 European institutions we find: (1) Country differences are related to differences in the institutional set-up of technology transfer and to the (regional) economic environment which suggests multi-level analyses to properly take these interactions into account. (2) Institutions in a country usually excel for one performance measure which we take as a supporting argument for the development of transfer strategies. (3) Having manufacturing companies and a large share of governmental R&D expenditure in the region matter more than the technology intensity and R&D intensity of the regional economy. The latter result is counterintuitive and indicates that further research is needed in order to understand better where the clients of university technologies actually come from.

Keywords Technology transfer • Regional technology demand • Academic entrepreneurship • Regional innovation system

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10.1 Introduction

The amount of literature on the relationship of universities with their surrounding regions is sizeable and swiftly growing. Most theorizing and empirical research conducted by innovation economists, regional scientists and economic geographers has focused on the impact of universities on regional economies (for a review see Drucker and Goldstein 2007). Uyarra (2010) distinguishes five different roles which are ascribed to universities in this work: (1) knowledge factory, (2) relational university, (3) entrepreneurial university, (4) systemic university, and (5) engaged university. We have learned a lot from this body of research, for instance on the localised nature of knowledge spill-overs from universities, the attractiveness of top universities and their star scientists to business enterprises, the multiple channels of interaction between academia and business, the importance of academic entrepreneurship, the role of universities in regional innovation systems and many other issues. However, this research has also been described as too much based on evidence from universities in Anglo-Saxon countries and to some extent ignoring the complexity and diversity of universities and their limited ability of collective action (Uyarra 2010).

A lot less work has looked at this relationship from the university perspective investigating the question: How does the socio-economic environment shape the abilities of universities to deliver their services of higher education, research and engagement with society? Research has mostly focused on the regional engagement and technology transfer part of this wider question and generally found an advantage for universities in wealthier and more technology-intensive regions. For instance, a recent study on Spanish universities looked at the effects of the regional stock of knowledge in the business sector (measured as accumulated R&D expenses per firm) on universities' licence agreements and spin-offs (González-Pernía et al. 2013). Though it did not find any significant effects for the variables of interest, regional dummy variables still raised the explanatory power of the estimations which led the authors to conclude: "This means that there are other regional characteristics, beyond the two that we used in our tests [...], which can be useful to understand the behavior and capacity of regions for technology transfer" (González-Pernía et al. 2013, p. 14). Analysing data for universities from the UK, Chapple and her co-authors found strong influences for region-level variables, concluding that agglomeration effects might act upon the commercialisation of research (Chapple et al. 2005).

Of note, we do not want to suggest with this, that the regional environment is the most important let alone the only influence on transfer performance that is related to geography. To the contrary, we find a lot of truth in suggestions of a multi-level determination of university excellence—no matter whether in regard to teaching, research or transfer—and warnings of a too narrow focus of policies which try to raise the prominence of universities in regional innovation systems (Fromhold-Eisebith and Werker 2013; Power and Malmberg 2008). For this reason we find it

highly desirable to keep an open eye on the role of other spatial levels as well, from local to national and even international.

This article analyses these issues and contributes to our understanding of the importance of the regional environment and other spatial levels for technology transfer. Thanks to a sufficiently large multinational dataset that we put together in 2011 and 2012 on behalf of the European Commission, we could include control variables for countries in regressions on transfer performance measures and discover interaction effects with institutional characteristics (of the universities and their transfer offices). The estimations use a wider set of regional socio-economic characteristics than previous studies and assess their relationship to knowledge transfer performance. For the latter we use four measures: two that are closer to research (the number of research agreements and patent applications) and two that are closer to the market (the number of license agreements and start-ups established).

We first give a short overview of the relevant literature, then describe the sample and data collection methods, present key results and close with a discussion and conclusions.

10.2 Research on Knowledge Transfer Performance

Previous studies have evaluated the effect of a large number of factors that can affect knowledge transfer performance of universities and other public research organisations, including the characteristics and practices of the knowledge transfer office (KTO), the characteristics and policies of the affiliated institution, and of particular interest to this paper the characteristics of the external environment.

10.2.1 Characteristics of the KTO and the Institution

The establishment and design of a KTO, an office for knowledge and technology transfer, is often an institutional decision taken by the administration of the university or public research institute. Once established, many KTOs are able to make independent decisions in the area of IP management and knowledge transfer. This ability, combined with its age and experience, number and qualifications of its staff, degree of autonomy from the institution, organizational structure and degree of centralization of services can influence knowledge transfer performance (for reasons of brevity we omit references to the relevant literature, a review can be found in a sister paper to this article, see Barjak et al. 2015).

Several institutional characteristics and policies can influence performance as well; previous work points to ownership (public-private), size, the existence of science departments or a medical faculty, research excellence and business orientation, institutional by-laws and policies for instance with regard to IP protection

and management, licensing and the distribution of commercialization revenues (for supporting evidence see again Barjak et al. 2015).

10.2.2 *Regional Characteristics*

A number of studies on the transfer performance of universities controlled for the regional market environment for university technologies. Mainly four issues have been investigated in this context (see also for an overview Table 10.1)¹:

1. **Technology intensity of the regional economy.** Being located in a technology-intensive region has positive effects on the demand for technology from regional companies and a more entrepreneurial climate is to be expected. Empirical studies for US universities using the Milken Institute Tech-Pole Index indeed found positive effects of being located in a high-tech region on the numbers of licences (Friedman and Silberman 2003) and on licensing income (Belenzon and Schankerman 2009; Friedman and Silberman 2003; Lach and Schankerman 2008). The results for start-ups are inconclusive (Friedman and Silberman 2003; O'Shea et al. 2005). In addition, studies using other indicators for technology intensity could not reproduce this finding: the densities of high technology organisations and high technology employment have not been found to relate to the licences executed by a university in the AUTM survey (Sine et al. 2003). The number of patents held by regional firms does not contribute to explaining invention disclosures to German KTOs (Hülsbeck et al. 2013); neither does the number of regional patent applications have an effect on licences in Europe and the US (Conti and Gaule 2011)—however there is a weak positive correlation with licence income (ibid.).
2. **Research intensity of the regional economy.** According to Siegel et al. (2003, 2005) industrial R&D in the state has a positive effect on the licensing productivity of universities. This finding could also be confirmed for UK universities using regional R&D intensity (Chapple et al. 2005). A European multi-country study found no links between regional business R&D spending (BERD) and patent applications and contract research, but a positive correlation with the number of start-ups (van Looy et al. 2011). The accumulated R&D expenses per firm in Spanish regions did not contribute to explaining licence agreements or spin-offs of regional universities in the study cited already above (González-Pernía et al. 2013). Algeri et al. (2013) found a positive coefficient for R&D staff at regional level with regard to university start-up numbers.

¹ We abstract from a few other variables which also have been tested in individual studies, such as social capital [correlates positively with university spin-off numbers in Fini et al. (2011)] or industry concentration [the lower the concentration the higher the number of invention disclosures to German universities in Hülsbeck et al. (2013)].

Table 10.1 Overview of findings on regional level variables and transfer performance

Dependent variables (KTO level)	Independent concepts (regional level)			
	Technology intensity	Research in the private sector	Overall output	Venture capital
# Invention disclosures	/ Germany (Hülsbeck et al. 2013)		/ Germany (Hülsbeck et al. 2013)	
#Patent applications		/ Europe (van Looy et al. 2011)		
# R&D agreements		/ Europe (van Looy et al. 2011)	/ Germany (Dornbusch et al. 2012) ^a	
# Start-ups	+ US (Friedman and Silberman 2003) – US (O'Shea et al. 2005)	+ Europe (van Looy et al. 2011) + Italy (Algieri et al. 2013) / Spain (González-Pernía et al. 2013)		/ US (Di Gregorio and Shane 2003) / Spain (González-Pernía et al. 2013) + Italy (Fini et al. 2011)
# Licences	+ US (Friedman and Silberman 2003) – US (Sine et al. 2003) / Europe & US (Conti and Gaule 2011)	+ US (Link and Siegel 2005; Siegel et al. 2003) + UK (Chapple et al. 2005)	/ UK (Chapple et al. 2005) / US (Link and Siegel 2005; Siegel et al. 2003) ^b	/ Spain (González-Pernía et al. 2013)
Licensing income	+ US (Belenzon and Schankerman 2009; Friedman and Silberman 2003; Lach and Schankerman 2008) + Europe & US (Conti and Gaule 2011)	/ US (Siegel et al. 2003) + US (Link and Siegel 2005) / UK (Chapple et al. 2005) / Spain (González-Pernía et al. 2013)	+ UK (Chapple et al. 2005) / US (Link and Siegel 2005; Siegel et al. 2003) ^b	+ US (Warren et al. 2008)

+significant positive relationship, –significant negative relationship, /no significant relationship

^aHowever, the study obtained a positive coefficient for consultancy activities

^bAverage annual real output growth in the university's state

However, not only private sector R&D seems to matter, but also public sector activities, though it is not fully clear how. In studies with data for Italian universities, both, negative effects (Fini et al. 2011) as well as positive effects (Algieri et al. 2013) of regional governmental R&D expenses on university

spin-off numbers have been found. Sine and his co-authors suggest that competition might explain the reduction of the number of licences executed by universities which are close to other licensing universities (Sine et al. 2003).

3. **Regional income.** Previous studies tend to find that different regional income measures are unrelated to transfer performance. With data from a large scale survey of German professors at higher education institutions, Dornbusch et al. (2012) find a U-shaped influence of regional income (GDP per capita) on the frequency of professors' consultancy activities, but not on their involvement in R&D co-operations with local partners. They explain this with other factors than regional income that supposedly drive R&D co-operation. In the UK data set of Chapple et al. (2005) the regional GDP index raises the technical efficiency of KTOs with regard to licence income, but not with regard to the number of licences. In their estimations of licensing productivity of US universities, Link, Siegel and Atwater found that the average annual output growth in the state was not significantly related to productivity (Link & Siegel 2005; Siegel et al. 2003). Hülsbeck et al. (2013) do not find a relationship between GDP per capita in German regions and invention disclosures at universities.
4. **Venture Capital related activities.** Local venture capital activity does not correlate with higher start-up rates in the US (Di Gregorio and Shane 2003). Along the same lines, an analysis based on Spanish RedOTRI data does not show a link between regional VC per firm and university spin-offs or university licence agreements (González-Pernía et al. 2013). However, in a study with US AUTM data and an additional survey, the total operating costs of TTOs over total net licensing revenues are lower, the more VC is available within a 100 miles distance (Warren et al. 2008). Taking Netval data from Italy Fini et al. (2011) show that the regional financial development index, measured as the probability that a household is shut off from the credit market, is positively related to the number of university spin-offs.

10.2.3 *National Influences*

Rather few empirical studies have investigated the mechanisms through which the national research and innovation system determines universities' abilities to commercialize knowledge (the innovation system literature frequently takes the opposite perspective and focuses on the contributions of universities and other elements of the system to corporate innovation activities).

The key issue of concern has been the ownership of academic Intellectual Property for which most European countries have a national default rule. This influences who owns academic patents, though not one-to-one as enforcement of the law varies by country, research and funding institutions may issue specific rules, and some scientists will by-pass the law (Geuna and Rossi 2011; Lissoni et al. 2008). However, the national IP regulations are a powerful influence on

different formal channels of knowledge and technology transfer, such as research collaboration (Valentin and Jensen 2007) or licences (Conti and Gaule 2011).

Conti and Gaule (2011) included several institutional characteristics, a control variable for regional technology demand and country dummies in their estimations on licensing performance of European and US universities. In 12 out of the 15 - European countries universities had lower licence income than their US counterparts; only Denmark, Belgium and Switzerland had (insignificant) positive coefficients, i.e. slightly higher licence income; in the latter two countries universities even had a significantly higher number of licences than in the US.

10.3 Methodology

10.3.1 Data Collection

Data on universities and public research institutes were collected through two separate surveys that were piloted in 2011 and repeated in 2012. Each survey pair referred to the preceding year (2010 and 2011). The European Knowledge Transfer Indicator Survey (EKTIS) collected data on the characteristics of KTOs, a few characteristics of the affiliated university or public research institute, who owns the intellectual property for discoveries, and data on performance outcomes for 2010 and 2011. The survey focused on the leading research-intensive universities and research institutes in 39 countries including 27 EU member states and 12 countries associated to the European Framework Programmes for research, development and innovation. The sample was weighted by each country's share of total European Government and Higher Education R&D expenditures (GOVERD), with data collected for approximately 500 universities and research institutes combined. The response rate for the EKTIS survey was 57.0 % in 2011 and 55.9 % in 2012. The second survey used a sub-sample of EKTIS respondents to collect information on institutional and national policies for knowledge transfer and attained a response rate of 50.0 % in 2011 and 39.8 % in 2012. Full details on the survey methodology plus copies of the two questionnaires are provided by Arundel et al. (2013).

The two sets of survey data were then linked. The number of cases for analysis is increased by including all respondents for at least one of the two surveys. If a respondent replied to both surveys, the results for the most recent year (2011) are used. Since economic conditions, research funding and knowledge transfer policies in Europe did not change notably between 2010 and 2011, any biases due to combining years should be minor. The linked dataset includes 170 cases for which 2011 data are available and 118 cases for which only 2010 data are available.

Regional-level data was then added to each institution taking data for NUTS 2 regions of the classification of territorial units in Europe. 316 NUTS 2 regions, each having a population between 800,000 and 3 m inhabitants, have been assigned in the 27 EU member states, the four EFTA countries Iceland, Liechtenstein,

Norway, and Switzerland, and the five acceding and candidate countries Montenegro, Croatia, Macedonia, Serbia and Turkey (as of January 1st, 2013) (Eurostat 2013). The NUTS classification does not cover Albania, Bosnia-Herzegovina and Israel and consistent regional data could not be included which led to the exclusion of six universities from the analysis.

10.3.2 Variables

Dependent Variables We examine the correlation between the regional socio-economic environment, a set of control variables for countries and institutional characteristics and four dependent variables: the number of patent applications plus three variables that measure the potential for transferring commercially valuable knowledge from universities or public research institutes to private firms, i.e. the number of research agreements with firms, the number of licenses, and the number of start-ups established (see Table 10.2). Most studies, in particular those from the USA, focus on licences, licence income and/or start-ups (see Table 10.1). Although a patent is not required for knowledge transfer, the number of patent applications is included in the output variables because of previous research showing a strong link for European universities between licensing and patented inventions (Arundel and Bordoy 2009). Research agreements can be further from commercialisation than licensing or start-ups, but they can also involve solving specific problems with existing products or processes. In addition, patent applications and R&D agreements have rather been neglected in previous work (see Table 10.1).

Table 10.2 Key performance indicators for universities and public research institutes

	N ^a	Mean	Median	Standard deviation	Percent zero ^b
<i>Universities</i>					
Patent applications	228	14.3	6	24.1	18.4
Licenses executed	200	11.3	3.5	21.5	24.5
Start-ups formed	214	5.2	2	14.6	33.2
R&D agreements with companies	161	170.5	68	259.9	4.3
<i>Research institutes</i>					
Patent applications	38	14.6	6.5	22.3	10.5
Licenses executed	37	13.7	3	28.2	24.3
Start-ups formed	38	1.3	1	1.3	34.2
R&D agreements with companies	31	249	30	892.3	0.0

Source: MERIT, European knowledge transfer indicator survey 2011 and 2012

^aNumber of KTOs reporting results for each performance measure (including zero outcomes)

^bPercent reporting 'zero' for each outcome. For example, 18.4 % of 228 universities reported zero patent applications in 2010 and/or 2011

Although data are available for license income and invention disclosures, we do not provide regression results for these variables. The cross-sectional nature of our data does not permit to use licence income, because the amount of income earned in 2010 or 2011 can depend on inventions that were made long before the survey reference year, when the values of the independent variables may have been very different from their values in 2010 or 2011. Like others before us, we consider invention disclosures rather as an input into commercialization activities than a performance measure (Chapple et al. 2005; Friedman and Silberman 2003; Link and Siegel 2005; Siegel et al. 2003). However, to include invention disclosures as an explanatory variable in the regressions we would need lagged data which we do not have.

Independent Variables The control variables cover the key influences on transfer performance as assessed in the literature. Two KTO variables include the number of employees (KTO_SIZE) and its age and squared age to account for nonlinear effects of age (KTO_AGE, KTO_AGE2, see Table 10.3). The three institutional variables include the number of researchers NUMB_RES (research output is expected to be closely correlated with this variable), if the institution has a hospital (HOSP), coded as 1 when present and 0 otherwise, and the type of institution, coded as 1 when a university and 0 if a public research institute (UNIVERSITY). The variable for the presence of a hospital is included to capture activity in health sciences while the type of institution is an important factor in the use of licensing and start-ups. The full data set shows that the former is more common in public research institutes and the latter is more common in universities. We also include a control variable for ownership status (OWNERSHIP), coded as 1 when the

Table 10.3 Descriptive statistics of independent dummy variables

	Universities			Research institutes		
	N	Yes	Percent	N	Yes	Percent
<i>Characteristics of the KTO and institution</i>						
HOSP: Institution has a hospital	247	49	19.8	40	1	2.5
OWNERSHIP: IP is owned by institution or companies (inventor or other = 0)	245	131	53.5	40	29	72.5
<i>Country dummies</i>						
AT: Austria	249	8	3.2	44	1	2.3
DE: Germany	249	49	19.7	44	17	38.6
DK: Denmark	249	6	2.4	44	2	4.5
FR: France	249	20	8.0	44	6	13.6
IE: Ireland	249	10	4.0	44	0	0.0
IT: Italy	249	18	7.2	44	3	6.8
NL: The Netherlands	249	6	2.4	44	2	4.5
ES: Spain	249	25	10.0	44	2	4.5
SE: Sweden	249	9	3.6	44	0	0.0
CH: Switzerland	249	8	3.2	44	4	9.1
UK: United Kingdom	249	40	16.1	44	2	4.5

institution or companies own the IP and 0 if the inventor or other parties own the IP. We furthermore include a set of country dummies for the eleven most frequent countries in the data set, to control for latent national specificities of the academic system and framework for knowledge and technology transfer.² These eleven countries contribute more than 80 % of the observations, the remaining 20 % of observations are contributed by 21 other European countries.

The independent variables of interest include indicators to control for the regional market environment for technologies developed by public research organisations. The data have been extracted from Eurostat (see Table 10.4).

- GDP in billion PPS in 2010, was included to control for the size of the region. Two other independent variables reflect the region's industry structure, regional employment shares in industry and in services, both for the year 2011. Employment in industry is measured by aggregating NACE sectors B-F and employment in services is measured by NACE sectors G-L.
- Average regional GDP per capita over a 3 year period (2008–2010) is used to measure regional income; squared regional GDP per capita serves to investigate whether regional income exerts a non-linear effect, as suggested by Dornbusch et al. (2012).
- The average EPO patent applications per million inhabitants in a region over a 3 year period (2008–2010) capture the technological intensity of a region.
- Two additional variables are used to measure business sector research activities: The average share of business enterprise expenditure on R&D (BERD) in gross domestic expenditure on R&D (GERD) reflects whether a region has a strong business research sector (or governmentally-funded R&D sector by taking the inverse); the average share of BERD in GDP measures regional R&D intensity. Both variables are calculated over a 3 year period (2008–2010).

A suitable indicator for regional VC availability that has been found as important in previous national analyses of transfer performance (see above) could not be included due to a lack of comparable data.

10.3.3 Analytical Methods

The independent variable in all regressions consists of the number of outcomes, using count data. As there are a significant number of zero responses (see Table 10.2), we use a negative binomial model appropriate for count data.

The regressions were first conducted using a dummy variable for the survey year (2011 versus 2010). The variable had no effect on any of the results except for the

² This covers (number of observations in brackets): Germany (66), the UK (42), France (29), Spain (27), Italy (21), Switzerland (12), Ireland (10), Sweden (9), Austria (9), the Netherlands (8), and Denmark (8).

Table 10.4 Descriptive statistics of independent variables

	Universities			Research institutes				
	N	Mean	Median	Standard deviation	N	Mean	Median	Standard deviation
Characteristics of the KTO and institution								
NUMB_RES: Number of researchers	211	2054.7	1500.0	2116.0	37	1618.3	971.0	2918.7
KTO_SIZE: KTO staff in FTE	247	9.3	5.0	11.3	40	9.1	5.3	10.7
KTO_AGE: age of KTO in years	221	12.0	9.0	9.3	38	18.97	13.5	18.6
Regional characteristics								
GDP_BIL_PPS: GDP in billion PPS	241	87.3	54.9	95.2	43	118.0	84.8	122.1
EMPL_INDUSTRY: Employment share in industry	245	0.2	0.2	0.1	44	0.2	0.2	0.1
EMPL_SERVICES: Employment share in services	245	0.3	0.3	0.1	44	0.3	0.3	0.1
GDP_CAP: GDP per capita in 10,000 €	249	29.5	27.7	14.5	44	34.1	31.6	12.9
BERD_GERD: Business enterprise R&D expenditures in percent of Gross R&D expenditures	244	55.4	58.5	19.5	43	54.0	55.8	17.5
BERD_GDP: Business enterprise R&D expenditures in percent of GDP	242	1.2	1.0	1.0	42	1.7	1.3	1.3
PATENTS_REG: EPO patent applications per million inhab.	244	132.7	101.6	123.5	43	217.0	177.4	161.9

number of licenses, indicating that license activity declined in 2011. However, the dummy variable for the survey year had no effect on any of the regional variables and is consequently not included in the final regressions given below.

The control variable for KTO age is the independent variable with the largest number of item missing values reducing the sample in the estimations by up to 23 cases. For this reason and in order to identify interactions between the experience of an institution with technology transfer and the other independent variables we estimated each model with and without the KTO_AGE variables. Each table includes the AIC value (Akaike Information Criterion), a goodness-of-fit measure in which smaller values are preferable.

10.4 Results

10.4.1 *R&D Agreements with Companies*

With regard to R&D agreements with companies we have the highest percentage of item non-responses of the four dependent variables contributing to the exclusion of 39–53 % of all cases (depending on missing values for independent variables). Hence, the estimations for this variable are the least precise among the four considered variables. As expected, the size of the institution (NUMB_RES) consistently contributes to explaining the variance of R&D agreements with companies across institutions (see Table 10.5). The older the knowledge transfer office (KTO_AGE) the more R&D agreements with companies were concluded; however, the effect is nonlinear. The relationship between the age of the KTO and the dependent variable is probably not causal, but an indication that more industry- and transfer-oriented universities established their transfer offices earlier.

The national context is of considerable importance as the country dummy variables show. We observe consistently negative coefficients for Sweden and Germany; i.e. institutions conclude fewer R&D agreements than in the heterogeneous set of other countries for which we did not include separate country dummies. At the same time the OWNERSHIP variable (1 for institutional/company ownership, 0 for inventor ownership) becomes insignificant, indicating that the country dummies capture its effect at least partially. The country dummies for Ireland and Italy are also negative and their impact increases in size in regressions that include control variables for the regional share of corporate R&D, corporate R&D intensity and technology intensity. In particular due to the low share of corporate R&D (BERD_GERD) in Irish and Italian regions and the low technology intensity (PATENTS_REG) the universities and research institutes in these two countries don't perform *worse* (for an explanation see below).

A consistently positive coefficient is observed for the Netherlands. Spanish institutions concluded significantly more R&D agreements compared to other countries but only in estimations that excluded the control variables for the KTO

Table 10.5 Regression results for R&D agreements

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
N	159	180	159	180	152	173	151	172
AIC	1909.975	2139.644	1891.368	2121.898	1813.049	2041.041	1799.436	2026.198
CONSTANT	3.462**	3.891**	3.362**	3.845**	1.057	1.377	0.368	1.348
NUMB_RES	0.366**	0.428**	0.342**	0.364**	0.305**	0.338**	0.285**	0.342**
KTO_SIZE	0.022*	0.006	0.002	-0.004	0.002	-0.004	0.006	-0.003
HOSP	-0.220	0.010	-0.195	-0.011	-0.127	0.106	-0.014	0.208
UNIVERSITY	-0.117	-0.044	0.161	0.302	0.038	0.164	0.178	0.269
OWNERSHIP	0.187	0.291+	0.046	0.147	0.284	0.395*	0.110	0.220
KTO_AGE	0.084**		0.102**		0.106**		0.097**	
KTO_AGE2	-0.002**		-0.002**		-0.002**		-0.002**	
AT			0.647	0.517	0.024	-0.191	-0.170	-0.189
DE			-0.594*	-0.422+	-1.083**	-0.971**	-1.264**	-1.086**
DK			0.548	0.564	0.224	0.108	-0.618	-0.366
FR			0.046	0.300	-0.298	-0.132	-0.377	-0.282
IE			-0.635+	-0.787*	-0.493	-0.713	-0.855+	-1.103*
IT			0.037	0.122	-0.782+	-0.833+	-1.757**	-1.707**
NL			1.345**	1.548**	1.779**	1.789**	1.437*	1.384*
ES			0.252	0.653+	0.427	0.756+	0.218	0.386
SE			-2.567**	-2.527**	-2.851**	-2.939**	-2.865**	-2.929**
CH			0.151	-0.007	0.129	0.023	0.993+	1.187*
UK			-0.163	-0.127	0.213	0.231	0.211	0.137
GDP_BIL_PPS					0.001	0.001	0.002	0.002
EMPL_INDUSTRY					8.309**	7.970**	11.525**	9.621**

(continued)

Table 10.5 (continued)

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
EMPL_SERVICES					-0.943	-1.218	-1.846	-3.147
GDP_CAP					0.030	0.055*	0.133**	0.139**
GDP_CAP2					0.000	-0.001*	-0.001**	-0.001**
BERD_GERD							-0.027**	-0.019**
BERD_GDP							0.137	0.124
PATENTS_REG							-0.002+	-0.003**

Source: MERIT, European Knowledge Transfer Indicator Survey 2011 and 2012

*p<0.05; **p<0.01; + p<0.1

age. In other words, the observed results for Spain are mainly due to the fact that KTOs are comparatively old (in fact almost 75 % in our sample were established before the year 2000), reflecting that institutions placed a focus on tech transfer some time ago and built up knowledge on how to collaborate with the corporate sector in R&D.

Among the regional level variables we observe no consistent effect for region size (GDP_MIL_PPS) and employment in services (EMPL_SERVICES). The share of employment in industry (EMPL_INDUSTRY) is strongly positive, suggesting that the primary corporate clients of universities and public research institutes for R&D agreements are manufacturing companies. GDP per capita is positive and significant. The inverse sign of the squared GDP per capita variable points to a U-shaped effect.

The share of corporate R&D expenditure to total regional R&D expenditure (BERD_GERD) is negative and significant. Conversely, the share of governmental R&D expenditure must have a positive effect on R&D agreements. We do not have a straightforward explanation for this, except that the BERD-GERD-share probably does not measure the absorptive capacity of companies—which is rather measured by the (non-significant) relationship of BERD to GDP—but whether a critical mass of non-corporate and predominantly public research exists in a region. If this is not the case, this is very likely the limiting factor and companies are unable to find academic research partners in this case. For patent applications per capita (PATENTS_REG) we observe a negative correlation. This indicates that in regions with a strong corporate technological basis firms work less with their regional academic partners. If they would do R&D only by themselves, we would observe a positive coefficient for R&D intensity which is not the case; another explanation could be that companies cooperate in R&D with partners from outside their region.

10.4.2 Patent Applications

Patent applications are the second dependent variable of transfer performance that is close to commercialisation. Among the included control variables the size of the institution (NUMB_RES) and of the transfer office (KTO_SIZE), and the age of the KTO are significant with the expected positive coefficients (see Table 10.6); the relationship for KTO_AGE is again nonlinear.

Most country dummies are insignificant, indicating that national differences are not a prominent influence on academic patenting in Europe—this might be surprising, but one should bear in mind that there has been a considerable homogenization with regard to IP ownership in European academia between 2000 and 2010. However ownership still matters (see model 1b) and the two countries with deviant ownership regimes for academic inventions, Italy and Sweden, still stick out. There the coefficients are negative, very likely a consequence of the fact that faculty may patent inventions outside of the institution. For France we also observe a negative

Table 10.6 Regression results for patent applications

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
N	212	235	212	235	204	227	202	225
AIC	1487.491	1646.374	1493.569	1653.066	1431.479	1587.724	1425.204	1577.764
CONSTANT	1.299**	1.427**	1.610**	1.712**	0.153	0.406	-0.196	0.104
NUMB_RES	0.258**	0.293**	0.275**	0.318**	0.311**	0.355**	0.303**	0.338**
KTO_SIZE	0.024**	0.025**	0.025**	0.021**	0.024**	0.019*	0.026**	0.020*
HOSP	0.024	-0.012	0.007	0.026	0.145	0.179	0.165	0.240
UNIVERSITY	-0.077	0.021	-0.153	-0.054	-0.173	-0.099	-0.161	-0.116
OWNERSHIP	0.226	0.259+	0.166	0.232	0.283	0.307+	0.203	0.218
KTO_AGE	0.043*		0.051*		0.033		0.031	
KTO_AGE2	-0.001*		-0.001**		-0.001*		-0.001*	
AT			-0.135	-0.272	0.119	0.052	0.041	-0.029
DE			-0.275	-0.184	-0.023	0.018	-0.030	-0.019
DK			-0.245	-0.158	0.383	0.504	0.251	0.306
FR			-0.730*	-0.675*	-0.369	-0.337	-0.348	-0.354
IE			-0.110	0.011	0.507	0.620	0.460	0.531
IT			-0.633*	-0.593+	-0.776*	-0.740*	-1.049*	-1.130**
NL			-0.107	-0.134	0.686	0.603	0.618	0.431
ES			-0.644+	-0.433	-0.353	-0.225	-0.410	-0.333
SE			-1.443**	-1.437**	-0.850+	-0.843+	-0.771	-0.731
CH			-0.423	-0.439	0.436	0.472	0.788	0.904+
UK			-0.307	-0.087	0.328	0.453	0.322	0.402
GDP_BIL_PPS					0.001	0.001	0.001	0.001
EMPL_INDUSTRY					3.712*	3.321*	4.992*	4.880*
EMPL_SERVICES					2.883	2.504	3.536	3.065

GDP_CAP					-0.029	-0.030	-0.006	0.003
GDP_CAP2					0.000	0.000	0.000	0.000
BERD_GERD							-0.011	-0.014*
BERD_GDP							0.091	0.088
PATENTS_REG							-0.001	-0.001

Source: MERIT, European knowledge transfer indicator survey 2011 and 2012

*p<0.05; **p<0.01; + p<0.1

coefficient which is significant as long as we do not include regional GDP to control for region size.

Employment in industry (EMPL_INDUSTRIY) is again a significant regional level predictor. As for R&D agreements, we observe a negative coefficient for the share of corporate R&D to total regional R&D (BERD_GERD) which we would explain in the same way.

10.4.3 Licence Agreements

For licence agreements which are closer to the market than the two previously discussed performance measures we obtain positive correlations for the control variables on size of the institution (NUMB_RES), size of the KTO (KTO_SIZE), age of the KTO (nonlinear, see KTO_AGE and KTO_AGE2), existence of a hospital (HOSP) and a negative correlation for universities, i.e. more licence agreements in non-university institutes (see Table 10.7).

Country dummies are consistently positive for Ireland and the UK; for Switzerland only, as long as regional level variables measuring income, research and technology intensity are not included. In Sweden a significant negative coefficient is observed in all models, the dummy variable for Italy is negative but not significant in contrast to the results found for patent applications. With regard to the regional level variables, we observe a non-linear relationship for GDP per capita similar to R&D agreements. We also obtain a small positive effect for regional patent applications per capita (PATENTS_REG); in other words, the higher regional technology intensity, the more licence contracts were concluded by the academic institutions in the region.

10.4.4 Start-ups Established

The last dependent variable stands for the number of start-ups that were established by an institution which is also a transfer result that is close to the market; size of the institution (NUMB_RES), size of the KTO (KTO_SIZE), and being a university correlate positively with the number of start-ups (see Table 10.8). The variable for KTO age slightly misses significance at the 10 % level.

Institutions in Germany, Ireland, Sweden, and Switzerland also are particularly successful with regard to establishing start-ups. At first sight, the same seems to be true for UK institutions. However, once we include the control variable for the age of the KTO, the dummy for the UK reverses the sign, and in models 2a and 3b we even observe significant negative coefficients for the UK. This suggests, that only due to their longer experience British universities are more successful with regard to establishing start-ups. Other aspects of the national environment in the UK are

Table 10.7 Regression results for licence agreements

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
N	196	218	196	218	189	211	188	210
AIC	1245.078	1478.091	1196.154	1394.418	1153.539	1345.200	1138.555	1332.780
CONSTANT	1.263**	2.370**	1.246**	1.889**	0.985	1.906	0.540	1.736
NUMB_RES	0.198**	0.196**	0.285**	0.295**	0.291**	0.302**	0.261**	0.281**
KTO_SIZE	0.040**	0.028**	0.025**	0.004	0.022*	0.002	0.018+	0.000
HOSP	0.204	0.172	0.570**	0.746**	0.369	0.548*	0.424+	0.558*
UNIVERSITY	-0.608**	-0.608**	-0.888**	-0.973**	-0.760**	-0.867**	-0.471+	-0.542*
OWNERSHIP	-0.050	-0.430**	-0.179	-0.243	-0.137	-0.205	-0.041	-0.114
KTO_AGE	0.083**		0.065**		0.048*		0.059*	
KTO_AGE2	-0.002**		-0.002**		-0.001**		-0.002**	
AT			-0.398	-0.584	-0.667	-0.829	-0.984+	-1.036+
DE			0.448+	0.410+	0.256	0.103	-0.284	-0.307
DK			-0.519	-0.481	-0.990+	-1.018+	-1.520**	-1.311*
FR			-0.393	-0.427	-0.389	-0.499	-0.202	-0.239
IE			1.264**	1.167**	1.032*	0.957*	1.383**	1.357**
IT			-0.331	-0.342	-0.357	-0.413	-0.384	-0.299
NL			0.651	0.737+	0.354	0.297	0.253	0.330
ES			-0.171	0.173	0.147	0.408	0.330	0.672
SE			-3.773**	-3.723**	-4.028**	-4.172**	-4.339**	-4.460**
CH			0.694+	0.884*	0.488	0.740	-0.358	0.140
UK			1.441**	1.744**	1.552**	1.737**	1.758**	1.939**
GDP_BIL_PPS					-0.001	-0.001	-0.002	-0.002
EMPL_INDUSTRIY					-0.172	-0.777	-0.100	-1.261
EMPL_SERVICES					-3.484	-4.665	-0.652	-2.269

(continued)

Table 10.7 (continued)

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
GDP_CAP					0.085**	0.094**	0.074*	0.067*
GDP_CAP2					-0.001**	-0.001**	-0.001*	-0.001*
BERD_GERD							-0.016*	-0.012+
BERD_GDP							0.002	0.056
PATENTS_REG							0.004**	0.004**

Source: MERIT, European knowledge transfer indicator survey 2011 and 2012

*p<0.05; **p<0.01; + p<0.1

Table 10.8 Regression results for start-ups

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
N	207	229	207	229	222	200	220	198
AIC	914.868	1146.422	878.323	1103.977	1082.333	862.289	1072.188	854.974
CONSTANT	-0.672*	-0.111	-1.097**	-0.861*	3.597	0.707	3.388+	0.032
NUMB_RES	0.186**	0.166**	0.180**	0.199**	0.191**	0.190**	0.182**	0.184**
KTO_SIZE	0.015+	0.030**	0.038**	0.018*	0.015+	0.036**	0.013	0.037**
HOSP	-0.449*	-0.741**	-0.341	-0.342	-0.379	-0.371	-0.352	-0.347
UNIVERSITY	1.031**	1.379**	0.875**	1.072**	1.021**	0.845**	1.137**	0.936**
OWNERSHIP	0.308+	-0.404*	0.199	-0.103	-0.087	0.294	-0.174	0.191
KTO_AGE	0.035		0.036			0.040		0.033
KTO_AGE2	-0.001+		-0.002*			-0.002*		-0.001*
AT			-0.130	-0.132	0.047	-0.265	-0.001	-0.365
DE			1.181**	1.068**	0.933**	0.883**	0.801*	0.755*
DK			-0.543	-0.300	-0.556	-0.881	-0.638	-1.123
FR			-0.532	-0.420	-0.954+	-0.893+	-0.905+	-0.818
IE			0.846+	0.730+	0.895+	0.865+	1.035*	0.987+
IT			0.388	0.364	0.185	0.138	-0.187	-0.361
NL			0.235	0.580	-0.112	-0.349	-0.095	-0.424
ES			0.074	0.221	0.372	0.017	0.356	0.006
SE			1.744**	1.722**	1.019+	1.157*	1.095*	1.338*
CH			0.592	0.772+	0.531	0.080	1.330*	1.360*
UK			-0.819*	1.665**	1.359**	-0.742+	1.553**	-0.500
GDP_BIL_PPS					0.001	0.000	0.002	0.001
EMPL_INDUSTRY					-4.181+	-1.888	-2.271	1.059

(continued)

Table 10.8 (continued)

MODEL	1a	1b	2a	2b	3a	3b	4a	4b
EMPL_SERVICES					-10.948**	-6.163	-10.666*	-4.943
GDP_CAP					-0.007	0.042	0.014	0.074*
GDP_CAP2					0.000	-0.001+	0.000	-0.001*
BERD_GERD							-0.017**	-0.020*
BERD_GDP							0.210+	0.146
PATENTS_REG							-0.001	0.000

Source: MERIT, European knowledge transfer indicator survey 2011 and 2012

*p<0.05; **p<0.01; + p<0.1

less conducive for academic entrepreneurship—however, our survey does not reveal which factors might be particularly problematic in the UK.

Among the regional variables we observe a strong negative effect for the share of employees in services (EMPLY_SERVICES), i.e. if this is high, we find fewer start-ups *ceteris paribus*. We lack an explanation for this result. Notably, we also observe a negative coefficient for industry employment (EMPL_INDUSTRY) though this is usually insignificant. The U-shaped relationship for GDP per capita that we already found for R&D agreements and licence agreements also comes up for start-ups in model 4b.

The share of corporate R&D to overall R&D (BERD_GERD) is again negative and significant, and the regional R&D intensity (BERD_GDP) is positive in one of the “full” models (without KTO_AGE) but slightly misses significance in the other one (with KTO_AGE). Regional technology intensity of the economy (PATENTS_REG) does not play a role for academic start-ups.

10.5 Discussion and Conclusions

We focus in this paper on national and regional level influences on the performance of technology transfer offices of European universities and non-university research institutes.

10.5.1 Country Results

It comes with little surprise that IP ownership differences matter. The effect is strongest for Sweden which sticks out for all four dependent variables, either positively (start-ups) or negatively (R&D agreements, patent applications and licence agreements). For research-related measures it can also be seen for Italy. However, the findings still permit the interpretation, that institutions are just less involved in the commercialization of academic research results in Sweden and Italy, and that its overall level is not lower, but simply more often taking place in direct relations between faculty and companies, as others have suggested (Jacobsson et al. 2013; Lissoni et al. 2008).

Ireland and the UK are the countries which stand out as those where institutions are most effective in generating market-related outcomes of their inventions and technologies. Institutions in Germany and Switzerland generate more start-ups than their peers in other countries. However, in Germany, Ireland and the UK this result is obtained on the back of research-related outcomes of commercialization: German and Irish institutions concluded significantly fewer R&D agreements with companies than their peer institutions in most other countries. With regard to start-ups, the good performance of institutions in the UK is mostly due to the long existence of the transfer offices and (presumably, as we did not measure this directly) their

bigger experience in the tech transfer business. Once we control for the founding date of the KTOs, the coefficient for the UK changes its sign. In Switzerland, it is the other way around, indicating that the KTOs of Swiss institutions which are relatively young still need to build up this start-up experience. Switzerland is also particular with regard to R&D agreements and patent applications: whereas the institutions don't perform well if regional characteristics are excluded, this changes in the most complete models 4a and 4b when regional income, research intensity and technology orientation are also included.

Dutch institutions seem to put a clear focus on R&D agreements with companies: the coefficient for the Netherlands is consistently bigger than for all the other countries and significant. For none of the other three performance measures we observe a clear result for the Netherlands. Spanish universities and research institutes also perform better on R&D agreements than their peers in most other countries, but only if we exclude the control variable for the founding date of the KTO. If we include this variable, the coefficient becomes smaller and insignificant. In other words, Spanish institutions perform better on R&D agreements mostly because of the age (and presumably experience) of their transfer offices.

For Austria and Denmark the results are mostly not different to the set of other countries and for France we observe a negative and weakly significant coefficient for start-ups.

10.5.2 Results for Regional Characteristics

Size of the region, measured through regional GDP, is not correlated to any of the four performance measures. However, sector structure contributes to explaining the transfer performance of the region's public research institutions:

- A strong base in manufacturing is positive for R&D agreements and patent applications; this could be an effect of a larger client base in industry for R&D agreements and academic patents which are frequently only applied for, if an industry partner shows interest in the invention;
- A large share of service employees in total regional employment is negative for start-ups.

For regional GDP per capita we observe inverse U-shaped effects for three of the four performance measures (R&D agreements, licence agreements, start-ups established). The top five regions in our dataset with the highest per capita income are London, Luxembourg, Oslo, Zurich and Hamburg—all five are characterised by financial and insurance activities, real estate activities, professional, scientific and technical services which are not the typical clients of academic R&D and licences. The coefficients for GDP tend to become larger the more other regional characteristics are included in the estimations. Above all the regressions on R&D agreements and start-ups indicate that a weak regional economic climate (low GDP) might be compensated by a dedicated focus on public R&D spending (the inverse of

BERD_GERD which reflects the share of corporate R&D spending to total regional R&D spending). In other words: universities in economically weak regions may raise their number of R&D agreements with companies (presumably from outside the region) and start-up numbers thanks to their R&D activities.

Including an indicator for the split of governmental/public and corporate R&D expenditures generates the interesting finding, that the larger the share of corporate expenditures, the smaller all four performance measures. We suggest that a large share of corporate R&D to total R&D in a region might indicate a lack of critical mass in public research which could reduce any of the transfer outcomes.

For regional technology intensity, measured as patent applications per capita, we observe a *negative* coefficient for R&D agreements and a *positive* coefficient for licence agreements. While the result for licences confirms some previous US papers (Belenzon and Schankerman 2009; Friedman and Silberman 2003; Lach and Schankerman 2008), the result for R&D agreements seems counterintuitive. Technology-intensive firms should demand R&D services from academic institutions. A possible explanation could be that technology-intensive companies would select their research partners more according to excellence than geography. However, wouldn't they select the technologies which they licence according to the same logic and shouldn't we expect a correlation between licences and R&D agreements, e.g. to carry out follow-up R&D after a licence contract has been closed? We lack a satisfactory explanation for this counterintuitive result.

For regional research intensity (BERD_GDP), we only observe one significant positive coefficient in model 4a on start-ups. This essentially confirms van Looy et al. (2011). In particular for licence agreements, we only got a positive result if we omitted several other regional variables from the estimations (GDP_CAP2, BERD_GERD, PATENTS_REG, result not shown). Our results cannot be compared to previous work on the US (Link and Siegel 2005; Siegel et al. 2003) or on the UK (Chapple et al. 2005) as those used different specifications.

10.5.3 Conclusions

The paper teaches us a number of lessons with regard to assessing the performance of universities and public research institutes in the area of knowledge and technology transfer.

First, comparisons of transfer performance at country level need to take a multi-level perspective and control for institutional features as well as regional characteristics, in order to understand the driving forces behind country differences. Closer analyses and comparisons of the estimation results show that some country differences originate in institutional differences (such as the ownership regime with regard to academic IP, or the older age of UK KTOs which contributes to their good start-up performance) or characteristics of the regional environment (R&D agreements and patent applications handled by Swiss KTOs becomes significant once we control for corporate/governmental R&D and patenting at regional level).

Second, in most countries the institutions are strong with regard to one channel of formal knowledge and technology transfer: R&D collaboration (the Netherlands), licencing (Ireland and the UK), or establishing start-ups (Sweden and Germany). Even though in Switzerland institutions compare well for more than one performance measure—taking the most complete models 4a and 4b—this suggests that it is very challenging for universities and research institutes to maintain the necessary infrastructure and support system to excel in different transfer channels. In addition, the national institutional set-up affects which transfer channels work better. Developing transfer strategies which take the internal and external conditions into account seems as a very adequate reaction to this situation for universities and public research institutes (Breznitz et al. 2008; Wright et al. 2008).

Third, the presence of a strong manufacturing sector in the region is important for universities' performance with regard to formal knowledge and technology transfer. A strong service sector has rather negative effects, and universities in service-oriented regions, like London, Luxembourg or Zurich, *ceteris paribus* perform worse than those in more industry-oriented regions like Stuttgart or the Basque country. This does not imply that the service sector is unimportant for universities or that there is no collaboration between universities and service companies; there is, of course. However, service companies usually do not take out patents and licences, and prefer other mechanisms than R&D contracts. In particular, informal channels are more important for service firms when acquiring knowledge from universities (see for instance Arvanitis et al. 2013). Still, it is surprising that a strong service sector also affects start-up numbers negatively. We can only speculate why this is the case, but our first pick would be, that the benefit packages in service companies, above all in the financial sector but possibly also in other advanced services and consulting for businesses, are more attractive than the potential gains from a start-up. A developed service economy would then be a disincentive to academic entrepreneurship.

From the consistently negative effect of the BERD-GERD ratio we can deduce, that governmental expenditure on R&D in a region plays a more important role than corporate expenditure for R&D. The rather weak results for regional R&D intensity and regional technology intensity fit into this quite well. However, this does not mean that governments are the key clients of academic technology transfer, of course, but governmental expenditure for R&D influences how much money universities and research institutes obtain for their research and for generating the results which later can be transferred. If regional corporate R&D and technology does not help to explain transfer performance, it must be corporate R&D and corporate technology demand from outside the region. In other words, we interpret this result as a pointer to the importance of non-regional relationships in the transfer business.

This is also where we would see one fruitful direction for further research: conducting similar analyses with other spatial levels as well, in Europe for instance NUTS 1 and NUTS 3, to tease out the distinction between different region sizes. Spatial regression analyses could also be an appropriate way to relate performance

to different geographic catchment areas of universities. Another interesting aspect could be to control for the presence of other institutions involved in knowledge and technology transfers in the region, in order to evaluate whether the resulting competition drives transfer performance or rather reduces it.

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Chapter 11

On the Changing Nature of Industrial Production: Implications for a Research Agenda in Aeronautics Industrial Policy

Anabela Reis, Joana Mendonça, Miguel Amaral, and Manuel Heitor

Abstract The geography of industrial production is continuously shifting towards the most cost effective locations, being particularly associated with increasing uncertainty. This paper presents a contextual analysis of industrial production dynamics leading to a policy research agenda. In particular, we use unbalanced panel data on 173 European regions, during 1999–2007, to examine whether knowledge, human capital and innovation capability help to explain the role of manufacturing on regional development. A number of regulatory, institutional and policy issues affect the analysis.

The relative inadequacy of existing frameworks to capture complexities of emerging distributed supply chains is discussed in the paper, which argues about the need for a new approach to analyse industrial production and innovation. We focus the analysis on aeronautics due to its strategic importance for industrial dynamics, innovation, human capital and socioeconomic development. The paper proposes a new research agenda on the changing nature of industrial production. Overall, this research aims at identifying pathways towards more resilient supply chains, benefitting the creation, development and accumulation of technological capabilities in aeronautics.

Keywords Industrialization • Geography • Policy • Uncertainty and aeronautics

11.1 Introduction

The world's industrial dynamics are changing at an increasingly fast pace and under increasing uncertainty. Relationships between players keep morphing and readapting to the sometimes disruptive new realities. Regardless of which industry value-chain segments companies operate, it is no longer possible to look solely at

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developments on closely related activities. In this context of increasing risk and uncertainty, a full holistic approach is required to understand and envision all the possible game-changing events that define a successful strategic positioning.

As Original Equipment Manufacturers (OEMs) learned how to integrate geographically dispersed operations efficiently, low value-added activities migrated to the most cost-effective location, especially to the rapidly growing emerging economies. One of the most important reasons for that was the scientific and technical knowledge transferred to foreign partners, which has allowed them to become state-of-the-art and produce higher quantities of components at lower prices. This displacement of manufacturing activities has put additional competitive pressure on established suppliers and at the same time has created new opportunities emerging ones.

Understanding how incumbents and new entrants can benefit from the changing nature of industrial production implies assessing which key conditions may leverage industrialization strategies and accelerate regional growth. Therefore, in this paper, we examine the role of industrial production on regional development, using data on 173 European regions, over the period 1999–2007. The results arising from our analysis corroborate previous studies in that knowledge, human capital and innovation capability are indeed paramount to fostering socioeconomic resilience through industrialization.

Previous studies have already pointed towards a relationship between industrial production and economic resilience. However, the existing available data have proved to be insufficient to establish a causal relationship. In addition, a number of regulatory, institutional and policy issues remain important. Therefore, we propose the setting of thematic avenues for future research addressing issues of uncertainty in industrial production. Our goal is to establish this agenda by looking into the specific case of aeronautics.

Aeronautics industrial production has been generally considered of strategic importance for regions and nations due to its potential for socioeconomic development over the years (see, for instance, Niosi and Zhegu 2005). However, many countries have struggled to establish their own aeronautics capability (Texier 2000).

Given the growing complexity and heterogeneity of emerging technologies, it is not surprising that the ability to manage supply-chain uncertainty remains a relevant problem in aeronautics (Simangunsong et al. 2012). In particular, high development costs associated with technological and market uncertainties make this industry very risky, confronting both OEMs and suppliers with significant risks. Governments' support and targeted policies might help to reduce risks (US Congress 1991), fostering the launch of new programs or the adoption of new technologies. Nevertheless, the boundaries and limits of public intervention remain a key issue in many political systems worldwide (e.g. Mazzucato 2013).

This paper contributes to two distinct but interrelated strands of literature on industrial innovation policy. First, it provides an empirical analysis of the role of manufacturing on regional development. Second, it discusses critical issues towards a resilient industrial production that remain to be assessed, proposing a new

research agenda in light of the aeronautical industry to look at industrial innovation in a context of increased uncertainty.

The paper is organized as follows. We begin by exploring data on European regions, contextualizing the role played by manufacturing on regional development. Next, we discuss the need for a new approach to analyse the industrialization phenomenon. Finally, we examine possible pathways for future research on the changing nature of industrial production in the light of the aeronautics industry. The paper ends with a summary section.

11.2 Capacity Building and the Role of Manufacturing on Regional Development

It is well known that the relative importance of manufacturing in the economy has been decreasing substantially in many countries, which have become service-based economies, with the notable exception of Germany and Nordic countries in Europe, and Korea and China in Asia. This has happened together with an increasing democratization of the access to higher education and the strengthening of the scientific base in many world regions, which fostered learning capabilities of these populations, leveraging their knowledge in new areas of application, and ultimately enabling cross innovations. On the other hand, the geographical concentration of industrial production has led many of those regions to increasingly lose their productive ability, leading to changes in employment structure and the mobility of skilled people. These changes raises new concerns for science and industrial policies, which need to be discussed in terms of new forms of stakeholder engagement.

11.2.1 Framing the Issue

Figures 11.1 and 11.2 present the evolution of gross value added (GVA) per capita for manufacturing and services in Europe for 1997 and 2007, visualizing manufacturing geographical dispersion at a macro territorial level (NUTS-2). Each map is colour-coded, with light shading denoting the 1st sextile of GVA per capita in OECD countries¹ and the dark shading denoting the 6th sextile. As can be seen in the figures, from 1997 to 2007, both manufacturing and service GVA per capita increased across OECD regions. In 1997, only about 11 % of the analysed

¹ OECD member countries are: Australia, Austria, Belgium, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, United States.

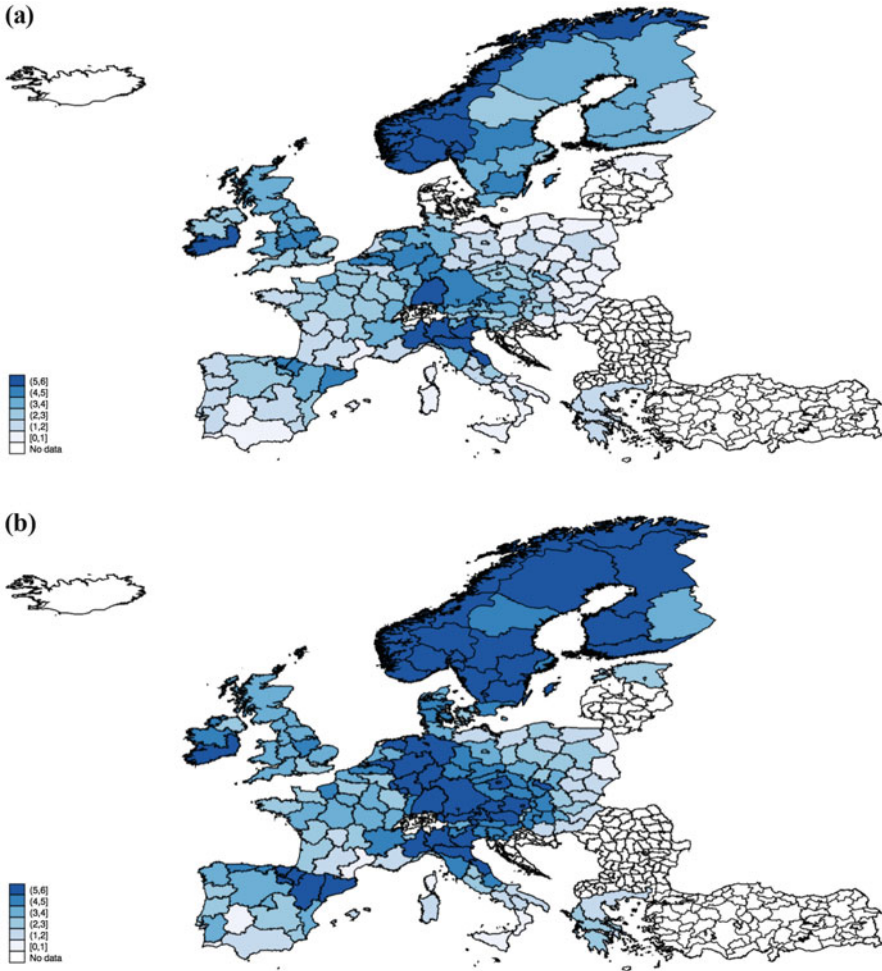


Fig. 11.1 Manufacturing GVA per capita in Europe, in 1997 (a) and in 2007 (b). (Data source: OECD)

regions had high GVA per capita in manufacturing, while in 2007 this value increased for 26 %. Likewise, regions with high service GVA per capita experienced an increase from 8 % to 26 %. One can also observe the apparent spatial clustering of high manufacturing GVA in Central and Nordic countries in Europe (Norway, Sweden, Finland, Germany and Austria). In comparison, Southern European countries such as Portugal, Greece and Spain present signs of low GVA in manufacturing activities.

Attracted by prospects of faster economic growth, many economies have undergone significant structural changes over the past decades, increasing the prominence of knowledge-intensive services related to manufacturing industries

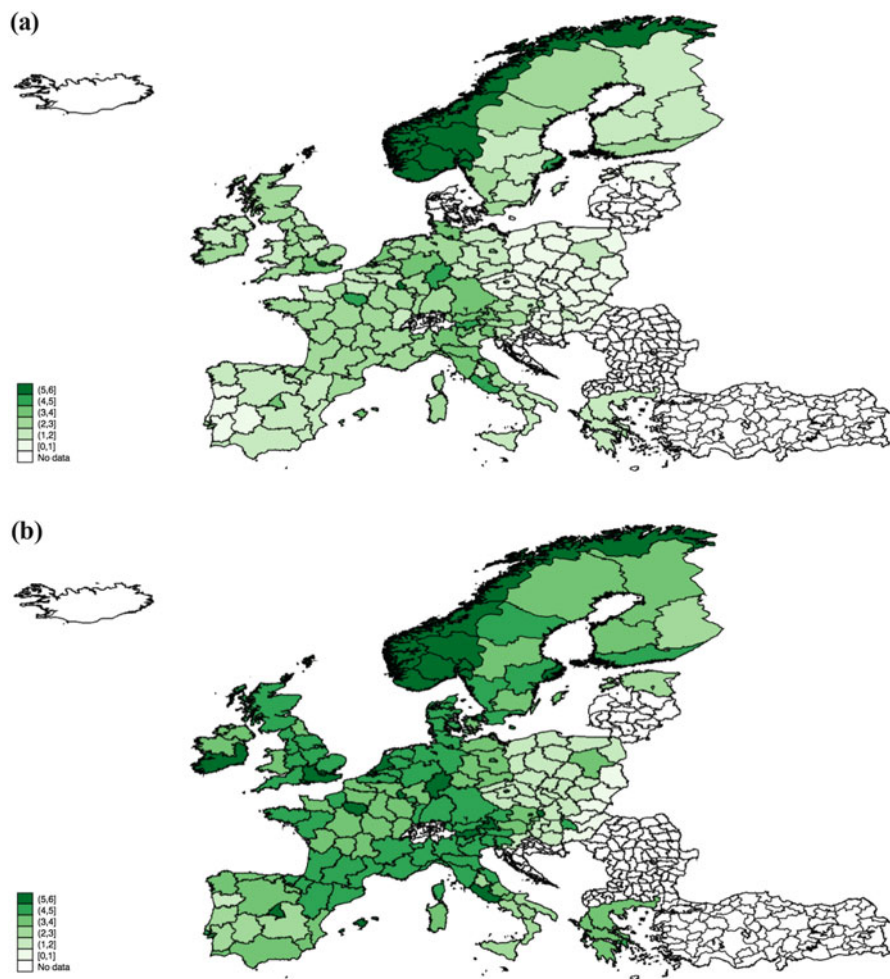


Fig. 11.2 Services GVA per capita in Europe, in 1997 (a) and in 2007 (b). (Data source: OECD)

(Hepburn 2011; Ghani and Kharas 2010). In order to react to the competitive pressures of globalization and the lack of adequate policy measures, many companies shifted their production activities abroad (Tassey 2010). Even though this strategy helped firms to survive, it has taken value out of regions and countries.

Moreover, much learning takes place in manufacturing facilities, as engineers and technicians come back and forth with their problems to design engineers and work with them to find better solutions. Therefore, losing manufacturing production reduces the accumulation of knowledge and capabilities, depriving the industrial ecosystem of new learning, which ultimately shrinks the potential for future innovation (Berger 2013).

Most important, since the modern global economy is constructed around supply chains, whose industries interact in complex ways, the loss of competitiveness in a particular industry is not an isolated event (Tassey 2010; Berger 2013). The disappearance of local capabilities hampers complementarities across related economic activities, reducing resources in which companies can draw on to supplement their capabilities not only when supplying products, but also when generating new ideas.

It is commonly believed that one of the most significant causes of manufacturing's employment decline in most advanced economies has been international trade (e.g. Lawrence and Edwards 2013). Therefore, in Table 11.1 we present the net trade goods per country.

By looking at these figures, we notice that Germany and China have shown remarkable trade surpluses in their goods, while other countries have experienced a dramatic rise in imported goods or a drop in exports or even a combination of both. Over the last years, the US has consistently shown a large negative surplus of traded goods, which gave rise to the Obama administration's concerns and efforts to increase exports and substitute imports for domestic production, promoting innovation in the domestic manufacturing sector (Wade 2011). Moreover, countries in which crisis effects were more severe are among the ones showing a negative surplus (e.g. Greece, Portugal and Spain). Also worth mentioning are the notable surpluses of Norway and Russia, which are strongly dependent on energy sectors.

It is noteworthy that when we look into EU-15 countries, the effects of the worldwide crisis seem to have vanished pretty quickly. These figures highlight the importance of looking in further detail at these data, considering exclusively the manufacturing sector. Even though this issue needs to be additionally analysed, it seems reasonable enough to assume that a strong industrial base fosters socio-economic resilience. Therefore, in order to understand how to leverage industrialization strategies and accelerate regional growth, it is first necessary to explore the role of manufacturing on regional development.

11.2.2 Data and Empirical Approach

The empirical analysis developed in this section is focused on European countries and investigates the role of manufacturing on regional development by testing whether knowledge, human capital and innovation capability help to explain regional manufacturing GVA. The GVA of a region can be used as a proxy of economic growth (e.g. Curran 2012). Thus, the lower the level of economic growth (manufacturing GVA) of a region, the higher the industrialization level of that region.

Data on regional dynamics is drawn from OECD regional database at a macro territorial level (NUTS-2) for the period of 1990–2010. The initial units of

Table 11.1 Net trade goods in billion of US dollars^a

Time	1960	1970	1980	1990	2000	2007	2008	2009	2010	2011	2012
Austria	-0.02	-0.06	-0.58	-0.66	-0.39	0.05	-0.25	-0.50	-0.54	-1.16	-0.99
Belgium	-0.01	0.01	-0.61	-0.17	0.90	1.61	0.46	1.35	1.37	0.79	0.57
Denmark	-0.03	-0.09	-0.21	0.31	0.51	0.35	0.55	0.94	1.05	1.29	1.16
Finland	-0.01	-0.03	-0.12	-0.04	0.97	0.69	0.39	0.16	0.06	-0.43	-0.28
France	0.05	0.01	-1.19	-1.22	-0.94	-5.93	-8.33	-6.49	-7.27	-10.29	-8.81
Germany	0.10	0.36	0.41	5.43	4.54	22.16	21.63	16.08	16.99	18.24	20.16
Greece	-0.04	-0.11	-0.45	-0.98	-1.83	-4.65	-5.30	-3.98	-3.24	-2.79	-2.31
Ireland	-0.02	-0.04	-0.23	0.26	2.19	3.14	3.46	4.42	4.68	4.92	4.50
Italy	-0.09	-0.15	-1.83	-0.99	0.15	-0.98	-1.59	-0.68	-3.31	-2.96	1.06
Luxembourg	-	-	-	-0.11	-0.24	-0.42	-0.54	-0.33	-0.44	-0.61	-0.72
Netherlands	-0.04	-0.14	-0.35	0.43	1.24	4.84	4.72	4.54	4.82	5.67	5.30
Portugal	-0.02	-0.05	-0.40	-0.71	-1.30	-2.47	-3.09	-2.28	-2.36	-1.90	-1.17
Spain	0.00	-0.20	-1.12	-2.67	-3.40	-11.32	-11.54	-5.47	-6.04	-5.83	-3.51
Sweden	-0.03	-0.02	-0.21	0.23	1.20	1.29	1.22	0.91	0.80	0.83	0.75
United Kingdom	-0.20	-0.27	-0.46	-3.31	-4.36	-15.27	-14.28	-10.86	-12.80	-13.51	-14.58
EU-15^b	-	-	-	-4.20	-0.77	-6.90	-12.50	-2.20	-6.24	-7.74	1.13
Norway	-0.05	-0.10	0.14	0.55	2.15	4.64	6.62	3.99	4.42	5.80	6.13
Switzerland	-0.03	-0.11	-0.52	-0.50	-0.17	0.96	1.52	1.82	1.56	2.21	2.12
Canada	-0.01	0.23	0.49	0.91	3.15	3.34	3.86	-0.41	-0.39	0.00	-0.60
Japan	-0.04	0.04	-0.96	4.37	8.28	7.64	1.66	2.38	6.30	-2.68	-7.25
Korea	-0.03	-0.10	-0.40	-0.40	0.98	1.22	-1.11	3.37	3.43	2.57	2.36
United States	0.46	0.27	-3.03	-8.48	-36.34	-67.40	-68.02	-41.97	-52.91	-60.65	-60.80
Brazil	-	-	-0.24	0.90	-0.06	3.34	2.08	2.11	1.68	2.48	1.62
China	-	-	-	-	2.01	21.83	24.79	16.30	15.13	12.97	19.23
India	-	-	-	-0.47	-0.74	-6.53	-10.59	-7.63	-10.32	-13.50	-16.40
Russian Federation	-	-	-	-	5.01	10.91	14.98	9.30	12.67	16.52	16.11

Data source: OECD

^aGoods comprise: (0) agriculture, forestry and fishery products; (1) ores and minerals; electricity, gas and water; (2) food products, beverages and tobacco; textiles, apparel and leather products; (3) other transportable goods, except metal products, machinery and equipment; and, (4) metal products, machinery and equipment

^bEU-15 countries are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom

observation are 176 NUTS-2 regions belonging to 21 countries of the former EU-28.² As a consequence of being recent members, Estonia and Slovenia had no data available for the full set of explanatory variables that will be used in the empirical analysis; therefore, these countries were ruled out of the analysis. On the basis of a preliminary inspection of the data, the period 1995–1998 was excluded due to scarce availability of regional data. It is worth nothing that even for the year with less regional data available (2006), our sample represents 46 % of the total population.

Thus, we use unbalanced panel data on 173 regions, over the period 1999–2007, to explore the role of manufacturing on regional development. This time series is of particular interest since it captures a period when regional growth in many developed countries was impacted by a move towards manufacturing outsourcing and technological advance (Curran 2012) and also because sectors codification are stable during this period (NACE Rev.2).

To test whether knowledge, human capital and innovation capability help to explain the role of manufacturing on regional development, in our empirical approach we used as a dependent variable the GVA at purchasing power parity (PPP) for each NUTS-2 region during the period of 1999–2007. Our proxy for knowledge is the share of the labour force with secondary and tertiary education attainment. The regional workforce in both manufacturing and service sectors is used as a measure of human capital available in the region. Regional innovation potential is captured by using the share of research and development (R&D) expenditures in GVA. Finally, data on total region population is used in order to account for region size. Table 11.2 provides the descriptive statistics of the main variables used in the empirical analysis.

Since GVA and total population show remarkable dispersion across the 173 regions, we use the logarithm of the distributions, limiting the effect of outliers. There are also significant differences in terms of employment in both manufacturing and services sectors. We find significant and highly correlated coefficients between logarithm of total population and the logarithm of employment in both manufacturing and services sectors. Probably, regions with higher employment levels attract more people. Thus, we model the differences between regions' employment as a series of dummy variables in order to get a more flexible specification of the regional employment. We choose the first quartile of employment as the base group, in the estimations we use the dummy variables corresponding to quartile 2, 3 and 4 of employment in manufacturing, as well as in services.

Table 11.3 shows the correlation matrix. A significant and high correlation coefficient emerges between higher levels of employment in manufacturing and

² OECD EU-28 (number of regions): Austria (9), Belgium (3), Czech Republic (8), Denmark (5), Estonia (1), Finland (5), France (22), Germany (16), Greece (4), Hungary (7), Ireland (2), Italy (21), Luxembourg (1), Netherlands (4), Poland (16), Portugal (7), Slovak Republic (4), Slovenia (2), Spain (19), Sweden (8), United Kingdom (12).

Table 11.2 Descriptive statistics

	Observations	Mean	Standard deviation	Minimum	Maximum
GVA in manufacturing (PPP)	1062	12558.060	16250.410	50.820	153469.000
Secondary education (% of labour force)	1062	47.337	19.172	8.603	83.017
Tertiary education (% of labour force)	1062	21.968	8.119	4.340	47.740
Total population	1062	2634130.000	2439299.000	25706.000	18100000.000
Employment in manufacturing	1062	226866.100	251240.100	400.000	2055400.000
Employment in services	1062	757774.700	796114.600	10100.000	5498900.000
Business R&D expenditures (% of GDP)	1062	0.785	0.822	0.000	5.203

Table 11.3 Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1. Secondary education (% of labour force)	1.000									
2. Tertiary education (% of labour force)	-0.345***	1.000								
3. Log of total population	-0.047	0.246***	1.000							
4. Employment in manufacturing Q2	0.230***	-0.163***	-0.263***	1.000						
5. Employment in manufacturing Q3	0.127***	-0.015	-0.025	-0.333***	1.000					
6. Employment in manufacturing Q4	-0.053	0.145***	0.739***	-0.332***	-0.333***	1.000				
7. Employment in services Q2	0.290***	-0.258***	-0.278***	0.422***	0.043	-0.307***	1.000			
8. Employment in services Q3	-0.035	0.107***	-0.024	-0.082**	0.388***	-0.102***	-0.333***	1.000		
9. Employment in services Q4	-0.136***	0.295***	0.771***	-0.297***	-0.112***	0.744***	-0.332***	-0.333***	1.000	
10. Business R&D expenditures (% of GDP)	0.084**	0.361***	0.269***	0.013	-0.012	0.177***	-0.071*	0.042	0.252***	1.000

Notes: *p < 0.05; **p < 0.01; ***p < 0.001

services. This indicates that regions with high employment in manufacturing are also characterized by high employment in services. Additionally, a significant and highly correlated coefficient emerges between the share of R&D expenditures in GVA and tertiary education. To control for this effect, we introduce a variable accounting for the interaction between these two indicators.

As previously mentioned, we use an unbalanced panel data. We take this into account when estimating the model, by using sampling weights. By focusing on regional rather than country performances, we control the results for country effects by including national dummies. Finally, we introduce year dummies in our estimation to capture time effects.

In order to determine the role of manufacturing on regional development, we estimate manufacturing GVA on a region through a discrete and logarithmic econometric model, as follows:

$$\log(y_{it}) = \alpha + X_{it} \beta + D_{it} \gamma + u_{it} \quad (11.1)$$

In this simplified approach, y_{it} represents the manufacturing GVA in a region i in year t ; X_{it} is a vector of regional characteristics—including levels of education as percentage of the labour force (secondary and tertiary), total population (in logarithmic form), employment in both manufacturing and services sector (three dummy variables for each), business R&D expenditures and an interaction term between tertiary education and R&D expenditures performed by the business sector; D_{it} represents the dummy variables; and u_{it} is the equation error term. Table 11.4 shows the results for five different models that attempt to identify main patterns of technical change.

The first model (i) uses knowledge indicators to explain manufacturing GVA: secondary education and tertiary education. Model (ii) introduces manufacturing employment. Model (iii) adds the regional workforce in services. In model (iv) information about regional innovation capability is introduced. And finally, model (v) adds the interaction term between the share of R&D expenditures in GVA and labour force with higher education.

11.2.3 The Role of Knowledge, Human Capital and Innovation Capability on Manufacturing

Our analysis revealed that manufacturing is positively associated with a wider range of qualifications, thus requiring a large base of available human capital, confirming Fingleton's (1999) argument that manufacturing sectors create jobs for a wide range of people. In addition, manufacturing activities, when compared to services, are associated with higher productivity levels, more balanced income distributions, higher income growth rates, and more ability to generate exports (Sirkin et al. 2011; Fingleton 1999). For instance, Sirkin et al. (2011) argue that an

Table 11.4 Regression results

	<i>log(ManGVA)</i>				
	(i)	(ii)	(iii)	(iv)	(v)
Secondary education (as % of labour force)	0.0154*** (0.00305)	0.00930*** (0.00284)	0.00814*** (0.00286)	0.00828*** (0.00282)	0.00738*** (0.00282)
Tertiary education (as % of labour force)	0.00912*** (0.00324)	0.0141*** (0.00324)	0.0191*** (0.00328)	0.0175*** (0.00326)	0.0254*** (0.00366)
<i>log</i> (Total population)	1.099*** (0.0203)	0.845*** (0.0392)	0.971*** (0.0460)	0.970*** (0.0458)	0.976*** (0.0455)
ManEmployment Q2		0.285*** (0.0419)	0.343*** (0.0409)	0.322*** (0.0414)	0.319*** (0.0416)
ManEmployment Q3		0.430*** (0.0511)	0.519*** (0.0473)	0.506*** (0.0471)	0.504*** (0.0476)
ManEmployment Q4		0.744*** (0.0729)	0.924*** (0.0651)	0.900*** (0.0646)	0.898*** (0.0651)
SerEmployment Q2			-0.185*** (0.0458)	-0.194*** (0.0463)	-0.211*** (0.0450)
SerEmployment Q3			-0.315*** (0.0611)	-0.330*** (0.0609)	-0.333*** (0.0602)
SerEmployment Q4			-0.593*** (0.0926)	-0.618*** (0.0926)	-0.637*** (0.0913)
Business R&D Expenditures (as % of GDP)				0.0617*** (0.0142)	0.298*** (0.0404)
TertiaryEducation (% LF) * R&D (% GDP)					-0.00939*** (0.00157)
Country dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Constant	-7.615*** (0.321)	-3.997*** (0.533)	-5.653*** (0.620)	-5.697*** (0.618)	-5.963*** (0.611)
Observations	1062	1062	1062	1062	1062
R-squared	0.911	0.925	0.929	0.930	0.932
F test	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses

Notes: Region weights were used in all models

***p < 0.01, **p < 0.05, *p < 0.1

over-reliance on services, without an adequate balance of industrial activity, damages exports' performance, reduces labour productivity and favours inequality.

Since the share of manufacturing sector in exports is approximately 70 % in major economies (Manyika et al. 2012), moving production away removes the domestic economic benefits potentially realized over the technology life cycle (Tassey 2010). In addition, shifts in industrial production have clear impacts on regional employment structure as they leave regions with specialized workforce without place in the labour market and, on the other hand, they create new job opportunities on regions receiving production (Cowie 2001). Cowie (2001) has also shown that the end of deindustrialization is usually social turmoil, triggering other systemic risks related to Social Unrest (Jovanovic et al. 2012). These two risks have a reciprocal causal relation between them since deindustrialization leads to social unrest and the latter leads to deindustrialization while social instability hinders attraction and retention of industrial activities. Our findings support this line of research as it shows that higher employment levels in manufacturing sectors are associated with higher manufacturing GVA and lower levels of regional employment in services sectors are linked to higher manufacturing GVA.

Nevertheless, manufacturing activities today require the existence of a group of complementary services. However, due to technology advances support services do not need to be in the same region that production. In fact, large corporations began to transfer many of their functions abroad, included R&D and detailed design (Berger 2005). This undermines domestic competitiveness since it removes the majority of private economy's R&D capabilities from the region (Tassey 2014), which is responsible for up to 90 % of business R&D spending in advanced economies (Manyika et al. 2012). Our empirical findings also stress that regional manufacturing GVA is positively associated with R&D.

A variety of studies have focused on the role played by human capital in promoting technological change and economic growth (e.g. Lucas 1988; Becker 1993). Knowledge, embodied in individuals, can build the sources of competitive advantage by firms and regions (Teece 1998). Deducing from the economic complexity explanation proposed by Hidalgo and Hausmann (2009), differences between regions arise from the fact that some activities cannot be imported, which indicates that regions need to have them locally available in order to produce. Thus, a region is more productive if it has more diversity on its "nontradable capabilities". Regions with more human capital will tend to be more innovative and entrepreneurial, thereby growing faster (Acs and Armington 2004). Furthermore, more diversified countries produce more complex products since they require a wider combination of human capabilities, and higher complexity is associated with higher economic growth (Hidalgo and Hausmann 2009).

This vast stream of literature shows that education, employment and R&D expenditures have been consistently associated with economic development and growth, which is once more evidenced in our analysis. Based on this evidence, higher levels of education and R&D should lead to higher levels of resilience and ability to handle uncertainty in industrialization processes.

11.3 The Need for New Approaches Towards Industrialization

Following Amsden (2001), recent research has documented changes in the emerging geographies of industrial production (e.g., Spence and Hlatshwayo 2012; Manyika et al. 2012). For instance, Spence and Hlatshwayo (2012) report that US industrial production has been shifting towards system integration and value added activities, causing a substantially decrease in manufacturing jobs. In fact, the weight of manufacturing in the employment structure has decreased around 40 % since the 1980s, as the number of US manufacturing jobs declined from 20 million in 1979 to about 12 million 30 years later (OECD 2010; Tassey 2010).

This change was caused not only by a productivity increase in production, but also by the migration of low value-added activities to more cost effective locations, including rapidly growing emerging economies, such as China, South Korea, India, Brazil, Mexico (Nairn 2002; Hepburn 2011). As emerging markets grow, they start to compete for more sophisticated functions, allowing the out-migration of more valuable parts of the supply chain, and increasing the competition for higher paid jobs. Consequently, firms from these emerging economies are growing and moving upstream in the value chain (Amiti and Freund 2007). This displacement of manufacturing activities has put additional competitive pressure on established suppliers and at the same time has created new opportunities emerging ones.

Understanding how incumbents and new entrants can benefit from the changing nature of industrial production implies assessing which key conditions may leverage industrialization strategies and accelerate socioeconomic growth. Therefore, in this section we address some of the critical issues when looking into the location of industrial production.

11.3.1 Critical Issues for Resilient Industrial Production

Evidence shows that industrial production is associated with high productivity levels, higher income growth rates, and the ability to generate exports. In addition, manufacturing activities today require the existence of a group of services, which leads to the generation of more jobs and a higher diversification on job requirements. However, given the changes in nature, complexity and geography of manufacturing activities, as well as the ability to react to exiting economic changes, the future of industrial production is developing in an environment of far greater risk and uncertainty than ever.

Processes related with diversification and industrial specialization are complex and essentially related with learning processes and incorporation of knowledge and technology in people and organizations. R&D has become the primary means by which firms gain understanding over new products and processes, which allow them at least to keep up with the technology evolution. Consequently, the

competitiveness of industries lies in the ability to produce and use knowledge and technologies mostly developed in a wide network of institutions consisting on a distributed knowledge base. Important factors to manufacturing industries include access to low-cost and/or high-skill labor (or both); proximity to demand; efficient transportation and logistics infrastructure; availability of inputs such as natural resources or inexpensive energy; and proximity to centers of innovation.

The current inadequacy of existing frameworks to capture the complexities of distributed supply chains in competitive environments and their dependency on information technology based systems reflects the need for an approach that allows understanding of the industrialization phenomena through a multi-perspective approach.

Different literature mirrors industry idiosyncrasies, thus sustaining the need to look in detail to specific sectors, without which it is not possible to understand issues related with the supply chain. Sectors differ in their degree of complexity and the configuration of their supply chains, in the extent to which parts of their activity can be relocated, and in the degree of knowledge complexity and production. Labour productivity growth is increasingly being concentrated in knowledge intensive activities, high technology and medium high technology manufacturing. Trade in high technology goods, such as aircraft, computers, pharmaceuticals and scientific instruments, accounts for more than 25 % of total trade, which represents a significant increase over the last two decades (OECD 2003). This trend has been followed by an increase in the generation and use of knowledge through investments in R&D, use of information and communication technologies (ICT), patenting, and development of scientists and engineers in OECD countries (OECD 2003).

11.3.2 On Aeronautics Specific Nature

The research proposed herein focus on the aeronautics sector since this industry is knowledge intensive, and represents important challenges towards industrialization. Moreover, the aircraft industry has been considered of strategic importance for many regions and nations due to their potential to foster employment and socio-economic development. It has, for example, been the most important industry to the US economy in terms of skilled production employment, value-added and exports (MacPherson and Pritchard 2003). Thus, discussing the changing nature of industrial production in the light of the aeronautics industry could help to uncover fundamental principles of innovation dynamics, which ultimately can be used to make better policy towards industrialization.

The increasing complexity and heterogeneity of emerging technologies, associated with high development costs in aeronautics makes it a highly risky sector for both OEMs and suppliers. In such an uncertain environment, this industry created new solutions for product development, including the establishment of risk-sharing partnerships. Risk sharing partnerships are a contractual modality in which

suppliers participate more actively in project development, thereby acquiring rights to their future sales income (Figueiredo et al. 2008). Consequently, firms started to concentrate in particular areas of knowledge. Major aeronautics OEMs have become more specialized in systems integration, as well as in developing and coordinating their supply chains. The reason for this has not been exclusively shaped by cost, quality or logistic factors, but also by offset agreements (MacPherson and Pritchard 2003). That is an agreement in which the seller promises to purchase components and/or to provide technology to manufacturers in the buyer's home country in exchange for a foreign sale. Therefore, scientific and technical knowledge are being transferred to foreign partners, which allows them to acquire important production skills and new manufacturing technology.

Transfer of strategic technology and knowledge allows emerging competitors to acquire new skills and new production capability, which in turn leads to higher ability to capture an ever-larger share of the value created in aeronautics. While OEMs become increasingly dependent on outsourcing, emerging economies are shifting to higher added value components of international supply chains, and their physical, human and institutional capital strengthens, allowing them to compete directly with the more developed ones (Bowen 2007). Accordingly, aeronautics production is gaining weight in China and Korea and declining significantly in the US; US employment in aircraft production has decreased from 1.9 million (in 1970) to 798,000 (in 2000) (MacPherson and Pritchard 2003).

In order to remain competitive, aeronautics OEMs have established assembly plants worldwide. Due to this tendency, the aeronautics industry in Portugal faces a singular moment in its history. The establishment of two Embraer's factories in Évora (metal structures and composites materials) brings renewed opportunities for both OEMs and potential suppliers. However, creating and developing the necessary knowledge base to integrate the aeronautics supply chain is not immediate. If one focus on the example of China and Korea, it took a large number of years of investment and cumulative capacity. Understanding this building capacity dynamics implies identifying some of the key issues in the process. For instance, how can existing players and new entrants in the aeronautics sector benefit from the changing nature of industrial production and which are key conditions and agents that may facilitate endogenous growth through aeronautics OEM establishment? Thus, in the next section we discuss future avenues of research that can address this question.

11.4 Towards a Research Agenda Under Increasing Uncertainty in Aeronautics

Aeronautics future is intrinsically connected with firms' ability to continuously adapt and improve its strategic assets to meet market-specific demands or even to create new strategic assets to exploit in existing or new markets. In this section, we

identify six pathways for further research on the role of aeronautics industrial policy that might be useful to explore, in particular in a context of increased uncertainty: (i) appraisal of regulatory frameworks to foster local content requirements towards global markets; (ii) local conditions for endogenous growth in times of increased financial vulnerability; (iii) management of emerging technologies; (iv) looking at new innovation patterns induced by emerging distributed supply chains; (v) looking at skills and human capital; and, (vi) addressing the role of small firms and different economic actors. Although these dimensions are relevant to other knowledge intensive industries, we will only analyse them in the aeronautics context. Through the development of these research lines, this study contributes to deepen the insights on aeronautics industrial production, discussing important implications on industrialization strategies that ultimately create socioeconomic resilience.

11.4.1 Appraisal of Regulatory Frameworks to Foster Local Content Requirements Towards Global Markets

Foreign direct investment through OEM establishment leads to job generation, skills, and income, lowering unemployment and helping to alleviate poverty in a given area (see, for instance, Alhakimi and Peoples 2009; Brock 2009 and Salehizadeh 2005). Moreover, numerous studies have shown that OEM establishment helps to enhance domestic suppliers and costumers' performance through standards implementation and information sharing (e.g. Carrillo and Hualde 1998). However, the shift towards modular production, the entrenchment of global supply chains and added pressure to cut down costs represent challenging obstacles in the creation of higher-level local suppliers. Making economies more diverse and specialized is extremely complex and requires persistent learning processes and embedding skills and technology into people and organisations (Conceição et al. 1998, 2003; Heitor and Bravo 2010; Sheffi 2005). Therefore, industries' competitiveness resides increasingly in the capacity to access and use knowledge and technologies in distributed knowledge bases, spread through a wide network of institutions (Conceição and Heitor 1999; Conceição et al. 2003). Given this context, what is the role of regulatory frameworks on aeronautics OEM establishment?

To tackle this question one should compare frameworks on OEMs establishment across different industries and locations. In particular, it could be interesting to look at the automotive industry since similarly to aeronautics it crosses several areas of knowledge and deals with a multiplicity of technologies, skills and organizational processes. Moreover, it also induces the development of high value-added chains with a multiplier effect on the economy due to the diverse and distributed knowledge bases within their global and complex value networks (Selada and Felizardo 2002). This comparison might yield important lessons relevant to the understanding of important patterns of OEMs establishment, ultimately leading to the design of more efficient regulatory frameworks.

11.4.2 Local Conditions for Endogenous Growth in Times of Increased Financial Vulnerability

Academic research has addressed and shown the importance of local content and creation of knowledge, whether through R&D development or human capital formation, justifying the need to look at the regional level (e.g. Baptista and Mendonça 2010). In agreement, our analysis shows that these factors are associated with higher GVA in manufacturing. Moreover, there is a broad consensus that the regional dimension is of central importance to understand innovation systems. For instance, Tödtling and Trippel (2005) provide four arguments supporting this view: (i) regions present different industrial specialization trends and innovation capabilities; (ii) knowledge spillovers are spatially bounded; (iii) tacit knowledge is more easily exchanged through personal contacts, which are facilitated by geographical proximity; and, (iv) policy capabilities and organizations are relatively bounded to territorial levels. In this context, how can we design, assess and implement mechanisms that may facilitate regional endogenous growth through aeronautics development?

In order to address this question, it might be helpful to look into regions that illustrate different processes of industrial production acquisition in aeronautics since this will allow to pinpoint key aspects and contextual facts that have influenced the evolution of aeronautics capabilities in these regions. Particular emphasis should be placed on both historical and geographical contexts of regional innovation because they provide an important contribution to understand the capacity building process (e.g. Heitor et al. 2004). Understanding suppliers' capabilities for integration on the aeronautics supply chain, including technologies and processes that allowed this integration implies identifying key players on the region. Therefore, a data-driven investigation of the historical evolution of particular companies in these regions could be relevant to derive patterns of change in their supply chains, which in turn could be used to derive lessons for industrial policy-making.

11.4.3 Management of Emerging Technologies

Increasing technology complexity along with increasing uncertainty in industrial aeronautics is forcing firms to rely on different actors in order to remain competitive in the future, particularly in modern knowledge based economies. There is a broad consensus in the literature that to stay ahead of the competition, firms have to engage with different types of partners to acquire ideas and resources from external environment (Laursen and Salter 2006). However, collaboration is not easy since sometimes companies find it difficult to overcome fears related to knowledge appropriation. Despite the difficulties in coordinating multiple actors with complex interests and different agendas, these partnerships bring companies together to

discuss ideas and brainstorm about new technologies. This experience ultimately reduces the risk associated with innovation and enhances the likelihood of emerging technologies come to life (Berger 2013). One of the main reasons for that is the set of complementary capabilities that companies can draw on to supplement their resources. Therefore, how do different players in aeronautics interact in their effort to manage emerging technologies under increasing uncertainty? How to address complementarities between different multiple actors to best resolve tensions arising out of the heterogeneous interests of participants? And, how to use the knowledge gathering through collaborations to leverage companies' strategies towards a more resilient aeronautics supply chain?

These questions should be addressed by looking into emerging technological fields, involving collaborative efforts of multi-organizational innovation networks and heterogeneous stakeholders in aeronautics. A possible methodological approach could include semi-structured interviews focusing on stakeholder's perceptions of the research progress, observed obstacles and strategies to overcome them, the role of different people involved in the project and the overall function of the projects. This research might help to uncover fundamental lessons to managing complexity, uncertainty and collaboration amongst emerging technologies in aeronautics, which ultimately could be used to foster and promote new industry-science relationships, involving end-users, technology-based firms and academic research groups.

11.4.4 Looking at New Innovation Patterns Induced by Emerging Distributed Supply Chains

Since the 1990s, global aircraft industry has established new solutions for product development to handle the increasing necessity of reducing costs, namely through risk-sharing partnerships (Figueiredo et al. 2008). Embraer pioneered this model of operation amongst aircraft OEMs, establishing a well-defined structure of its supply chain (Figueiredo et al. 2008). Risk share partners join the design phase, adding technological value to the project and thereby acquiring rights to future sales income of products (Fig. 11.3). Risk suppliers are responsible for supplying equipment, avionics, components and services ordered by the company, participating in the last Joint Definition Phase. Firms in the lower level of the value chain receive raw material and design from the OEM and sell manpower services, such as machining and chemical treatments.

Other OEMs such as Boeing and Airbus followed this new systems integration approach. OEMs are increasingly decentralizing not only components, but also design and engineering tasks to international risk-sharing partners. These changes in production have impact on several levels, including innovation development. Therefore, how are innovation dynamics evolving and affecting the industrialization/deindustrialization processes?

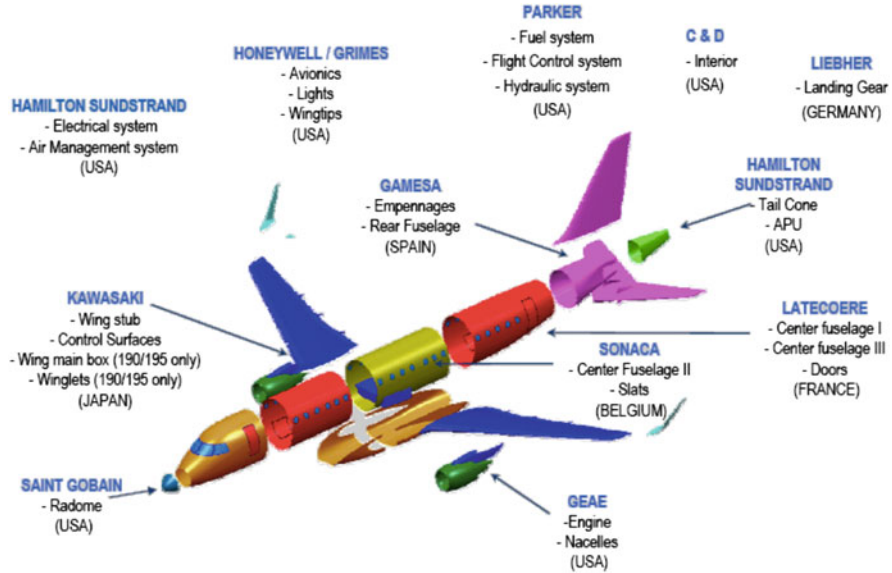


Fig. 11.3 Risk sharing partners of Embraer ERJ 170/190. (Source: Figueiredo et al. 2008)

The increasing outsourcing of aircraft technology brings new challenges and opportunities for both OEMs and suppliers. On one hand, by devolving R&D tasks, without internalizing value chain activities inside the home country, OEMs competitiveness becomes strongly dependent on external factors (Luz and Salles-Filho 2011). On the other hand, new technologies and aircraft architectures allow newcomers to enter this sector and become part of the supply chain. Thus, future research exploring this theme may draw on the identification and characterization of new innovation patterns. Moreover, methodological tools should include qualitative case study and quantitative comparative studies to complement and support the analysis and network analysis to map supply chains. This methodological approach could help to uncover fundamental principles of innovation dynamics in aeronautics.

11.4.5 Competences, Skills and Human Capital: Deepening Our Understanding on Performance and Capacity Building

Hidalgo and Hausmann (2009) suggest that changes in countries' productive structure can be seen as a combination of the process by which countries find new products as unexplored combinations of the capabilities they already possess, and the process by which countries accumulate new capabilities and combine them

with other previously available capabilities to develop yet more products. According to them, cross-country income disparities can be explained by differences in economic complexity, as measured by the diversity of capabilities. In addition, diversification is associated with the capacity of firms, regions or countries to recover following a disturbance or disruption, coming from a crisis, for example.

It has been long acknowledged that human capital is central to our understanding of technological change and economic growth (Lucas 1988) and human capital investments, namely expenditure in formal education and training, can explain the production advantage of the most advanced countries (Schultz 1961). Knowledge, embodied in individuals, can build the sources of competitive advantage by firms and regions (Teece 1998). Countries differ significantly in their human capital levels, and in the availability of qualified human resources, which determine the capabilities of each economy. In fact, one possible explanation for differences in GDP between countries is that some of the individual activities that arise from the division of labour, such as property rights, regulation, infrastructure, specific labour skills, cannot be imported, which implies that countries need to have them locally available in order to produce. Therefore, countries' productivity resides in the diversity of its available "nontradable capabilities," and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions (Hidalgo and Hausmann 2009).

The issue is how regions and economies develop processes of transforming human capital into competitive advantages in different sectors, are able to contribute to knowledge generation and commercialize technology and from there acquire socioeconomic resilience.

Regions and countries with more human capital will tend to be more innovative and entrepreneurial, thereby growing faster. Also, according to Hidalgo and Hausmann (2009) more diversified countries produce more complex products, in the sense that they require a wider combination of human capabilities, and higher complexity is associated with higher economic growth. More than the availability of a strong industrial base, most of the well performing economies share other common features. One of those features is diversification of activities, meaning that the economic and, particularly, industrial manufacturing output, is distributed across a broad set of activities, which allows not only for mitigating risks but also for enhancing the capacity of the innovation system and the growth potential of the economy as a whole. This diversity can be found in countries such as Korea or Taiwan (Amsden 2001; Berger 2005). Other common feature is supply chain and knowledge networks' complexity, related to the interactions between people and organizations measured in terms of the activities and job positions needed to produce and certain good within an economy.

Following this literature, we propose a research approach focused on competences and skills. There is a wide body of literature research focusing on skills and human capital, but they diverge in their approach on the definition of skills and competences and their role in defining human performance, leaving a gap in

building a literature on competences for industrialization, integrating with the innovation dynamics.

There is a substantial amount of research on the trajectory of skill demands in manufacturing (Osterman and Weaver 2014), showing that the industrialization processes require a higher level of skilled labour, and pointing future problems in competence levels in the future of the industry. Looking at the specific case of industrial development in aeronautics, is there a skill mismatch for manufacturing? Has technological evolution changed the needs for competences and skills for manufacturing? Or are the measurement and concepts of competences we use leading to a fake skill mismatch? To answer these questions, future research should include the collection of data on competences and skills and movement of workers for specific regions, which underwent a recent industrialization process in the sector, and comparing with other regions that have a longer history of industrial activity in aeronautics. This research requires development of new methodological approaches, framing the existing definitions and measurements of key concepts.

11.4.6 Institutional Factors: The Role of Small Firms and Different Economic Actors

Nelson and Pack (1999) have emphasized the role of entrepreneurial ability in the industrial success of the newly industrialized economies. Technology-based entrepreneurship is increasingly seen as a key element of regional competitiveness and that has been taken as “the model” for many other regions and countries worldwide. Knowledge creation and knowledge spillovers are essential elements in stimulating economic development, and technology based firms are seen as an important source of new employment and important promoters of technological change (Feldman and Audretsch 1999). Nelson and Pack (1999) argue that the ‘effectiveness of entrepreneurship’ (or entrepreneurial ability), which they see as a vital determinant of the rate of assimilation of technology had a key role in the structural transformation of economies such as Korea and Taiwan.

Similarly, Silicon Valley and Route 128 in the Boston-Cambridge area were propelled mainly by new technology and the creation of start-ups—Apple, HP, Google, and Intel, to name a few. Naturally, the formation of Silicon Valley cluster did not occur suddenly; it was a process that evolved over 40 years and it was a process that was only possible due to a set of conditions that came together, such as new ideas, creative people and a culture of risk taking (Venkataraman 2004).

Gries and Naudé (2010) provide a model to illustrate the role of the entrepreneurial innovation in industrialization, and defend that the entrepreneurs provide essential roles. Not only they create new firms, develop new products and introduce new process, but also their activity has impact in employment creation. As these firms grow, they will tend to specialize, leading to increases in innovation. In addition, entrepreneurial activity can create incentives for further investments in

human capital formation, and given that the process of industrial catching up requires different levels of skilled labour, entrepreneurs cause an increase in the demand for educated labour, thus facilitating the industrialization process.

Notably, beyond the concentration of people and skills in a number of regions, a key issue that has differentiated North America from many other countries and regions is the availability of a mix of public and private funding sources, in a quite diversified pattern and, most of them, of easy access to small and medium-sized enterprises (SMEs). It is in this context that a few countries have tried to emulate the Small Business Innovation Research (SBIR) program, which remains unique in many of its characteristics. Although many difficulties have been found in the public support to continue SBIR (as well as that of TIP³ at NIST⁴), its enormous success and impact should be further acknowledge. This is a program of the outmost importance and relevance that has helped American innovative firms to growth. In addition, many other schemes to fund and support new technology-based firms have been used in America in quite original ways, namely through public procurement through the Defense and Energy Departments.

In addition, authors have argued that the development of new technology based firms is dependent of the existent economic structure, and their integration in productive chains (Ács and Naudé 2011). Thus, how do different economic structures lead to different effects of entrepreneurial activity in aeronautics? To address the development of aeronautics capabilities issue, emphasis should be put on the role of small firms and other players in development of local content, and integration in the complex supply chains in aeronautics.

11.5 Summary

The present study presents a contextual analysis on the changing nature of industrial production in European regions. We present an empirical analysis investigating the role of manufacturing on regional development by testing whether knowledge, human capital and innovation capability help to explain regional manufacturing GVA. Our results show that education, employment and R&D are associated with higher regional manufacturing GVA. Finally, we discuss future avenues for research development in the aeronautics industry.

Based on the literature we argue that industrial production in aeronautics continues to morph and adapt to new realities. Thus, it is no longer possible to look into specific industry segments of the value-chain, a broader approach is needed to understand and react to existing economic changes.

Following this argument, we raise some important questions to be addressed in further analysis. Development of this research has several implications. First, firms

³Technology Innovation Program.

⁴National Institute of Standards and Technology.

interested in integrating the aeronautics supply chain can take informed strategic decisions based on the current industry landscape. OEMs interested in developing and consolidating their supply-chains, by facilitating access to critical information that allow the identification and qualification of suppliers in less-known regions and, as such, improving their competitive performance in scenarios of higher initial risk. Researchers working towards an improved understanding of innovation dynamics taking place in this sector can benefit from our analysis. In addition, policy-makers interested in industrial policy in general and aeronautics in particular may gain additional knowledge from our results.

The study presented raises several issues and naturally, to contribute further to capacity building in aeronautics more research is required, which will necessarily imply a methodological and conceptual reflection on existing data, measures and classifications used to analyse industrial production in aeronautics.

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Chapter 12

Linking CSR to National Competitiveness and Innovation

Nikolaus Seitz

Abstract Recently, the Corporate Social Responsibility (CSR) agenda emerged to be core subject in business, politics and academia. Although, the entire debate about CSR had initially been started from asking whether societies at large might benefit from companies engaging in CSR, up to now this question is highly under-researched. This is more unexpected given the fact that most governments throughout the globe have yet been framed their development agendas around promoting the CSR concept. The following study adds value to the existing literature by analyzing whether entire nations can benefit from companies investing in CSR policies. In particular, this study links the national level of CSR and different measures of national competitiveness. Therefore, we adopt the arguments that are usually discussed within the “Business case for CSR” on firm-level, and translate them to the macroeconomic context. In accordance with the business case arguments, we conclude that while investing in CSR, companies promote national innovativeness, the quality of human resources, productivity, and standards of living within a country.

Keywords Corporate social responsibility • National competitiveness • Innovation policy

12.1 Introduction

Do Ethics pay off? Although, this question is as old as the debates about Corporate Social Responsibility (CSR) itself, it has still not been sufficiently answered. Over the last 40 years most research along this line argued that CSR enhances a firm’s overall competitiveness, especially due to innovation, reputation, cost and risk reduction (e.g. Carroll and Shabana 2010; De Bakker et al. 2005; Heal 2008; Kurucz et al. 2008; MacGillivray et al. 2003; Margolis and Walsh 2001; Orlitzky et al. 2003). Besides those “Business Case” arguments, whether CSR also support

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national competitiveness is highly under-researched (Boulouta and Pitelis 2014; Carroll and Shabana 2010; European Commission 2008; Swift and Zadek 2002; Zadek 2006). This is all more surprising given the fact that national governments throughout the world intensively began to promote CSR as strategic key in fostering sustainable competitiveness (Albareda et al. 2007; Boulouta and Pitelis 2014; Habisch and Jonker 2005). In fact, it even governs the development programs of the OECD, European Union or UN.

However, despite its practical relevance, the linkage between CSR and measures of national competitiveness still lacks both from conceptual and empirical rigor (Boulouta and Pitelis 2014; European Commission 2008; Zadek 2006). The few notable exceptions here translate the traditional ideas of a joint corporate provision of private and public goods into the CSR framework, arguing mainly within the sphere of political and welfare economics (e.g. Bagnoli and Watts 2003; Besley and Ghatak 2001, 2007; Kotchen 2006; Kotchen and Moore 2007). Recently, scholars and governments have been asking for further research that analyzes the CSR-national competitiveness link within the framework of comparative economics, such as modern growth theory or industrial economics (Boulouta and Pitelis 2014; European Commission 2008; Zadek 2006). In response to these claims, the following review commentary aims to fill this gap by adopting the well-established “business case” arguments from the micro-firm-level perspective onto the national-context: Therefore, we build on the assumption of prior studies (e.g. Boulouta and Pitelis 2014; European Commission 2008; MacGillivray et al. 2003) that the aggregate CSR practices of all individual companies contribute to a country’s overall competitiveness in the same way, as they promote a firm’s competitiveness on the micro-level: CSR, for instance, promotes higher levels of innovation, attracts human capital and spurs a firm’s profitability which that in turn, finally drives national competitiveness through increased innovativeness and economic growth.

The structure of this chapter is as follows. First, we outline the meaning of CSR and competitiveness and review the recent literature of the CSR-competitiveness link. Then, we lay the conceptual framework of CSR as a Business Case on a country-level. Finally, we underpin our arguments by providing an empirical outlook with descriptive statistics that intuitively support our theoretical considerations.

12.2 Linking Competitiveness and CSR

Over the last 60 years, CSR has become one of the central issues in academia, politics and business. Since the debates over CSR has started both arguments for and against CSR have been extensively discussed across scholars and practitioners (e.g. Aupperle et al. 1985; Blowfield and Murray 2011; Carroll and Shabana 2010; Kitzmueller and Shimshack 2012; Margolis and Walsh 2001). Arguments in favor of CSR usually outline that both business and societies at large could benefit from CSR initiatives (Freeman 2010; Kurucz et al. 2008; Porter and Kramer 2002; Porter

and Van der Linde 1995). But although, the initial discussions about CSR have been centered on the socio-economic impact of companies investing in CSR (Baron 2001; Blowfield and Frynas 2005; Carroll and Shabana 2010; Davis 1973; Heal 2008), the vast majority of previous research, however, focusses on the “business case” arguments, rather than exploring the linkage between CSR and national competitiveness (Boulouta and Pitelis 2014; European Commission 2008; Roman et al. 1999; Swift and Zadek 2002). In fact, the extent of research along the “Business case for CSR” is significant: Over the last 40 years of research hundreds of studies have been conducted to proof the business case of CSR—both empirically or theoretically (e.g. Barnett 2007; Godfrey et al. 2009; Kurucz et al. 2008; Margolis and Walsh 2001; McWilliams and Siegel 2000, 2011; Orlitzky et al. 2003); but despite its great popularity neither the concept of CSR, nor competitiveness is sufficiently defined (e.g. Carroll 1999; Dahlsrud 2008; Kurucz et al. 2008; Van Marrewijk 2003; Vilanova et al. 2009).

Since the concepts of CSR and “competitiveness” are both nebulous and controversial, especially at the macro-level, this section derives a basic understanding of both core constructs.

12.2.1 Defining Corporate Social Responsibility

CSR evolved to be a main subject of geo-political agendas, public debates and research: today, journals, magazines, firm websites, political statements, and blogs—all kind of media comment CSR out as breaking issue. Even the business community, for its parts, mainstreamed the CSR concept as core objective of their firm strategies (Heal 2005, 2008; Kitmueller and Shimshack 2012; KPMG 2013). Although it is in popular use, CSR and all what it stands for is not satisfactory defined (e.g. Carroll 1999; Dahlsrud 2008; Van Marrewijk 2003; Waddock et al. 2002). There is an remarkable history associated with defining the CSR concept (Carroll 1999; Carroll and Shabana 2010; Van Marrewijk 2003), but even after almost 40 years intensive debating, the approaches remain so fragmented that CSR still suffers from conceptual vagueness (Orlitzky et al. 2003; Waddock et al. 2002). Today, CSR is often threaten as an umbrella concept that embraces every issue that is randomly dealing with the field of Business and Society (Carroll and Shabana 2010)—including the often synonymously used concepts of Corporate Philanthropy, Corporate Citizenship, Stakeholder Value, Stakeholder Management, Sustainability, The Ethical Company or Business Ethics (Vilanova et al. 2009). But even though, notions of CSR are insufficiently defined, some “contested” working definitions had been carried out through (Aguilera et al. 2007; Kurucz et al. 2008). Dahlsrud (2008), for instance, explores that most studies grounded their definition on several basic pillars an economic perspective, social, environmental and voluntariness dimension, or stakeholder management (Dahlsrud 2008). A definition that counts for all of these five dimensions is suggested by the European Commission. Accordingly, the EU defines CSR as a “[. . .] concept whereby companies integrate

social and environmental concerns in their core business operations and in their interactions with their stakeholder on a voluntary basis” (European Commission 2001). In contrast to prior popular used definitions, e.g. Carroll’s (1991) concept of a four-staged pyramid of CSR, the one’s of the EU differs due to their comprehensive understanding of CSR: Accordingly, CSR is not an add-on strategy, but an integrative management model that expands the traditional bottom-line of business by adding further, i.e., social and environmental aspects (European Commission 2011; Visser 2011). Thereby, the EU Commission draws upon the concept of the triple-bottom line and translates it to the organization, assuming that CSR initiatives are the direct implementation concept of the goals of Sustainable Development on firm-level (European Commission 2001, 2008, 2011).

CSR initiatives have many faces and are sometimes even hard to distinguish from traditional management practices. Reviewing the vast body of classifications Vilanova et al. (2009) identify five major sub-categories: (1) Vision, including reputation, governance, code of conducts/ethics and legitimacy; (2) Community relations, such as Sponsoring, Corporate Funding, Public-private partnerships; (3) Workplace and employee relations, e.g. HRM, Diversity Management, Life-long-learning, Corporate Volunteering, Safety Policies, human rights issues; (4) Accountability, including transparency, Corporate Reporting and communication. And (5) Market-place, including CSR practices that are directly related to core business issue, such as cause-related marketing, R&D, fair pricing, product quality, green products.

In sum, there are many CSR definitions but due to their holistic approach, the framework of the EU Commission (2001) recently evolved to be the most cited one, even in international research (Dahlsrud 2008). Hence, in this chapter, we adopt the concept of the EU assuming that CSR policies comprise every business practices that aim to promote social and environmental objectives alongside with profit-making.

12.2.2 Defining Competitiveness

Although initially rooted in organizational economics, the multidimensional framework of competitiveness can be applied at all levels of analysis, e.g. firm, industry, regional or national level (Aiginger 2006; Boulouta and Pitelis 2014; European Commission 2008; Porter 1985, 1990; Vilanova et al. 2009). Although commonly in use, there is no consistent definition of competitiveness, neither on the micro nor country level (e.g. Aiginger 2006; Krugman 1994; Porter 1990). Besides this definitional issues, the question what are the main sources of competitiveness, ever since remains an open but prevailing issue in academics (Vilanova et al. 2009). At least since the 1980s, different approaches to the nature and sources of sustainable competitiveness have emerged, both on national and regional (Krugman 1991; Porter 1990; Romer 1990; Storper and Scott 1995) as well as

company level (Barney 1991; Grant 1996; Porter 1985)—but without any complete closure yet. In sum, nevertheless, some basic features are evident in the literature: Reviewing the prominent definitions on the firm level, most authors summarize competitiveness as firm's strength among rivals (Vilanova et al. 2009; Porter 1985). It is shown in an organization's ability to produce either goods or services that are either newer, or of superior quality or lower costs than competitors (cf. European Commission 2008; Porter 1985). This ability, in turn, is driven by a combination of different antecedents, e.g. company's capacity to innovate, its level of productivity, flexibility and profitability, the quality of its relationships with internal and external stakeholders, its reputation or strategic position (cf. Barney 1991; Freeman 2010; Kay 1993; Pitelis and Vasilaros 2010; Porter 1985; Wernerfelt 1984; Wicks and Berman 2004). In the broadest sense, at the firm level, competitiveness is often synonymously treated with most notions of corporate performance (Cava and Mayer 2007; European Commission 2008; Vilanova et al. 2009). Therefore, common measures of competitiveness at the firm-level often include classical performance indicators, e.g. ROA, ROE, ROS (Margolis and Walsh 2001; McWilliams and Siegel 2011; Orlitzky et al. 2003).

At the country level, however, there is a similar picture: Consequently, in line with the basic definition on firm-level, a country can be defined as being more competitive, when it outperforms other nations. But since there is no well “defined bottom line for countries as there is for business” (Boulouta and Pitelis 2014, p. 351 according to Krugman 1994), the concept of competitiveness seems much more complex on the national than firm level; reviewing the literature, there is bandwidth of definitions that includes both traditional economic measures, e.g. growth or productivity (Porter 1990), or indicators for innovativeness or learning capabilities (Audretsch et al. 2006; Florida 1995, 2001), or even measures of social welfare (Stiglitz et al. 2009). But despite all differences, most common approaches share two basic ideas: First, that competitiveness is a multidimensional construct, hence, measuring national competitiveness means accounting for an entire set of different economic indicators, rather than focusing on a single measure (Aiginger 2006; Porter 1990; Stiglitz et al. 2009); and second, a country's competitiveness is embodied in its ability to create welfare and raise living standards for its citizens (Aiginger 2006; European Commission 2008; Scott and Storper 2007; Stiglitz et al. 2009; Swift and Zadek 2002; World Economic Forum 2012). Although there is some conceptual rigor, some basic indicators classifying national competitiveness evolved to be commonly accepted, including social as well as economic categories: commonly used measures for national competitiveness are GDP per capita, GNI per capita, HDI, educational level and innovativeness (Aiginger 2006; Porter 1990; Schwab and Porter 2008; Stiglitz et al. 2009). Due to their holistic approach, recently, several benchmark-indices garnered great attention across practitioners and the academia, e.g. The Global Competitiveness Report by the World Economic Forum, or the World Competitiveness Yearbook by IMD. Both annual benchmarks, for instance, rank a large number of nations to a wide set of different policy, institutional and socio-economic key indicators of national competitiveness.

12.2.3 *The CSR-Competitiveness Link*

The CSR-Competitiveness link has gained noticeable attention across academics and practitioners (Baron 2001; Carroll and Shabana 2010; Falkenberg and Brunsæl 2011; Godfrey et al. 2009; Kurucz et al. 2008; Roman et al. 1999; Weber 2008). Kitzmueller and Shimshack (2012) notices that while CSR emerged to be “New Business Imperative” (cf. Waddock et al. 2002), researchers shifted their perceptions from initial asking, “whether there should be CSR” to “why do we observe CSR” (cf. Kitzmueller and Shimshack 2012). However, with the change of perspective, the level of analysis has moved away from a macro-economic context to firm-level analysis, searching for what has become known as the “Business case for CSR” (Carroll and Shabana 2010; Lee 2008). In short, the business case asks, whether firms can perform better by attending social and environmental objectives within their core operations (e.g. Carroll and Shabana 2010; Fisman et al. 2005; Godfrey et al. 2009; Griffin and Mahon 1997; Margolis and Walsh 2001). Up to now, a long tradition of scholars has explored the link between company’s investments in CSR and firm’s competitiveness—with a focus on conceptualizing, specifying or testing different CSR policies and their specific impact on notions of competitiveness (Carroll and Shabana 2010; Godfrey et al. 2009; Margolis and Walsh 2001; Orlitzky et al. 2003; Roman et al. 1999). But, although hundreds of studies have been carried out during the past four decades, results are still inconclusive and lack from both empirical and conceptual rigor (Barnett 2007; De Bakker et al. 2005; Griffin and Mahon 1997; McWilliams and Siegel 2000, 2011; Orlitzky 2005; Wood and Jones 1995).

Regarding the conceptual nature of the CSR-competitiveness link, it should be underlined that there is no uniform reasoning for how CSR may contribute to firm’s competitiveness (Carroll and Shabana 2010; Kitzmueller and Shimshack 2012; Vilanova et al. 2009). Instead many different approaches have been discussed, each within a distinct theoretical framework and assumption. Screening the literature, four prevailing approaches can be identified: (1) an instrumental approach (Freeman 2010; Jones 1995; Waddock et al. 2002), (2) an institutional case (McWilliams and Siegel 2001; Wicks and Berman 2004), (3) a resource-oriented (Fombrun et al. 2000; Russo and Fouts 1997) or (4) a market-based strands (Porter and Kramer 2002). Although, all approaches differ within their theoretical framing, they all can be broken down to the one basic reasoning: While investing in CSR, firms build up organizational legitimacy, reputation and trustworthy relationships with all stakeholders. Thus, companies might benefit from increased cooperative behavior and commitment of their stakeholder, thus, reduced transaction costs (Barnett and Salomon 2006; De Bakker et al. 2005; Jones 1995; Wicks et al. 1999). As a result, CSR policies can have an positive effect on all indicators of competitiveness, including cost structure, human resources, market advantages, innovation, risk and reputation management, and financial performance (Carroll and Shabana 2010; De Bakker et al. 2005; European Commission 2008; Kurucz et al. 2008; Orlitzky et al. 2003). Just giving some examples, CSR fosters brand

loyalty and reputation (Bagnoli and Watts 2003; Fombrun et al. 2000; Porter and Kramer 2002; Sen and Bhattacharya 2001) that enhances human resource performance (Collier and Esteban 2007), helps to attract and retain high-qualified human capital (Brekke and Nyborg 2008; Collier and Esteban 2007; Kim et al. 2010; Turban and Greening 1997; Valentine and Fleischman 2008), fosters a firm's innovativeness due to trustworthy stakeholder-dialoging (Gallego-Álvarez et al. 2011), smalls risk of political and social regulation (Baron 2001), creates new markets, (Pivato et al. 2008; Porter and Kramer 2002; Porter and Van der Linde 1995), preserves margins (Bagnoli and Watts 2003; Porter and Kramer 2002) and low capital costs (Godfrey et al. 2009). All in turn, CSR might lead the firm to increased profitability, superior growth and resistance against crisis (Fombrun et al. 2000). Hence, it has been suggested that CSR positively influences firm's competitiveness through several mechanisms and complex pathways.

Regarding the empirical evidence: Since the measuring of corporate competitiveness turned out to be difficult, research that has explicitly focus on the link between CSR and competitiveness is rare. Most studies, however, have proved the relationship while testing for a positive relationship between CSR and corporate financial performance (henceforth, CFP) as measurable outcome and adequate proxy for a firm's long-run competitiveness (Carroll and Shabana 2010; Roman et al. 1999; Vilanova et al. 2009). Since the 1990s more than hundred studies have been published within the CSR-performance link, but unfortunately without any consistent, generalizable results (Barnett and Salomon 2006; Orlitzky 2005; Orlitzky et al. 2003). Hence, some scholars show a positive, negative, neutral or even no statistical link between CSR and overall firm's competitiveness (cf. Margolis et al. 2007; Orlitzky et al. 2003). Other papers, however, refuse the idea of a universal business case and confirm that CSR activities are only related to some dimensions of competitiveness and performance outcomes, and that the impact varies from firm to firm each depending on individual contingencies (Barnett 2007; Barnett and Salomon 2006; Carroll and Shabana 2010; Dixon-Fowler et al. 2013). In sum, empirical research suggests that a firm that invests in CSR will either perform better, worse, or the same as it might have done otherwise (Kurucz et al. 2008). In response, Barnett (2007) commented that even "after more than thirty years of research, we cannot clearly conclude whether a one-dollar investment in CSR returns more or less than one dollar in benefit for the firm" (Barnett 2007, p. 406).

Recently, some major advances within the search for a Business Case of CSR have been achieved by several meta-analytical studies: For example, Margolis et al. (2007) presented a review of 167 empirical studies along the CSR-CFP link, in which they conclude that the aggregation of all individual findings suggests a slight positive correlation between CSR and a firm's performance across all analyzed studies. In addition, Orlitzky et al. (2003) had even confirmed that positive CSR-performance relationship within their prominent meta-analysis. Besides the overall linkage, the authors even provide some basic explanations for the mixed results of prior studies. Thus, their psychometric analysis reveals that previous inconsistencies mostly stem from conceptual and methodological differences,

especially those involving the definition and operationalization of the (latent) meta-variables, i.e. CSR and corporate (financial) performance. In sum, although, past meta-analytical findings show that there seems to be a positive relationship between CSR and firm's competitiveness, they fail to proof for a causal linkage. Most results, however, suggest that the CSR-competitiveness relationship tends to be bidirectional, rather than unidirectional (Orlitzky et al. 2003). Hence, CSR can not only result in increased competitiveness, but vice versa (cf. Waddock and Graves 1997).

Although, mixed findings suggest that there is no reason for assuming that CSR can always enhance firm's competitiveness, there are growing calls for business to adopt a wider range of social and environmental responsibilities within their core business. Especially, governments or (non)governmental-organizations have begun to promote the diffusion of CSR within their development programs: Today, CSR-promoting policies can be seen as an essential part in most national agendas across the globe (Albareda et al. 2007; Habisch and Jonker 2005).

Besides the beneficial effects of CSR on firm performance most governments promote CSR while outlining that the CSR activities of all companies might have also a positive impact on the competitiveness of an entire nation (European Commission 2001, 2008; MacGillivray et al. 2003); hence, that the business case arguments might also apply to the country level. The European Commission (2008, 2011), for instance, makes a strong case that companies engaging in CSR might have a measurable impact on all of the factors that determine future national competitiveness, e.g. innovation capabilities, productivity, human capital and reputation (European Commission 2008, 2013).

Despite the popularity of these arguments in current politics, systematic research on whether countries may increase their competitiveness through CSR is rare (Boulouta and Pitelis 2014; Carroll and Shabana 2010; European Commission 2008; Zadek 2006). Previous mainly theoretical-driven studies angled their analysis solely from welfare economics arguing that CSR can lead to a second best-equilibrium, when governments fail to provide public services and goods (e.g. Besley and Ghatak 2007). One of the few exceptions that explicitly addresses strategic considerations of CSR on a country level is the work by MacGillivray et al. (2003) for AccountAbility (cf. MacGillivray et al. 2003): After plotting their own developed Corporate Responsibility Index (CRI)—a composite Index that attempt to capture resulting outcomes of CSR practices within a country (MacGillivray et al. 2003)—against measures of national competitiveness (Global Competitiveness Index Score, GNI) the authors found a positive linkage. These overall results could be supported by the recent work by Boulouta and Pitelis (2014). The authors tested the influence of the competing National Corporate Social Performance (NSCP) index, published by SAM, on more differentiated measures of national competitiveness (e.g. innovation, unit costs and human capital). Their findings even suggest that CSR can enhance the national competitiveness, in terms of GDP per capita.

Although there is little empirical support for a Business case of CSR at national level, the underlying mechanisms behind are still under-conceptualized. With the

next section, we develop a theoretical framework for studying the effects of CSR on national competitiveness. Thereby, we draw on modern economic growth theories and expand the well-established Business Case arguments onto the macro context. Alongside with our discussion, we provide descriptive statistics to support our arguments.

12.3 CSR and National Competitiveness

In wake of globalized trade, increasing competition, product standardization, and mobility, not only companies but entire nations are competing with one another (e.g. Florida 2001; Porter 1990). This development had given the traditional discourse about the sources of sustainable national competitiveness a new impulse. Over the last decades, several antecedents of national competitiveness have been intensively discussed across academia and politics, including innovativeness and entrepreneurship, human capital, and social capital (e.g. Acs and Audretsch 1989; Audretsch and Feldman 1996; Audretsch et al. 2006; Florida 1995, 2001; Furman et al. 2002; Romer 1990). Recently, politicians across the globe started promoting CSR as an instrument for fostering superior national competitiveness. But how and whether the individual CSR initiatives might contribute to national competitiveness is still highly under-researched (Boulouta and Pitelis 2014; European Commission 2008; MacGillivray et al. 2003; Zadek 2006). In this section we develop a theoretical framework for the business case on a macro-economic level.

12.3.1 A Framework

The literature regarding the CSR-competitiveness link on a firm level, names several determinants of competitive advantage, including cost effectiveness, reputation and risk management, innovation, and human capital (Carroll and Shabana 2010; European Commission 2008; Kurucz et al. 2008). However, reviewing the literature on the antecedents of national competitiveness, reveals several key antecedents, including (1) trade and unit cost economies (e.g. Krugman 1991), (2) factor and locational theories (e.g. Dunning 1988; Porter 1990), (3) innovation, human capital and entrepreneurship (Audretsch and Lehmann 2005; Romer 1990; Schumpeter 2000), (4) and institutional and cultural factors and socioeconomics (e.g. Griffiths and Zammuto 2005; Storper and Scott 1995; Florida 2001).

Obviously, there seem to be interactions and overlapping effects between the determinants. By outlining how these effects are working, we further make a strong case that CSR can positively affect every one of these determinants. Hence, while translating the CSR business case arguments into a national context, we identify on two major pathways, how CSR might contribute to national competitiveness: First, CSR promotes national innovativeness while enhancing the quality of stakeholder

relations and national stock of human resources; and second, CSR raises the national productivity.

12.3.1.1 CSR as Source for National Innovativeness

Since the rise of the knowledge based economies, a country's ability to innovate and create knowledge emerged to be key driver of competitive advantage (Audretsch and Lehmann 2005; European Commission 2013; Florida 1995; Furman et al. 2002; Romer 1990; Scott and Storper 2007). Several authors, however, have point out that CSR strategies can enhance the innovation capacity of a firm (Gallego-Álvarez et al. 2011; Porter and Kramer 2002; Porter and Van der Linde 1995), which in turn might foster the innovativeness of an entire economy (European Commission 2008). According to the firm-based literature there appear to be three main pathways in which CSR contributes to a firm's innovativeness (European Commission 2008): (1) higher levels of innovation that result from stakeholder engagement (European Commission 2008; Freeman 2010; Gallego-Álvarez et al. 2011; Wicks and Berman 2004); (2) new business opportunities (Hillman and Keim 2001; Jenkins 2009; MacGregor and Fontrodona 2008; Porter and Kramer 2002); and (3) creating innovation-friendly organizational structures (Gallego-Álvarez et al. 2011; Wicks and Berman 2004).

Most authors suggest that while engaging in CSR, companies invest in trustworthy relationships by considering different stakeholder interests, e.g. Customer, employee, supplier etc. Stakeholders, for their part, reward getting their interest satisfied by committing to the company (Aguilera et al. 2007; Carroll and Shabana 2010; Fombrun et al. 2000; Freeman 2010; Jones 1995; Wicks et al. 1999). This in turn fosters cooperative behavior; enables information flows and shared knowledge creation on all markets and within all stakeholder groups (Gallego-Álvarez et al. 2011). As a result, it is suggested that CSR promotes open and stakeholder-driven innovation processes; enhances the learning capabilities and firm's entire adaptability to market dynamics and social challenges (European Commission 2008; Heal 2008; Kurucz et al. 2008; Porter and Kramer 2002).

In addition, there is a strong case that while engaging in CSR companies can create new market opportunities. Porter and van Linde (1995), for instance, highlight that CSR policies usually require investing in new technologies, products and processes that can establish new industry benchmarks, create new business opportunities, or face social needs. The development and diffusion of renewable technologies, the expansion of the markets for organic food, green products, new business models or the rise of social entrepreneurship, are prominent examples of how corporate social responsibly behavior can serve as catalyst for product and process innovations (Boulouta and Pitelis 2014; Porter and Kramer 2002).

Another aspect is the argument that CSR enhances a firm's quality of work force (Albinger and Freeman 2000; Brekke and Nyborg 2004, 2008; Collier and Esteban 2007; Turban and Greening 1997). Along this line, it is argued that companies that invest in CSR directly raise the quality of the national human capital stock

(Boulouta and Pitelis 2014; Zadek 2006). As the competitive advantages of nations shifted from cost-based to knowledge-based strategies, human capital turned out to be main source of national competitiveness (Audretsch and Lehmann 2005; Florida 2001; Romer 1990). Thereby, it is not surprising that enhancing skill and educational level of human resource has become a central issue in most governmental agendas across globe. CSR policies usually cover for Human Resource (HR) strategies, including education programs, career trainings, life-long-learning and work-life-balance programs (Vilanova et al. 2009). Besides those core business strategies, educational private-public-partnership became a regular CSR practice. On an aggregate level, companies that individually invest in educational and HR initiatives might contribute to a high qualified work force, which in turn may foster national innovativeness.

In addition, since the emergence of a global war for talents national competitiveness is increasingly depending on its abilities to retain and attract new talents (e.g. Florida 2001). Along this line, some authors empirically underline that companies that invest in CSR are magnets for talents: Several surveys suggest that especially high-educated human capital feels attracted to companies with a good CSR reputation (Turban and Greening 1997; Albinger and Freeman 2000; Brekke and Nyborg 2008; Collier and Esteban 2007). Since talents are highly mobile, companies attracting those talents expand the national stock of human capital, which in turn, promotes a nation's overall capacity to innovate (Florida 2002/2012).

In addition, CSR might also enhance a country's cultural diversity, open-mindedness, tolerance and level of social inclusion. CSR policies are commonly framed around diversity management and inclusion strategies (Vilanova et al. 2009). Organizational studies suggest that certain levels of heterogeneity (cultural, background, age) within a work force supports innovation outcomes due to higher levels of problem-solving competencies and creativity (Van der Vegt and Janssen 2003). On a national level, melting-pot theorists, however, argue in the same line. For instance, Richard Florida's work (1995, 2002/2012) reveals that cultural diversity and national innovativeness are positively correlated.

Along similar lines of reasoning, Zadek (2006) has described how CSR can bring innovation in politics and governance—both on a national or global scale: Furthermore, a more efficient macro-institutional surrounding can support innovation outcomes and unit cost economies, and ultimately may help a country to preserve its global competitive position vis-à-vis other nations (Boulouta and Pitelis 2014; MacGillivray et al. 2003).

12.3.1.2 CSR as Source for Cost Advantages

Since Adam Smith (1776) comparative trade advantages are discussed to be main sources of national competitiveness. Along the business case, it is widely discussed that companies that invest in CSR may reduce their overall operating costs, thus, increase their level of productivity and profitability (Barnett 2007; De Bakker

et al. 2005; European Commission 2008; Godfrey et al. 2009; Griffin and Mahon 1997; Kurucz et al. 2008; McWilliams and Siegel 2000): Proponents of cost saving argument, however, suggest that CSR policies do not only indicate that firms use all of their resources in a productive and resource-saving way; but CSR may also contribute to cost savings, e.g. in the field of human resources, supplier management, access to finance and future (sub-)political risks (Baron 2001; Carroll and Shabana 2010; Fisman et al. 2005; Kurucz et al. 2008). In regard to human resources, Frank (2004) and Nyborg and Zhang (2013) found that companies with a good CSR reputation pay lower wages. A firm's CSR engagement provides identification, thus, in turn serves as intrinsic incentive structure for employees, and results in lower cost of financial (extrinsic) compensations (Kim et al. 2010). Consequently, a company may benefit from CSR through labor donation, higher levels of employee commitment (Brekke and Nyborg 2008; Collier and Esteban 2007; Kim et al. 2010; Turban and Greening 1997) and reduced operating costs (Bénabou and Tirole 2010; Kim et al. 2010; Nyborg and Zhang 2013).

Analogously, the same beneficial mechanisms are working regarding suppliers and financiers (e.g. Carroll and Shabana 2010; Godfrey et al. 2009; Kurucz et al. 2008): Companies may benefit from CSR through reduced capital and agency costs. CSR is business's acknowledgement to invest in corporate transparency, legitimacy and stakeholder dialoging (e.g. Carroll 1999; EU Commission 2011; Fombrun et al. 2000; Dahlsrud 2008). Along the business case arguments, many authors emphasize the role of CSR in establishing trustworthy relationships with suppliers and investors (e.g. Carroll and Shabana 2010; Fombrun et al. 2000; Freeman 2010; Godfrey et al. 2009; Roman et al. 1999). According to neo-institutional economists, trust is generally seen as an institution that systematically reduces uncertainty within a social transaction (cf. Wicks and Berman 2004; Wicks et al. 1999). Consequently, being known as trustworthy partner CSR may lower the potential risks of one-sided underinvestment and reduce agency costs. On a national scale, however, country's may benefit from these effects due to lower costs of capital (European Commission 2008).

Additionally, CSR may reduce the costs of political or sub political regulation. Along this line, many authors underline that CSR is a preemptive strategy for avoiding political and social regulation, e.g. new restrictions or boycotts (Baron 2001; Fombrun et al. 2000). According to most definitions, CSR encompasses a company's commitment to self-regulation, even when it goes beyond compliance and formal law (Baron 2001; Carroll 1999; Kurucz et al. 2008). Hence, companies that engage in CSR, establish voluntary extended social and environmental standards within their business operations, which in turn might reduce governmental and social regulation practices (Baron 2001; Fombrun et al. 2000). As a result, both company as well as countries may benefit from CSR: On the one hand, companies reduce their risk/cost of regulation and social pressure; and governments, on the other side, can reduce their regulation efforts and social investments (Boulouta and Pitelis 2014; Swift and Zadek 2002; Zadek 2006). Along these lines, one has to mention that CSR practices can even promote innovative governmental practices through social dialogue, joint governance initiatives and public-private partnership

(Boulouta and Pitelis 2014; MacGillivray et al. 2003; Swift and Zadek 2002; Zadek 2006). Welfare theorists, for instance, have recently found that CSR can provide “second-best” solution/equilibrium when government fails to cover a sufficient provision of common goods (Besley and Ghatak 2001, 2007; Kitzmueller and Shimshack 2012; Kotchen 2006; Kotchen and Moore 2007).

In sum, while companies invest in CSR, they might foster national productivity. Thus, countries can also gain location advantages, that in turn, attract FDI and other companies locating. That in turn may contribute to economic growth, welfare, and boosts national innovativeness.

12.3.2 *Empirical Outlook*

In sum, our previous theoretical discussions suggest that the aggregate CSR engagement of individual firms might fuel national competitiveness along all key indicators that are traditionally discussed. Hence, CSR can contribute to national competitiveness through reducing overall unit costs, increased productivity, innovativeness and welfare. Even if these theoretical arguments seem plausible, there has been only little empirical evidence, in particular regarding CSR on a national level (Boulouta and Pitelis 2014). Thus, while providing some descriptive statistics, we provide intuitive evidence for our arguments towards the CSR-competitiveness link on a national level.

We build our empirical outlook especially on data provided by the “Global Competitiveness Index (GCI) 2012-2013”. The GCI is a yearly provided report published by the World Economic Forum. Since 2004, the GCI ranks 148 economies due to their productivity and their ability to provide high levels of prosperity to their citizens (World Economic Forum 2012): Based on a composite index it benchmarks all countries across 12 pillars of national competitiveness, e.g. institutional antecedents, infrastructure, macroeconomic environment, health and education, or innovation. The Global Competitiveness Report comprises 110 variables, of which one third comes from publicly available sources (e.g. IMF, UN Stats) and two thirds come from an Executive Opinion Survey (13,000 respondents in 148 countries in 2012; World Economic Forum 2012). Due to its comprehensiveness, the GCI is one of the most common cited indices for national competitiveness (Lall 2001; Porter et al. 2008).

A systematic overview over all employed variables and their sources is given by Table 12.1.

Table 12.1 Overview: variables, measures and sources

Variable name	Measures	Source
GDP per capita	<i>Gross domestic product (GDP) per capita</i>	
	GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. Data are in current international dollars based on the 2011 ICP round.	World Bank, International Comparison Program database (World Development Indicators)
Government expenses	<i>Government expense (% of GDP)</i>	
	Expense is cash payments for operating activities of the government in providing goods and services. It includes compensation of employees (such as wages and salaries), interest and subsidies, grants, social benefits, and other expenses such as rent and dividends.	World Bank, International Comparison Program database (World Development Indicators); International Monetary Fund, Government Finance Statistics Yearbook, and World Bank and OECD GDP estimates;
Labor productivity	<i>GDP per person employed</i>	
	GDP per person employed is gross domestic product (GDP) divided by total employment in the economy. Purchasing power parity (PPP) GDP is GDP converted to 1990 constant international dollars using PPP rates. An international dollar has the same purchasing power over GDP that a U.S. dollar has in the United States.	International Labour Organization: Key Indicators of the Labour Market database (KILM 8th edition)
National level of CSR	<i>Ethical behavior of firms</i>	
	Question asked in “The Executive Opinion Survey” (The Global Competitiveness Report 2012–2013): In your country, how would you rate the corporate ethics of companies? 1 = extremely poor—among the worst in the world; 7 = excellent—among the best in the world.	The Global Competitiveness Report 2012–2013, World Economic Forum, GCI data platform (January 2014)

(continued)

Table 12.1 (continued)

Variable name	Measures	Source
Number of patent applications	<i>PCT patent applications</i>	
	Number of applications filed under the Patent Cooperation Treaty (PCT) per million population (2008–2009 average); Total count of applications filed under the Patent Cooperation Treaty (PCT), by priority date and country divided by population.	The Global Competitiveness Report 2012–2013, World Economic Forum, Switzerland, 2012
Tertiary education	<i>Level of tertiary education attainment</i>	
	Labor force with tertiary education is the proportion of labor force that has a tertiary education, as a percentage of the total labor force.	International Labour Organization: Key Indicators of the Labour Market database (KILM 8th edition); World Bank, International Comparison Program database; World Development Indicators

12.3.2.1 CSR as Source of Innovativeness: Outlook

Most studies have tested the relationship between CSR and innovativeness solely on firm-level, however, studies within a macro-economic context are rare (European Commission 2008). Nevertheless, in order to support our central argumentation we provide a scatter plot that intuitively demonstrates how CSR and national innovativeness are related (Fig. 12.1). The graph shows that the data from aggregate CSR of individual firms and national innovativeness are positive correlated. As measure for aggregate national CSR we build on the variable “Ethical behavior of firms” suggested by WEF—a variable that ranks all sampled countries along the level of corporate ethics (for an detailed overview of all variables, see Table 12.1). As measure for national innovation capacity, we adopt the commonly used proxy for innovation activity as number of patent applications (Acs and Audretsch 1989).

Along with our innovation argument, we discussed that CSR may raise the human resource stock of an entire nation. The relationship drawn by Fig. 12.2 even supports this assumption: Hence, between human resource and levels of national CSR is a positive correlation. As proxy for high-qualified human capital stock, we build on data of the WORLD BANK, ranking countries due to the percentage of labor force with 3rd level education.

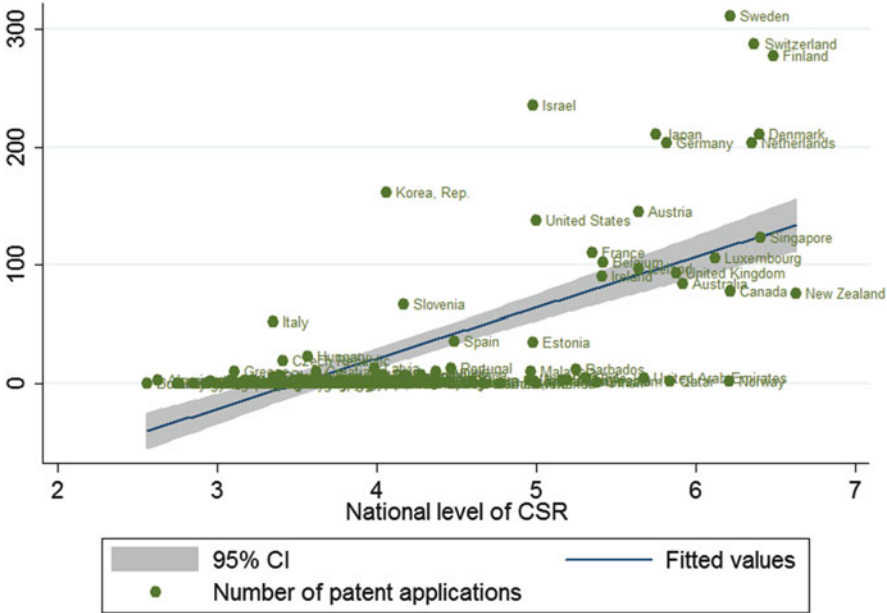


Fig. 12.1 National CSR and innovativeness

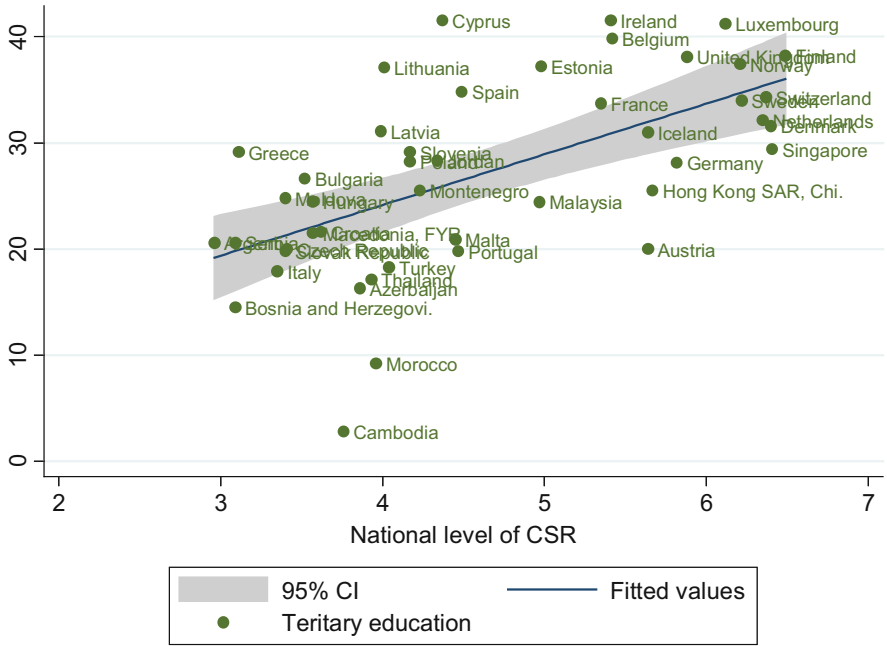


Fig. 12.2 National CSR and human resource

12.3.2.2 CSR as Source of Cost Advantages: Outlook

In Addition to the CSR-innovativeness link, we further discussed that CSR may raise the overall economic efficiency of a nation due to fostering productivity. Beside theoretical considerations, however, we provide empirical support. Hence, Fig. 12.3 shows that there is a strong positive correlation between “Ethical behavior of firms” and levels of national productivity, here—as traditionally—measured by GDP per capita (e.g. Porter and Van der Linde 1995). Along our argumentation, we assume that CSR may enhance labor productivity while reducing labor costs. Figure 12.4 supports this assumption. Hence, national levels of CSR and labor productivity (Output per Worker) are even positive related.

In addition, we had argued that companies that engage in CSR may contribute to lower regulatory costs and costs of social goods provision for governments—through self-regulation and private provision of public goods of companies (e.g. social and environmental standards, joint governance, educational partnerships etc.). Our findings, however, do not support our arguments. Fig. 12.5 suggest that governmental expenses and national CSR are slight but positively correlated.

Summarizing, all graphs underline our general argumentation, whereas CSR might contribute to several antecedents of national competitiveness, e.g. innovation outcomes, stock of human capital and national cost structures and levels of productivity.

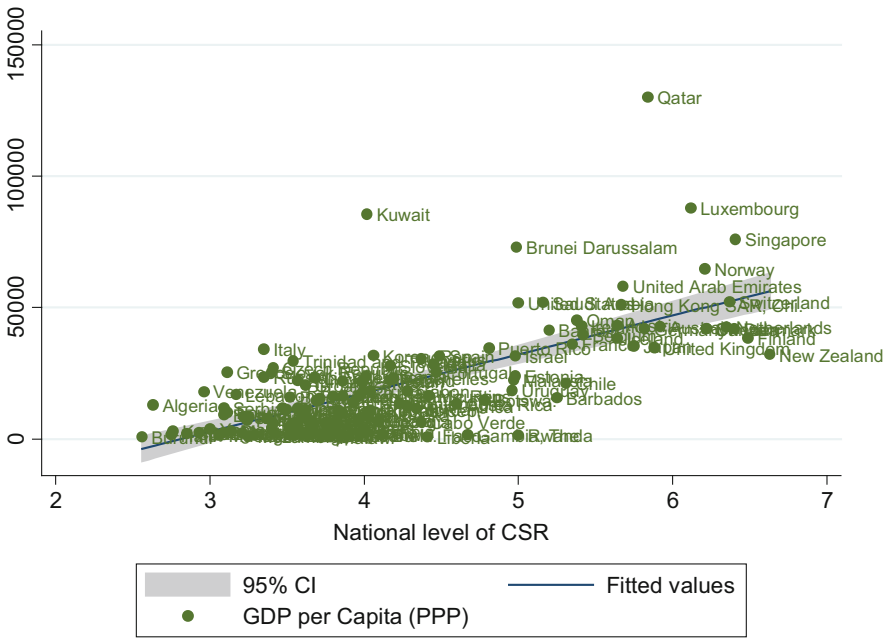


Fig. 12.3 National CSR and productivity (GDP per capita)

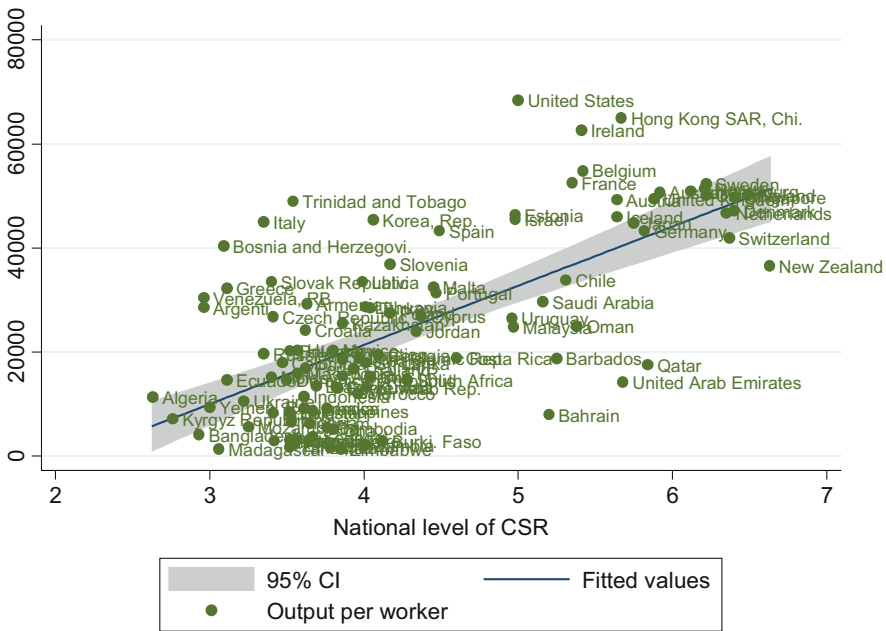


Fig. 12.4 National CSR and labor productivity (GDP per person employed)

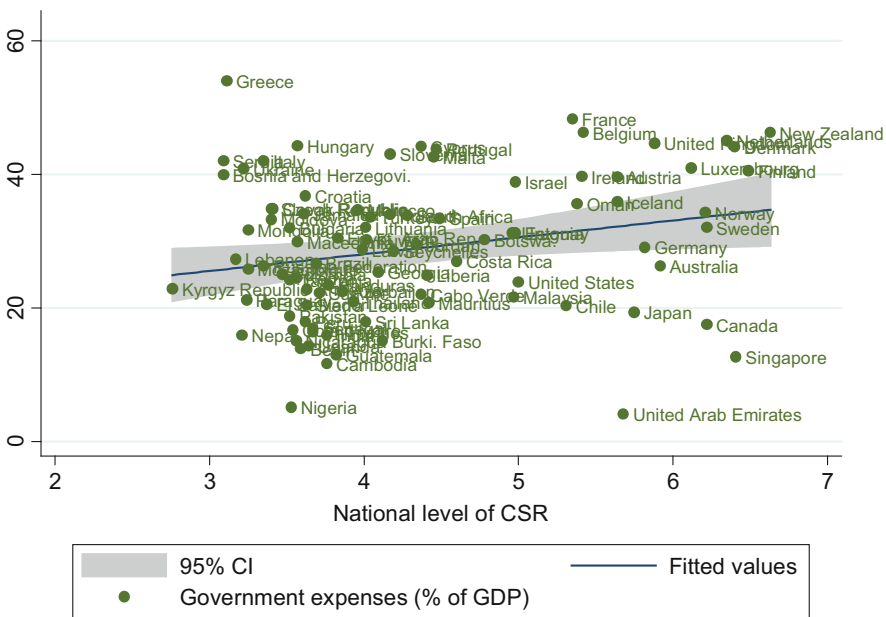


Fig. 12.5 National CSR and government expenses

12.4 Discussion and Conclusion

CSR has evolved to be priority theme in national development programs across the globe: Recently, governments promote the concept of CSR as motor of national competitiveness. But despite its popularity, whether there is any systematic linkage between companies investing in CSR and national competitiveness is under-researched. In response, we provide a conceptual framework arguing that the aggregate CSR may contribute to national competitiveness through several pathways. For instance, we suggest that the aggregate CSR of individual companies attracts talents, enhances national innovativeness and productivity. In addition, we argued that CSR might reduce the national cost structure through self-regulation and corporate funding, which in turn, leads to locational advantages that may attract companies locating. In sum, we argue that CSR can contribute to higher levels of productivity, economic growth and social welfare. While discussing the underlying mechanisms, we borrowed our arguments from the well-established business case for CSR.

In order to underline our argumentation, we further provided descriptive statistics to support our main assumptions: We therefore plot the national CSR performance against all discussed antecedents of national competitiveness, e.g. productivity, economic growth, innovation and human capital. Due to the nature of descriptive statistics, their validity and significance is limited: Hence, we could solely demonstrate correlations; whether there is any causality between CSR and our measures of national competitiveness, or which others determinants influence national competitiveness, however, needs further empirical testing. Consequently, the link between CSR and outcomes of national competitiveness might also be other way round or bidirectional. As result, our findings may even support the arguments that are discussed on the firm-level within the so called “Slack Resource Theory” or within the idea of a “circle for virtuous” (e.g. Orlitzky 2005; Waddock et al. 2002): Hence, we might even argue that not CSR enhances national competitiveness, but the superior performance of national firms set “slack” resources free which can be invested in CSR policies. Or, according to the theory of a virtuous circle: CSR and national competitiveness are self-enforcing concepts. Nevertheless, future research should account for these relationships.

However, our suggested framework adds value to two major streams in recent literature: First, it might complete the traditional discourses about the nature and responsibilities of business in society; and second it introduces CSR into the field of economic geography: Within this line, it can be discussed whether promoting CSR might be an adequate political instrument for fostering regional and national development, e.g. side-by-side with innovation and entrepreneurship policies.

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Part V
The Role of Universities

Chapter 13

Universities in a Metropolitan Environment: The Case of London

Peter Wood and Helen Lawton Smith

Abstract This paper addresses problems of assessing the external impact of university research in the context of a complex metropolitan region. It is a response to criticisms by Huggins (Entrep Reg Dev 20(2):185–206, 2008) of the performance of higher education institutes (HEIs) in London. Huggins argued that, in the early 2000s, the involvement of London's HEIs in commercial knowledge transfer to the wider economy was lower than might be expected, especially in view of the city's national domination of financial venturing services.

This paper argues that London supports one of the most diverse and open regional economies in Europe, offering wide potential for commercial HEI outreach for many forms of scientific, technological, biomedical, architectural, artistic, media, design, and other professional expertise. In recent years, many types of innovation in London have been described as 'hidden', unmeasured by conventional technology-based innovation indices [NESTA (Hidden innovation, 2007)]. By definition, therefore, these create special difficulties for assessing the outreach contribution of HEIs in the city.

Keywords Universities • Knowledge transfer • Metropolitan environments • London • Third mission

13.1 Introduction: Universities and Metropolitan Economies

The economic and other impacts of universities on their regions have attracted a burgeoning volume and variety of research in recent decades. In general, the focus has been on the means by which their scientific and technological expertise may be

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directed to supporting commercial, and especially industrial competitiveness. As Uyarra (2010) has suggested, however, the range of relevant regional university impacts has been progressively expanded over the past three decades. Early studies focused on the possibility of encouraging regional industrial spillovers from specific forms of scientific research, or more generally on fostering closer university-industry links and a more active approach to the commercial exploitation of research.

More recently, attention has, perhaps inevitably, become extended beyond higher education institute (HEI) support for scientific and industrial research, to their wider regional and local roles, for example in economic, social and cultural development, including their capacity to draw on wider resources to support such needs (see Glasson 2003; Charles 2003). This emphasises a ‘third strand’ mission or functional responsibility, through extra-mural activities that go beyond traditional teaching and research (see O’Shea et al. 2004; CBR/PACEC 2009). Approaches based on concepts such as “regional innovation systems” (Cooke 1998; Asheim and Gertler 2005; Asheim et al. 2011), “regional eco-systems” (Harrison and Leitch 2010), or “regional triple helix spaces”, based on universities, industry and government working together at a regional level (Etzkowitz 2008), embody ideas of putting in place effective channels for universities’ output to be accessible and appropriated by private and public sector organisations.

However, Uyarra (2010) concludes that HEI performance measurements of such processes may still distort policy towards activities that are easily measured, rather than those requiring the greatest attention in support of wider regional development (OECD 2007). She also notes that the type and degree of regional HEI engagement is likely to differ according to the number of university establishments in a region, the significance of competition and/or collaboration between them, and the extent to which they are embedded in a coherent regional development strategy (Boucher et al. 2003; Kitagawa 2004; Perry 2012). Moreover, HEIs of different types (e.g. research-led, teaching intensive, discipline-based) vary widely in their forms of knowledge-based external engagement (Bagchi-Sen and Lawton Smith 2012).

The priority given in much of the research literature to HEIs as agents of technological innovation and international competitiveness is perhaps inevitable, given the costs of such research and the imperatives of globalised competition. It has nevertheless diverted attention from their wider educational, cultural and social purposes within civic society, beyond simply supporting such research (e.g. May 2006; Marginson 2010; Goddard 2013). This is perhaps no better illustrated than by the actual diversity of HEI activity in a global city region such as London. In recent decades, Greater London HEIs have expanded to support not only international commercial and public sector research, but also the full range of tertiary teaching and professional training required in a major global metropolis. As a consequence, the scale and diversity of London’s HEIs now overshadow those of every other UK region, as we shall see, and every other centre of higher education in the UK, including the research of Oxford and Cambridge Universities. Such activity in London is scattered across many institutions, however, perhaps obscuring its scale, variety and regional impact in national perceptions of HEIs (see Huggins

2008). Similar situations may apply in relation to other global metropolitan regions, reflecting the common focus in HEI studies, not just on scientific and technological research, but also on smaller, more tractable city regions, with fewer, and more singular HEIs.

This paper seeks to redress this bias, firstly by briefly summarizing the limitations of conventional studies of HEI/regional relationships in a metropolitan context, especially where measurement focuses on scientific and technological outputs. It then presents evidence for the scale and variety of HEIs in Greater London, first in aggregate comparison with other UK regions, and then in more detail within London itself. Some general conclusions are drawn about the variety of regional economic relationships, in research, teaching and other, “third strand”, relationships, that emanate from the HEI system in a global city region such as London. These clearly extend far beyond the merely technological, reflecting the true diversity of HEI activity in a metropolitan context.

13.2 The ‘Third Mission’ of HEIs in a Metropolitan Context

The analysis of ‘third mission’ HEI roles in regional economies is now embedded in academic and policy discourse in many countries (see the 2013 Witty Review of ‘Universities and Growth’ on the UK).¹ They are widely seen as ‘engines of growth’, incubating new firms or acting as nodes in networks of innovators (Arbo and Benneworth 2007), as well as offering wider potential economic, social and cultural benefits (Trippel et al. 2012; Goddard et al. 2013). Many such activities have a de facto local impact, for example when innovative spin-offs remain in their home locality (Zang 2008). Often, however, technology-based associations depend on a match between HEIs and their regional economy to support outputs such as patents and licenses, or the collaborative exchange of expertise (Lendel 2010). In any case, even when not retained regionally such knowledge exploitation contributes to national GDP (Universities UK 2014).

Any local match between regional firms’ technological requirements and university research output is subject to a number of contextual caveats, for example in relation to sectoral specialisation, or through the geographical outcomes of broader economic processes (see Rip 2002; Ponds et al. 2010). Various practical issues affect both the impact of technology transfer and the wider social opportunities arising from university initiatives (Goddard et al. 2013). There is thus no automatic correspondence between the university mission, the needs of a regional economy, and any local/regional impacts. Martinelli et al. (2008) for example find that entrepreneurial universities do not necessarily have a strong regional impact.

¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/225442/bis-13-1048-independent-review-universities-and-growth.pdf (accessed May 4, 2014).

Goldstein (2009) also measures universities' technology transfer by distance, types of research and kinds of universities. He finds spillovers from basic research to be less localized than from applied research, with those from highly ranked research universities most geographically widespread. It has also been shown that the density of universities in a region influences whether they act alone or in conjunction with other institutions to facilitate technology transfer (Uyarra 2010).

Such considerations must also apply in assessing the role of different HEIs in the 'multi-university' context of a global metropolis such as London. There has been little research consideration, however, of the regional impact of such a full spectrum of research, professional training and academic teaching, or its contribution to the growing economic and cultural dominance of such cities. There is, of course, a continuing challenge in encompassing such a diversity of impacts, and how they are recorded and measured. Since the early 2000s surveys have been conducted in many countries, including the UK, Spain, US, Canada, to monitor and assess universities' performance, including their local and non-local impacts, although this has been mainly in relation to processes of technology transfer (Rossi and Rosli 2013). In the UK, the annual Higher Education Business and Community Survey (HE-BCI) of close to 150 UK HEIs, as its name suggests is more comprehensive, although the published analysis often remain focused on patterns of research earnings and expenditure. This paper nevertheless presents some evidence from this source, drawing on data for 2007–2012.

13.3 London in a UK Context

The context to each universities' regional significance in the UK depends on the number of universities in each region and their type and degree of regional engagement in research, teaching and 'third mission' outreach activities. In turn this is affected by the volume of research undertaken, supported an array of stakeholders and end users in public and private sectors and in wider civil society (Hazelkorn 2010 in Goddard et al. 2013). Figure 13.1 shows the number of HEIs in each UK region in 2009–2010. The dominance of London is evident, with more than twice the number of institutions than either of the next two regions, Scotland and South East England outside London. Many of London's specialist institutions are relatively small in staff numbers, however, and Fig. 13.2 shows regional full time equivalent academic employment in HEIs, showing London to be less dominant, especially compared with SE England. It nevertheless still has the largest numbers employed in "Russell Group" research-intensive HEIs and specialist medical institutes, in the more teaching-oriented 'post 1992' HEIs, and especially in arts-oriented training institutions.

Table 13.1 shows the regional pattern of research income across the UK between 2007 and 2012. Taken from the annual HE-BCI data, this shows institutional numbers, research investment during the period and full time equivalent research and teaching staff numbers, both totalled over 5 years between 2007 and 2012. In

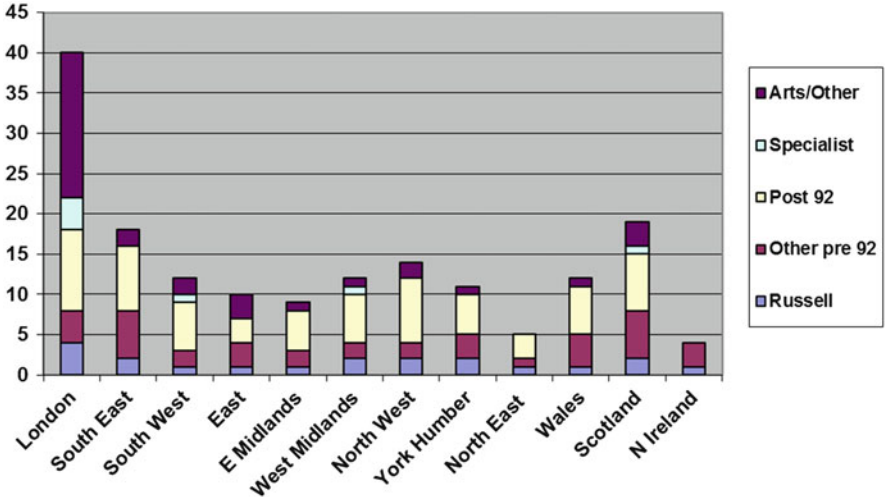


Fig. 13.1 Regional numbers of HEIs, 2009–2010. *Source:* HE-BCI (2013)

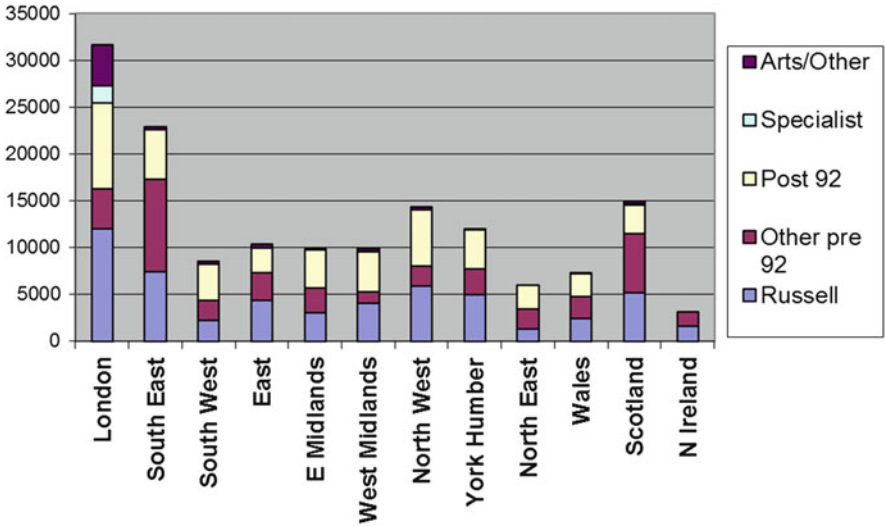


Fig. 13.2 Regional HEI FTE employment, 2009–2010. *Source:* HE-BCI (2013)

this period, UK higher education received an annual average of over £4 billion research funding from all sources, £28,800 per head of staff. The table shows how the pattern was dominated by London and the South East region, which together accounted for 42 % of national research income over the 5 years. London HEIs themselves attracted over one quarter of national research investment, and employed about one fifth of university staff. It is notable that the only other UK

Table 13.1 Regional patterns of HEI research income, 2007–2012: all institutions

Region (no. of institutions)	Amount £k	FTEs (5 years)	£k/FTE p.a.	% of total	
				£k	FTEs
East (5)	£1,501,508	31,927	£47.0	7.34	4.50
East Midlands (9)	£975,810	47,073	£20.7	4.77	6.63
London (42)	£5,234,357	142,962	£36.6	25.58	20.14
North East (5)	£701,454	30,217	£23.2	3.43	4.26
Northern Ireland (3)	£322,745	15,222	£21.2	1.58	2.14
North West (13)	£1,775,109	70,639	£25.1	8.67	9.95
Scotland (18)	£2,433,312	74,991	£32.4	11.89	10.57
South East (21)	£3,311,638	115,596	£28.6	16.18	16.29
South West (11)	£975,054	39,365	£24.8	4.76	5.55
Wales (12)	£662,583	34,437	£19.2	3.24	4.85
West Midlands (11)	£1,053,145	48,120	£21.9	5.15	6.78
Yorkshire and Humber (11)	£1,519,265	59,243	£25.6	7.42	8.35
	£20,465,980	709,792	£28.8	100.00	100.00

Source: HE-BCI 2013

regions where the share of national HEI research income was higher than that of staff were Eastern England, dominated by Cambridge University, and Scotland.

A simple comparison of regional research earnings such as this, however, makes no allowance for the variable numbers and institutional mission of HEIs in each region, most obviously between over 40 London HEIs and the smaller numbers in other regions. As we have seen, many of the London institutions, although regionally, and often nationally, important centres of training and teaching, are not primarily research oriented. In contrast, the East and North East regions each include only 5 institutions, and Northern Ireland 3, with the numbers in the other regions between 9 and 13. Evidently, the number and variety of institutional types based in London is not comparable with other UK regions.

Table 13.2 therefore shows the importance of the nationally more research intensive universities in generating regional research incomes. These are defined as attracting an average annual research funding during 2007–2012 of at least £15 million. The 59 such UK institutions (from a total of 161) attracted almost £19 billion of the £20.4 billion of national HEI research spending, and employed 60 % of their academic staff. These institutions' annual research income thus averaged £44,700 per FTE staff. It was highest, at over £50,000, in London, Eastern England and the South East, and lowest in Wales (£26,600) and Northern Ireland, (£31,199). The dominance of London, Cambridge and Oxford over national university research is therefore evident, but London's 18 research intensive institutions are also especially significant. Together, they attracted more university research income than all the other comparable institutions in the East and South East regions, including Cambridge and Oxford combined.

The low research income averages per HEI for London noted in 2000–2001 by Huggins (2008) were thus weighted by the performances of the newer ('Post-1992')

Table 13.2 Regional patterns of HEI research income, 2007–2012: research intensive institutions

	Amount £k	FTEs (5 years)	£k/FTE p.a.	% of total	
				£k	FTEs
East (2)	£1,495,144	27,009	£55.4	7.83	6.30
East Midlands (3)	£896,116	27,687	£32.4	4.70	6.46
London (18)	£5,063,133	91,043	£55.6	26.53	21.25
North East (2)	£653,299	17,067	£38.3	3.42	3.98
Northern Ireland (1)	£254,000	8170	£31.1	1.33	1.91
North West (3)	£1,605,881	36,271	£44.3	8.41	8.47
Scotland (8)	£2,312,869	56,250	£41.1	12.12	13.13
South East (7)	£2,989,576	58,706	£50.9	15.66	13.70
South West (3)	£861,303	21,838	£39.4	4.51	5.10
Wales (4)	£623,641	23,425	£26.6	3.27	5.47
West Midlands (4)	£986,352	27,934	£35.3	5.17	6.52
Yorkshire and Humber (3)	£1,344,928	32,987	£40.8	7.05	7.70
	£19,086,242	428,386	£44.6		

Source: HEBCI 2013

HEIs and its many arts-based training institutions. The contributions to economic development of such institutions are, of course, in general quite distinct from those of older established, research-based HEIs. In the former, there is a greater emphasis on widening regional and local access to higher education, and to supporting local development, including SMEs, rather than international or national scientific, corporate or sectoral needs (HE-BCI 1999–2000). A survey by Goddard et al. (2013) has demonstrated, for six English universities in three large cities, that significant numbers of academics are engage in ‘public good’ activities such as informing policy, contributing to health and well-being, environmental sustainability, cultural enrichment and helping the socially excluded. The arts-based institutions are also primarily training-based, with their economic and social impacts felt through the long term quality of the creative economy, in design, fashion and the performing arts, often through many forms of specialist consultancy in London.

13.4 The Diversity of London’s HEI Research

The diversity of HEI activity in London is summarised in Table 13.3, based on their size, measured as full time equivalent (FTE) academic staff numbers. Most dominant are the large, multi-disciplinary colleges, historically associated with the University of London (UL) as it evolved after the 1820s. Now virtually independent institutions, in order of current FTE numbers these include University College London (UCL), Imperial College (IC), King’s College UL (KCUL), Queen Mary UL (QMUL), Birkbeck College UL and Royal Holloway UL (RHUL). There are also a dozen other specialist UL institutions, including the London School of

Table 13.3 Full-time equivalent staff, 2009–2010

	FTE staff	% of total
<i>University of London: Russell Group</i>		
University College London	4488	
Imperial College of Science, Technology and Medicine	3358	
King's College London	3048	
Queen Mary and Westfield College	1675	
London School of Economics and Political Science	1073	
Total	13,640	44.4
<i>Other University of London: Specialist medical/veterinary institutions</i>		
The Institute of Cancer Research	590	
St George's Hospital Medical School	533	
London School of Hygiene and Tropical Medicine	513	
The Royal Veterinary College	253	
The School of Pharmacy	120	
Total	2008	6.5
<i>Other University of London: Multi-faculty institutions</i>		
Birkbeck College	1113	
Royal Holloway and Bedford New College	848	
Total	1960	6.4
<i>Other University of London: Humanities-based institutions</i>		
The School of Oriental and African Studies	590	
Goldsmiths College	398	
Institute of Education	348	
London Business School	108	
University of London (Institutes and activities)	83	
Total	1525	5.0
<i>Other universities/Colleges in Greater London</i>		
Kingston University	1453	
The University of Westminster	1155	
The City University	1140	
The University of Greenwich	960	
Brunel University	845	
London Metropolitan University	793	
Middlesex University	750	
Thames Valley University (University of West London from 2011)	698	
The University of East London	615	
Roehampton University	465	
St Mary's University College, Twickenham	278	
Ravensbourne	68	
Heythrop College	65	
Rose Bruford College	63	
Total	9345	30.4

(continued)

Table 13.3 (continued)

	FTE staff	% of total
<i>London Arts Institutions</i>		
University of the Arts, London	1315	
Guildhall School of Music and Drama	223	
Trinity Laban Conservatoire of Music and Dance	190	
Royal Academy of Music	148	
Royal College of Music	135	
Conservatoire for Dance and Drama	113	
Royal College of Art	93	
Courtauld Institute of Art	35	
Total	2250	7.3
London total	30,728	

Economics (LSE), Goldsmiths UL, the School of Oriental and African Studies (SOAS) and the Institute of Education (IoE). UCL, IC, KCUL, the LSE and, since 2012, QMUL are each formally members of the national Russell Group of more “research intensive” universities.²

The larger of the colleges now incorporate most of the medical education and research in London, linked with the city’s teaching hospitals and clinical trial facilities (NESTA 2006). Some specialist UL medical research institutions nevertheless remain separate, including the London School of Hygiene & Tropical Medicine (LSHTM), the School of Pharmacy, St George’s Hospital Medical School (SGHMS) and the Institute of Cancer Research (ICR), as well as the Royal Veterinary College (RVC). Ten other institutions were awarded university status in the mid twentieth century, including City and Brunel Universities, and eight former polytechnic were added after 1992, the largest in 2012 being Kingston and London Metropolitan universities. London also supports some of the UK’s nationally and internationally most important creative arts and design colleges, including the various Royal Academies (e.g. of art, music, dance, drama) and the University of the Arts (design, fashion and media), offering training in creative and technical skills in music and other performing arts, design, the media, and increasingly in related ICT activities.

The pattern of London’s higher education research income from all sources is summarised for 2011–2012 in Table 13.4. This was particularly oriented to medicine, both in five specialist medical research institutions and the four “research intensive” multi-faculty colleges of the University of London. The former employed 6.6 % of London’s HEI staff, but attracted 13.2 % of its university research funding. The multi-faculty colleges, with 46 % of London’s HEI staff, were responsible for just under three-quarters of its research funding from all sources. The rest of London’s higher education system, with 46 % of HEI staff,

² <http://www.russellgroup.ac.uk/> (accessed April 17, 2014).

Table 13.4 Staffing and research income London HEIs 2011–2012

London HEIs 2011–2012	FTEs staff	% of total	Research income	
			£'000	% of total
Research intensive (4)	13,144.8	45.9	858,282	73.7
Specialist medical research (5)	1,885.38	6.6	154,260	13.2
Specialist social-humanities research (6)	2,055.81	7.2	44,851	3.9
Teaching/research (6)	4,282.83	15.0	83,382	7.2
Primarily teaching (10)	6,062.98	21.0	22,327	1.9
Arts training (8)	1,404.68	4.9	1655	0.1
	28,836.48	100	1,164,757	100

Source: HEBICI 2013

shared the remaining 12 % of research income. Much of this was in less costly to perform social sciences and humanities research, including by such prestigious institutions as the London School of Economics, the School of Oriental and African Studies, the London Business School and, outside London University, the Royal College of Art. Other HEIs also balanced generally lower cost research with teaching. They included London University colleges, such as Royal Holloway and Birkbeck, and more recent foundations, such as Surrey and Brunel Universities. As we have already emphasised, further groups of institutions are primarily devoted to the full range of scientific, technical, vocational and creative education and training required in a diverse global metropolis, including eight nationally important centres in the creative arts.

The institutional income pattern among London's more research intensive HEIs is shown for 2007–2012 in Table 13.5. It is dominated by Imperial College and UCL, although, as might be expected, the highest incomes in relation to staff numbers were in the specialist medical research institutions, including the London School of Hygiene and Tropical Medicine, the Institute of Cancer Research and the School of Pharmacy, to which may be added St George's Hospital Medical School, as well as the Royal Veterinary College.

Medical, or even science based institutions are not the only recipients of significant research earnings, however. As well as the other multi-faculty colleges of London University, including King's, Queen Mary, Royal Holloway and Bedford and Birkbeck, high per capita earnings also go to the London School of Economics, the Institute of Education, the London Business School, and the Central Institutes of the University of London. Outside the University of London, Brunel University and the Royal College of Art also attracted significant income per head of staff.

When research strengths are assessed in relation to national rankings of university research income, therefore, the two major London colleges appear in the UK's top six for a range of disciplines. While IC and UCL, alongside London's specialist institutes, are significant centres for medical research, their national research importance also derives from a range of physical, biological and engineering sciences, as well as strengths in some other disciplines. Imperial College, between

Table 13.5 Research intensive institutions in London, 2007–2012

London research intensive institutions	Research income	FTEs	Income/ FTE
Imperial College of Science, Technology and Medicine	£1,454,401.00	16,254.64	£89.48
University College London (UCL)	£1,323,163.00	21,064.88	£62.81
King's College London	£695,351.00	14,717.09	£47.25
Queen Mary and Westfield College	£344,708.00	8,229.15	£41.89
London School of Hygiene and Tropical Medicine	£311,317.00	2,547.31	£122.21
The Institute of Cancer Research	£244,622.00	2,870.44	£85.22
London School of Economics and Political Science	£111,021.00	4,628.49	£23.99
St George's Hospital Medical School	£90,718.00	2,187.03	£41.48
Institute of Education	£83,911.00	1,693.11	£49.56
Brunel University	£74,216.00	4,322.83	£17.17
Royal Holloway and Bedford New College	£71,101.00	3,315.42	£21.45
The Royal Veterinary College	£54,032.00	1,200.53	£45.01
Birkbeck College	£49,428.00	2,885.62	£17.13
The School of Pharmacy	£30,835.00	580.44	£53.12
London Business School	£13,705.00	509.81	£26.88
University of London (Institutes and activities)	£11,831.00	420.66	£28.12
Royal College of Art	£8,264.00	512.4	£16.13

2007 and 2012, for example, was in the top six income earners in most mathematical, physical and biological sciences, a variety of engineering disciplines, and also in business and management studies. UCL was ranked similarly in earnings for mathematical, physical and biological research, chemical and civil engineering, and dentistry. It was also a top six research earner in psychology and behavioural studies, architecture and the built environment, and in humanities and language based studies.

The diversity of London's HEIs is also illustrated by earlier data from the HE-BCI survey, in Table 13.6, showing the different modes of external research income in 2007. This shows the performance of the various groups of London HEIs in terms of a 'concentration index' for each source of income compared with their share of London HEI employment. Indices significantly above 1.00 indicate a higher than average involvement per full-time equivalent staff in each income source. The dominant position is illustrated within London of the Russell Group institutions (which numbered 4 in 2007), through their shares, and thus volumes of income from intellectual property licences, contract research and spin-off companies. In contrast, the specialist medical institutions relied more on income from collaborative, often publicly funded, research, contract research and some spin-offs. In other specialist University of London HEIs there was much collaborative research (e.g. at the Institute of Education), as well as consultancy and contract income. The table also confirms the quite different higher education 'missions' in their metropolitan environment performed by London's newer (e.g. "post-1992")

Table 13.6 Concentration quotients (per FPE)

	Types of research funding			IP income	Spinoffs
	Collaborative	Contracts	Consultancy		
Russell Group Colleges	1.13	1.87	0.94	2.35	1.76
Other colleges	0.97	0.51	1.55	0.11	0.79
Specialist medical	3.69	1.71	1.05	0.55	1.64
Other University of London	3.76	1.85	2.66	0.04	0.00
Other universities	0.49	0.29	0.76	0.1	0.38
Arts institutions	0.33	0.07	0.74	0.32	0.18

Source: HEBICI (2013)

and arts-based education and training institutes, as indicated by Goddard et al. (2013), inevitably less oriented towards the need for high income scientific research.

13.5 Conclusions: The Variety of London's Economy

Comparison of London's universities' aggregate research 'performance', such as that by Huggins (2008), with that of HEIs in the smaller and less diverse regions elsewhere in the UK, is clearly misleading. Some universities elsewhere in the UK undoubtedly match the quality of research in London's HEIs, but the city also supports a nationally and in some respects an internationally unique scale and range of tertiary education and professional training. This is the context within which the outreach of London's HEIs needs to be judged. This is not to deny the validity of some of Huggins other conclusions, arguing that London's financial sector, in effect, had 'other fish to fry' in the early 2000s than providing the sort of capital and management knowledge required for the commercialization of university research.

Of course, many of London's research institutions also have other priorities than the exploitation by private capital of their research. The high dependence in London on the public sector for seed finance, noted by Huggins, may, in part, reflect the importance of hospital-based biomedical research, for example, or of specialist social science and humanities institutions. Huggins may also have been correct to highlight poor HEI-financial sector networking in London, although various policies have been initiated since 2000 to improve HEI access to entrepreneurship skills, incubators and venture capital (Lawton Smith et al. 2014). Our analysis of more recent research income also confirms the dominance of a few of the largest University of London institutions. The diverse levels of research income across London's HEIs nevertheless simply reflects the wider scale and diversity of its higher education "ecology" compared with other, smaller UK regions, and include

many nationally, as well as regionally important institutions devoted to education and training.

The distinctive scale and profile of London HEIs are not the only reasons why their commercial engagement cannot simply be compared with other UK regions. The wider processes of knowledge exchange and innovation in the city are also unlikely to be similar. London's is one of the most diverse and open regional economies in Europe, with apparently wide potential for commercial HEI outreach for many forms of scientific, technological, biomedical, architectural, artistic, media, design, and other professional expertise. Even if London's financial networking does bypass its HEI's needs, as Huggins suggests, many of their knowledge-based professional and creative functions offer other forms of outreach within the city that may be only more weakly available elsewhere in the UK. Such commercial knowledge transfer is also not necessarily based on technological innovation, often depending as much on labour quality as capital investment. London offers a rich environment for the licence-based commercialisation of HEI ideas through established corporate and spin-off and other SME businesses. Some sources of innovation are also supported particularly by metropolitan demand, for example in construction and transportation, or in national public services. Compared with other regions therefore, seed capital may not be so critical in initiating the diffusion of new ideas or even disseminating them through new companies. It is to be expected that there must be a more diverse range of external engagement in London's HEIs than elsewhere.

In recent years, many types of innovation in London have been described as 'hidden', unmeasured by conventional technology-based innovation indices (NESTA 2007; Wood 2009). By definition therefore, these create special difficulties for assessing the outreach contribution of HEIs in the city. For example, in 2007, NESTA argued that UK biomedical innovation often goes unrecorded because much R&D originates within the network of university laboratories and National Health Service hospitals, rather than being initiated commercially (NESTA 2007, 25). Such biomedical research is particularly characteristic of London HEIs. More generally, pervasive forms of hidden innovation are associated with the growth of the 'knowledge-related' financial, business and creative services, few of which engage in science-based R&D or patenting (*ibid.*, 26–27; 30–31; Wood 2009). NESTA argued that innovation policies may be misdirected if they neglect the importance of 'non-technological' business process and creative sector innovation, which are nationally dominated by the types of 'knowledge-intensive' businesses concentrated in London. London HEI outreach must be expected to reflect these activities.

The focus of much HEI 'third stream' policy on technological innovation and associated spin-off companies therefore neglects other innovative forms of outreach in London, exemplified by medical research or internationally competitive service functions. Diffusion from research laboratories may occur through liaison with clinical practice and the wider health services. The London-dominated professions may also play a more innovative role than elsewhere, for example in architecture, design, business consultancy, and computer systems and software development,

linked to the training of graduates and the knowledge networks surrounding its many HEIs.

The contributions to economic development of London's newer and arts-based HEIs must also be quite distinct from that of conventional, established research and science-based HEIs. We have explained how the rationale and functional basis of the 'post 1992' universities is primarily to widen regional and local access to higher education, including support for local and regional development (HE-BCI 1999–2000). London's specialist arts-based institutions are also primarily training-based, with an economic value judged through their contribution to the UK's creative economy. Relations between HEIs and London's economy must thus inevitably be more complex than suggested by the conventional outreach models commonly applied in smaller regions with a few HEIs, based on technology-based networking relations. Unless the diverse functions of metropolitan HEIs are recognised, their distinctive regional and national roles cannot be adequately encompassed.

In summary, Greater London demonstrates a much larger number and wider variety of HEI sizes, functions and missions than other UK regions. In particular, it has a higher proportion of staff in small, specialist, medically-related and arts/humanities institutions, with different kinds of potential national and international impacts than any narrow focus on strategic science and technology might recognise. Collectively, London's institutions encompass a wide range of entrepreneurial and other outreach roles (Etzkowitz 1983; Clark 1998). These include the vocational training functions required by a metropolitan economy, as well as the forms of community interaction more common, for example, among the 'post 1992' universities. Such processes, many distinctive to London as a global capital city, perhaps also hint at the wider complexity of assessing the multiple contributions of HEIs in any region.

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Chapter 14

Putting the Region First: Knowledge Transfer at Universities in Greater Manchester

Cornelia Lawson

Abstract Knowledge transfer has become one of the major policy goals of governments across the world and is being encouraged at the national and EU level. While policy makers and academics continue to look for a knowledge transfer model that will work for all universities, some recent analyses have shown that specific local and historic conditions that affect a university's ability to engage with the region need to be considered. This paper looks at the knowledge transfer activities of the three universities in the Greater Manchester area. All three universities are closely linked to their local environment and can trace their origin to the mid-nineteenth century and the development of Manchester as the "first industrial city". Differences in research priorities and funding (cuts) have affected their development and left us with three distinct knowledge transfer strategies.

Keywords Knowledge transfer • Universities • Economic development • Co-evolution

14.1 Introduction

Policy makers and academia are increasingly discussing the role of universities in engaging and fostering communities and regions (e.g. Etzkowitz et al. 2000; Arbo and Benneworth 2007). The policy discourse on the role of universities is dominated by knowledge and technology transfer objectives that stress the importance of university-business links and commercialisation of university research for wealth creation and regional economic development (Etzkowitz et al. 2000).

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While knowledge and technology transfer and regional engagement have been encouraged through central government incentives and most universities now have technology transfer offices, the types and levels of engagement and commercialisation differ between universities (Andersen and Rossi 2011) and regions (Phan and Siegel 2006). Phan and Siegel (2006), suggesting, therefore, that university development can be seen as a co-evolutionary process, and that institutional theory and evolutionary economics could form a suitable approach to explaining the differences in university technology transfer across institutions and regions. Roles performed by universities, including regional roles, are path-dependent and are influenced by the university's adaptation processes and its environment. In this context, Feldman and Desrochers (2003) point out that a university's culture and institutional context, expressed through its history and mission, strongly influence its ability to successfully engage in knowledge transfer (Kenney and Goe 2004).

In this paper we focus on the development of three universities in the Manchester region and their almost 200 year history. As a centre of the industrial revolution, Manchester can be considered the world's first industrial city (Hall 1998). The development of its universities is closely linked to that of the local industry, championing a new type of educational development driven by the demands of local businessmen that is also representative of other industrial cities in the UK.

In what follows we first discuss the importance of universities for regional development and the co-evolution of universities in regions. Section 14.3 will discuss the current missions of universities in Manchester and the history of their interactions with industry. We first use current data to illustrate the different knowledge transfer roles of the three universities. The historic perspective then enhances our understanding of the three organisations, their importance for the local economy and how historic development has created three distinct knowledge transfer strategies. Finally, in Sect. 14.4 we will look at how this co-evolutionary process still shapes knowledge transfer today. Section 14.5 concludes.

14.2 Universities and Their Regions

14.2.1 *Contribution to Regional Economic Development*

The past 20 years have seen a growing interest in both research and policy circles in the nature and implications of the so-called knowledge-based economy, and specifically the contribution of academia to economic development and innovation. The objectives and outcomes of university knowledge and technology transfer and their economic impacts at the regional, national and international levels have been investigated by a large and growing literature. Universities have traditionally been an important source for knowledge creation and economic growth as they support industrial innovation through solving fundamental research problems (e.g. Aghion et al. 2008; Gibbons and Johnston 1975; Nelson 1986) and contribute directly through licensing of inventions resulting from their research

(e.g. Henderson et al. 1998; Thursby and Kemp 2002). Modern science and technology industries have been built on the expertise of university research. Discoveries at research institutions provided the basis for many new commercial opportunities leading to the development of new industries (in the case of biotechnology or microelectronics) and transforming existing ones. Driven by economic changes in the 1970s which saw industries under-investing in research and shrinking university budgets, policy makers have emphasised that links between the science base and industry would improve regional economic growth and competitiveness. Encouraging such links and the successful commercialisation of university inventions have since become major policy goals in the US and in Europe. Governments across the world are providing incentives for researchers to engage in research partnerships with industry and other external partners, to undertake projects with greater commercial prospects, and to offer courses tailored to the demands of local industries (Drucker and Goldstein 2007). In the UK, for instance, since the 1980s government reports have emphasised the importance of university-industry partnerships and research driven by societal needs and technology foresight (Tapper 2007). The university's role in the region and in regional development has become a particular focus for analysis and policy (Chatterton and Goddard 2000; Uyarra 2010).

Universities contribute to regional economic growth through knowledge production, dissemination and transfer. In addition they perform an important anchoring role within the region through their sheer size (and associated role as major employers and sources of local goods and services) and volume of investment in both infrastructure and buildings (Drucker and Goldstein 2007). In addition, they take on the role of regional leadership through strong historical links with the region and contribute to the cultural landscape (Boucher et al. 2003), shaping regional identity (Breznitz and Feldman 2012).

Despite these varying roles, most conceptualisations of the university's wider regional and societal impact focus on the commercial or entrepreneurial aspects of the university and see collaboration with industry, knowledge transfer or commercialisation as the main emerging missions alongside research and teaching (Uyarra 2010). Studies that measure the regional economic impact of universities have found that spillovers from academia are localised, including the location of spin-off companies, and that co-location with universities is linked to increased innovative activity in firms and regions (see Drucker and Goldstein 2007 for a review of the literature). However, at the same time authors have found disparities concerning the extent to which regions benefit from such spillovers and the extent to which universities perform these roles (Drucker and Goldstein 2007). Both depend on the type of institution as well as regional characteristics. Leading institutions create the greatest overall contribution to their region simply by size (Huggins and Johnston 2009) while at the same time they are less engaged than new institutions, perhaps because they are more concerned with national and international university rankings rather than their regional development role (Boucher et al. 2003). In the region, the level of regional control and funding power positively affects the extent to which regional actors benefit from university knowledge, as does regional identity (Boucher et al. 2003). Moreover, universities in smaller more peripheral regions, which are more dependent upon universities (Huggins and

Johnston 2009), adopt a more active local development role (Boucher et al. 2003). Existing approaches and studies investigating the relationship between universities and their regions often fail to capture the interdependence between the two. Universities not only create spill-overs but are influenced and shaped by their regions, including their knowledge and technology transfer mechanisms. Therefore this paper adopts a co-evolution approach (Lewin et al. 1999) that considers the interplay between the adaptation of universities, their knowledge transfer dynamics and the dynamics of the institutional systems within which universities are embedded.

14.2.2 Universities and Their Co-evolution in Regions

The co-evolutionary framework incorporates an embeddedness view where universities not only providing solutions to economic problems but shape and are shaped by networks, politics and regions. Following previous work on the co-evolution of firms (Lewin et al. 1999; Dosi and Marengo 2007; Geels 2014), we can address the co-evolution of universities and their environment, including various regional actors, social movements and politics.

Co-evolution of universities is an outcome of internal and external developments. In the context of universities the main channels that influence the university system are funding structure, regional (student) population and economy, as well as advancements in science. The university affects all these through active engagement in teaching, research and external funding acquisition and collaboration. The establishment of links with industry and other external actors, in particular, is one of the primary manifestations of universities' regional impact. Universities thus evolve with the surrounding industry and the demand for collaboration and skilled human capital.

In terms of theory the co-evolutionary framework has used insights from evolutionary economics and institutional theory (Geels 2014). Evolutionary theory considers processes that are path-dependent and therefore assumes a persistent heterogeneity between organisations (Dosi 1982). Organisations adapt to environmental pressures by selecting or reinforcing existing organisational forms while resisting more complex changes. Also, a university's adaptation to external pressures due to changes in the regional or political landscape is likely to be enabled and restricted by its unique historical path dependence in terms of knowledge transfer adaptation. Institutional theory also addresses the importance of pressures and norms to which organisations conform (DiMaggio and Powell 1983; Scott 1995). Organisations are influenced by the institutional environment in which they operate. In the case of universities these can be government regulations, professional standards and other leading international universities. For example, following the success of technology transfer in some universities, others adopted similar regulations first through mimicking and later in response to government and funding pressure.

Both theories traditionally assume a passive view of the organisation which adapt to selection environments and isomorphic institutional pressures (Geels 2014). However, two-way interactions exist between organisations and their environment.

We need to keep in mind that organisations are embedded in social and political structures (Polanyi 1944) and can use their power to shape these. In the co-evolution framework organisations interpret pressures from the environment and make strategic decisions regarding their future. If organisations interpret changes or pressures as temporary they will take no action. An increase in environmental pressures may cause them to leave their path-dependent adaptation strategy and instead explore new strategies (Lewin et al. 1999). Initially strategies will be aimed at defending the organisation against external pressures, but as pressures increase the organisation will seek to change and adapt to meet new challenges. In the case of universities this includes collective actions to defend themselves against governmental policies. Large universities may be able to shape policy and regional markets by virtue of their economic and political power, and may guide the strategy of other universities. When faced with increasing performance problems, organisations can be expected to intensify their restructuring strategy, first by changing elements close to their existing organisation, for example improving their general efficiency or making symbolic changes to mission statements (Geels 2014). Only if problems are recognised as structural, more radical adaptive actions are taken resulting in new organisational forms or collaborations (Lewin et al. 1999), and a foundational redevelopment of the organisation including its values and core competencies (Geels 2014). The theory also concludes that organisations that do not experience external pressures remain locked in their historic path.

14.3 Co-evolution of Universities in the Manchester Region

14.3.1 *Contribution to Regional Economic Development*

The analysis focuses on the two Manchester universities, the University of Manchester and Manchester Metropolitan University (MMU), both situated in close proximity to one another, as well as the University of Salford, located 2 miles to the west. The University of Manchester is the most research intensive of the three, ranking highly in UK and international university league tables. They employ almost six times as many staff in science, engineering and technology (SET) than the other two universities (see Table 14.1). This is also reflected in a much higher number of Ph.D. students, publications and research income in SET subjects. MMU on the other hand is primarily a teaching institution, as reflected in the low number of staff and low levels of research income. The University of Salford, despite being much smaller than the two Manchester institutions, and having more students per

Table 14.1 University basic statistics (for 2012/2013)

	University of Manchester	MMU	University of Salford
Undergraduate students total	26,955	26,214	15,580
Undergraduate students SET	9769	8275	4385
Staff total	4115	1546	1044
Staff SET	1662	364	208
Ph.D. total	3720	615	625
Ph.D. SET	2090	255	320
Publications SET (2008)	1698	103	361
Research council funding SET in £000s (2008)	58,880	773	3,666
Quality related HEFCE funding SET in £000s (2008)	22,087	635	4,321

Note: HEFCE Higher Education Funding Council for England

Data source: Authors' own compilation and calculation based on Higher Education Statistical Agency (HESA) and Thomson Evidence data

academic staff than the University of Manchester, attracts similar levels of research funding per academic and has more publications per member of staff.

An analysis of present university strategies (as stated on their websites) and knowledge transfer data (from the Higher Education-Business and Community Interaction (HE-BCI)¹ survey) will provide a first picture of further differences between the three universities in terms of regional engagement. The University of Manchester describes itself as a world-class research university with a vision to provide top research and to attract excellent researchers (UoM 2011). It aims to provide research with a wider economic impact and identifies its three main contributions to economic development as technology transfer, engaging in research collaboration with industry and as meeting national skill needs. These indicate a supra-regional orientation and a focus on innovation.

MMU identifies itself as a university “for world class professionals” and puts learning and student development at the core of its strategy (MMU 2011). Its main three contributions to economic impact were identified as widening participation, meeting regional skill needs, as well as research collaboration with industry. MMU thus has a primarily regional focus and an interest in serving needs of the local industry and in enabling students to join higher education and to be entrepreneurial.

Finally, the University of Salford describes itself as the “enterprising university” with strong community links. At present it sees its main economic contributions as developing local partnerships, engaging in research collaboration with industry and widening participation. This regional strategy that primarily aims to benefit small local businesses has been expanded in the University’s latest strategic plan, with a

¹ HE-BCI is an annual survey conducted since 2001, taking into account third stream income, university mission statements and non-commercial activities.

goal to join the top league of UK research institutions. The University has further recognised that it is lagging behind in knowledge transfer and aims to better exploit its opportunities for innovation (UoS 2009). Thus, Salford is currently at a point of reorientation and expansion in an attempt to move closer to the University of Manchester.

A university's knowledge transfer culture is also reflected in its ties with external partners. The HE-BCI survey, conducted annually by the Higher Education Funding Councils, gives some evidence of the levels of engagement with businesses and the extent of commercialisation activities. Here we report numbers from the academic year 2006/2007, the year before the financial crisis, which brought about changes that will be discussed in more detail in Sect. 14.4. Further, it is the last year that MMU reports details on engagement with the region.

The HE-BCI survey asked university managers about several channels of industry engagement, the types of companies and where they were located. Details of income generated through each channel are reported in Table 14.2. The survey revealed that the University of Manchester generates the greatest amount of income from businesses, reflecting their stronger research focus. However, Salford generates more income from small and medium sized enterprises (SMEs), especially through consultancy contracts. MMU and Salford receive most of their income from local businesses. More than 90 % of their business research, consultancy and teaching contract earnings come from within the region, while less than one sixth of the University of Manchester's business contracts are in the region. Salford creates the largest local income.

In terms of patent and licencing income, MMU and Salford lag behind. Neither university has a convincing intellectual property (IP) strategy, and this is reflected in their inability to generate any returns from their research activities. Nevertheless,

Table 14.2 University knowledge transfer activities (in 2006/2007)

In £000s	University of Manchester	MMU	University of Salford
Contracts large businesses (in Region)	9005 (904)	552 (497)	109 (97)
Contracts with SMEs (in Region)	777 (561)	100 (100)	927 (927)
Consultancy contracts large business (in Region)	1517 (108)	571 (514)	890 (801)
Consultancy contracts SMEs (in Region)	137 (79)	246 (246)	1092 (985)
Courses for large business (in Region)	2291 (293)	199 (179)	137 (129)
Courses for SMEs (in Region)	32 (0)	451 (451)	113 (113)
IP Income	5016	3 ^a	10
Spin-off turnover	14,847	298 ^a	7500
Number of Staff dedicated to knowledge transfer	38	21	58
Share of academic Staff involved with businesses	50	20	35

Data source: Compiled from HE-BCI data

^aIP information missing for MMU for 2006/2007. 2008/2009 Values are displayed

Salford has generated some profitable spin-off companies. MMU also supports such entrepreneurial activities, but financial data is not available pre 2008. The figures for the academic year 2008/2009, just following the crisis, indicate some spin-off activity but far less than the other two institutions. The spin-off turnover generated at the University of Manchester, considering its size and research capacity, is not as high as could be expected, perhaps due to its primary focus on invention licensing.

Finally, we look at the number of knowledge transfer support staff and members of staff involved with businesses as reported in the HE-BCI survey. All three universities have a technology transfer office (TTO) and Salford has the largest number of knowledge transfer professionals. The share of academic staff involved in knowledge transfer activities is highest at the University of Manchester but has been increasing at all three institutions.

14.3.2 Foundation of Higher Education Institutions in the Nineteenth Century

University development and roles performed by universities can be seen as co-evolutionary processes. We therefore need to look at the start of the higher education development in Manchester to understand how these three quite different institutions could form and how they shaped their region and national politics.

Higher education in England at the beginning of the nineteenth century was dominated by Cambridge and Oxford and calls for reform were left unaddressed. With the start of a scientific age that contributed to the wealth and growth of industrial cities, came a requirement for technical education and scientific knowledge. The religiously driven education at the two traditional universities was no longer apt as it did not provide sufficient levels of training in mathematics, sciences and engineering. Moreover, it barred nonconformist students from entering their institutions. The situation was very different in Scotland where universities could flourish and were independent of the Church (Nature 1876a). Though the University of London was established as a secular degree awarding body, a desire for a more localised education, especially across the industrial North of England arose (Thompson 1886). It was these elements of a scientific age and religious struggle combined with a spirit of enterprise and innovation that would drive the foundation of educational institutions in the Manchester area, which, in 1800, emerged as the world's leading industrial city (Hall 1998). Thus, universities developed out of the interaction between forms of social movements and economic organisations, and technical change.

In Manchester the first technical colleges were established following initiatives of local businessmen and the nonconformist church. In 1783, the College of Arts and Sciences was founded, offering evening classes to suit the schedule of working men, but due to “a superstitious fear of a tendency of a taste for knowledge to unfit young men for ordinary business” (Wheeler, 1836: 491) the institution was soon closed. There was a perception at the time, that “higher education spoilt youths for business” (Thompson 1886: 3). Similarly, the nonconformist college founded in

1786, the Manchester New Academy, had to move to York due to a “lack of energy” on the side of the original supporters (Wheeler 1836).

From 1790 onwards the population of Manchester grew rapidly from “less than fifty to three hundred thousand inhabitants, with a total of nearly a million people living in the surrounding conurbation” (Platt 2005: 16–17) in 1835, making the Manchester-Salford area the second most populated in the UK. The increase in wealth amongst merchants led to an increased requirement for education and culture, resulting in the establishment of, amongst others, the Royal Manchester Institution in 1823 and the Manchester Mechanics’ Institute in 1824 (Wheeler 1836) which also held lectures in Salford until Salford opened its own institute in 1838.

While the Mechanics’ Institute aimed to help craftsmen learn basic sciences it did not offer systematic courses (Thompson 1886). Efforts to establish a college or university of general education in Manchester started in 1829. In 1836 Harry Longueville Jones presented a document entitled ‘Plan of a University for the town of Manchester’:

“In all directions the circle of Manchester is full of life and intelligence, manufactures of every kind occupy the inhabitants of the towns; the movement of money is immense; commercial activity is carried to an extraordinary pitch; mechanical ingenuity receives there daily new developments; the minds of men are in a state of electric communication of ideas; their political sentiments indicate the restless vigour of a rising and sturdy people; their religious opinions are full of fervour and piety. Yet one thing still is wanting—the vast population of South Lancashire wants a centre of intelligence and moral improvement; it requires one if not two ‘seminaries of sound learning and religious education’.” (as quoted in Thompson 1886: 21)

The attempts to establish a university were abandoned the following year due to the small number of enrolled students (Nature 1876a). Also the Manchester New College, which was moved back to Manchester in 1940 struggled with student numbers as did similar establishments founded in Salford. This struggle was primarily attributed to the rapid industrial development that required a large working force and drew urgency away from education (Thompson 1886). It may also be due to the insecure financial situation of these early institutions and an inadequate system of elementary education to prepare for higher technical instruction (Cowan 1968). These early pressures caused the young institutions to fail as they were yet unable to adapt to regional social and economic requirements.

The foundations for a university in Manchester were laid when Owen’s College was founded in 1851 with the endowment from a local textile merchant, who remarked in his will that the college should teach “in such branches of learning and science as were then and might be thereafter usually taught in the English Universities” (Nature 1876b). The new institution drew from both the renewed interest in education and substantial commitment from both social institutions and economic actors. The institution also adapted a more rigorous strategy to attract students and teaching staff and expressed a strong vision for expansion. From the very first moment the college aimed to become a university, as further asserted in 1873 by one of its professors, Sir Benjamin Brodie:

“[I]f I say that this is the foundation of an university, I say so from what appears to me to be a very good reason, for I believe that Owen’s College boasts all the essential constituents of an university; and I have no doubt that before long it will go forth into the world equipped as an university in every respect” (Nature 1873: 508).

Further, the college received considerable sponsorship for its expansion from local business men and local councils without any aid from the state. The college offered day and evening courses without requiring any religious training, thus serving the working people and avoiding religious struggle. The push towards the status of a university grew and in 1880 Owen’s College was granted the Royal Charter as the first constituent college of Victoria University, a new university not attached to any of the traditional institutions.

“The Owens College was the first example of the successful establishment in a manufacturing town of an institution which gave to all corners a University education. [...] In the midst of a great democratic movement, it has been practically proved that culture and learning need not be the exclusive property of the few” (Nature 1887: 385).

The regional political context was also favourable to the establishment of a university. The regional authorities took great interest in education and, in interaction with social movements and economic actors, were able to provide an environment that prepared the people of Manchester for higher education. Manchester and Salford were at the forefront regarding educational matters, being amongst the first towns to appoint a School Board, following the 1870 Elementary Education Act,² to better coordinate educational efforts in the area. The school boards started offering evening classes themselves, which were to complement the existing educational efforts, but led to some competition with existing colleges in the case of Salford, accelerating their failure (Cowan 1968). In Manchester, on the other hand, school board education complemented the Technical School that had been formed from the Mechanic’s Institute in 1883. With the demise of technical colleges in Salford, the school board was the main provider of education and in 1896, following the Technical Instruction Act 1889,³ founded the municipal Salford Technical Institute, the predecessor of the University of Salford. Also the Manchester Technical College became a Municipal Technical School, following the 1902 Education Act.⁴ Mechanical engineering, chemical works, textiles and construction were the dominant industries in Salford and also led the choice of subjects offered by the new municipal technical institute, instituting the importance of industry-led courses. Thus, the active interaction between political institutions, social movement and economic organisations led to the co-evolution of a higher education system that served the provision of skilled human capital to local industry.

²The Elementary Education Act of 1870 recommended the establishment of school boards to provide elementary education.

³The Technical Instruction Act of 1889 allowed local authorities to offer technical or manual education.

⁴The Education Act of 1902 allowed local authorities to offer higher education.

Neither of the two technical institutes in Manchester and Salford had the same vision as Owen's College to become a university. Instead they saw their primary mission as providing "systematic instruction in those branches of knowledge which have direct bearing upon the leading industries of the district" (Powell and Dayson 2013). This highlights the importance of internal strategies for university development.

In summary, at the turn of the century, Manchester and Salford boasted a well-integrated educational system that offered courses for all levels of qualification and that allowed working people to proceed into higher education. According to Simmons (1901) the investment provided for education and the participation in technical education was amongst the highest in England. He went on to remark:

"In the arrangements which the Technical Instruction Committee of its City Council and its School Board jointly have made to secure the co-ordination of all educational efforts within their borders, and so avoid that over-lapping which is such a prolific source of loss and disappointment in many other districts, this centre of the great cotton industry may well serve as an example of a community where the first object of public men is to secure educational efficiency and not to assist the glorification of a particular board or committee." (Simmons 1901: 336)

The efforts of local businessmen to provide the working population with higher education proved successful. With financial resources made available by the wealthy people of Manchester and the support of the local authorities, institutions were formed, giving evidence of successful interaction. The close co-evolution of science and industry enabled Manchester to attract leading teachers to its institutions. With the efforts of the school board, a system for providing education at all levels was in place in 1900; the Manchester-Salford area offered one university, two colleges of technology and several smaller local colleges offering evening and non-degree courses.

14.3.3 The Twentieth Century: Expansion and Knowledge Transfer

14.3.3.1 University Foundations in Manchester and Government Policy

In 1905 the University of Manchester was officially instituted with the dissolution of Victoria University. The municipal technical school became the constituent college of the university whilst retaining some independence (later named Municipal College of Technology). Salford received royal assent and became the Royal Technical Institute (later Royal Technical College) in 1886 as a consequence of Salford's status as centre of technical competence and instruction that was recognised beyond the Manchester region.

As early as 1912, there had been a requirement for more advanced education of engineers as was pioneered in Germany and Switzerland. After the war central government increased its commitment to higher education. The incoming Labour

government appointed committees to consider higher technological education and the demand for scientific manpower. The committees recommended an expansion of universities, the transformation of technical colleges into universities and the creation of 'institutes of technology' as a strategy to increase the number of students in science and technology (Bocock and Taylor 2003). While this development led some universities to increase their science and technology courses, as was the case in Manchester through the collaboration of the University and the College of Technology, the government did not compel universities to offer more professional courses and they remained autonomous in their decision making and their structures remained unchanged (Bocock and Taylor 2003). This development reflects the first stage of strategic reorientations of organisations, where political pressures are considered temporary and no or minor changes are made to operational regimes (Geels 2014).

However, in 1955, control of the higher education institutions was transferred from local authorities to central government, due to their increasing financial dependence and the inability of local authorities to meet these financial requirements. Through efforts by its Vice Chancellor, the Municipal College of Technology received university status in 1956 and all its non-degree courses were moved to a technical school in 1966. It was now called the University of Manchester Institute of Science and Technology (UMIST). The links between regional governments and universities were thus cut and universities were more likely to be subjected to national policies that could now be better enforced through their dependence on centralised public funding.

The Royal Technical College Salford was designated as a College of Advanced Technology in 1960 following a government initiative on technical education. It was encouraged to increase its share of advanced university courses and aimed to focus on sandwich courses in collaboration with local firms while continuing to offer technician education (Brentnall 1957). Following the Robbins Report in 1963 it was awarded the status of university in 1967. In its founding charter it pledges to 'foster an academic environment which is enterprising and applied to business and the professions'. Its technical education was moved to a newly formed technical college. Thus, while offering more advanced technical education, the links to local industry were retained. The policy co-evolved with the university and enabled it to build on its established strengths and strategies with no need for radical re-orientation.

The removal of regional control and downsizing of technician education coupled with the national focus on rankings and internationalisation that ensued left a gap in regional education. In 1964, the incoming Labour government found that universities were not doing enough to accommodate wider participation and economic growth. They established a public sector of higher education with the formation of polytechnics that were to become the people's universities to provide higher technical education (Tapper 2007). In 1970, thus, the Manchester Polytechnic was formed from a number of professional colleges in Manchester and placed under the control of the local authority. However, in 1992, as part of a greater reform on higher education funding that also attempted to break the financial ties

with local authorities, these polytechnics gained the status of universities (Tapper 2007) and MMU was founded. The Manchester-Salford area thus became the home of a fourth university until the University of Manchester and UMIST finally merged in 2004.

Following the co-evolution of universities in interaction with regional authorities and social and economic movements in the nineteenth century, the twentieth century was marked by restructuring that put institutions under central government control and enforced stricter rules on the types of courses that could be offered, thus partially breaking the links with the region. These developments reflect the second stage of strategic reorientations of organisations (Geels 2014). Political pressures are noticed and courses are adjusted to meet the needs of the funding regime.

14.3.3.2 Universities and Their Role in the Region

In this age of expansion and centralisation of higher education, Manchester's institutions sustained their links to local businesses and continued offering industrial services thus pursuing a similar strategy to before. During the first half of the twentieth century higher education institutions were under the jurisdiction of local education authorities and part of a local education strategy that also emphasised relations with local businesses. There were links between the technical colleges and the surrounding industry through sandwich courses and industry led courses in areas of interest to the engineering, chemical, textile, mining, building and printing industries. The College of Technology conducted industrial research, often in collaboration with firms of the local area (BoE 1918). Salford would set up a committee of industry representatives to provide advice, a move that was unusual in the first half of the twentieth century (Powell and Dayson 2013) but reflected the organisation's overall strategy to maintain close links with local businesses. Manchester Polytechnic would retain the profile of a vocational college until 1992 when it became a university.

Also the University of Manchester was concerned about its linkages with local businesses. In 1938, the Vice Chancellor of the university issued a document titled "A Partnership between Science and Industry" which emphasized the university's role in training students for employment in industry. The University set up a committee to investigate research policies putting particularly emphasis on industry needs (UoM 2010). A Joint Research Council (JRC) of the Manchester Chamber of Commerce and the University of Manchester was set up in 1944 as a direct effort of regional and university actors. Its aims were similar to those commonly found in present day policy reports on the role of science for economic growth. They were concerned with the application of science, the appointment of knowledge transfer professionals, the provision of technologies to small firms, encouraging innovation in industry, as well as investigating scientifically the needs of local businesses while considering economic and sociological problems (Nature 1944, 1949). No similar body existed at the time "and it quickly became instrumental in promoting Manchester as the new centre of direct university-industry co-operation" (UoM 2010).

The interaction between the regional authority's education and development policies and the University's strategy thus enabled the establishment of new knowledge transfer activities that considered the expanding science base of the university. Through the integration of the technical college into the University and the activities of the JRC, the University retained close links to local businesses and continued to drive innovation in the area.

The JRC also received continuing support from the central government and after 1959 focussed its activities on providing technical information services to local businesses. Set up in 1948, the Manchester Technical Information Service (MANTIS) originally acted as a technical library and later provided technical advice in conjunction with the JRC and the central government. This also provided the first example of cooperation between local organisations and regional representatives of the central government (Taylor 1966). The developments in Manchester also informed policies of the central government, giving evidence of how higher education institutions shape politics in a co-evolutionary framework. As part of the government's Industrial Liaison Officer (ILO) scheme to establish industry-science links across the country, MANTIS was moved to UMIST and became part of its Bureau of Industrial Liaison in 1964 with the goal to further promote industry-science links. In 1965 government also took a more active role in providing its own joint research initiatives, including in Manchester, and the JRC was dissolved (UoM 2010). The central government thus adopted successful initiatives pioneered in Manchester to apply them across the country. However, the government's ILO scheme was discontinued in 1973 and the Bureau lost its government support. It subsequently continued to operate but without the involvement of its original founders and support from the central government it became primarily oriented towards its own academic activities and less concerned with regional needs. The change of policy strategy thus changed the way universities in Manchester engaged with local businesses. Government's emphasis on excellence and a funding regime concerned with national and international rankings gradually transformed universities, leading them to drop part of their traditional civic mission. These developments reflect the second stage of strategic reorientations of organisations, where political pressures are interpreted as concerning operational issues and retrenchment strategies are taken to improve efficiency of the organisation and symbolic changes to mission statements are made (Geels 2014).

14.3.3.3 Formation of Institutional Companies for Technology Transfer

While during the first half of the twentieth century the link between universities and local businesses was organised primarily through training activities and collaborations, the second half of the twentieth century saw the emergence of an internally focussed knowledge transfer strategy that sought the commercialisation of academic activities. While liaison offices such as the one established at UMIST remained the main structure for forging links with industry in the UK during the

1970s and 1980s, some universities set up their own limited liability companies to actively market their inventions. This allowed the adoption of a commercial approach which could be considered beneficial for successful technology transfer (European Research Associates 1988) and could help protect academics from the pressure of prospective industry partners (Ashworth 2009). The University of Salford set up a company, Salford University Business Services Ltd⁵ (SUBS), initiated in 1969 with a government grant, to coordinate links with industry. This included better coordination of graduate placements and industry-led courses with the objective of raising income for the university. It grew to become one of the largest and most successful university consultancy and technology transfer companies in the UK and presents one of the most interesting examples of science-industry collaboration (European Research Associates 1988; Richardson 1995). It primarily provided support to SMEs in the region. University strategy thus changed to seize additional financial sources through links with local industry. This development was partially spurred by the increased costs for research and universities' increasing dependence from government.

Further, due to the severe financial crisis in the 1970s that led to a determination within the government to cut public expenditure, the university funding budget was reduced by 18 % (Ashworth 2009). These developments pushed universities to adopt a more pro-active strategy to promote excellence and to monetise on their scientific knowledge; the third stage of strategic reorientations of organisations. Political pressures increasingly threatened the existence of universities, leading to strategic changes involving new collaborations and the exploration of new income sources (Geels 2014).

The University of Manchester thus followed Salford's lead by forming Vuman Ltd. in 1981, a limited liability company that acted as a contractor on behalf of the University to enable successful knowledge transfer. Already since 1972 it had been offering services to industry through its University Research Consultancy Service and the first license agreement was reached in 1976. Vuman bundled these activities and those already offered by individual departments with a primary focus on licensing and spin-off formation (UoM 2000). This was perhaps a reaction to the patent act of 1977 that allowed universities to own university inventions and encouraged a more rigorous intellectual property regime. This development was rather different to that in Salford, where the focus was on consultancy and graduate placement. In 1985 Vuman had a turnover of £1 million (European Research Associates 1988). At UMIST, which had hosted the Manchester industrial liaison officer and had operated an internal liaison office after 1973, a limited liability company, UMIST Ventures Ltd (UML), was incorporated in 1989. Similar to Vuman, UML primarily focuses on commercialisation of university inventions and spin-off formation. Research collaborations were fostered to benefit the university.⁶

⁵ Previously Salford University Industrial Centre Ltd, renamed in 1986.

⁶ In 2004 it merged with the University of Manchester's innovation company.

Meanwhile, the Manchester Polytechnic, not a full university at the time of these developments but a local authority institution, was limited in the exploitation of its inventions until 1985, when the Further Education Act⁷ enabled it to commercialise work carried out by its staff. However, also following these changes it did not set up an exploitation company, but continued to offer its set of business-led courses and services to SMEs. Following the award of university status in 1992, it had an integrated ‘Metropolitan research, innovation and consultancy’ unit (METRIC) that combined consultancy and technology transfer services with general research contract and assessment services. Additionally, in 2000 the university set up an external relations division with a business partnership officer to establish a central contact point for external partners. It was thus the last organisation in Manchester to take a more proactive role in technology transfer.

14.3.4 New Forms of Institutional Regional Involvement

Salford and other technical universities experienced the most dramatic cut in public funding during the early 1980s. The University Grants Committee (UGC), which held responsibility for distributing funding to universities, took a decision to cut grants selectively (Tapper 2007). Block funding to universities was thus reduced and replaced with selective and excellence based grants. Salford was faced with a 44 % cut in funding forcing it to downsize significantly, but the existence and success of SUBS helped it to survive. It launched a ‘Campaign to Promote the University of Salford’ (CAMPUS) as a charitable trust in coordination with SUBS. In total 200 companies contributed to the campaign that managed to raise almost £3 million from consultancy work and £700,000 from professional education in 1984/1985. This amount was much higher than that raised by any other UK university (European Research Associates 1988). The success of the campaign suggests that UGC was paying too much attention to public grants in its assessment and not to industry links and that indeed it had wanted the entrepreneurial university model to fail (Redfearn 1981; Powell and Dayson 2013). Following its successful campaign, Salford increased the share of funding from contractual sources to almost 50 % in 1989 (Ashworth 2009). CAMPUS continued its activities and established several funding streams to sponsor knowledge transfer and enable researchers to hold joint appointments in industry and academia (European Research Associates 1988). This immense pressure and the ensuing developments can be considered as the fourth stage of strategic reorientations of organisations (Geels 2014). Salford was forced to examine deep structural elements and allowed

⁷The Further Education Act of 1985 enabled local authorities to supply “goods and services through further education establishments”.

for a foundational redevelopment of the university, including changes to core competencies and organisational model.

Salford and Manchester have thus been at the forefront of industry-science links throughout their histories. Other universities followed their lead and established central commercialisation units throughout the 1990s and 2000s. Around this time, faced with further changes to government funding and a recession, Salford's commercialization company SUBS started to lose money (Powell and Dayson 2013). In this environment Salford decided to change its approach to business liaison by establishing entrepreneurial activities as the third pillar of the university in an effort to become the first truly entrepreneurial university. SUBS was dissolved in 1998 and replaced by a new division that placed regional engagement at the centre of the university. Managerial and administrative changes followed and Salford established itself as 'Academic Enterprise' that not only focused on links with industry but also on those with other actors in the community. As such, it may have been instrumental in driving the development towards the engaged university and predated the government's interest in impact and a formal third mission for universities (Powell and Dayson 2013). These developments again highlight how institutions not only adapt to government policy but actively inform it.

14.4 Importance of Co-evolution for Knowledge Transfer Today

A look at the historic development of universities in the Greater Manchester region and their approaches to knowledge transfer shows that it is important to take into account the co-evolution of universities within the science system when evaluating knowledge transfer activities today. In Sect. 14.3 we saw that the three universities understand themselves and their knowledge transfer role quite differently. This was apparent not only from their strategy statements but also from the amount of external income that could be sourced through various knowledge transfer channels. The University of Manchester was from its founding days driven to become a leading research university and while it maintained links to local businesses these were mainly aimed at increasing the university's revenue and providing a better teaching experience to its students. Especially after the Manchester Joint Research Council was dissolved in the 1960s, the university primarily forged a transfer strategy aimed at exploitation and research income creation. As a result it now is one of the leading research universities in the UK, generating a large share of its income from contracts with large firms all across the UK and the world.

The University of Salford, on the other hand, always saw itself as an institute of technology that was serving its region and the regional economy. As such it maintained close linkages with local businesses and regional authorities throughout its entire history and was continuously on the forefront of developing new ways to engage with local businesses, for example by opening one of the first knowledge transfer offices in the UK. These close links came to its aid when it was faced with

sever funding cuts and enabled it to become one of the first universities to generate a significant amount of income from external sources. The close relationship with the region was further emphasised when it became the first UK university to fully take on a third mission. Throughout its history it has aimed at giving back to the region and establishing truly mutual links. The results of this development can be seen in the high amount of external income from primarily small local businesses and its successful start-up policies. It has, however, neglected to commercialise its own IP, perhaps partly due to a lesser focus on research than the University of Manchester. These shortcomings are addressed in its 2009 strategy document (UoS 2009).

Finally, MMU, the last university to form in Manchester, has maintained a local profile due to its much longer history of providing local education and consultancy, which represented one of its main missions up to 1992. MMU was also up until 1985 legally limited in its ability to develop an IP strategy and did not do so until 2000. This would suggest that MMU should exhibit lower levels of exploitative technology transfer and lower levels of research partnerships. In Sect. 14.2 we saw that MMU is indeed still little involved in direct technology transfer through start-up creation and patenting. It does, however, provide a large amount of professional teaching to local businesses and has a relatively high income from research and consultancy contracts with local firms, though less so than Salford.

The historic perspective thus shows that knowledge transfer at universities is driven by a process leading back at least 100 years. It also shows how universities and their strategies are affected by external developments. Higher education institutions in Greater Manchester first provided education to meet the needs of industry in a vibrant industrial city, and financial crises that led to funding cuts and changes in educational policy affected how universities related to the region.

In 2008, the UK was again hit by a financial crisis leading to a reduction in GDP of 7.2 % between 2008 and 2009 and the UK's austerity policy led to a further decrease in university funding. It also affected the cashflow of businesses in the Greater Manchester region and their intentions for investment (GMCC 2013), including investment in academic research. Table 14.3 illustrates how the latest crisis has impacted the three universities. It reports the values for 2011/2012 and the percentage change since 2006/2007.⁸ Regional values were not available for MMU, but we can infer from previous years that more than 90 % of income will have come from within the region.

The numbers show that income streams from local companies have decreased significantly and have badly affected the two universities that primarily rely on such regional links. While the local income of the University of Manchester also decreased, their income from UK and international companies increased sufficiently to leave them with an overall increase from industry contracts of more than 50 %. At the same time Salford and MMU, whose main links are with local firms, registered a decrease in overall business income of 25 % and 37 % compared

⁸ Values for 2007 were reported in Table 14.2. The percentage changes in income are calculated adjusting for annual inflation.

Table 14.3 University knowledge transfer activities (2011/2012 values and percentage differences compared to 2006/2007)

In £000s	University of Manchester		MMU		University of Salford	
	Total	Region	Total	Region	Total	Region
Contracts large businesses	16,564	968	436	–	285	200
	+63 %	–5 %	–30 %	–	+131 %	+82 %
Contracts with SMEs	727	389	1	–	469	217
	–17 %	–39 %	–99 %	–	–55 %	–79 %
Consultancy contracts large businesses	2777	50	400 ^a	–	805	253
	+62 %	–59 %	–38 %	–	–20 %	–72 %
Consultancy contracts SMEs	198	47	84	–	464	272
	+28 %	–47 %	–70 %	–	–62 %	–76 %
Courses for large business	4276	99	700 ^a	–	127	86
	+65 %	–70 %	+211 %	–	–18 %	–41 %
Courses for SMEs	46	0	169	–	186	156
	+27 %	0 %	–67 %	–	+45 %	+22 %
Change in overall income from businesses	+58 %	–29 %	–25 %	–	–37 %	–66 %
	Total	Diff	Total	Diff	Total	Diff
IP Income	1826	+68 %	3	–	50	+340 %
Spin-off turnover	18,164	+8 %	405	–	8128	–4 %

Note: Percentage changes in real terms since 2006/2007

Data source: Authors' own compilation and calculation based on HE-BCI data

^a2010/2011 values are reported for MMU in some instances. MMU reports are subject to large variation and should be read with caution

to 2006/2007. This shows that the local strategy left them very vulnerable when local firms were hit by the crisis.

Looking at IP income we see that there has been a sharp decrease for the University of Manchester of almost 70 %. This value is up from 2010/2011 but still far behind the high IP income levels of 2006/2007.⁹ MMU and Salford were largely missing any convincing IP strategy before the crisis and have only now started to become more active, showing a first modest IP income increase. All three universities have been able to maintain their start-up activities, with modest increases for the University of Manchester and a small decrease for Salford, suggesting that these start-ups were less affected by the crisis. This again emphasises the importance of viewing differences in university's knowledge transfer success as a path dependent process. Institutional structures established prior to the crisis, affected the knowledge transfer profile we observe today.

⁹ Values for 2012/2013 show no further recovery. 2013/2014 values were not available at the time of writing.

14.5 Conclusions

This paper has investigated the historic co-evolutionary development of universities in the Manchester region to make two contributions to literature. Firstly, it can be used to address the research agenda on turbulences in the science (funding) system and how they affect the role of universities in their regions. Especially in view of the last financial crisis and the fresh changes to the funding of universities in the UK this historical analysis helps to understand the strategic decisions taken by universities. The analysis in Sect. 14.3 showed that substantial reorientation of university strategy to address changes in the science system involves initial resistance followed by gradual remodelling of organisational and knowledge transfer structures, including new methods of funding acquisition, monetising on scientific knowledge and changes in core missions. These developments represent those observed in the co-evolution of firms in industries (Geels 2014).

The paper also provides a showcase for using a historic co-evolution approach to understand the development of universities' regional role. In doing so we can address causal mechanisms in knowledge transfer. This paper focussed on the ranges of local and national pressures that shaped the development paths of universities' knowledge transfer strategies. The analysis shows that science-industry links have been common place in the UK throughout the nineteenth and twentieth century and that universities have adopted knowledge transfer strategies as early as the 1940s. These roles were formalised in relation to the educational and research goals of the individual institutions, providing further evidence of path-dependency.

The historic co-evolutionary analysis adds further complexity to the simple statement that "the period from which a university originates in the UK also tends to have a strong correlation with the type of institution it has grown to become" (Goddard et al. 2014: 5). The picture is more complex than this, as all universities in Manchester trace their roots to the industrial revolution and developments prior to the award of university status have been instrumental in shaping their future paths. The development of these universities has led to a number of distinct university groupings within the UK with distinct regional development and knowledge transfer roles (Goddard et al. 2014). However, these groupings are increasingly moving towards becoming the same type of institution through homogenous national policy that emphasises excellence and international rankings.

The historic perspective thus shows that the policy of the UK education authorities to evaluate universities based on measurable outcomes and to distribute grants according to a standardised assessment, has denied the complementary diversity that had developed up until 1980. It disregards the autonomy of the institutions in terms of developing a knowledge transfer strategy best suited to the institutional and regional conditions. Even within a single region, three different strategies could develop in parallel serving different purposes and audiences, thus complementing each other. This complementary co-evolution is important in a region with high economic activity and needs to be preserved.

The universities of Greater Manchester have reacted differently to the needs of their region. Throughout history they have been shown to take a proactive role in shaping their relationships with industry, including in response to changing demand conditions. They have put the needs of the region first and as such have benefitted from these links as well as contributed to the economic development in the region. The decline in research income for the more locally oriented institutions, Salford and MMU, could be seen as a weakness of a local strategy leaving them more vulnerable, but at the same time these two universities will be instrumental in rebuilding the local economy following the recent economic crisis.

As a consequence, governments and academics need to accept that different institutions can perform different roles regarding knowledge transfer. The push over the last 30 years to homogenise higher education and to create direct competition where there used to be complementarity has created a strain for universities and for their regions. This could lead to these universities becoming less innovative in their approach to knowledge transfer, rather leading them solely to adapt new policy requirements.

More research is clearly needed to investigate how university strategies and new governance modes for knowledge transfer have shaped their environment. This paper also did not provide a full analysis of other local actors in the Manchester region that might have affect university strategies. Specifically, research collaborations within a firm's strategic portfolio that may evolve with firm strategy and competitive dynamics need to be considered. A dynamic analysis that considers the demands of local industry would provide the comprehensive background for exploring university-industry relationships and how they change over time. These are important question for future research.

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Chapter 15

Why Do Universities Internationalize?

Organizational Reputation and Legitimacy

Mattia Cattaneo, Michele Meoli, and Stefano Paleari

Abstract This article investigates the internationalization process in higher education at the institutional level. Drawing on an original perspective informed by organizational theory, we propose two theoretical dimensions of universities' internationalization: international reputation and local legitimacy. Building upon the categorization proposed by Knight (*Journal of Studies in International Education* 8(1):5–31, 2004), we argue that international reputation and local legitimacy permeate rationales for international institutional development with respect to the different status of a university. Specifically, non-ranked universities do not exploit internationalization benefits to acquire an international reputation, as ranked universities do; rather, they do so primarily to gain legitimacy in the local context. These institutions suffer from higher information asymmetries in disclosing the value of their educational services, and try to provide a signal to students and their families and help them perceive their quality. We make use of explorative case studies referring to two Italian universities highlighting the different reasons universities have to pursue an internationalization strategy. We conclude that universities of different ranking pursue internationalization for dissimilar purposes, either to distinguish at a global level and to secure a place on the national map.

Keywords Internationalization • Universities • Reputation • Legitimacy • Academic ranking

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15.1 Introduction

In today's globalized market for higher education, the international expansion of academic institutions can be defined as a developmental necessity rather than a choice (Chan 2004), and universities are forced to find new ways to distinguish themselves on the international map and gain greater visibility. As a result, the volume of universities' international activities has expanded tremendously in the last two decades (Altbach and Knight 2007), with the establishment of study-abroad programmes, the exchange of students and technical staff between campuses, expansion of foreign language offerings and international education programs, and institutional cooperation among networks in various countries (Van Damme 2001). Nevertheless, despite this emphasis on internationalization, institutional rationales, concepts, motivations, goals, and desired outcomes regarding internationalization have not yet been clearly defined in the literature (Dewey and Duff 2009, p. 501), and a theoretical examination of related motivations and challenges is in order (Enders 2004). This paper builds on earlier works, examining university internationalization rationales and situating them within an integrated theoretical model. Our examination draws on organizational theory, with particular reference to the notions of reputation and legitimacy, which are major motivating factors in institutional development.

To date, discussions of university internationalization have focused primarily on research institutions and internationally recognized universities (e.g. Horta 2009), suggesting that research capabilities represent core factors for globally recognized institutions (Marginson 2006). Indeed, the inclusion of research universities in international league tables, such as the Times Higher Education (THE) ranking or in the Academic Ranking of World Universities (ARWU), shows that these institutions compete at a global level, and aim to be identified as the highest status universities (Washington and Zajac 2005).

Nevertheless, internationalization largely influences universities' missions independently from their belonging to worldwide ranking. Essentially, all universities are now judged in terms of two frames of reference: the national and the global (Marginson 2006). For instance, research and teaching now aim to generate international scientific output and train open minded and globally oriented students. The cross-border characterization of education is now pervasive and inescapable (Gumport and Sporn 1999).

Although the degree of cross-border engagement varies from university to university, the potency of global reference does not, and it is therefore a topic of increasing relevance for academic managers and policymakers. However, previous literature has failed to note that internationalization strategies incur very high costs for universities and rarely result in actual profits (Altbach and Knight 2007). In this respect, we wonder why non-ranked universities, often lacking in financial and human resources, should invest, according to the level of autonomy ensured by each specific system, in the expensive and potentially fruitless pursuit of internationalization.

Previous literature has already investigated the rationales of higher education internationalization and has pointed to socio-political, cultural, economic and academic motivations (e.g. Knight and de Wit 1995, 1999; Knight 1997). Recent updates of those rationales by de Wit (2002) and Knight (2004) highlight that institutions' internationalization has gained increasing importance and that, in these terms, a clear distinction must be made between national and institutional rationales. The internationalization of higher education has important consequences at a national level, but in countries where internationalization is not so prominent (Knight 2004), institutional-level rationales tend to be more institution-specific and to carry more weight.

This paper's original perspective is couched in organizational theory, which is used to consider the institutional-level rationales for internationalization. Two specific motivational dimensions are proposed: reputation and legitimacy. Improving upon previous categorizations only considering international reputation as a motivation, we argue that international reputation and national legitimacy in fact permeate all other institutional rationales, but in different measure, according to the inclusion of universities to academic rankings. Because of the divergent objectives of universities included or not in international worldwide ranking (Winston 1999), internationalization strategies and goals may differ accordingly.

For instance, let us consider the possible roles that the 'student and staff development', part of the institutional rationales mentioned by Knight (2004), play in the internationalization efforts of ranked and non-ranked universities. By providing local students with international contacts and resources, a non-ranked university can produce a national workforce with skilled capabilities and access to potential international networks. This builds the reputation of the university in the national context, lends legitimacy to its image, and increases its appeal to stakeholders. In contrast, ranked world-class universities are prestige-driven institutions (Marginson 2006). These universities have no difficulty attracting students from all over the world, as courses and degrees from those institutions offer students a more valuable 'positional good' (Hirsch 1976) in the labour and academic markets. Their internationalization efforts therefore focus on selecting the best students in the world, providing them with excellent training, and enhancing university prestige through their achievements.

Differently from previous literature, this paper argues that non-ranked academic institutions, which generally compete for national students and funding, implement and exploit international activities to improve perceived value in the eyes of local and national stakeholders. Indeed, the imperfections in the knowledge market imply that teaching quality may depend more on the status of an institution rather than on the type of services and goods provided-i.e., credence vs. experience goods (e.g. Podolny 1993). Consequently, when information asymmetries make it difficult for families to assess the educational services provided at non-ranked universities, students and their families often rely on other signals to assess the quality of an institution. Then, as a means to gain legitimacy in the local environment, non-ranked universities may seek other ways to enhance their attractiveness—for

example by employing foreign professors, enrolling a high percentage of international students, and forging partnerships with cross-border institutions.

The central arguments of this paper are as follows: (1) that university internationalization is a way to signal the assessment of a university towards the social system; (2) that organizational reputation and legitimacy are two dimensions driving university internationalization; and (3) that international reputation motivates ranked universities to undertake an internationalization strategy, while national legitimacy motivates non-ranked universities' investments in this direction. Our theoretical discussion examines how these different motivations derive from differences in the scopes and roles of particular universities.

Two case studies will be implemented to explore our theory. The two universities were selected with respect to their different status in terms of presence in international academic rankings (Cattaneo et al. 2015a): in particular we considered a ranked university and a non-ranked institution according to the Shanghai University's Annual Ranking of World Universities (ARWU), both located in the North of Italy. Interviews were conducted with two main key academic figures responsible for the internationalization of each university. Evidence are consistent with our expectation: the ranked university internationalizes to increase its reputation in the eyes of both competitors and international potential students, while the non-ranked university perceives an internationalization strategy aiming to legitimate itself at a national level.

The remainder of this paper is organized as follows. In Sect. 15.2, we consider previous studies on the rationales for university internationalization and introduce the theoretical framework used here, and we also discuss in detail the internationalization of universities with respect to organizational reputation and legitimacy. In Sect. 15.3, we report our case study research, and Sect. 15.4 concludes.

15.2 Theoretical Background

15.2.1 *Rationales for University Internationalization*

University internationalization is not a recent phenomenon, and its execution has concerned higher education systems since their medieval European origins. However, the effort to categorize the rationales behind such strategies is a recent one and has been underway only since the 1990s. To date, the literature has generally neglected the institutional aspects of internationalization (i.e. the reason that universities internationalize). For instance, Aigner et al. (1992); Scott (1992), and Johnston and Edelstein (1993) did not mention any university-specific rationale among the imperatives of higher education internationalization they identified.

University-level rationales have come into focus thanks to the contributions of Knight and de Wit (1995, 1999) and Knight (1997), who clearly enumerate institutional rationales among other socio-political, cultural and economic motivations.

In particular, they suggest that the institutional rationales for internationalization are twofold: on the one hand, university's internationalization strengthens higher education by providing students with a broader, more knowledgeable worldview, improving their ability to work in teams, and preparing them for interaction with foreign cultures. On the other hand, internationalization contributes to a university's international reputation, positively affects the institution's core structures and activities, and enables new initiatives that would be impossible with local resources.

In light of recent changes in higher education systems, several studies have consequently attempted to update rationales for internationalization (de Wit 2000, 2002; van Vught et al. 2002). de Wit (2002) updates them, highlighting that the academic rationale of *profile and status* seems to become predominant in higher education systems. This has been identified as a direct consequence of increasing competition for international rankings.

However, Knight (2004) is the first to explicitly suggest a net division between *national* and *institutional* rationales as two important and disparate classes. The former concern internationalization processes at a system level through policy, funding programs and regulatory frameworks, for example. The latter relate to the place where internationalization concretely takes place. Among other institutional rationales, Knight (2004) emphasizes the importance of international branding, through which universities seek to improve their status. However, she openly wonders whether the desire of academic institutions to build an international reputation should be seen as a distinct category of rationales, or whether it might in fact influence all the other existing rationales. In other words, the author considers international branding as a means to an end, interpreting it as a rationale and leaving the issue open to further discussion.

Thus, we can identify two gaps that may be addressed. First, we currently have an incomplete knowledge of the rationale concerning university's reputation and its determinants; second, we have a need for a better clarification of institutional rationales in general (Dewey and Duff 2009). In this study, then, we move forward from previous studies, detailing the rationales for internationalization from a productive new perspective rooted in organizational theory.

In this paper, we argue that university reputation is not just a rationale but is rather an inherent principle of internationalization that, together with organizational legitimacy, drives the rationales of ranked and non-ranked universities. Indeed, scholars generally rely on the different sub-elements of the academic rationale class (Table 15.1) to explain what actually works to increase international reputation. For instance, they claim that a university's international recognition is the result of attracting the brightest scholars and students, a higher number of international students, and high profile research and projects. In this respect, we suggest that the institutional rationales identified in de Wit (2002) (Profile and status; International academic standards) and Knight (2004) (International branding and profile) may be investigated in light of the organizational constructs of reputation and legitimacy.

Table 15.1 Previous categorizations of internationalization rationales

Academic and institutional rationales	
Panel A—de Wit (2002)	
<i>Academic</i>	International dimension to research and teaching
	Extension of academic horizon
	Institution building
	Profile and status
	Enhancement of quality
	International academic standards
Panel B—Knight (2004)	
<i>Institutional</i>	International branding and profile
	Income generation
	Student and staff development
	Strategic alliances
	Research and knowledge production

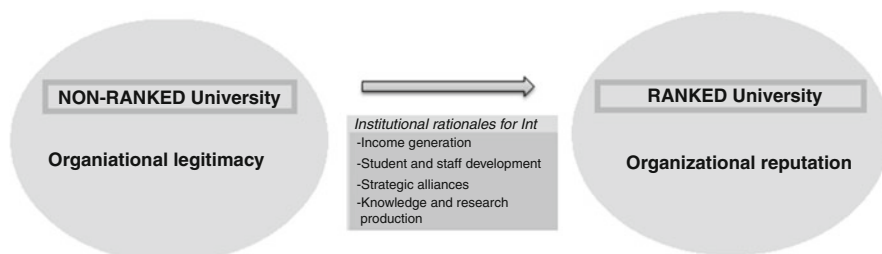
This table shows the rationales for university internationalization identified by de Wit (2002) and Knight (2004). The rationales in bold are those characterizing the principle of organizational reputation outlined in Sect. 15.2.2 which permeates all other institutional rationales according to the inclusion of universities to academic rankings

Source: Authors

Figure 15.1 shows our new setting, wherein institutional rationales are to the same with respect to organizational reputation and legitimacy, which, in turn, are functions of universities’ belonging or not to international rankings. We review the institutional rationales that have been identified so far, and we rely in particular on the academic rationales described by de Wit (2002) and the institutional ones discussed by Knight (2004). The international reputation dimension we consider in the model comprises three categories of the rationales reported in Table 15.1: ‘profile and status’, ‘international branding and profile’, and ‘international academic standards’, as suggested by Knight (2004). Then, because of the similarity between rationales described by Knight (2004) and by de Wit (2002), such as ‘student and staff development’ and ‘international dimension to research and teaching’,¹ we focus the analysis on the four institutional rationales introduced by the former: ‘income generation’, ‘students and staff development’, ‘strategic alliances’ and ‘research and knowledge production’. Second, we highlight in Fig. 15.1 that the dimensions of reputation and legitimacy rely on the same rationales.

In fact, universities having higher reputation and to exploit internationalization in a different way from those aiming for legitimacy in the national context. Table 15.2 below details how ranked and non-ranked universities take advantage

¹ In describing the ‘students and staff development’ rationale, Knight (2004) defines ‘internationalization as a means to enhance the international and intercultural understanding and skills for students and staff’ (p. 26). Similarly, de Wit (2002) proposes the ‘international dimension to research and teaching’ rationale under which ‘internationalization efforts are intended to . . . prepare faculty, staff, and students to function in an international and intercultural context’ (p. 96).



Source: Authors

Fig. 15.1 New model of institutional rationales for internationalization. This figure shows how institutional rationales for university internationalization are a function of the two organizational constructs of legitimacy and reputation. Rationales are the same for each university when internationalizing (Income generation; Student and staff development; Strategic alliances; Knowledge and research production), but their connotation is different with respect to the two dimensions identified. The *arrow* indicates the shift from legitimacy to reputation according to the inclusion in international rankings. *Source:* Authors

of the income generation that arises from a particular strategy, namely, the correlated increase in both the knowledge and capabilities of staff and students, and in opportunities for strategically advantageous alliances.

In the following section, we introduce the concepts of organizational reputation and legitimacy and describe their application to the internationalization of universities of different status (ranked and non-ranked universities). Then, we detail the existing connections between internationalization's institutional rationales and its two organizational dimensions.

15.2.2 *Organizational Reputation and Legitimacy: University Internationalization*

According to prior contributions on organizational theory, we may view status, reputation, and legitimacy as complementary specifications of organizational identity, rather than competing forms of social judgments (Rao 1994; Washington and Zajac 2005). In our case, organizations' actions are viewed in terms of their consequences for reputation and legitimacy, which universities seek to maintain and improve over time to perceive a higher status level. These two factors relate to the evaluation of benefits and hazards of an organization's activity, which can impact the judgment² of different actors (Ruef and Scott 1998).

In recent decades, numerous studies have tried to depict the similarities and differences of reputation and legitimacy by comparing their main features (e.g. Rao

² Social judgments are here defined as an evaluator's decision about the properties and attributes of an organization (Bitektine 2011).

Table 15.2 Rationales of internationalization with respect to the inclusion of a university in international rankings

Rationales	Definition from Knight (2004)	Ranked universities: organizational reputation	Non-ranked universities: organizational legitimacy
Income generation	Institutions are increasingly interested in internationalization as a way to generate alternative sources of income	Universities are mainly driven by status attraction, not by revenues or expansionary aim per se (Marginson 2006). Revenues arising from internationalization are presumably re-invested to continue a worldwide expansion through partnerships with governments and other institutions in foreign countries (e.g. Singapore-MIT program, Malaysia MIT program)	Income generation represents a main rationale for internationalization. The recent decrease in public funding and the increase in operational costs are leading higher education institutions to look for external resources. Low-status universities' international activities indicate their ability to adapt to new contexts, increasing their survival and signalling their suitability for funding
Student and staff development	Internationalization is a means by which to enhance the international and intercultural understanding and skills of students and staff	Universities do not have difficulties in attracting worldwide students, since the courses taken at those institutions are of high value to students and to the labour and academic markets. Internationalization is thus a way to select the best students in the world, train them well, and enhance the university's standing	Universities internationalize by providing students better contacts and resources, which aid their entry into the job market as skilled, capable, and internationally connected workers. This contributes to the reputation of an academic institution in the local or national context, and such activities augment a university's legitimacy among external stakeholders
Strategic alliances	Building international network linkages for different purposes, for example, academic mobility, benchmarking, joint curriculum or program development, seminars and conferences, and joint research initiatives	The resources from international alliances are interpreted as substitutes for national resources. Universities look for privileged collaborations in order to increase their potential and standing. For instance, MIT pursued a partnership with the University of Cambridge because of the latter's records in science and	The ability to develop international institutional linkages and/or more complex networks is part of universities' strategy to embed themselves in the local or national context. In some cases, collaborations may be in name only, existing not to facilitate continuous and active exchange of information but rather to justify

(continued)

Table 15.2 (continued)

Rationales	Definition from Knight (2004)	Ranked universities: organizational reputation	Non-ranked universities: organizational legitimacy
		engineering and the high number of high-tech firms located around the university (Cambridge Science Park) (Heitor 2012)	resource allocation and to signal their activities (Chan and Dimmock 2008)
Research and knowledge production	International and interdisciplinary collaboration is key to solving many global problems, such as those related to environment, health, and crime. Institutions and national governments are therefore making the international dimension of research and knowledge production a primary rationale for internationalization of higher education	Internationalization is primarily a way to increase the quality and the quantity of scientific research production in order to maximize the status of the institution. Status is indeed a function of both a highly selective student body and research performance (Marginson 2006). Indeed, this is the rationale operating in global rankings of universities (e.g. ARWU ranking)	Universities' internationalization in scientific research may signal access to on-going contacts with emerging technologies. Universities become key players in the national context, attracting the interest of both the government and the industry when dealing with national innovation programs and projects

The table reports the definition of the institutional rationales listed and details the different effects of each rationale with respect to the inclusion of a university in international rankings and the two organizational dimensions

Source: Authors

1994; Gioia and Thomas 1996). In particular, scholars have defined both reputation and legitimacy as multidimensional constructs whose constitutive dimensions may often partially overlap (e.g. Suchman 1995). The traits associated with the cognitive categories of ‘legitimacy’ and ‘reputation’ have much in common when the attributes that define the latter are inferred from the past actions of a firm and assigned to it (Bitektine 2011). Nevertheless, these two judgments evidently differ from each other: the concept of ‘legitimacy’ is based on the *similarity* of an organization in comparison with others, while ‘reputation’ arises when an organization is *different* from the existing ones (Deephouse and Carter 2005). As suggested by Bitektine (2011, p. 173), these organizational constructs relate to two explanatory questions that concern evaluating university stakeholders: a judgment of legitimacy, that is, *Does the organization belong to any familiar class or category?* and a judgment of reputation, that is, *How will the organization perform/ behave in the future relative to other organizations in the set?*

In order to evaluate why universities with different status (i.e. ranked or non-ranked universities) pursue internationalization, we now turn to a discussion

of these two organizational concepts and their application in universities' international activities, highlighting their effects on evaluators' (i.e. stakeholders') judgment.

15.2.2.1 Organizational Reputation and University Internationalization

Reputation has been often assessed in the literature in terms of quality (Podolny 1993) and esteem (Dollinger et al. 1997). Shenkar and Yuchtman-Yaar (1997) argue that reputation is equal to the prestige and the goodwill needed to develop the encompassing concept of organizational standing. Each organization is often evaluated in terms of status compared to its equivalents. In the higher education market, students and their families emphasize the importance of attending 'big name' universities (credence good). Regardless of the quality of instruction (experience good) they actually provide, such academic institutions are often sought after because they are thought to provide students with access to the best jobs.

Ranked universities are more secure in their roles than non-ranked organizations. They may therefore rely on an internationalization expansion strategy to improve their reputation in the global context. Indeed, Horta (2009) points out research universities have implemented international programmes in order to gain higher positions in international rankings. In today's globalized marketplace, word-class universities are racing for reputation, investing a great deal of resources to hire the best faculties and attract the best students from around the world (van Vught 2006). In this context, internationalization represents a strategy of global competition to increase the reputation of ranked universities.

Table 15.2 details why ranked universities internationalize to increase their reputation according to institutional rationales. In particular, we highlight that these academic institutions look for cross-border linkages and collaborations as a substitute for national resources, where the latter are not able to guarantee a high level of performance. International and local/national resources are not mutually exclusive and can in fact be mutually reinforcing. Ranked universities select those resources that allow them to raise their standing (e.g. higher tuition fees for international students at research universities in the UK and USA systems).

Against this background, we formulate the following proposition:

Proposition 1 Ranked universities internationalize to increase their reputation in the global context.

15.2.2.2 Organizational Legitimacy and University Internationalization

Legitimacy refers to 'the generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate' (Suchman 1995, pp. 573–574).

Specifically, three types of legitimacy are used to classify the different proxy measures according to the source of legitimacy: (1) sociopolitical regulative, (2) sociopolitical normative, and (3) cognitive legitimacy (e.g. DiMaggio and Powell 1983; Zimmerman and Zeitz 2002). Briefly, the regulative dimension is related to the conformity to regulations, rules and standards set by the government, credentialing associations, and other public endorsed organizations. Normative legitimacy is conferred when an organization demonstrates that it is appropriate and desirable by adopting the social norms and values of the surrounding society or institutional environment. Cognitive legitimacy arises when an organization adheres to a system of widely shared beliefs and assumptions that is accepted within its domain of activity.

The present focus is on normative and cognitive legitimacy. We believe that regulative legitimacy is less relevant in such a context, as the state plays a direct role in managing competition in the higher education sector. Indeed, the state acts as a regulator, a major financier, and, in several cases, as a direct producer in directly managing universities. Although higher education systems are moving towards ‘quasi-market’ models (Le Grand 1991) where the role of the state should be relatively limited, a massive number of public institutions continue to characterize the sector to date, implying that regulatory legitimacy is less pivotal in higher education systems.

Normative and cognitive legitimacy are most relevant to universities seeking legitimacy in the national context. These two components are also difficult to empirically distinguish from one another (Zeitz et al. 1999), even if scholars are now able to differentiate them conceptually. On the normative side, universities may demonstrate their desirability and appropriateness by creating international networks, which enhance their perceived legitimacy (e.g. Aldrich and Fiol 1994). Networks indeed add to the national endorsement of the organization by providing credibility, facilitating access to external resources, and building a positive image. On the cognitive side, internationalization contributes to legitimacy by creating a knowledge base through a set of actions appropriate to a system. In particular, the costs to supply valuable services with an international character—M.Sc. programs offered entirely in English (valid for non-English speaking countries), the presence of foreign professors and students, and active Erasmus programs and international conferences, for example—are part of a deliberate strategy to signal higher suitability in the national context. Internationalization may thus be a strategy for a university to build trust among stakeholders through its activities.

Moreover, according to institutional theory, an antecedent of legitimacy is *isomorphism* (DiMaggio and Powell 1983; Meyer and Rowan 1977), that is, the extent to which an organization is similar to other organizations in an organizational field. Internationalization is no novelty in higher education system; yet it is certainly a contemporary concern, and it is frequently mentioned in universities’ current mission statements.³ Internationalization can also provide a way to conform

³ About half of US research universities include internationalization in their strategic plans (Siaya and Hayward 2003).

to common standards and membership requirements (Tolbert and Zucker 1983); thus, non-ranked universities internationalize to legitimate themselves in the local context by conforming to the activities of others universities while also seeking to set themselves apart from their local competitors.

For each institutional rationale, Table 15.2 explains why non-ranked universities implement international activities to secure and advance their positions into the national environment. Unlike ranked universities, which exclusively exploit internationalization to seek privileged and valuable resources, these academic institutions primarily want to attract the interest of external shareholders by pointing to impressive activities and their potential value in the national context. Non-ranked universities are moved by the objective to become legitimate operators in the local social system. For these universities pursuing the strategy to become a ranked university might be highly expensive and a too long (if possible) process.

These points lead us to formulate a second proposition as follow:

Proposition 2 Non-ranked universities internationalize to legitimate in the national context.

15.3 Case-Study Research

Given the aim of the paper and our conceptual framework, we adopted an exploratory approach. Specifically, we investigate two different and exemplary case studies to in-depth examine the features characterizing each case and clearly identify the features that distinguish each case from the other (Yin 1994). We select two different universities in the same competitive context (Cattaneo et al. 2015b) in the North of Italy having a clear different status as measured by as their presence in international rankings. The University R can be classified as a ranked university since it has been ranked in the ARWU ranking since 2003, while the University NR was selected because it has never being ranked in international rankings.

Table 15.3 shows the main features of the two universities. Both are public institutions offering three degree levels to their students: Bachelor, Master and Doctorate courses. Though only the University R is included in international rankings, both the two universities are classified as ‘Research Active’ by the EUMIDA database.⁴ In terms of internationalization, data highlight that both academic institutions enrol almost 5 % of foreign students. Regarding the internationalization at an academic level, the University NR hired a higher percentage of foreign professors (10 %) while the University R seemed not to have perceived such strategy in the recent years. As far as the internationalization of a university is related to use of the English language, both universities offer English-degrees at a master level.

⁴ A European University Data Collection launched by the Research and Innovation DG in 2009.

Table 15.3 Data

Universities' characteristics		University R	University
Legal status		Public	Public
More than 100 years		Yes	No
Research active		Yes	Yes
Internationally ranked (ARWU)		Yes	No
Degrees in English		Yes	Yes
Highest degree awarded	Bachelor	Yes	Yes
	Master	Yes	Yes
	Doctorate	Yes	Yes
Students	Italian (%)	94.6	95.2
	Foreign (%)	5.4	4.8
	Total (no.)	20,000–25,000	15,000–20,000
Professors	Italian (%)	99.1	90.0
	Foreign (%)	0.9	9.610.0
	Total (no.)	500–1000	250–500

15.3.1 Results of the Interviews

The interviews, held on February 2014 with the former Vice Rector for internationalization of the University R and the Vice Rector for internationalization of the University NR, are reported in the Appendix.

The information collected suggest that both universities consider internationalization as a necessary process to remain competitive in the academic arena and to attract additional funds. In particular, the University NR relies on internationalization as a strategy to survive, become more prestigious and be recognized as an innovative university at a national level. More specifically, as reported by the Vice Rector ‘we internationalize to become a university of reference [...] we create a network of universities to be competitive both on the territory and a national level’. The main purpose of the internationalization strategy is to ‘train young minds for our country and not to increase reputation, which can be a consequence, a projection of the internationalization process, but not our primary objective’.

On the contrary, internationalization is used to increase the attractiveness of students and foreign professors and enhance the international visibility at the University R. To increase the reputation at an international level, the University R is indeed conscious of the necessity to be ranked in international ranking. As reported by the former Vice-Rector: ‘we want to increase our visibility outside Italy to attract more international students, which are part of a measure in international rankings [...] We also care about Italian ranking, but our competitors are mainly international’.

By considering the different actions related to the internationalization strategy of a university, one of the main differences between the two universities is related to

the consequences of the internationalization process. The University R is more focused in positioning itself inside an elective international network of research universities. On the contrary the externalities associated to the internationalization strategy of the University NR contribute to signal its presence in the local environment. As an example, this university promotes new international initiatives with important top-class universities, aimed to study some key issues (e.g. mobility, sustainability, health) of the city wherein it is located. Such interactions allows the engagement of the students with local stakeholders therefore reinforcing the relationships with the local environment.

Both Vice-Rectors underline that the difference between the two universities dates back to their foundation. The former, was established in the fourteenth century as a pure university, repository repositories of knowledge and wisdom, with the preservation and transfer of existing knowledge as the main goal. The latter is instead a recent university, founded in the second half of the Twentieth century, clearly focused in transferring knowledge and technology to the industrial territory.

Concluding, the interviews suggest that internationalization is a way to enlarge the international standing of University R, which tries to become more and more attractive for worldwide students, and the legitimacy at a national level of the University NR. Legitimacy, indeed, arises when the actions of an entity are recognized to be social valid and appropriate. The internationalization strategy of the University NR contributes to increase the value of the institution at a local level, providing more international highly skilled human capital on the territory and valuable services arising from outstanding international collaborations. Further, it is important to note that the years elapsed from the establishment may indeed determine the behaviour of universities. While younger universities would perceive legitimacy to be recognized at a national level, older organizations wants to be recognized as credence good.

15.4 Conclusion

This article represents an original contribution to the higher education literature, bringing a productive new perspective from organizational theory to bear on the internationalization strategy of universities. In prior literature, researchers have mainly addressed this issue from a wider perspective, discussing the internationalization of higher education in terms of national and institutional rationales (e.g. Knight and de Wit 1995, 1999; Knight 1997; de Wit 2002). By only focusing on institutional-level rationales for university internationalization, this paper tries to disentangle and conceptualize the motivations that lead different status universities to implement this expensive strategy. We suggest that legitimacy, and especially its normative and cognitive characterizations, may explain why non-ranked universities choose to invest in internationalization activities. By pursuing international activities, non-ranked universities can achieve a 'legitimate' position in the national context and may be identified as proper actors by external stakeholders

(e.g. government, students, families, firms, other universities). The analysed case studies qualitatively confirm our expectations. They show that the University R, a ranked university at an international level (e.g. ARWU, THES ranking), perceive internationalization to increase its reputation at a global level. On the other side, the University NR, a non-ranked university, internationalizes in order to signal its presence at a local and national level. In this case, attracting more foreign professors and, consequently, increasing the university's international standing is a clear strategy to become a university of reference on the local environment.

Against this theoretical backdrop, let us revisit the empirical contribution provided by Chan and Dimmock (2008) concerning the internationalization of two different universities: a British university, which aspires to be an international university committed to the region, and a Hong Kong university, which aims to be a good university and which internationalizes primarily to serve the motherland. Organizational theory here provides appropriate tools to discern that reputation and legitimacy are two main drivers influencing the different internationalization patterns of those two dissimilar universities. The motivations for internationalization that Chan and Dimmock (2008) report for those two cases of internationalization are entirely compatible with our discussion.

Our new categorization has some practical implications. To our knowledge, the pursuit of national legitimacy has not yet been enumerated under the benefits of internationalization. The global surveys on internationalization of higher education that have been published by the International Association of Universities since 2003 should enrich their analysis by incorporating this dimension into their assessments. Second, university managers may realize that the investments they will make to internationalize their institutions may be a way to reinforce the standing of the university in the national context, even if near-term profits are unlikely. Further, this theoretical contribution also highlights what policymakers should expect when ranked and non-ranked universities internationalize. Our categorization indeed attempts to clarify the reasons that a world-class university internationalizes with inevitably different purposes than does a non-ranked local university.

We intend the theory and propositions advanced in this paper to serve as first steps in new directions, and much future research is needed, including empirical tests of these theoretical constructs. To date, the categorizations and arguments on internationalization have found no empirical validation, with rare exceptions. For instance, following Bennett and Kane (2011), one might examine why academic institutions internationalize, providing a questionnaire to all the universities belonging to a specific higher education system, and using survey items to test our theoretical framework. Researchers could also investigate in depth whether and how the several approaches to internationalization should differ with respect to the aim of universities in increasing reputation or legitimacy.

In conclusion, we offer a final note on our use of the term 'status' here. Status is not a dichotomous argument; on the contrary, 'status grouping may be theorized as items on an ordinal scale' (Bitektine 2011, p. 161). There is a fair bit of blurriness to university status, and of course, it is impossible to categorize academic institutions accurately on this criterion alone, especially when only using two classes (low and

high) to do so. Nevertheless, in this context, we focus on ranked and non-ranked universities in order to easily observe contrasting patterns in their internationalization strategies. This leads to a clearer recognition of the central constructs, relationships, and logic of the internationalization phenomenon. Nuances and finer distinctions remain to be addressed in future work. For instance, the difference in goals between the internationalization of private and state-funded universities, even if they are both ranked or not. Being the former profit orientated organizations, future researches should take into account this issue to perform accurate quantitative analysis of the phenomenon.

Acknowledgments This work benefited from valuable inputs from Professor Manuel Valsassina Heitor and Hugo Horta, Instituto Superior Tecnico, Lisboa.

Appendix

This section reports selected questions held with the former Vice Rector for internationalization at the University A and the Vice Rector for internationalization at the University B on February 2014.

General Questions

Which is the definition of university internationalization inside your university?

<i>University R</i>	Internationalization is a meeting point among people or institutions, similar to a university mission, but different in terms of realization. In this regard, it is important to remember that universities born based on the mobility of their students.
<i>University NR</i>	Internationalization is a set of different initiatives taking place at different levels. As assessed in mid-December 2013 in Padua by the representatives of the EUA (European Universities Association) there is no a coherent and well-accepted definition of internationalization. Following the proposed definition of EUA, the internationalization of Higher Education is ‘the process of integrating the international, the intercultural or the global dimension into the purpose, function or delivery of higher education’.

Is the process of internationalization important for a university today? Why?

<i>University R</i>	The internationalization is today essential for the sustainability and the growth of each kind of university in Italy, both in the

North and in the South. We can identify two reasons: firstly, we want to attract international students and professors to enhance our visibility and attractiveness; second, the internationalization allows receiving government and European funds.

University NR Today, in periods of cuts of government funding and increased budgetary pressure the internationalization is a necessary process to survive and become a more prestigious and innovative university. In our university, we are aware of these trends, and we would consequently internationalize to become a university of reference, creating a network of universities to be competitive both at a national and international level.

How does your university internationalize?

University R The investments in foreign professors represent the first way to perceive an internationalization strategy, which in turn promote research collaborations and the attractiveness of international students. Direct initiatives have been also put in place during the last decade to attract students from emerging countries. Some of them would provide research grants to facilitate the attendance of courses. The university also promotes students exchanges with other partner universities in emerging economies for visiting periods and/or projects.

University NR The internationalization process is composed by two actions: teaching and research. While the first is performed mainly 'in home', the research is the result of collaborations with other universities in different countries. It is important to bring together research and teaching for a valuable international strategy with other international universities. Two examples can be identified at our university: (1) a collaboration with a top-class university in the US, a program aimed to work out some important challenges for our city, as themes associated with mobility and health; (2) a multicultural project involving our university (Faculty of Economics), a university from Austria, and a further one from Russia to promote the mobility of students during their studies.

How much of your university's total effort is devoted to the internationalization process?

University R I am not able to quantify the financial effort for internationalization, but the investments have increased year by year.

University NR It's difficult to quantify the internationalization effort, but the 'real cost' for each international course can be estimated in approximately 150,000€.

Rationales for Internationalization

Does the internationalization process generate any monetary income for the university?

University R The only unquantifiable part of income is the ability to become more and more competitive in the international arena.

University NR The only financial resources directly derive from a central level (government). The incentives devoted to internationalization depends on 4 indicators: (1) Nr. of Erasmus students, (2) Nr. of foreign students enrolled, (3) Nr. of doctorates enrolled, and (4) The percentage of European funds received.

Do you want to signal the presence of the university at the national level through internationalization or to increase its international standing?

University R We want to increase our visibility outside Italy and attract more and more international students, given their weight on international rankings. We really believe on this strategy. We even hired a person responsible to constantly monitor the University of Pavia in the international rankings, such as the ARWU, the THES and the QS. We also care about Italian rankings, but our competitors are mainly international.

University NR The purpose of our university is to rely on the process of internationalization to train young minds for Italy and not necessarily to increase the reputation of the university. This could be an indirect effect in the medium term, if the internationalization process is successful.

Perspectives for the Future

University R Internationalization is one of our main focuses for the future. We should start more international classes and increase the percentage of foreign students. We also aim to expand our boundaries out of Europe, looking to important emerging economies as Asia.

University NR Since we have exponentially started the internationalization process since a decade, now we should proceed prudentially. This will heavily depend on the demographic trends and the number of immigrant students of the next years.

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Part VI
Technology and Innovation

Chapter 16

Managing Resources in the Generation and Development of Research Based Spinoffs: Evidences from Israeli ICT Cases

Chiara Verbano, Avi Wasser, Maya Lincoln, and Karen Venturini

Abstract Research-based spinoffs (RBSOs) have raised a great interest in recent years for their economic and social implications. The literature has studied this phenomenon from three different perspectives: resource-based, business-model driven, and institutional. Due to the possible correlation between the approaches, this work aims to suggest an integrated framework, adopting the four stages model of spinoff development. To present the application of the framework we performed an extensive examination of two RBSOs operating in the ICT sector. Results highlight the level and types of technological, human, financial and social resources (including also the institutional linkages), and their evolution and importance in the generation and development of these new high tech companies.

Keywords Academic spinoff • Research-based spinoff • Resource based view • Israel startups • ICT

16.1 Introduction

The emergence of the “knowledge economy” in the 1980s, characterized by its competitive processes based on the introduction into the market of products with high scientific and technological content, has caused the spread of the spinoff’s phenomenon. In particular, referring to the public sphere, the dictates of the new economic theory promulgated the presence of universities and centers characterized by an intense research activity such as the dissemination and use of the public

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research. Rosenberg and Nelson (1994) and Mansfield (1991) have described research-intensive universities as significant agents of technological change and regional economic development. Moreover, academic spinoffs are recognized as one of the most important mechanism for transferring technologies from academia to the industrial system.

Over the last 30 years scholars have shown that spinoffs produce an important direct and indirect contribution to the generation of knowledge, to the dissemination of technological knowledge in the local economy, to the recovery of productivity through the achievement of earnings and the creation of new jobs.

Despite the benefits, the phenomenon of spin-off has not had a strong acceleration. The academic enterprises are faced with many obstacles and sometimes they become insurmountable. One obstacle is definitely the lack of resources and competences. For this reason, we investigated in depth the management of resources needed for the activation and development of spinoffs.

A thorough study of literature has allowed us to identify some gaps and consequently to propose new research questions on the topic of spinoffs resources and performance. The research conducted so far have studied the resources from different theoretical perspectives but did not provide a holistic view of the phenomenon that integrates all theoretical perspectives. Moreover the literature has focused on the study of the resources necessary to generate the spinoff, omitting the study of the resources in their evolution over the years.

The objective of this study is to analyze the evolution of resources and institutional linkages among all phases of development of a spinoff.

To achieve this goal, we used a model of spinoff life-cycle (Vohora et al. 2004) divided into four important phases: opportunity recognition, entrepreneurial commitment, threshold of credibility, threshold of sustainability and gathered all the resources studied in the literature for spinoff. For each phase, we checked what were the resources needed and what are the most important.

In this paper we decided to analyze two Israeli ICT spinoffs. Israel demonstrates an outstanding example with regard to the emergence of spin-off companies and high-tech start-ups. Singer and Senor (2009) named Israel “The Start-Up Nation”, due to the relatively large amount of startup companies—especially in the field of ICT.

Our contribution is therefore the development and testing of a new integrated framework, from one side, and the detailed investigation of two cases of Israeli spinoffs (context little studied) following a new path of study, from the other.

From the analysis of both cases, interesting insights emerge for public research institutions engaged in enhancing the results of their research through entrepreneurial initiatives, for local and national governments and private firms interested in supporting academia-driven start-ups. Knowing what are the resources that companies have used at various stages and what are the most important ones allows the founders to implement strategies that facilitate the success of these enterprises.

Section 16.2 is devoted to the review of the literature on research-based spinoffs, Sect. 16.3 carries out the research questions pursued and the methodology of analysis adopted, Sects. 16.4 and 16.5 are respectively devoted to the analysis of

the two cases, and finally Sect. 16.6 summarizes the study's findings and conclusions.

16.2 Literature Review

The spinoff is a company founded with the aim to market one or more inventions generated inside an R&D lab of another organization (parent organization). Sometimes it is called in a different way, depending on the public or private nature of the parent organization: if the parent organization is a company, the spinoff is called industrial spinoff and, if the parent organization is a university or a public research, the spinoff is called respectively academic spinoff or research-based spinoff (Rogers et al. 2001). The academic spinoff differs from the industrial start-up company from one side for the origin of the subjects that promote entrepreneurship (typical environments of the research) and the role played by these (university students, researchers, Ph.D. or postdocs, technical staff or professors), from the other side for the peculiarity of the initiative promoted.

Significant importance was attributed to these last types of spinoffs in the literature, as they are considered a mechanism usable by the government to generate economic impacts from their R&D activity (Roberts and Malone 1996).

The characterizing elements of a research-based spinoff are: the outcome of the transferring process (the new firm), the parties involved (the parent organization, the new firm, the entrepreneur and the venture investor) and the core elements that have been transferred (technology and people) (Djokovic and Souitaris 2008); some authors have highlighted the human element who move himself from one organization to another (Nicolaou and Birley 2003; O'Shea et al. 2008).

In this research authors have adopted the following definition: "The research-based spinoff is a new company created by staff that previously were or currently are employed in a university or in a public research institution. The company is formed to exploit new technology or knowledge produced by research within the university or the public research institution" (Smilor et al. 1990; Steffensen et al. 2000; Clarysse et al. 2011).

Despite the extensive literature devoted to the theme of spinoff, the success of these organizations, both in terms of survival and in terms of return they generate, is limited (Wright et al. 2012). The obstacles and limitations these enterprises face in the early years of their life are often insurmountable. The problems may be related to the lack of resources and competencies.

The managerial literature has studied the phenomenon of spinoffs from three different theoretical perspectives: the resource-based view theory (Barney et al. 2011), the business model perspectives and the institutional perspectives (Mustar et al. 2006).

According to the resource-based perspective, four types of resources are important for a spinoff to achieve competitive advantage: technological, human, social and financial ones (Djokovic and Souitaris 2008). Technological resources refer to

characteristics of the technology transferred from the parent organization such as the degree of innovativeness and the technology's stage of development, the scope of technology, the quality and legitimacy of the firm's R&D, and the regulation of intellectual property rights (Heirman and Clarysse 2004; Shane 2001; Lee et al. 2001). Human capital resources refer to the attributes of personnel involved in the spinoff, such as the size of the founding team, the founders' background, the professional management experience and organizational size (Mustar et al. 2006). Network (or social) resources refer to relations established by the spinoff with government, research organizations, universities, industrial companies and any other relevant actor. Network can facilitate the emergence of ventures providing the opportunity identification process, access to loci of resources, generating timing advances and constituting a source of trust (Nicolaou and Birley 2003). During the pre and post formation, RBSOs have relationship with two main sectors: research and industry. Keeping post-formation link with university can provide RBSOs with tangible resources (laboratory facilities, access to research equipment) and intangible resources (access to human capital and scientific and business knowledge). Interaction with industry is determinant to find external support and services, to access external resources not available in-house, to promote the new company, and to look for business advice (Birley 1985). The industrial parties are venture capital investors, suppliers, competitors, customers. The personal networks of founders had a long term positive effect on performance. The more successful university start-ups are generated by universities having strong working relationship with venture capital investors and possessing great amount of contacts with the industry (Powers and McDougall 2005). Financial resources refer to the amount and type of funds the spinoff obtains. It is often difficult for RBSOs to receive funding from venture capital firms, due to the non-managerial context from which they come, the lack of resources and potential conflicts with a public entity.

The business model perspective has focused the attention on RBSO's business model: in particular the market segment, the position in the value chain, the estimated cost structure and profit margin. There are different RBSOs typologies, depending on the activity undertaken, on how the technology has been transformed into a commercial value and on its growth orientation (Mustar et al. 2006). For Heirman and Clarysse (2004) two other elements may affect the organization and configuration of the spinoff resources: the complexity of the selling process, i.e. the characteristics of the buying office in terms of the number and accessibility of decision makers, and the size and geographical dispersion of markets that the spinoff faces. Shane (2001) proposed that the tendency for an invention to be exploited by forming a new company to market, varies according to the attributes of the technology regime (age of technical field, tendency towards market segmentation, effectiveness of patents, and importance of complementary assets).

The institutional perspective has examined how the parent organization supports the RBSO from the initial configuration to the later development; in particular, it classified the RBSOs on the basis of the spinoff degree of dependence on source technologies (Roberts 1991), the strategic choice made by the parent institute, referring to incentive systems, rules, procedures, use of surrogate entrepreneur,

supporting mechanisms as technology incubators and technology transfer office (Boeker 1989; Moray and Clarysse 2005; Cooper 1985; Powers and McDougall 2005). Some studies analyzed also the government support mechanism for USOs in U.S. and Europe, others evaluated the effectiveness of governmental TT policy (Shane 2004).

The spinoff, as any other organization, has its own life cycle. The literature has studied this life cycle identifying the main stages that characterize its development. Among the few studies on that topic, Ndonzuau et al. (2002) recognize four main phases of USO creation: business idea generation from research, finalization of new venture projects, launching spinout firms from project, strengthening the creation of economic value. Instead other scholars (Vohora et al. 2004) distinguish four critical junctures in the development of a spinoff:

1. Opportunity recognition, which is the period from the R&D phase in the parent organization until the recognition of business opportunity, comprising the verification of the technology and understanding of the market potential;
2. Entrepreneurial commitment, in which there is the definition of the business plan, the identification of resources and capabilities possessed and the acquisition of possible patent protection;
3. Threshold of credibility, the period dedicated to the re-orientation of the strategic plan, in which the resources and knowledge to integrate or to acquire in order to overcome gaps and weaknesses are recognized;
4. Threshold of sustainability, in which the focus is on generating revenues and economic value over time towards consolidating the company.

From the literature review, the following gaps emerge:

- The resource-based perspective lacks analytical studies on the impact of technological resources on RBSO's performances. The only variables considered are patents obtained and the product development stage.
- Almost all previous studies do not consider a dynamic view of spinoff creation and development, and generally limit the analysis to the RBSO's foundation period. It emerges the need of empirical studies on the evolution of RBSOs over time i.e., considering the different types of resources, business models, and linkages with universities in the more advanced stages of the RBSO's life. In many cases the post-foundation period is very critical for the success of the RBSO, hence an elaborated research timeline is required.
- The three theoretical perspectives adopted in the literature on this topics (the resource-based perspective, the business model and the institutional perspective) can benefit from unification, that will allow to study how different bundles of resources, business models and institutional linkages effect the spinoff performance. Hence, the development of an Integrated Resource Approach, that currently does not exist, is highly required.

16.3 Objectives and Methodology

16.3.1 Objectives

The objective of this study is to analyze the evolution of resources, institutional linkages and external mechanisms among all phases of development of a RBSO focalizing on a type of spinoff characterized by a specific industry: information and communication technology (ICT) (Druilhe and Garnsey 2004).

The choice of a particular sector is due to the fact that the resources driving RBSO's performances are different, depending on type of business. Therefore the authors decided to focus on ICT sector because it is one of the most active and innovative industry-types in spinoff generation. The chosen sector holds a significant presence in Europe, USA, Japan, and Israel and is one of the most important sectors for numbers of spinoffs generated by universities or public research institutes.

In more detail, the aim of the paper is to answer the following research questions:

1. Which are the resources used in the various development phases of RBSO? Did they change in time and if yes- how?
2. What are the most important resources for the success of RBSOs in every phases of their formation?
3. To pursue these objectives the authors have created a new integrated framework, and performed a detailed field-verification on two case studies.

16.3.2 The Framework for the Empirical Analysis

Given the gaps previously highlighted, we aimed to create a framework that overcomes several limitations of former frameworks. To this extent, we will consider the four types of spinoff resources (Fig. 16.1) and the external mechanisms in the four stages of RBSO development.

In order to integrate the three different perspectives adopted by the managerial literature for the analysis of research-based spinoffs, we added into the category of social resources the supporting mechanisms adopted and the specific resources

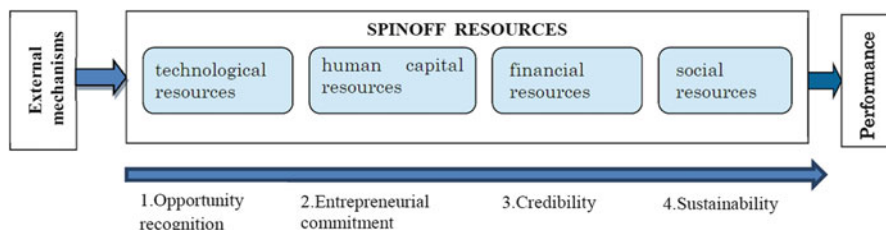


Fig. 16.1 The comprehensive theoretical framework adopted

offered by the parent organization (university or research institution). Moreover, national or local incentives and facilities were added into the external mechanisms. To the extent of evaluating the evolution of a spinoff's resources over time, we adopted the stages of a RBSOs formation and development identified by Vohora et al. (2004) with the four critical junctures: (1) opportunity recognition, (2) entrepreneurial commitment, (3) threshold of credibility, (4) threshold of sustainability.

Fatherly, to create an operative framework for the empirical analysis, we carried out a literature review, focused on dimensions and variables of the constructs. Table 16.1 demonstrates the results of this review work that has considered all the dimensions significant for the specific object of analysis (ICT spinoffs). Table 16.1 listed also the main literature consulted.

16.3.3 Case Selection, Data Collection and Analysis

To answer the research questions, we adopted a retrospective multiple case study approach, using longitudinal data collection (asking participants to reflect back upon their experiences and attitudes) (Featherman 1980). This approach allows an in-depth understanding of the process and has been scarcely investigated in prior studies (Rothaermel et al. 2007).

The Israeli setting seems very interesting and well suited to study the object of analysis, therefore cases were selected according to the following criteria:

- ICT spinoff with headquarters operating in Israel,
- Spinoff generated by public research institute or university,
- Spinoff with at least 8–10 years old, in order to analyze all the four stage of development of RBSO. The overcome of start-up phase is a condition for the success of a RBSO.

In Table 16.2 the main characteristics of the cases selected are described; as can be observed the two cases well differentiated in terms of parent organization, ICT segment of activity, ownership and facilities.

Data collection was performed during web meeting interviews with one of the founders of each of the spinoffs. According to the empirical framework, the interviews were semi-structured, including open and closed questions. The interviews have been preceded by the collection of information from the website of companies and other relevant sources such as magazines, and have been completed by analyzing documents and reports provided by the companies. Data collection has been finally verified and integrated by a second founder who controlled the answers previously obtained. For privacy reasons the cases have been anonymized.

Both companies will be analyzed in the following manner: first, we will provide general background information and review the development stages. Secondly, we will analyze the resources used for the process of spinoff creation and development-at each stage. Finally we'll refer to the research questions.

Table 16.1 Constructs and dimensions of resources influencing RBSO^a

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustain.
Techn. Res.	Degree of innovativeness				
	Stage of development of the technology				
	Ability to patent/protect the technology				
	Scope of technology				
Human Resources	Type of parent organization (PO)				
	Founders position in PO				
	Formal team size				
	Team size active in management				
	Ph.D. experience/scientific background in active founding team (on tot.)				
	Sector experience of one of the founders				
	Management experience				
	Previous entrepreneurial experience of team				
	Variety of backgrounds and work experience in the team				
	Joint working experience and cognitive similarity of the team				
	Presence of surrogate entrepreneur				
Fin. Res	Type of funding	–			
	Amount of funding (Mil.\$)				
Social Resources	<i>Relationship with PO (level of importance):</i>				
	Supporting strategy, mechanisms and fin. incentives towards spinoff				
	Tangible resource such as laboratory facilities, access to research equipment				
	Intangible resources (ex. access to human capital, scientific and business knowledge)				
	Previous RBSO experiences of PO				
	Scientific quality and perceived image of PO				
	Quality/support of technology transfer office				
	<i>Contacts with industrial, financial, research organization</i>				
	Venture capital investors				
	Financial institutions				
	Commercial partners				
	Competitors				
	Customers				
	Suppliers				

(continued)

Table 16.1 (continued)

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustain.
	Other research centres				
	Others: consulting entrepreneurs				
	RBSO strategies to access missing resources: paid consultants				
Extm.	National or regional incentives, or facilities				
Performance	Sales growth rate	–			
	Employment growth rate				
	n. patents				
	Quality certification				
	R&D investments				
	Tot. liabilities and equity				
	Prizes and awards				

Main literature consulted: Djokovic and Souitaris (2008), Clarysse et al. (2011), Heirman and Clarysse (2004), Shane (2004), Bigliardi et al. (2013), De Cleyn and Braet (2010), Egeln et al. (2003), Ensley and Hmieleski (2005), Franklin et al. (2001), Knockaert et al. (2010), Rasmussen (2011), Rickne (2006), Schmelter (2004), Taheri and Van Geenhuizen (2011), Wright et al. (2006), Zheng et al. (2010), Walter et al. (2006)

^aMore details are available on request by the authors

16.4 Results from Analysis of Case “Alpha” Medical Devices Software

16.4.1 General Background and Review of Development Stages

Alpha Medical Devices develops and markets its proprietary automated image processing software products for blood vessel analysis in patients with suspected cardiovascular disease. The company’s first FDA-cleared product provides fully automated, real-time analysis of Coronary CT angiography (cCTA) to enable the practical application of cCTA in detecting coronary artery disease. The CTAnalyzer System improves the utility of coronary CTA in the emergency department (ED), to triage chest pain patients and optimizes workflow in cardiology and radiology departments. Alpha’s systems are designed to provide advanced technology solutions to major clinical and economic challenges in the diagnosis and management of CAD and other blood vessel disorders. The company’s product performs fully automated analysis of cCTA studies in real time in patients with suspected CAD. The System is among the first systems approved in the U.S. for use in coronary artery disease. Coronary Artery Disease (CAD) and stroke, the consequences of atherosclerosis, are leading causes of mortality in the U.S., accounting

Table 16.2 Main characteristics of the two cases selected

	Case Alpha	Case Beta
Year of foundation	2006	2005
Location	Israel + sales branch in the US	Israel + sales branches in Europe and US
N. Employees	5	17
Revenue	0.2 Millions USD	Several millions USD
Firm product	Image processing software for medical applications	Business Process Management Software
Industry	ICT for Bio-Medical Devices	ICT for business applications
Market	Hospitals, private clinics, medical imaging centres	Enterprises, governments, public organizations
Parent organization	Technion (Israeli Inst. of Technology)	Haifa University
Founders	Four researchers and academics	Five researchers
Ownership	Venture capitalists, business angels (90 %) and founders (10 %)	Privately owned by founders
Facilities	Initially public research software labs, then transfer to private offices with software labs	Private science park
Main motivation for starting company	Innovative idea, team of experts, revolutionary development in cardiology that needs technological support	Innovative idea aimed at a rapidly growing market

Table 16.3 Main events and stages of development in the history of Alpha Medical Devices

Phase	Description
Opportunity recognition (2004–2005)	Initial ideas were discussed by the founding team of the company at the Technion (Israel Institute of Technology). The founders came to the conclusion that there is a possibility to develop a medical application to image processing algorithms and software.
Entrepreneurial commitment (2006)	The group of founders decided to launch a commercial company, approached investors and started establishing the R&D and business organizations.
Credibility (2007–2010)	Alpha announced the closing of a first significant financing round led by a USA based VC fund. The funds were be used to launch the beta version of the technology during 2006. The company has already identified leading radiologists to participate as beta sites.
Sustainability (2010–2013)	Additional financing rounds. Awarded Four U.S. Patents Covering Technology for Automated Analysis of Coronary CT Angiography. Commercial systems sold to customers.

nearly 25 % of deaths. CAD alone, Alpha's initial focus, affects some 16 million people in the U.S., causes 1.2 million heart attacks, and over 450,000 deaths. The direct costs of CAD are estimated at over \$87 billion. Timely and accurate evaluation of suspected CAD patients is among the keys to improving patient care, reducing costs, and improving efficiency in delivering care. For example, for the six million patients who enter ED in the U.S. each year with chest pain, the central challenge is to identify rapidly those who need immediate treatment and rule out non-cardiac patients. However, nearly 85 % of these cases are false alarms. Because diagnostic techniques are often equivocal, nearly two million, primarily low risk, patients are admitted to hospitals for further testing at an annual cost of \$10–13 billion, where acute coronary syndrome is subsequently ruled out. Additionally, 3–5 % of patients are discharged from the ED due to missed diagnoses. Such missed diagnoses account for approximately 20 % of ED-related malpractice cases. The company is collaborating with clinicians at a number of leading academic centers and hospitals in the U.S.A. and abroad to document the system's benefits. In addition, the company is exploring additional applications in blood vessel analysis.

The main events and stages of development in the history of Alpha Medical Devices are presented in Table 16.3.

16.4.2 Detailed Analysis of Resources Used in the Process of Creation and Development

Following the research framework, the resources used during each phase of development were divided between technological, human, financial and network resources and were identified together with the external mechanisms and

performance. Regarding the technological resources, the degree of innovation, i.e. the newness of the core technology compared to technologies commercialized in the market, was assessed by the managers of Alpha Company with a high score in all phases. The technological innovativeness of the product has never decreased in the stages of life of the spin-off. Rather different values were registered for the stage of development of the product, because at the beginning of the first phase the technology was just an idea then, thanks to huge investments, became in the final phase a market ready product. The ability to patent or protect the technology was always “high”. The registration of a patent has ensured the company a constant guarantee of protection. Finally, the ability to generate different products from the technological platform (called scope of technology), it was low in each phase because the solution adopted is about raw technology and algorithms.

The second group of resources were dedicated to the human ones. First of all the scientific and managerial experience of the founders’ team were considered. Alpha company had among its founders several Phds, specialized in ICT science and technology, but there was nobody with experience in the ICT business. The company has gained this experience over the years. Regarding the managerial experience, there was a good knowledge relating to the general management and operations management just from the beginning, instead the financial, legal and commercial knowledge have grown over time. The distribution of entrepreneurial experience—from high to medium and finally high—was also characterized by a variable trend. The variety of backgrounds and work experience of the founders’ team have always been there, even though growing over time—not an organic growth but rather a demonstration of fluctuations. The majority of the team members knew each other in all phases and did not have different point of views on how to manage the spinoff. Finally, the spin-off did not have any surrogate entrepreneur.

Considering the financial resources used by the company in each stage, the spin-off raised \$9 million from venture capital funds and business angels. This created a significant obligation to these bodies and required the involvement of the investors in the actual management of the company. Minimal were the funding from other sources, such as government grants, founders’ own capital, bank dept, etc. The company did also not use any external incentives—as it had an extended amount of external VC funding.

The last group of resources are those dedicated to the network of contacts, called social resources. The first relationship is with the parent organization (PO). At the beginning, the company enjoined an intensive relationship with the PO characterized by the usage of infrastructure, tangible and non-tangible resources of the PO, whereas in the other stages these ties were loosened. Anyway, the spin-off cared little the network of contacts with other business organizations such as commercial partners, competitors, suppliers, probably because was so engaged in research activities in the first three stages, while linkages with venture capitalists and other research centres was relatively high. The strategic choice of the spin-off was to fill the gap of resources and competences hiring external consultant in all phases.

Analysing the performance of the spin-off, can be observed that the company became profitable in the fourth phase. Company does not expect to develop a sales mechanism but to sell the technology or merge with a large player in the field of medical devices. The employment growth rate was high in stages 2–3, but was reduced after the technology was completed, because less R&D resources were required, and also expenses in R&D has been decreasing.

Table 16.4 illustrates the level of each resource in the RBSO's phases.

16.4.3 *Answers to Research Questions*

In response to the first research question, i.e. how the resources change at different stages of development of the spinoff, the following considerations emerge:

- Technological resources. The degree of innovativeness of the technology remained high in all stages of the development of the spinoff. The level of protection of the technology and the scope of the technological platform remains constant (high) over time—and even becomes stronger with the addition of patents.
- Human resources. The scientific experience of the team that founded the spinoff varies. The managerial experience shows fluctuations and background of the team changes along periods—not in an organic growth pattern. The company's product is related to medicine, hence the need in employing experts with a very specific know-how- e.g on FDA permissions. Nevertheless there is some lack—in different stages in management and business expertise (only medium levels)—again compensated by outsourcing.
- Financial resources. There was some or infrastructure support of the parent organization at the early stage. The spinoff then moved on with extensive recruitment of funds from a business angels and VCs. During the last phase there is also usage of management loans.
- Network resources. In general, the company established a relationship with consultants and research institutions, as well as with other scientific partners such as hospitals. The focus was on gaining field experience and accreditation.

The answer to the second question stems from the analysis of Table 16.4:

- At all phases, the most important resources seem to be financial and technological. Less focus has been given to business orientation. Between human resources, the most relevant resource in the beginning is a strong academic background of founders, that was gradually completed with managerial and entrepreneurial experiences
- In the third and 4th phases, we see a strong reliance on paid external consultants. We also see that in the last two stages there is a significant increase in quality

Table 16.4 Assessment of spinoff resources in each stage of development of case Alpha

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustain.
Techn. Res.	Degree of innovativeness	H	H	H	H
	Stage of development of the technology	L	L	M	H
	Ability to patent/protect the technology	H	H	H	H
	Scope of technology	L	L	L	L
Human Resources	Type of parent organization (PO)	Technion			
	Founders position in PO (R = researcher, A = academic staff, N = none)	R/A	R/A	R/A/N	R/A/N
	Formal Team size (L = 1 founder, M = 2–3 founders, H > 3 founders)	H	H	H	H
	Team size active in management (L = 1, M = 2–3, H > 3)	H	M	M	L
	Ph.D. experience/scientific background in active founding team (on tot.)	H	H	H	H
	Sector experience of one of the founders	L	L	M	H
	Management experience	M	M	M	H
	Previous entrepreneurial experience of team	H	M	M	H
	Variety of backgrounds and work experience in the team	M	L	M	H
	Joint working experience and cognitive similarity of the team	H	H	H	H
	Presence of surrogate entrepreneur	N	N	N	N
Fin. Res	Type of funding (VC = venture capital, BA = business angel, L = loan)	–	VC, BA	VC, BA	VC, BA, L
	Amount of funding (Mil.\$)		1.2	5	2.8
Social Resources	<i>Relationship with PO (level of importance):</i>				
	Supporting strategy, mechanisms and fin. incentives towards spinoff	H	L	L	L
	Tangible resource such as laboratory facilities, access to research equipment	H	L	L	L
	Intangible resources (ex. access to human capital, scientific and business knowledge)	H	M	L	L
	Previous RBSO experiences of PO	H	H	H	H
	Scientific quality and perceived image of PO	H	H	H	H
	Quality/support of technology transfer office	L	L	L	L
	<i>Contacts with industrial, financial, research organ. (n. of entities and types)</i>				
	Venture capital investors	L	H	H	H

(continued)

Table 16.4 (continued)

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustein.
	Financial institutions	L	L	L	L
	Commercial partners	L	L	M	M
	Competitors	L	L	L	L
	Customers	L	L	M	M
	Suppliers	L	L	L	L
	Other research centres	L	L	H	H
	Others: consulting entrepreneurs	H	H	M	L
	RBSO strategies to access missing resources: paid consultants (<i>numbers</i>)	L	L	H	H
Extm.	National or regional incentives, or facilities	L	L	L	L
Performance	Sales growth rate	–	L	L	H
	employment growth rate (n. employees)		–5	H(13)	L(5)
	n. patents		L	M	H
	quality certification		L	H	H
	R&D investments		H	H	H
	Tot. liabilities and equity		None	n.a.	9 M\$
	Prizes and awards		L	M	M

certifications; patents etc. between the technological resources- the company focused in creating actual products and package the technology in a products that can be distributed. At last three phases there was small reliance on PO- but rather a strong relationship with financing bodies such as venture capitalists.

- In the last phase (sustainability), contacts with commercial partners distributors becomes more significant.

16.5 Results from the Analysis of Case “Beta” Business Applications Software

16.5.1 General Background and Review of Development Stages

Beta Business Applications started-up as a group of academic researchers, focused on various aspects of BPM (Business Process Management) and GRC (Governance, Risk and Compliance). While conventional BPM research studied higher-level, “rough-cut” business process models, the Beta team theorized that modelling the lower, more detailed levels of business processes is possible—down to the basic

Table 16.5 Main events and stages of development in the history of Beta Business Applications

Phase	Description
Opportunity recognition (2004)	Initial ideas were discussed by the founding team of the company at the University of Haifa. The founders came to the conclusion that there is a possibility to develop an innovative BPM application to assist the business operations of organizations.
Entrepreneurial commitment (2005)	The group of founders decided to launch a commercial company and started establishing the R&D and business organizations.
Credibility (2005–2006)	The company launched initial version of solutions suite, and completed sales to initial key customers.
Sustainability (2006–2013)	Further development of the solution suite and extension of the offering. Recognition by global IT analysts. Enlarging the market and establishing a business relationship with partners and distributors.

particles, or “Genome” of the business. The research also analysed the combinatorial relationships between business process artefacts, dealt with new and efficient methods of searching and querying business process repositories, and described algorithms for automatic generation of business process models. In 2004, some fellows of the research group decided to invest their attention and skills towards the development of an on-demand, innovative BPM systems. This endeavour yielded Beta’s BPM Suite, by now the most seasoned and comprehensive SaaS (Software as a Service) solution in the BPM domain. The Beta BPM Suite goes way beyond conventional offerings, by enabling direct connectivity to ERP systems (such as SAP and Oracle); automatically generating tailor-made process models based on organizational characteristics; and managing the entire lifecycle of business processes, covering the phases of: design, change management, process improvement, quality assurance, and related enterprise software implementation. Following an experience gained at hundreds of BPM projects, Beta decided to complement its BPM offering with GRC capabilities, aiming to assure that enterprise processes comply with external and internal regulations, while taking into account related risk factors. GRC specific functionality includes the management of risks and controls, periodical audits, collection of related events, financial impact of risk events, deficiency remediation plans, cumulative diagnostics, a flexible reports engine, tasks scheduling and tracking, requirement handling, change management process and sign-off on processes, controls and policies.

The main events and stages of development in the history of on Beta Business Applications are presented in Table 16.5

16.5.2 Detailed Analysis of Resources Used in the Process of Creation and Development

Analysing the resource assessment given by the managers of the second spin-off, the following considerations emerge. The degree of innovation had a fixed high

level at all phases, while the stage of development of the technology was increased from low to high after the second phase. Initially the work on the technology was carried out in a relatively low scale, and as the company developed and had more R&D resources, the technology was significantly more developed. The ability to protect the technology was always constant as “low”, because the intellectual protection is very difficult with any software. The main protection is the complexity of know-how, and the market positioning. Finally, the scope of the technology was high at the beginning, but as the market became clearer, the scope sharpened into actual applications serving well defined market segments.

Considering the human resources, the founders had an experience in industrial engineering and information systems; they worked as researchers in the parent organization but on research topics different from those of the spin-off. So the founders could not boast of a specific knowledge of the spin-off's sector, but they had an entrepreneurial experience. The level of knowledge in general management, technical, financial, commercial management and consulting was high from the first phase, while the sector experience was low in the early stages and growing in others.

From the opportunity recognition phase, the team had a variety of backgrounds: technical, commercial and managerial experience. Industrial engineering deals with several aspects of business management and this characteristic can be very helpful to start-ups and the team of founders did not need to employ any surrogate entrepreneur. The majority of the team members knew each other in all phases and did not have different point of views on how to manage the spinoff.

The founders also funded the spinoff with own capital in all phases, with the addition of operative revenues in the last phases. This created a situation in which the company has no debts and is owned by founders- all at the expense of taking a significant (personal) risk at the initial stages. In this case, it is more accurate to refer to the “funding” as “operating revenues”, as the company funded its operations from internal resources.

In relation to the social resources, the company had no relationship with the PO, except occasional consulting with ex-peers that took place at the initial stages. At later phases, researchers (from PO- and other research institutions) were part of an advisory board. There was no financial or infrastructure support from the PO whatsoever at all phases but the scientific quality of the PO and its previous experiences in the creation of spinoffs was important at the time of the creation of the company. The contacts with customers existed in all four phases, very few contacts instead with financial institutions and suppliers and with commercial partners and competitors, except in the last phases. It was decided not to use VC funding, despite a few possibilities to do so, as it was possible to develop growth without creating equity obligations. In the first two phases, the company used personal network of advisors in order to have access to missing resources and competences. In the third and fourth phases, the company worked to establish a structured advisory board. The decision of the company not to use any external incentives was motivated not by fear of dependency on mechanisms, but rather to let the free market decide on its actual future.

Finally considering the performance, the company became profitable at the third phase. The revenues grew at a range of 20–35 % per year, and so did employment. The employment growth rate was also based on alternative methods such as free-lancing.

Table 16.6 illustrates the level of each resource in the RBSO's phases.

16.5.3 *Answers to Research Questions*

In response to the first research question, i.e. how the resources change at different stages of development of the spinoff, the following considerations emerge:

- Technological resources. The degree of innovativeness of the technology remained high in all stages of the development of the spinoff. In the meanwhile, the degree of development also rises with the offer of finished products and related services. The level of protection of the technology and the scope of the technological platform remains constant (low) over time with.
- Human resources. The scientific experience of the team that founded the spinoff is high at all stages of the spinoff's life, characterizing it as a high-tech company, while the managerial experience and background of the team is also high -due to the fact that the company's product is related to industrial engineering and management- hence relatively high business and management capabilities of the founders; this is an anomaly that can explain positive results that were achieved. The relevant competencies enabled the spinoff to properly develop its business processes—aiming to create competitive advantage.
- Financial resources. There was no financial (or infrastructure) support of the parent organization. The spinoff is instead funded from by founder's investment and net income.
- Network resources. In general, the company established a relationship with customers, as well as with business partners in the form of Solution Integrators and distributors. The focus was on sales and creating real win-win value generation.

The answer to the second question stems from the analysis of Table 16.6:

- In the first three phases, the most important resources seem to be technological-then (4th stage) the focus became (even) more business oriented. Between human resources, the most relevant resource is wide scope of founder's skills; also other resources are relatively high.
- In the third phase (credibility), between the technological resources- the company focused in creating actual business results in the form of sales to end users—as opposed to results that are not tangible. At all phases- there was no reliance (or even no connection) on PO or with financing bodies such as venture capitalists.

Table 16.6 Assessment of spinoff resources in each stage of development of case Beta

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustain
Techn. Res.	Degree of innovativeness	H	H	H	H
	Stage of development of the technology	L	L	H	H
	Ability to patent/protect the technology	L	L	L	L
	Scope of technology	H	M	L	L
Human Resources	Type of parent organization (PO)	Haifa University			
	Founders position in PO (R = researcher, A = academic staff, N = none)	R	R	R	R
	Formal Team size (L = 1 founder, M = 2–3 founders, H > 3 founders)	H	H	H	H
	Team size active in management (L = 1, M = 2–3, H > 3)	H	H	M	M
	Ph.D. experience/scientific background in active founding team (on tot.)	H	H	H	H
	Sector experience of one of the founders	L	L	M	H
	Management experience	H	H	H	H
	Previous entrepreneurial experience of team	L	L	M	H
	Variety of backgrounds and work experience in the team	H	H	H	H
	Joint working experience and cognitive similarity of the team	M	H	H	H
	Presence of surrogate entrepreneur (Y = yes, N = no)	N	N	N	N
Fin. Res	Type of funding (OC = own capital, OR = operative revenues)	–	OC	OC + OR	OC + OR
	Amount of funding (Mil.\$)	–	<\$1 M	<\$1 M	Several \$M
Social Resources	<i>Relationship with PO (level of importance):</i>				
	Supporting strategy, mechanisms and fin. incentives towards spinoff	L	L	L	L
	Tangible resource such as laboratory facilities, access to research equipment	L	L	L	L
	Intangible resources (ex. access to human capital, scientific and business knowledge)	M	L	L	L
	Previous RBSO experiences of PO	H	H	H	H
	Scientific quality and perceived image of PO	H	H	H	M
	Quality/support of technology transfer office	L	L	L	L

(continued)

Table 16.6 (continued)

Resources		Phases			
		Opp. Rec.	Ent. Com.	Credib.	Sustain
	<i>Contacts with industrial, financial, research organ. (n. of entities and types)</i>				
	Venture capital investors	L	H	M	L
	Financial institutions	L	L	L	L
	Commercial partners	M	H	H	H
	Competitors	M	H	H	H
	Customers	L	M	H	H
	Suppliers	L	L	L	L
	Other research centres	L	L	L	L
	Others: consulting entrepreneurs	L	M	M	L
	RBSO strategies to access missing resources: personal network of advisors/ Advisory Board	L	M	H	H
Extm.	National or regional incentives or facilities	L	L	L	L
Performance	Sales growth rate (yearly)	–	L	L	H
	Employment growth rate (n. employees)		L (5)	H (13)	L (17)
	N. patents		L	L	L
	Quality certification		L	L	L
	R&D investments		H	H	M
	Tot. liabilities and equity		NA	NA	NA
	Prizes and awards		L	M	H

- In the last phase (sustainability), contacts with commercial partners (solution integrators) is the main enabler for creating increased growth. So over all the conclusion is external focus, no reliance on non-market incentives and finally having the proper set of skills from the beginning—throughout all the stages

16.6 Discussion and Conclusion

The main objectives of this paper were analyzing the evolution of resources of ICT RBSO following a dynamic, integrated approach, in order to understand the importance and modifications of the different types of assets.

To this extent an empirical framework has been developed considering technological, human, financial and social resources (comprising also the linkage with the parent organization) and four stages of development in the history of the spinoff. This framework then has been tested and verified through application on two Israeli RBSOs from the ICT industry.

As attended, both cases possessed a good level of technological resources and in particular high degree of innovativeness, along all stages of their life, but in the case Alpha, the development of the technology required more time and investment, that is typical of the segment of biotech-medical devices served by this company. The huge amount of funds required in this case were provided by Venture Capital and business angels, while in the case Beta the financial resources were supplied by the founders and by the operative revenues already in the 3rd phase.

Both cases have arrived to the phase of sustainability with satisfactory performance, high as to economic-financial aspects only for the case Beta, probably because case Alpha needs more time to obtain the results of its investments. Referring to human resources can be observed that the two cases have benefited at foundation from both scientific experience, while they were lacking sector experience. The managerial experience is not always present among the researchers of universities or public institutes. The management training of scientists could definitely expand the possibilities of success in the commercialization of their discoveries (Petroni et al. 2011). ICT business experience were acquired during time on the field, until reaching a high level in almost all dimensions of human resources in the stage of sustainability, and it was balanced by the linkage with consulting entrepreneurs previously.

Social resources were low in the first two phases in case Alpha, but it was supported by the parent organization mainly in the first stage, and further it gradually develops contacts with customers, commercial partners, research centers and consulting entrepreneurship. Case Beta, instead, had a lower support from parent organization, but earlier developed linkages with customers, commercial partners, competitors and consulting entrepreneurship.

Moreover, analyzing comparatively the two cases some relations among the types of resources required can be hypothesized. What seems to emerge is that the degree of innovativeness and the stage of development among technological resources, in particular in the first two stages (that means until spinoff foundation), influence the time to market of the innovation and the R&D effort needed to reach the market. These two variables, depending also on the specific segment of activity, are connected to the type and amount of financial resources and also to the type of social resources. In case Alpha, for example, the innovation reaches the market 4 years after the spinoff foundation, and the huge investment is still required at foundation led to the choice of financing mainly with venture capital and to develop strong relationships with research institutes. In the case Beta the commercialization started immediately after the foundation and therefore the founders were able to finance the company with own capital and operative revenues; at the same time, they built from the second stage relationships with business partners, as mentioned before.

These considerations suggest to insert in the framework of the analysis the variable "time to market" among the technological resources, and to verify the emergent relations among the types of resources with further analysis.

The proposed integrated framework is, to our knowledge, one of the few frameworks proposed in the literature that includes the resource based perspective

and the institutional linkage in a dynamic view, with the aim to deeply analyze the whole process of spinoff generation, following an integrated approach. Previous studies, instead, consider mainly a single perspective, and very few papers present a longitudinal approach.

The testing of the framework reveals its potentiality of a comprehensive analysis of spinoff resources along their different dimensions and time. For these reasons, it can be used in following studies to deepen the knowledge of spinoff creation, with the final intent to provide useful indications and guidelines to future entrepreneurs, universities and research institutes, facilitating entities, as well as local or national agencies, potentially involved in spinoff generation.

The model has been tested so far on two cases belonging to ICT industry, and therefore further testing and verification are planned to be carried out in other industries and Countries. Moreover, a more extended empirical testing should allow a deeper understanding of the phenomenon and reliable indications about the relation between level of different types of resources and performance.

These limitations will be carefully considered and will hopefully generate inform future research. We believe, however, that this paper represents a valuable basis for future research and managerial discussions in the field.

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Chapter 17

Virtual Products and Physical Resources: Software Companies and Spatial Agglomeration

Alexander Werbik

Abstract According to established agglomeration theories, companies located in clusters face a permanent stress field: They profit from better access to resources such as skilled labor, capital, and business partners, but also face increased competition for these resources. Established cluster concepts emanate from the assumption that companies within such a stress field generate competitive characteristics. The paper examines whether this mechanism is also transferable to the producers of virtual products. Empirical evidence from a large-scale study of the German software industry is used to analyze whether software companies headquartered in one of the 25 biggest German software clusters are more competitive than those outside these areas of industrial agglomeration. Evidence is provided that software firms in clusters are neither more competitive, nor do they have a better access to relevant resources. It is argued that the software industry is increasingly integrated into a global competitive environment and is less dependent on physical proximity regarding local resource allocation. Since several traditional factor-based arguments of various established cluster theories are not entirely transferable to producers of virtual products, the stress field of local resource access and competition is partially suspended.

Keywords Software Industry • Internationalization • Competition • Resources • Cluster

17.1 Introduction

Over the past few years, the term “cluster” has been established to describe “a *geographic concentration of interconnected companies [...] in a particular field that compete but also cooperate*” (Porter 2000: 16). Based on concepts by Von

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Thünen (1826) and Marshall (1920), especially Porter's (1991) contributions at the end of the twentieth century helped to leverage this field of research (Thomi and Sternberg 2008). In this context, the social sciences citation index (SSCI) reflects a strong growth in cluster articles from various scientific disciplines during the past two decades (ibid 2008). The vast majority of the respective theoretical and empirical contributions emphasizes the impact of geographic concentrations on the development of companies' competitive characteristics (Porter 2000). The central theoretical assumption is the alleged improved access to resources, such as capital, skilled labor, infrastructure and cooperation partners from which cluster-based companies profit (Dahl 2002; Porter 2008; Ferrary and Granovetter 2009; Wennberg and Lindqvist 2010; Lechner and Leyronas 2012). Simultaneously, the same firms face more rigorous local competition for these resources due to a higher concentration of competing firms (Grundgreif 2011). This stress field is supposed to stimulate the development of internationally successful enterprises (Porter 2008).

This paper subsequently raises the question whether this mechanism of improved resource access and fiercer local competition is also transferable to software companies, which are located in areas of industrial agglomeration. Although the San Francisco Bay Area is often mentioned and analyzed as representative of a successful software cluster, research theory has not yet analyzed industrial agglomerations in terms of software companies' special characteristics. This is particularly relevant with regard to two aspects:

1. The theoretical foundations of the cluster theory are rooted in the analysis of the nineteenth and twentieth century manufacturing industries.
2. Software companies producing virtual goods and services, as well as organizations with an increasing level of virtualization, display several distinct industrial characteristics and therefore have different requirements regarding their geographic location.

Before this background, the authors' objective is to examine whether the theoretic advantages of clusters also apply to software companies in spatial agglomerations. Owing to the increasing digitalization and globalization, producers of software products are theoretically enabled to realize economic advantages regardless of their location (Picot 1995) and to perform highly specialized tasks within virtual networks (Malone et al. 2011). Via online access, they can exchange information intensively and obtain the resources they need, such as capital, employees, goods and services, on a global and partially virtual level (Malone and Laubacher 2003; Buxmann et al. 2008; Malone et al. 2011). In this respect, it is assumed that the relative significance of software companies' locations has decreased.

17.2 Software Industry

Previous studies and recommendations are predominantly based on cluster analyses, which discount the special characteristics of individual industries. However, software companies specifically distinguish themselves by several industrial singularities:

Global Sourcing: An increase in digitalization involves stronger location independence, regarding companies' sourcing performances. Software firms producing and offering digital products and services are pioneers of the virtualization of business processes and the digitalization of the value chain (Picot et al. 2008). Important resources such as capital, software tools, services, and business contacts can be procured virtually and globally. At the same time, the resources themselves, as well as their utilization, are also subject to an increasing virtualization (ibid 2001). Former physical productivities can be relocated in the virtual space and carried out by workers who are located in different global locations. This argument also applies to research and development activities, which are a central competitive criterion in the software industry (Boja 2011).

Hyper-Specialization: Owing to the economy's increasing "hyper-specialization", value-creating activities are increasingly transferred to virtual space (Malone and Laubacher 2003). In this context, various activities are carried out by a high number of specialized employees who are located around the globe (Malone et al. 2011). This specialized workforce requires virtual teamwork and facilitates a "virtual labor mobility" (ibid 2011). Producers of software products have the freedom to cooperate location independent in virtual teams (Gallenkamp 2011), to make online contacts with relevant cooperation partners and investors, and to outsource software development activities on a global scale (Buxmann et al. 2008). While virtual cooperation can be realized globally, the argument of specialization advantages within industrial agglomerations carries less weight with regard to software clusters.

Costs: The fast and easy reproduction of "perfect duplicates" enables software firms to reproduce virtual products at low variable costs (ibid 2008). The decrease in variable costs is determined by an exponential increase in digital units' handling, transmission, and storage performance, as well as by a decline in the respective costs over the past decades (Picot et al. 2002). Owing to the lower transportation costs of virtual products and services (Leamer and Storper 2001), the relevance of traffic infrastructure and geographic proximity should be shifted towards an electronic infrastructure (Picot et al. 2008). Disposal and distribution via the Internet is cost efficient and almost entirely location independent (Picot et al. 2008).

Internationalization: The classic argument in favor of clusters, concerning the regional stress field of competition and cooperation (Grundgreif 2011) in a local context, is nullified in the software market. Software companies are forced to grow fast and internationalize early due to strong network effects (Buxmann et al. 2008).

Global competition and international customers force software firms to compete, source, and cooperate on an international level (ibid 2008). This casts doubt on the traditional perception that clusters offer better access to local resources, knowledge spillovers, and to positive external effects due to their spatial proximity. Simultaneously, it challenges the argument that local competitive pressure stimulates innovation (Porter 1991).

Therefore, the basic assumption of established cluster concepts that spatial proximity of companies, suppliers, customers, and business partners has a positive effect on local companies should be further empirically evaluated.

Against this background, the paper analyzes the resource access and competition of German software companies inside and outside of software clusters. Owing to global competition and value creation (Picot 2012), international labor division (Buxmann et al. 2008) and the increasing hyper-specialization of the value chain (Malone et al. 2011), spatial agglomerations should have little effect on software companies' competitive performance. Therefore, software firms in cluster should neither be more competitive nor have better access to resources such as skilled labor, capital, and business networks.

17.3 Research Design

Data was collected between September 9th and October 18th, 2011 from an online-based survey of high-level managers of German software-based companies.

The questionnaire consisted of three sections. The first part comprised open questions about the company, including the annual, national, and international turnovers over the past 3 years, the number of employees over the past 3 years, and the postal code of the companies' headquarters, as well as their founding year. The second part covered semantic differentials and Likert-scale type questions about the business model, product- and marketing strategies, the national and international growth strategy, growth barriers, capital and human resources, regional factors and institutional issues. The third part covered general assumptions and open questions.

The selected companies were extracted from the "Hoppenstedt Firmeninformationen GmbH" (www.hoppenstedt.de). The database provides B2B business information on 850,000 companies headquartered in Germany, Austria, and Switzerland. Out of this population of companies, only ICT businesses and producers of embedded systems located in Germany were extracted. The database comprised a total number of 114,848 software companies and 29,266 producers of embedded systems. All the CEOs of these companies were sent an invitation letter via email.

The response rate was 11 %, with a retention rate of 21 %. In order to guarantee the quality of the data set, all the samples with more than 25 % missing values and a questionnaire that had been less than 80 % completed, were excluded from the adjusted data set. Of the remaining 869 samples, those companies that did not

provide their postal codes as well as producers of embedded systems were also removed, since only producers of intangible software products were relevant for the analysis. This resulted in a final data set of 440 software companies.

The analysis follows a two-step procedure. In order to qualify as a sufficient condition, a region has to have an above average concentration of a particular industry undertaking the same industrial activity (Alecke and Untied 2006). Such an above average spatial concentration is identified in the “Software Atlas Germany” (www.softare-cluster.org). In step two, software companies’ cluster-constituting elements (ibid 2006) are examined to allow an empirically determined statement about software clusters’ relevance for local software firms.

The selection of software clusters was based on the “Software Atlas Germany” published by Fraunhofer ISI (Leimbach and Wydra 2011). The Index identifies the geographic concentration of the German software and IT industry.¹ Furthermore, the postal codes of these industrial agglomerations were determined, in order to assign software companies to one of these clusters. The remaining 440 software firms were divided into two groups depending on their headquarters’ postal code. The companies of the first group were headquartered in one of the 25 biggest German software clusters. The companies of the second group had their principal office outside of these areas of industrial agglomeration. Software companies headquartered in a cluster were coded “1,” otherwise “0.”

This paper thus examines whether German software firms headquartered in software clusters are more competitive and have better access to resources such as skilled labor, capital, and business networks.

17.4 Data Analysis

Overall, 122 software companies were headquartered in one of the examined clusters, while 318 companies had their principal office outside. Table 17.1 shows the distribution of software companies inside and outside German software clusters. To prevent the firm size causing a t-test bias, the companies were further divided into four groups according to their number of employees.

In order to shed more light on the discussion about the relevance of the major cluster-constituting elements, two-sided t-tests were conducted on the basis of a 5 % level of significance. The level of competitiveness was measured by the revenue per employee during the last fiscal year, the company’s level of internationalization and the level of innovativeness. The level of internationalization was determined by asking the respondents to indicate the percentage of their company’s

¹ The Fraunhofer Institute for Systems and Innovation Research (ISI) has analyzed the German software industry in a geographic context since 2010. The number of employees in the software and IT services in the administrative district is measured and mapped in relation to the nationwide average.

Table 17.1 Companies with their principle office inside and outside of software clusters

	Company size	Cluster companies		Non-cluster companies	
		N	%	N	%
1	Very small	18	14.8	70	22.0
2	Small	67	54.9	162	50.9
3	Medium	25	20.5	57	17.9
4	Large	11	9.0	28	8.8
5	n/a	1	0.8	1	0.3
	Total	122	100.0	318	100.0

revenues that originated outside their domestic market during the last fiscal year. This corresponds with Li and Yue's (2008) operationalization of international diversification. The company's innovativeness was quantified by asking the respondents whether their software firm develops new technologies, focuses on technically mature products, and distributes finished goods rather than Add-Ons. The local resource access was measured by the availability of capital, skilled employees and cooperation partners.

17.4.1 Competitiveness

The results presented in Table 17.2 show that software companies in clusters do not exhibit more competitive characteristics. Software firms within clusters ($M = 3.34$; $SD = 1.00$) neither focus more often on developing new technologies ($p = 0.311$; $t = 1.013$) than their counterparts ($M = 3.23$; $SD = 0.93$) nor do they focus more often on the development of technological advanced products ($p = 0.688$; $t = -0.401$), Add-Ons ($p = 0.275$; $t = 1.090$) or international products ($p = 0.680$; $t = 0.413$). In all four cases, no significant differences could be detected. Apparently software firms in clusters do not compete more often via new product innovations than their competitors outside of spatial agglomerations. The survey shows similar findings concerning the revenue per employee, as well as the degree of internationalization. Both variables were nearly equivalent between both groups (see Table 17.2).

17.4.2 Resource Access

The companies' resource access was determined via the access to qualified employees, capital, and business contacts. When it comes to the general availability of capital ($p = 0.785$; $t = 0.273$), no significant differences could be detected between the two groups. In this respect, cluster companies ($M = 3.11$; $SD = 1.51$) did not differ from their counterparts ($M = 3.06$; $SD = 1.55$). These findings

Table 17.2 Means, standard deviations and level of significance for study variables

		Cluster	N	Mean	SD	p	t
1	Revenue per employee ^a	1	101	0.12	0.08	0.728	−0.348
		0	258	0.12	0.08		
2	Level of internationalization ^b	1	103	14.79	21.12	0.658	−0.026
		0	274	13.68	21.81		
3	Focus on new technologies	1	118	3.34	1.00	0.311	1.013
		0	299	3.23	0.93		
4	Focus on technological advances products	1	119	3.97	1.02	0.688	0.401
		0	305	3.93	0.89		
5	Focus on add-ons	1	117	3.41	1.08	0.275	1.090
		0	303	3.27	1.21		
6	Focus on international products	1	119	3.13	1.06	0.680	0.413
		0	308	3.07	1.09		

1 = Cluster-company; 0 = Non-cluster-company

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

^aAverage in million euros

^bAverage in percentage

contradict the assumption that firms in clusters have easier access to financial resources and are better capitalized. Furthermore, no differences could be detected concerning the availability of human capital ($p = 0.139$; $t = 1.482$). In contrast to previous assumptions, non-cluster-companies ($M = 3.36$; $SD = 1.12$) had no more difficulties filling their vacancies with adequate staff than companies in the comparison group ($M = 3.54$; $SD = 1.18$). The results do not match the argument that firms in clusters profit directly from a pool of qualified labor (see Table 17.3).

Another aspect of the analysis was the access to networks and cooperation partners. Table 17.3 shows that there is a significant difference between the two groups regarding the physical contact frequency with potential business partners ($p = 0.000***$; $t = 6.804$) and customers ($p = 0.000***$; $t = 6.096$). Cluster-companies have more physical contacts with potential customers (Cluster-Group: $M = 3.51$, $SD = 1.27$; Non-Cluster-Group $M = 2.75$; $SD = 1.23$) as well as with potential business partners (Cluster-Group: $M = 3.60$; $SD = 1.22$; Non-Cluster-Group $M = 2.78$; $SD = 2.10$). This finding is not surprising, since there are a more interfaces for establishing contacts with other stakeholders in spatial agglomerations. However, despite a greater physical contact density, the level of cooperation is not higher. The last two rows of Table 17.3 show that software companies inside clusters do neither cooperate more often with external partners for domestic growth ($p = 0.702$; $t = -0.383$) nor for international growth ($p = 0.330$; $t = 0.976$) than firms outside spatial agglomerations do. These findings are interesting, because the higher inter-connectedness of stakeholder in clusters is considered a major argument in favor of spatial agglomerations.

Table 17.3 Means, standard deviations and level of significance for study variables

		Cluster	N	Mean	SD	p	t
1	Capital availability	1	113	3.11	1.51	0.785	0.273
		0	301	3.06	1.55		
2	Human capital availability	1	114	3.54	1.18	0.139	1.482
		0	278	3.36	1.12		
3	Physical contacts with business partners	1	122	3.60	1.22	0.000***	6.804
		0	317	2.78	2.10		
4	Physical contacts with customers	1	122	3.51	1.27	0.000***	6.096
		0	316	2.75	1.23		
5	Domestic cooperation	1	119	2.97	1.24	0.702	-0.383
		0	313	3.02	1.30		
6	Foreign cooperation	1	58	2.79	1.52	0.330	0.976
		0	154	2.56	1.52		

1 = Cluster-company; 0 = Non-cluster-company

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

17.5 Implications

The findings of the study show that in respect of spatial agglomerations, the software industry has ambiguous possibilities at best. The results indicate that software clusters do not lead to companies being more competitive as no divergence could be detected between the two groups. Regarding the revenue per employee, the degree of internationalization and the level of innovativeness, software firms in industrial agglomerations are no better positioned than their counterparts outside the 25 biggest German software clusters.

The data set does not provide any evidence that spatial agglomeration of the knowledge-intensive software industry (Boja 2011) leads to an increase in research and software development. Owing to the relatively low level of innovation, spatial agglomerations of the software industry cannot be attributed to the creation of new and outstanding technologies. In this respect, the outcomes of the study reflect the findings by Isaksen and Hauge (2002), since no explicit higher level of innovativeness could be detected. The marginal differences between the two comparison groups indicate that software companies compete regardless of the location. Concerning the recruitment of qualified employees, non-cluster-companies have no more difficulties to hire adequate staff.

Since software firms are increasingly embedded in a global competitive environment (Boes et al. 2008) and can potentially offer intangible products in virtual spaces (Picot et al. 2008), the findings support the thesis that classic theoretical cluster arguments concerning an easier access to resources become obsolete. Through an increasing usage of information and communication technologies and, therefore, a decrease in physical market services, a virtual field of competition seems to be more relevant (ibid 2001).

When it comes to the relevance of software clusters for the intensification of contacts and business networks, company managers show higher physical contact frequency with potential business partners when their company is located in an industrial agglomeration. The physical contact frequency with relevant stakeholders did however not result in more intensive patterns of cooperation. No evidence was found that cluster companies engage more often in cooperations for domestic and international growth. These findings support Ganesan et al. (2005), who show that spatial proximity does not automatically results in a more intense cooperation patterns. In this context, it should be also considered that software companies are more embedded in global communication and information networks. Therefore networks in the software industry should be seen in a global context rather than a local one.

However average cooperation patterns might also be the result of a lack of an informal infrastructure in German software clusters. An informal infrastructure, which consists of meeting points for interaction and communication, enables local entrepreneurs to access important formal and informal business contacts (Jonas 2006) and supports the development of a creative social environment (Florida 2003). It is therefore possible that such an infrastructure has not yet developed in the analyzed areas of spatial agglomeration.

17.6 Limitations and Future Prospects

The study shows that various specific features of the software industry do not apply in established cluster concepts. However, several limitations should be considered:

1. The importance of labor mobility within clusters should be taken more closely into account. The available data set, did not allow the analysis whether companies profit from knowledge spillovers generated by a local migration of skilled workers. Further research is recommended to analyze the role of specialist knowledge in the software industry in respect of workers' spatial mobility. In their contributions, Dahl and Sorenson (2012) emphasize regional limitations regarding the mobility of employees. Thus, companies are primarily created in regions where entrepreneurs are already socially rooted (ibid 2012).
2. The analysis did not focus on the social environment of software companies. The question whether the social and economic environment has a positive effect on the spatial concentration of the German software industry was not considered in this study. Future research should take the relevance of a local business environment, as well as an informal infrastructure for the creation and development of business contacts into account.
3. The importance of regional brands has not yet been finally clarified. Martin and Sunley (2003) indicate that clusters play a key function as regional lighthouses for national industries. They direct political attention to the respective industry and can mobilize social forces and investments, which enable stronger growth in

the respective regions and industries (ibid 2003). The current study does not yet provide sufficient evidence of the extent to which the popularity of a region acts as a magnetic force regarding the settlement of new firms in clusters.

4. Regarding the suggestion by Menzel and Fornahl (2010), the timeline should be considered more closely. The “Software Atlas Germany” shows that software clusters grew nationwide during the past years (Leimbach and Wydra 2011). It is possible that specific resources and contact possibilities have not as yet been developed within these areas. In this context, it should be considered that the German software industry is fairly young and that most clusters are still growing. In order to judge the usage of spatial agglomerations for the software industry, researchers should focus their future research on the changes in the access to relevant resources such as capital, skilled labor, business partner and other stakeholders over time.

17.7 Conclusion

The study aimed to analyze the importance of location for producers of nonmaterial software products. In this context, the level of competitiveness, access to human capital and financial resources, as well as cooperation characteristics of software companies were investigated. Non-parametric tests were conducted in order to explore the differences between software companies headquartered inside the 25 biggest German software clusters and their counterparts outside those spatial agglomerations.

With regard to the major constituting elements of a cluster, no differences could be detected between the two groups. The analysis showed that software firms headquartered in one of the 25 biggest software clusters in Germany are no more competitive than their counterparts outside such agglomerations. Furthermore, software companies in clusters have no better access to capital than those outside clusters and therefore do not generally profit from a local resource concentration.

The most notable point of the analysis is that software companies seem to compete globally and obtain their resources regardless of their location. The higher contact frequency with potential business partners does not result in different patterns of cooperation, despite more options for networking. These findings are relevant for future cluster research and cluster policy alike. Prospective studies should focus stronger on the importance of an informal and entrepreneurial infrastructure for software firms while traditional cluster elements should be adapted to the special needs and characteristics of the software industry.

From a producer of nonmaterial software products' point of view, the findings do not provide any evidence that being located in a cluster is beneficial. The constituting elements of traditional clusters do not seem to apply to software firms. Spatial agglomerations in this industry should rather be seen as a pool for human capital, potential customers and business partners. In combination with an entrepreneurial milieu, such a pool could be beneficial for regions seeking to become software

industry centers. Should these findings be substantiated in future research studies, a modification of the established cluster theories is recommended. The specific and location-independent characteristics of the software industry should be considered more severely in order to provide a target-oriented cluster policy.

The findings are also crucial for cluster politics, since the creation and development of high-tech clusters is a central pillar of economic policy (BMBF 2006). By understanding the special characteristics of software producers inside and outside clusters better, national and international policy makers can determine a regional economic policy that better meets the needs of the software industry.

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Chapter 18

Technology Foresight for Regional Economies: A How-to-Do Guide

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Abstract This study presents a how-to-do-guide on technology foresight for regional economies to orient future investigations on this under-investigated topic. Through quantitative and qualitative methods, the study identifies a list of 24 relevant technologies in mechatronics, which has been chose for its relevance in the regional economy that is addressed by the present study. The prioritization of these technologies is based on both the attractiveness index and dynamism index. The attractiveness index is calculated by a triangulation of data (patent and patent citations, EU's 7^o framework, venture capitalists' investments, and interviews) collected through multiple databases. The dynamism index measures the increase of patent intensity through time. A ranking of 24 technologies is identified according to these two indexes.

Keywords Foresight • Technological change • Smart specialization • Patents • Horizon 2020

18.1 Introduction

Technology Foresight (TF) which evokes a vital process of each pro-active company, region or country. It gathers a wide variety of instruments and mechanisms for a rich description of technology trajectories in different industries. This research presents an accurate methodological procedure matching quantitative and qualitative methods applied to mechatronics. The quantitative investigation is made of three types of TF methods, namely patents and patents citations, EU financing programmes, and VC investments. The qualitative study involves both technological experts from universities and public research organizations around the world, and local entrepreneurs as references for the regional interest of each technology.

The study is applied to the regional area of Bergamo, in Northern Italy, belongs. R&D expenditures in Bergamo are closed to the Lisbon targets of 3 % GDP and

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meanwhile it is depicted as a SME-based economy. The medium-high level of innovation activities (Hollanders et al. 2009) of SMEs has been strengthened in the recent period as demonstrated by the increase of patenting activities. Despite that, policy-makers and entrepreneurs notice a general difficulty of traditional sectors (above all manufacturing one) to integrate a more technologically skilled workforce and instruments in this territory. TF projects help local SMEs facing competition from emerging economies. The main purpose of this study is to provide guidelines for further studies in the under-investigated topic of TF for regional economies.

Section 18.2 reviews the literature on TF, with a focus on the regional aspects. Section 18.3 describes the methodology, in which patents and patent citations are triangulated with EU's financing programmes, venture capitalists' investments and experts' opinions. Section 18.4 presents the results and Section 18.5 concludes.

18.2 The Relevance of Technology Foresight for Regional Economies

In the last 60 years, a multitude of methods that analyses the future technology trajectory has been developed. At the beginning, the majority of studies on technology "forecasting" were in the military sector, particularly in the United States. At the core of these studies, there is the aim to support a stimulating discussion and decision-making process about technology outlooks and not a mere prediction of the future. The diffusion of TF actions has recently increased, especially as a strategic planning mechanism in a large number of countries. Nowadays, the potential of strategic foresight in science, technology and innovation is of extreme importance for establishing countries policies and regional or companies' development processes.

The OECD defines TF as "the process involved in systematically attempting to look into the longer-term future of science and technology, the economy and society with the aim of identifying the areas of strategic technologies likely to yield the greatest economic and social benefits" (OECD 1996). In this view, new entrants in the European Union are encouraged to present a TF analysis, helping both national companies and international venture capitalists to understand investment opportunities. At sub-national level, some regional areas share the characteristic elements attributed to small countries, principally the geographical proximity of actors and the limited spatial range. A distinguish benefit for conducting a TF research within these boundaries is to profit from economies of scale and scope while maintaining flexibility (Keller et al. 2014). SMEs take advantages from a shared platform on technology directions launched by customers, competitors and national and international players. TF projects in regional economies prepare small entrepreneurs for discontinuous change acquiring new outlooks for contingent new incentives. While large established firms are used to develop constantly technology road maps (Phaal et al. 2003), SMEs could benefit from a TF studies at regional level.

18.3 Methodology

Previous studies in the field of TF, principally described quantitative methodologies on the use of automated mechanisms to find information on databases (Rohrbeck 2010). Publication and patent analysis (Porter 2005; Wartburg 2005; Daim et al. 2006; Chang et al. 2009) are the most widely used methods. As Rohrbeck (2010) suggests, automated mechanisms limit a deep examination of technological evolution in its early stages. In addition, many authors highlight (Ernst 1998; Fabry et al. 2006; Chang 2012) that abundant patent information are useful for a lot of analysis (i.e. on technological capabilities, evaluation of business technologies, the pinpoint of opportunities and technological positioning), but have a feedback looking showing out-dated technologies (Khan and Dernis 2006; Lee et al. 2012). This limitation remains also using a keyword-based approach in technological road mapping. Text-mining practices allow to extract keywords that represent the main contents of documents and discovers patterns with technological implications. The keyword-based approach improves the efficiency and effectiveness of the road mapping process.

With the aim to overcome these points of weakness, previous researches adopted different methodologies, such as expert panels, scenarios developments, Delphi studies, actor workshops, brainstorming, and scenario interviews (Ronde 2003; Rowe et al. 2005; Landeta 2006; Rohrbeck 2010). Also approaches of SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) and STEEP analysis (Social-cultural, Technological, Economic, Ecological-environmental, and Political-legal) have been defined. Expert panels or Delphi studies based on questionnaire aim to investigate the opinion and suggestions about target technologies. The informations are collected through a multiple iterative process that entails high cost and complexity (Kostoff 1998).

Our methodological baseline for the quantitative analysis envisages a data collection through:

- Patent data and patent citations (through ORBIT and ESPACENET databases);
- European Union's 7^o framework (financing projects registered in CORDIS database);
- Venture Capital investments (based on Zephyr database).

As previous literature demonstrates, patents and patent citations represent a good proxy about R&D activities in a territorial economy or in a company (Jaffe and Trajtenberg 2002). When a company decides to protect an innovation, implicitly, signifies that the entrepreneur imagines future earnings from the commercial exploitation of that innovation. In this study, Germany is selected as the technological benchmark for patenting activity. Germany has the highest expenses on R&D than the main European countries and it is strong in mechatronics. Secondly, both Lombardy and Bergamo's economies have a solid relationship with the German ones. The comparative link is related to import-export transactions and the economic structure of the geographical areas. The investigation of patents in

German companies highlights a sample of 2891 businesses with 177,159 registered patents from 2007 to July 2012 (ORBIS database). The research focuses on automation, manufacturing machine, electrical and electronics machine and devices, identifying the mechatronics European code (Nace Rev. 2).¹ Patents information comes from ESPACENET, which allows longitudinal researches because it has been collecting more than 70 million of international patents. The weight of each technology is computed as square root of the sum between the patents number and the ratio of patent citations and years after the patent publication.²

The use of publicly sponsored research as a tool for technology foresight is a valuable although yet under investigated approach (Salerno et al. 2008). The analysis of EU financing programmes is based on project finance in the 7th EU framework related to mechatronics. We relied on the CORDIS database and selected projects from 1997 to 2013. The argument of each project guides the investigation of core technologies' details. Examples of project arguments are: innovation, robotics, technology transfer, electronics, micro-electronics, nanoscience, nanotechnologies, information and communication applied technologies, network technologies. Through the analysis of 72 EU-financed projects (7^o framework), we count in how many projects each single mechatronic technology is financed.

ZEPHYR database collects over 40,000 companies around the world that receive financial funds from Venture Capitalists and Private Equity. As in the patent analysis, the selection of targeted companies is based on Nace Rev. 2 (with Ateco codes detailed above) and a financing period from 2007 to July 2012. The final sample consists of 638 venture capitalists investments in start-ups in mechatronics. These were clustered within a group of technologies based on (i) the selection of keywords, and (ii) the detailed investigation of the technology developed by the business.

The result of the three sets of quantitative methods is the baseline for our work. Qualitative methods link these results with the regional area investigated. Interviews and mailing surveys with experts and local entrepreneurs allow to assess the attractiveness of each technology, which is calculated through an intensity scale with zero at the minimum point (i.e. few attractive technologies) and two as the maximum level (high level of attractiveness). Three references groups are involved: first, international experts, mainly from universities; second, local entrepreneurs, with structured interviews to the Innovation Commission of Confindustria

¹ In detail, the selection shows these Ateco codes: 28 Manufacture of machinery and equipment; 26.20 Manufacture of computers and peripheral equipment; 27.11 Manufacture of electric motors, generators and transformers; 28.23.09 Manufacture of office machine and devices; 33.20 Installation of industrial machinery and equipment.

² Years after the patent publication is a proxy of the period useful for a possible citation of that patent.

Bergamo³; finally an email survey involving a large number of entrepreneurs, who are asked to ‘rate’ each technology.

Using the results of the quantitative and qualitative study, we investigate the attractiveness and the dynamism of each technology. In the construction of the attractiveness index, interview method adds value to results in two ways. The expert opinions help to (i) redefine the extension of each technological cluster and (ii) to consider the territorial borders of the TF project. In particular, the technology attractiveness index is the outcome of the arithmetic mean of these normalized indexes:

- Patent persistence;
- EU’s funds and venture capitalist’s investments;
- Expert opinions.

The dynamism index measures the increase of patent intensity. Precisely, it is calculated by the ratio between the patent number of a technological cluster (patents published from 2010 to 2012) and the patent number of the same cluster published from 2007 to 2009. This index aims to measure the growth rate and the persistence of technologies clustered. At the end, a list of 24 technological clusters are prioritized by these two indices, according to attractiveness for mechatronics businesses in the area of Bergamo and the forward looking of each cluster.

18.4 Results

The multi-path methodological procedure conducts at the list of 24 technological clusters depicted below. Table 18.1 shows the TF project output for the regional economy of Bergamo. The sub-indicators of the attractiveness index are normalized at 1.00 and the level of attractiveness is calculated by the arithmetic mean of the three sub-indicators. Again, the index of attractiveness is normalized at 1 for “Autonomous collaborative/cognitive robots”, which is the technological cluster with the highest level of attractiveness for mechatronics industries. In this case, for example, the level of EU’s funds/Venture Capitalists’ investments and interviews are more than 1.00. The maximum level of attractiveness considers these exceptions.

Technologies with high levels of patent persistence index are considered for high intensive capital businesses. EU’s funds endorse technologies with a high level of patentability and it is possible that these technologies are applied in large companies. At the contrary, venture capitalists bet on start-up with usually has no intensive capital nature. These multiple points of view increase the adaptability of the results to local businesses in different phases of life cycle. Figure 18.1 shows

³Founded in 1910, Confindustria is the main organization representing Italian manufacturing and services companies.

Table 18.1 The list of 24 technologies

	Attractiveness	Patents EU	EU + VC	Interviews
Autonomous collaborative/cognitive robots	1.00	0.75	1.00	1.00
Intelligent monitoring systems	0.94	0.95	0.81	0.83
Micro-actuators	0.89	0.71	0.74	1.00
Electrical Discharge Machining (EDM)	0.86	0.82	0.52	1.00
Piezoelectric devices	0.85	0.71	0.77	0.83
Optical motion tracking	0.84	0.81	1.00	0.50
Monitoring civil engineering structures	0.75	0.55	1.00	0.50
Robot movements control	0.71	0.41	0.72	0.83
Vehicle control systems	0.67	0.72	0.47	0.67
Transportation Packaging Systems (TPS)	0.64	0.59	0.50	0.67
Applications of laser technologies	0.63	1.00	0.22	0.50
Optical instruments for material analysis	0.60	0.78	0.19	0.67
Microtomography (m-CT)	0.59	0.82	0.46	0.33
Modern composite materials	0.58	0.59	0.66	0.33
Materials analysis and testing	0.53	0.76	0.21	0.50
Measuring technologies	0.52	0.65	0.11	0.67
Cryogenic treatment	0.45	0.32	0.41	0.50
Solid Oxide Fuel Cell (SOFC)	0.34	0.27	0.65	0.00
Friction Stir Welding (FSW)	0.33	0.56	0.00	0.33
Silicon integrated lasers	0.28	0.39	0.38	0.00
Quantum cascade lasers	0.28	0.17	0.60	0.00
Machine optimisation systems	0.23	0.47	0.00	0.17
Remote Laser Welding (RLW)	0.21	0.32	0.27	0.00
Plasma technology	0.05	0.13	0.00	0.00

the 24 relevant technological clusters according to attractiveness and dynamism indexes.

The first five technologies have high levels of both indexes; in the middle of the picture, there are technologies with medium levels of both indexes, such as: monitoring civil engineering structures (no. 7), vehicle control systems (no. 9), modern composite materials (no. 14), materials analysis and testing (no. 15). In the left corner, there are technologies with scarce attractiveness and dynamism placed at the bottom of the list (i.e. Remote Laser Welding (RLW) no. 23, Plasma Technology no. 24). The comparison of both the indexes it is quite interesting because highlights as some technologies show high level of attractiveness and low level of dynamism and just the opposite. For example, machine optimisation systems (no. 22), cryogenic treatment (no. 17), solid oxide fuel cell (SOFC) (no. 18) have low attractiveness, but a high level of dynamism.

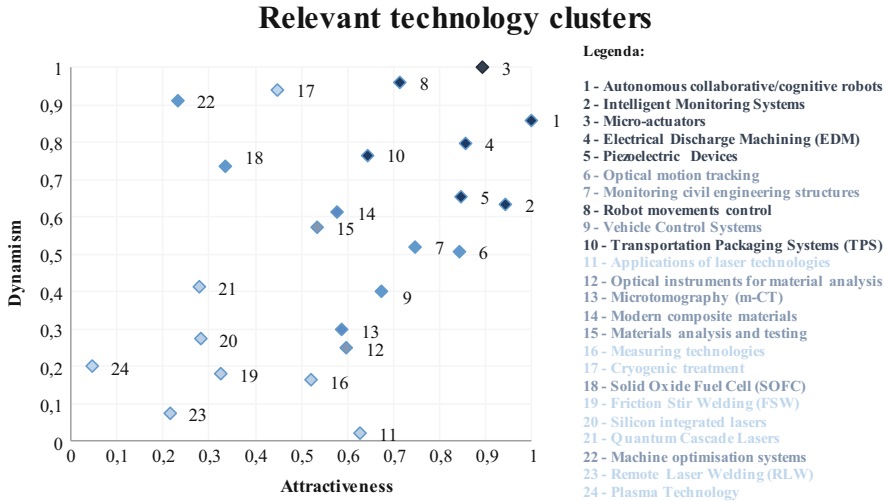


Fig. 18.1 Relevant technological clusters according to attractiveness and dynamism indexes

18.5 Conclusions

This chapter presents a how-to-do-guide on regional Technology Foresight. Through quantitative and qualitative methods, the study identifies a list of 24 relevant technologies in mechatronics. The prioritization of these technologies is based on both the attractiveness index and dynamism index. The attractiveness index is calculated by a triangulation of data (patent and patent citations, EU’s 7° framework, venture capitalists’ investments, expert opinions) collected through different databases. The dynamism index measures the increase of patent intensity.

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Part VII

Finance and Innovation

Chapter 19

The Effect of Government R&D Incentives on International R&D Trade

C. Bachmann and M. Baumann

Abstract In the past years, the awareness of the importance of business research and development for the economy has grown significantly. In order to encourage businesses to conduct R&D, governments are increasingly providing tax incentives or grants. To date, most literature has focused on proving the efficiency of these incentives, while their impact on international trade in R&D services has been largely ignored so far. Conducting an empirical analysis, this paper finds that R&D incentives have opposing, time variant effects on international R&D trade. The results indicate that government decisions on R&D incentives should also take the scale of R&D incentives of its major trade partners into consideration.

Keywords Innovation policy • R&D incentives • Business R&D • International trade

19.1 Introduction

The accumulation of innovation as a result from research and development (R&D) is essential for the future development of economies (Aghion and Howitt 1992). It helps companies to stay competitive, to create new jobs and it spurs sustainable economic growth.

Several empirical studies prove that an increase in domestic R&D capital has positive effects on the domestic output (Griliches 1987; Grossman and Helpman 1994). However, from a macroeconomic perspective, companies tend to invest less in R&D than it is socially desirable (Jones and Williams 2000). They underinvest because they cannot yield the total profit that can be generated by this knowledge (Bozeman and Link 1985). In order to compensate domestic businesses for these external effects and to promote national business R&D, governments can establish financial incentives. There is a vast amount of literature analyzing the efficiency of

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such government tools for the promotion of R&D (Hall and van Reenen 2000; Mansfield and Switzer 1985; Czarnitzki and Hussinger 2004; Lach 2002; Bloom et al. 2002).

So far, most literature on government R&D incentives focused on the measurement of the efficiency of incentives on R&D business expenditures and ignored its impact on foreign R&D caused by international trade in R&D services. The technological advances in the past two decades facilitated the transfer of knowledge and data which lead to an increasing number of R&D service providers (Chiesa et al. 2004). Companies have become more flexible in choosing locations to conduct R&D and in acquiring R&D services. To date around 25 % of research and development services are conducted by external companies (Edwin et al. 2009). Especially pharmaceutical companies such as Roche, IT companies such as IBM, Accenture or Microsoft and automotive companies such as General Motors are increasingly displacing research centers to different countries (Hemphill 2005).

Like other local companies, R&D service providers benefit from national incentives which enable them to be more competitive in international R&D trade. Hall and Van Reenen (2000, p. 467) already concluded that R&D incentives might also depend on “policies in other countries as the theory of tax competition suggests”. Competition on R&D conducting businesses among governments would imply that the number of these businesses is scarce. Companies in other countries would have to buy R&D services from these countries since they are cheaper and more competitive. However, this would only apply if the respective R&D supplier would be able to increase its capacity along with the demand for R&D services. The goal of this paper is to shed light on the impact of R&D incentives on international trade in R&D services. We intend to answer the following research questions:

Which factors determine international trade in R&D services? Do government incentives for R&D services influence international R&D trade and if so, in which way?

19.2 Theoretical Framework

When analyzing the effects of R&D government support on international trade in R&D services, it is important to understand the determinants of international trade and how these are affected by R&D support. In the following sections, international trade will be measured by the balance of trade which is able to capture the cross-country flows of goods and services. The balance of trade N^D is the difference between imports and exports. The demand for imports M^D and exports E^D is a function of the price ratio of the domestic price P_D , the foreign price P_F , the domestic income Y_D and the foreign income Y_F (Khan and Ross 1977, p. 150).

$$M^D = F\left(\frac{P_F}{P_D}, Y_D\right) \quad (19.1)$$

$$E^D = F\left(\frac{P_D}{P_F}, Y_D\right) \quad (19.2)$$

Therefore, the balance of trade is determined by the domestic and foreign price of the specific R&D service as well as the domestic and foreign income.

$$N^D = \left(\frac{P_F}{P_D}, Y_D, Y_F\right) \quad (19.3)$$

In the next step, we need to identify how government R&D support influences R&D prices and business income. Business income can be described with a CES-function where Y represents the total output of firm i , K is the physical capital, L is labor and R is the knowledge capital (Griliches and Mairesse 1991). R&D expenditures increase a company's knowledge capital R which again increases an economy's total output. Thus, the government can support total output by providing incentives for businesses to increase their R&D expenditures. A company's decision on the amount of knowledge capital $R(RD, \theta, \cdot)$ depends amongst others (displayed with a single dot) on its effective user costs which result from the R&D expenditures RD and the amount of government support θ .

$$Y_i = AK_i^\alpha L_i^\alpha R_i^\alpha \quad (19.4)$$

The goal of government support is to decrease the user costs of R&D and thereby incentivize businesses to conduct research projects. R&D government support can either support specific industries (e.g. by grants) or a broad range of businesses conducting specific types of R&D (e.g. by tax incentives). By influencing the amount of business R&D expenditures, government support also affects total output $Y_D(RD, \theta, \cdot)$.

Proposition 1 Government support for R&D services fosters domestic output Y_D which again affects international R&D trade.

$$N^D = \left(\frac{P_F}{P_D}, Y_D(\theta, RD, \cdot), Y_F\right) \quad (19.5)$$

In most cases, government R&D support addresses two types of R&D conducting businesses: (1) Businesses which conduct R&D to stay competitive and (2) commercial R&D service providers which aim to provide R&D services to other businesses (AusIndustry 2011). In the latter case, government R&D incentives decrease the costs of R&D service providers which might be passed on to the price of R&D services. Probert et al. (2013, p. 1278) find that the price of these R&D services is in most cases not fixed but depends on the time and materials used.

If these resources are in some way subsidized by the government and since the market structure of contract R&D organizations (CROs) is highly fragmented and oligopolistic (Gad and Spainhour 2011), the decreased costs could lower the price for R&D services. Against this background, increased domestic government support might decrease the domestic price for R&D services $P_D(\theta, RD, \cdot)$.

Proposition II Government support for R&D services decreases prices for domestic R&D service providers P_D which makes it more attractive for foreign investors to acquire R&D services and thereby affects international R&D trade.

$$N^D = \left(\frac{P_F}{P_D(\theta, RD, \cdot)}, Y_D(\theta, RD, \cdot), Y_F \right) \quad (19.6)$$

In the following sections we will analyze how R&D support influences the price of R&D service providers as well as total productivity and how these determinants impact international R&D trade.

19.3 Empirical Specification

International R&D trade flows can be measured by R&D net trade which is the difference in the volume of cross-country imports and exports of R&D services (Warner and Kreinin 1983). The volume of imports is determined by the total productivity (which can be measured by the GDP) and prices (*PRICE*). The higher the productivity of a country (*GDP*), the more likely are companies to import R&D services. If the domestic price is high, companies will rather choose to import R&D services from foreign vendors. Since we are interested in the marginal impact of the determinants on R&D imports (elasticity), we take the logarithm of all dependent and independent variables.

$$\log(IMP_{i,t}) = \beta_0 + \beta_1 \log(GDP_{i,t}) + \beta_2 \log(PRICE_{i,t}) + \varepsilon_{i,t} \quad (19.7)$$

Exports are imports from the perspective of the foreign R&D service supplier. Since net trade is a combination of the import and export equation, the determining factors are the sales resulting from R&D activities and the price of R&D services, each respectively from the domestic (*GDP*, *PRICE*) and foreign (*FGDP*, *IPRICE*) location.

The volume of the difference between R&D imports and exports varies. In order to make the impact of government R&D support on R&D net trade comparable among countries and eliminate other factors which might influence the overall trade volume (such as global changes in supply or demand), we measure the net trade (*NET*) as a ratio of exports (*EXP*) and imports (*IMP*) of R&D services. The measure captures relative changes of imports compared to exports and shows if there is a R&D trade deficit (greater than 1) or surplus (smaller than 1).

$$NET_{i,t} = \frac{IMP_{i,t}}{EXP_{i,t}} \quad (19.8)$$

Thus, the R&D trade balance can be described as follows:

$$\begin{aligned} \log(NET_{i,t}) = & \beta_0 + \beta_1 \log(GDP_{i,t}) + \beta_2 \log(FGDP_{i,t}) + \\ & + \beta_3 \log(IPRICE_{i,t}) + \beta_4 \log(PRICE_{i,t}) + \varepsilon_{i,t} \end{aligned} \quad (19.9)$$

Since we look at overall exports and imports, we can assume that all analyzed countries face the same world price and world GDP. Since we use a fixed effects regression and all analyzed countries face the same foreign world economy *FGDP* and import price *IPRICE*, we can omit these factors in the regression. Therefore, the trade equation for our analysis can be reduced to:

$$\log(NET_{i,t}) = \beta_0 + \beta_1 \log(GDP_{i,t}) + \beta_2 \log(PRICE_{i,t}) + \varepsilon_{i,t} \quad (19.10)$$

We expect that higher productivity (*GDP*) encourages companies to import R&D services while exports are driven by the demand of other countries. An increasing domestic price (*PRICE*) incentivizes companies to import more R&D services.

Hypothesis I International trade in R&D is positively correlated with domestic output and prices of R&D services.

In the next step we identify how government R&D support influences domestic output and domestic prices. Theory suggests that government support increases R&D expenditures (Hall and van Reenen 2000) which again spur economic growth (Wakelin 2001). Thus, there should be a positive relationship between government R&D support and business spending on R&D. There are two types of R&D incentives: The first is direct support, e.g. via subsidies, the second is indirect support via R&D tax incentives. The ratio of the volume of R&D support—foregone tax revenue due to R&D tax incentives (*TAX*) and claimed subsidies (*SUB*)—to business R&D spending (*BERD*) represents the engagement of governments in providing support for business R&D. The higher the ratio, the more business R&D expenditures are financed by government support.

$$R\&D\ support\ ratio = \frac{TAX + SUB}{BERD} \quad (19.11)$$

Thus, business R&D is determined by the R&D support ratio and the overall output. Both should have a positive influence on business R&D spending.

$$\log(BERD_{i,t}) = \beta_0 + \beta_1 \log(R\&D\ support\ ratio_{i,t}) + \beta_2 \log(GDP_{i,t}) + \varepsilon_{i,t} \quad (19.12)$$

Hypothesis II There is a positive relationship between government support and business R&D expenditures.

We argue that government support does not only influence domestic business R&D but also the costs for R&D service providers. In order to test *Proposition II*, we analyze if R&D service providers pass the obtained benefits from governmental R&D support (*R&D support ratio*) on to their customers.

$$\log(PRICE_{i,t}) = \beta_0 + \beta_1 \log(R\&D\ support\ ratio_{i,t}) + \varepsilon_{i,t} \quad (19.13)$$

Hypothesis III Cost advantages from government support decrease the domestic price of R&D service providers.

Figure 19.1 illustrates the opposing influence of government support on the determining factors of international trade. On the one hand, R&D support decreases domestic prices. As a consequence, imports decrease and exports increase (*NET* decreases). On the other hand, it increases business R&D expenditures and indirectly the productivity of a country (*NET* increases). Therefore, the theoretical analysis suggests that GDP as well as tax credits or grants influence international trade in R&D services in two mutually conflicting ways. The regression analysis will show that these effects are time variant.

In order to find out if the influence of government R&D support on R&D service providers is more dominant than the influence on R&D conducting businesses, we substitute GDP and domestic prices for government R&D support (which influences both variables).

$$\log(NET_{i,t}) = \beta_0 + \beta_1 \log(R\&D\ support\ ratio_{i,t}) + \varepsilon_{i,t} \quad (19.14)$$

Hypothesis IV Government support impacts international trade in R&D services in opposing ways.

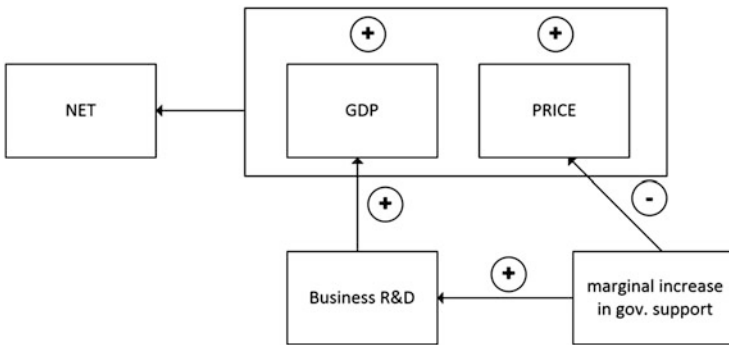


Fig. 19.1 The influence of government R&D support on the R&D trade balance

19.4 Data

In order to avoid cultural and structural differences that could have an impact on the analysis, we focus on data from three developed, English speaking countries: the United States, Canada and Australia. Different from other countries, these three countries have a long history of government R&D support. Still, historical data on forgone tax revenue on R&D due to tax incentives for these countries is only available for a limited time span from 1991 to 2008. For better comparison, all data is expressed in real terms of the national currency.

19.4.1 Data on Government R&D Support

Government support on business R&D can either be direct in form of grants or procurements or indirect through tax relief. The government expenses for the direct promotion of business R&D are taken from the OECD statistics on business R&D expenditures (BERD). The database contains specific information on direct government funding of BERD. This can either occur in form of contracts, grants or donations or in the appropriation of other resources (OECD 2002, p. 114).

Figure 19.2 shows the historical development of the ratio of direct government support to total business R&D expenditures. It becomes evident that in general the share of direct R&D support to total business R&D spending decreased during the

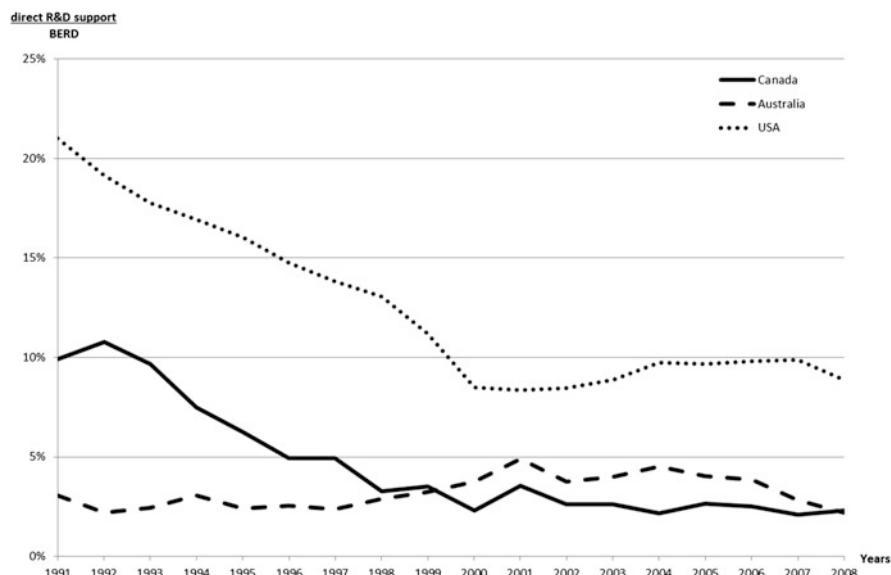


Fig. 19.2 Historical development of direct government R&D support

last decades. Compared to Canada and Australia, the United States still have the highest direct R&D support ratio. In the last decades, Australia introduced various programs aimed at supporting business R&D. In 1993, the Industry Innovation Program reorganized separate specific R&D grant programs and in 1994 direct support for small businesses was introduced. In 1996, the program “Strategic Assistance for Research and Development” was introduced which granted additional support to small and medium enterprises conducting R&D. The duration of the program was extended in December 1997. The programs caused an increase of the direct government support ratio from around 3 % up to 5 %. Canada’s direct government support system consists of lots of small and a few larger R&D support programs such as the Industrial Research Assistance Program. Still, the overall direct government support ratio of Canada decreased quite sharply from over 10 % to 3 %.

While we can observe a decrease in direct R&D support, indirect R&D support has become popular. Different from other research papers which try to estimate the user costs of R&D, we take a different approach by focussing on the forgone government tax revenue from R&D tax incentives. The B-index would be an inadequate measure since it assumes that a company benefits from full tax advantages (OECD 2013a, p. 107). Other measures [such as the user cost of R&D investment (Bloom et al. 2002)] also depend on certain assumptions (such as on depreciation rates). The advantage in using estimates of forgone tax revenue is that it provides information on the scale of how much tax revenue would have been generated without tax credits. The data was compiled from publications of the statistics departments of the respective national governments.¹ The tax credit rate for R&D in Canada and the USA totals 20 %. Australia has a R&D tax concession which allows deducting 150 % of eligible R&D expenditures. Figure 19.3 illustrates how much R&D business R&D expenditures were subsidized through tax incentives. Other than Canada and the USA, we observe a sharp reduction of indirect R&D support in Australia which is due to stricter laws for R&D tax credits. In 1996, for instance, Australia reduced the R&D tax concession rate from 150 to 125 % among with other restrictions regarding the eligibility for the R&D tax concession. From 2001, the legislation regarding R&D tax credit became more favorable, for example with the introduction of incremental tax concessions and better access of tax credits for small businesses. Interestingly, indirect support for R&D in the United States is comparably low. The sharp drop of claimed tax credits in 1995 is due to legislation difficulties. As a result, the government could not pay tax credits from July 1995 to June 1996. In Canada, the ratio for claimed tax credits for R&D increased sharply from 2000. Still, the government did not drastically change its R&D tax credit policy.

¹For Canada: Department of Finance Canada (2011) and earlier versions; United States: IRS (2014); Australia: Australian Department of Industry (2012) and earlier versions.

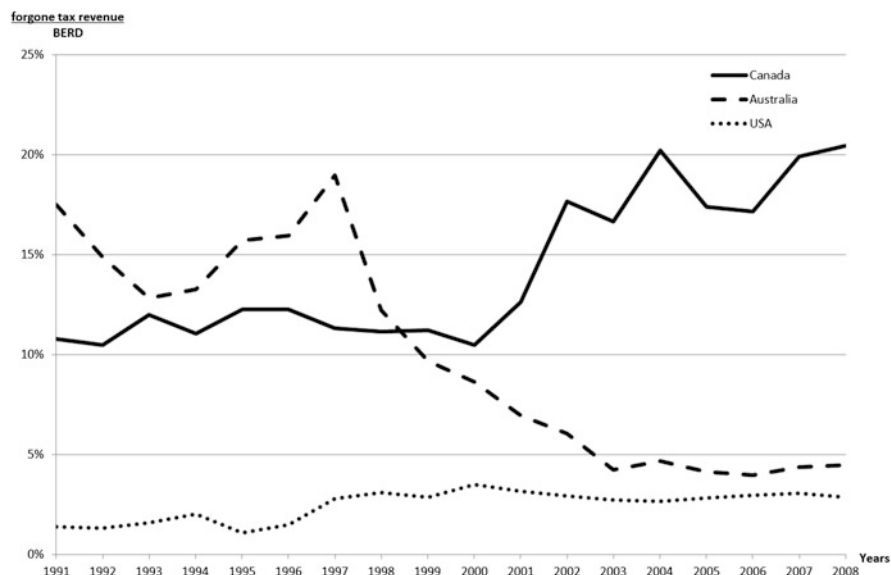


Fig. 19.3 Historical development of indirect government R&D support

19.4.2 Productivity Data

The total productivity of a country—measured by the GDP—influences the amount of R&D services which is exported or imported. Since we focus on sales which are driven by R&D activities and the manufacturing sector accounts for an average of 80 % of business conducted R&D (Bloom et al. 2002; Young 1996), it is reasonable to limit the variable for GDP to the manufacturing sector. We gathered (gross value added) GDP data from the OECD and national statistics departments.² In order to eliminate influences from cross-sectoral technological changes of R&D expenditure data, we implement aggregated data on sales that accrues from R&D activities in our analysis.

19.4.3 Research and Development Data

The gathered economic data on R&D comprises business R&D expenditures, the volume of imports and exports of R&D services as well as the price level of R&D services of each analyzed country.

² USA: U.S. Department of Commerce – Bureau of Economic Analysis (2012); Australia and Canada: OECD.StatExtracts (2013).

19.4.3.1 Business R&D Expenditures

R&D tax incentives support businesses that engage in R&D activities. A typical measure that is used to assess this engagement is the expenditure on R&D in the business sector (BERD). Our main source for these expenditures is the ANBERD database of the OECD. This database publishes annual data of business R&D expenditures. For our analysis we focused on national BERD which were actually funded by businesses.³ We complemented missing or incomplete data with the statistics from the national statistics departments.⁴

19.4.3.2 Imports and Exports of R&D Services

The data on the amount of worldwide imports and exports also stems from a combination of OECD data⁵ and data of the national statistic departments.⁶ Since imports and exports are a very broad term, we ensured that imports and exports of R&D services underlie a consistent definition. We define R&D imports and exports as transactions between a resident and non-resident party (OECD 2013b, p. 50; Statistics Canada 2011).

19.4.3.3 Price of R&D Services

International R&D trade is affected by the relative costs of R&D services. We measure these costs with the GDP deflator for R&D. The GDP deflator is a measure which is designed to capture price changes from a specific base year. This is necessary for the calculation of productivity measures such as the GDP in real terms. Since the regression in our analysis is also designed to capture changes in the price ratio we can use the GDP deflator for R&D services. The historical data has been collected from publications of the respective national government statistics.⁷

³ The OECD provides aggregated data on BERD funded by governments, foreign sources or other national sources.

⁴ For Canada: CANSIM (2013a); United States: National Science Foundation (2008); Australia: OECD iLibrary (2013).

⁵ The OECD publishes annual data on international trade in services. In some cases this data can be disaggregated to imports and exports of R&D.

⁶ Australia: OECD iLibrary (2013); United States: U.S. Department of Commerce – Bureau of Economic Analysis (2013); Canada: CANSIM (2013b).

⁷ GDP deflators are derived from the ratio of the gross domestic product in current and real terms; Sources: Canada (CANSIM 2013c); Australia: Australian Bureau of Statistics (2013); United States: OECD.StatExtracts (2013).

19.4.4 Country Specific Types of R&D

The characteristics of research and development vary across countries. From the government perspective, the importance of specific R&D depends on the respective industry in which it is conducted and its contribution to economic growth. Table 19.1 provides an overview on the most important industries in all three analyzed countries and the industries which mostly drive the economy.⁸ In Canada, for instance, the mining, oil and health industry is an important driver of the economy. Since these industries are most productive for Canada, the government supports these industries by offering various R&D subsidies. Main driver for the Australian economy is the financial and mining industry. In the United States, professional, scientific and technical services represent the strongest driver for the economy. The United States has therefore increased its budget for R&D funding by 7.3 % from 2001 to 2011 (AAAS – American Association for the Advancement of Science 2008, 2010).

Table 19.1 Most important industries and economy drivers

Country	Rank	Industries which contribute most to absolute GDP	Industries which contribute most to GDP growth
Canada	1	Finance and insurance, real estate and leasing and management of companies and enterprises	Mining and oil and gas extraction
	2	Manufacturing	Utilities
	3	Health care and social assistance	Construction
	4	Public administration	Transportation and warehousing
	5	Retail trade	Professional, scientific and technical services; accommodation and food services
United States	1	Financial and insurance services	Professional, scientific and technical services
	2	Professional and business services	Manufacturing
	3	Manufacturing	Arts, entertainment, recreation, accommodation and food services
	4	Educational services, health care, and social assistance	Educational services, health care, and social assistance
	5	Retail trade	Transportation
Australia	1	Financial and insurance services	Financial and insurance services
	2	Manufacturing	Mining
	3	Real estate	Real estate
	4	Construction	Manufacturing
	5	Mining	Construction

⁸ The data is a collection of the following sources: Canada: Industry Canada (2011); Australia: Australian Bureau of Statistics (2013); United States: Bureau of Economic Analysis (2013).

Table 19.2 Tests of the assumptions of the linear regression

Criteria	Assumption	Test	H_0
Residuals independently and identically distributed	Homoscedasticity	Breusch-Pagan-test (BPT)	Homoscedasticity
	Autocorrelation	Durbin-h-test (DHT)	No autocorrelation
	Normal distribution	Central limit theorem	
Eointegration		Augmented dickey fuller test (ADF)	Root of unity/non-stationary
Endogeneity		Implementation of lagged variables as well as time and country dummies	

19.5 Linear Regression Assumptions

Before starting the regressions, we need to ensure that the regressions lead to unbiased results with high explanatory power. The assumption of a linear regression is that residuals have to be independently and identically distributed. This implies that the residuals are homoscedastic, not autocorrelated and normally distributed. Since we analyze time series data which might involve common trends in the dataset, we need to assure that the data is cointegrated and does not lead to spurious results.

We hope to control for unobserved variables such as common technology improvements (over time) and structural effects (over countries) by using fixed-effects estimators and including country and time dummies in our regression. We attempt to avoid the problem of endogeneity by adding instrumental variables including lagged and dummy variables. In order to avoid simultaneity, we add lagged variables as instrument variables to the regression. Table 19.2 shows the tests which were used to test the regression assumptions.

19.6 Empirical Analysis

After having assured that the regression does lead to valid results, we apply the data on the formerly identified regression equations.

19.6.1 The Determinants of International Trade in R&D Services

Starting with *Hypothesis 1*, we test in which way international trade in R&D services is determined by the overall output and the domestic price. The assumption

Table 19.3 Regression assumptions for *Hypothesis I*

Tests	p-values
BPT	0.1977*
DHT	0.4534*
ADF	0.01607*

The asterisks (*) behind the p-values indicate that the regression assumption is met

Table 19.4 The influence of output and prices on the R&D trade balance

Dependent variable: trade balance in R&D services	
	IV (lagged NET)
NET-1	0.55340*** [0.12416]
GDP	4.35742*** [1.21239]
PRICE	2.14073** [0.91156]
Adj. R^2	0.52231
Observations	54
Country and time dums	YES

Robust standard errors are displayed in parentheses

*/**/***: p-value below 15 %/5 %/1 %

tests indicate that the results from the estimators are unbiased and the residuals are independent and identically distributed (Table 19.3). The Breusch-Pagan-test (*BPT*) rejects the hypothesis that the residuals are homoscedastic, the Durbin-h-test (*DHT*) does not deny that the residuals are not autocorrelated. The Augmented Dickey Fuller (*ADF*) test indicates that the residuals are stationary.

The results from the regression confirm the expectations (Table 19.4). The *GDP* as well as the *PRICE* of R&D services are both significant and have substantial impact on the R&D trade balance (*NET*). If the *GDP* (respectively *PRICE*) increases by 1 %, the import-export ratio increases by 4.36 % (respectively 2.14 %). The regression equation explains 52.23 % of the overall variance of the net trade data.

Answer to *Hypothesis I*: The total productivity has a positive influence on the volume of R&D imports compared to R&D exports. The same applies for increased domestic R&D prices.

19.6.2 The Impact of Government Support on Business R&D Expenditures

Hypothesis II states that government R&D support encourages businesses to conduct more R&D. The efficiency of these fiscal incentives has been extensively proven in the research literature (Hall and van Reenen 2000; Mansfield and Switzer

Table 19.5 Regression assumptions for *Hypothesis II*

Tests	p-values
BPT	0.661*
DHT	0.2269*
ADF	0.03711*

The asterisks (*) behind the p-values indicate that the regression assumption is met

Table 19.6 The influence of government support on business R&D

Dependent variable: business R&D expenditures	
	IV (lagged BRD)
BRD-1	0.962123*** [0.066455]
R&D support ratio	0.247641*** [0.062291]
GDP	1.692266* [0.911384]
Adj. R ²	0.51309
Observations	54
Country and time dums	YES

Robust standard errors are displayed in parentheses

*/**/***: p-value below 15 %/5 %/1 %

1985; Czarnitzki and Hussinger 2004). Hægeland and Møen (2007) find that tax incentives have the highest impact on R&D expenditures, followed by grants. The assumption tests indicate that the regression is valid (Table 19.5).

The regression confirms these results (Table 19.6). It becomes evident that direct and indirect government funding substantially increases business financed R&D expenditures (*BRD*). Furthermore, the general output that accrues from these investments positively correlates with R&D spending (169.23 %). The results show that government support also has a positive impact (24.76 %) on business R&D.

Answer to *Hypothesis II*: An increase in government R&D support spurs business R&D expenditures.

19.6.3 The Impact of Government Support on the Domestic R&D Price

The costs for R&D services depend on the type of research. If we assume that there is competition among the R&D service providers, the price is somewhat determined by the marginal costs. In this case, the costs for conducting research are influenced by the scale of R&D support (R&D support ratio). General technological improvements in fields such as information technology that might impact R&D service costs are captured with fixed effects. The assumptions for a valid regression are not rejected (Table 19.7).

Table 19.7 Regressions assumptions for *Hypothesis III*

Tests	p-values
BPT	0.6504*
DHT	0.9498*
ADF	0.01324*

The asterisks (*) behind the p-values indicate that the regression assumption is met

Table 19.8 The influence of government R&D support on R&D prices

Dependent variable: R&D price	
	IV (lagged price)
PRICE-1	0.555771*** [0.167573]
PRICE-2	0.486593** [0.188871]
R&D support ratio	−0.046809** [0.015661]
Adj. R^2	0.50988
Observations	54
Country and time dums	YES

Robust standard errors are displayed in parentheses

*/**/***: p-value below 15 %/5 %/1 %

The result from the regression which is displayed in Table 19.8 confirms that the cost reductions from the R&D support (*R&D support ratio*) also result in slightly lower prices of R&D services (*PRICE*; −4.68 %).

Answer to *Hypothesis III*: The amount of government support decreases the price of R&D.

19.6.4 The Impact of Government Support on the R&D Trade Balance

In the next step, we analyze the impact of government support on the trade balance of R&D services. The basic assumptions for the regressions are met (Table 19.9).

The regression shows that the impact of government support on the R&D trade balance is dynamic (Table 19.10). In the year of the marginal increase of government R&D support the trade balance is negative (−0.61). One year later, however, the impact of government R&D support on the R&D trade balance turns positive (0.61).⁹

The results indicate that government R&D support might have a time-variant effect on the R&D trade balance (illustrated in Fig. 19.4). In the short run, an

⁹ Adding more information of price and GDP weakens the significance of government support. Still, the dynamic impact of government support on R&D trade remains the same.

Table 19.9 Regression assumptions for *Hypothesis IV*

Tests	p-values	p-values
BPT	0.4234*	0.06867*
DHT	0.44*	0.564*
ADF	0.07014*	0.01143*

The asterisks (*) behind the p-values indicate that the regression assumption is met

Table 19.10 The influence of government R&D support on the R&D trade balance

Dependent variable: trade balance in R&D services (NET)		
	IV (lagged NET)	IV (lagged NET)
NET-1	0.941865*** [0.060244]	0.56009*** [0.12256]
R&D support ratio-1	0.614769* [0.359053]	0.51445* [0.30512]
R&D support ratio	−0.606663* [0.341847]	−0.50589* [0.31089]
GDP	—	4.11240*** [1.20280]
PRICE	—	2.17946** [1.02467]
Adj. R ²	0.49119	0.48772
Observations	54	54
Country and time dums	YES	YES

Robust standard errors are displayed in parentheses

*/**/***: p-value below 15 %/5 %/1 %

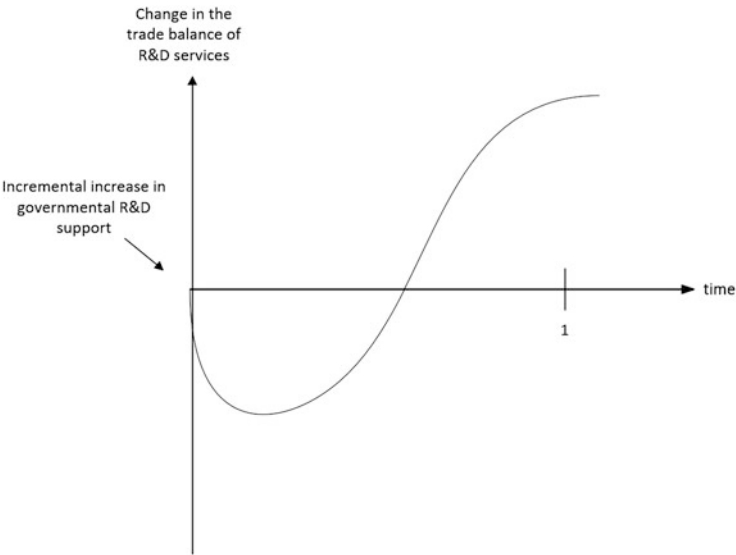


Fig. 19.4 The dynamic influence of government R&D support on the R&D trade balance

incremental increase in government R&D support increases exports compared to imports since the increased R&D support makes it more attractive for domestic and foreign investors to conduct R&D in the respective country. As a result, the R&D support ratio is negative. In the long run, however, the local economy benefits from the more domestic R&D spending which increases the overall domestic productivity. This again affects the demand for R&D which leads to an increase in the R&D trade balance. Consequently, the 1-year lagged R&D support ratio is positive.

Answer to *Hypothesis IV*: In the short run, the government support decreases the import-export ratio. In the long run, it increases the import-export ratio.

19.7 Limitations

The amount of available data which comprises variables from three countries and a time span from 1991 to 2008 limits the explanatory power of the empirical results. The analysis is based on crude macroeconomic data but provides promising results. Especially the measure for the indirect government support is based on assessments and is therefore prone to potential bias. Government support for R&D can occur in various types and targets at different industries. Since this paper focuses on the effects of government support on the economy in general, the outcome of such specifications in the target group may potentially bias the empirical analysis.

19.8 Conclusion

A country's total output and the domestic price of R&D services significantly influence international trade in R&D services. Government R&D incentives influence these determinants—they spur domestic R&D expenditures and decrease the price of domestic R&D service providers. From a short-term perspective, R&D support increases the attractiveness for foreign companies to acquire domestic R&D services which increases R&D service exports. In the long term, R&D support supports economic growth which results in a higher demand for R&D services. This again increases the R&D trade balance. Overall, the results indicate that R&D support is an effective tool for increasing a country's attractiveness for R&D intensive businesses. However, the induced growth has also positive external long-term effects on the R&D activity in other countries.

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Chapter 20

Equity Crowdfunding of an Entrepreneurial Activity

Giancarlo Giudici

Abstract Several countries around the world are introducing specific regulations allowing new ventures to collect equity capital through an open call to the Internet users (equity crowdfunding). So far, the market is still in an embryonic phase but expectations are interesting, also due to the problems faced by start-up companies in funding the early-stage growth. The main challenge is to understand if equity crowdfunding may boost the development and investments of new ventures competing (or cooperating) with professional investors (business angels, funds, banks), with adequate protection for the crowd of funders. In this chapter the features of this new industry are presented, and a research agenda for the future is introduced.

Keywords Crowdfunding • New ventures • Entrepreneurship

20.1 Introduction

Belleflamme et al. (2014) define crowdfunding as “an open call, mostly through the Internet, for the provision of financial resources either in form of donation or in exchange for the future product or some form of reward and/or voting rights”. A crowdfunding campaign aims at collecting finance from the wide audience of the web users and may be organized directly by an initiator through its own web site, or through dedicated platforms (crowdfunding platforms, here after CFPs) charging a fee for this service.

The growing popularity of crowdfunding stems from the paradigm of crowdsourcing, namely the collection of contributions (ideas, feedbacks, suggestions) from a large group of people to achieve a task within a project, benefiting from the collective ‘wisdom of the crowd’ (Suroviecki 2005). Indeed, initiators of a crowdfunding campaign usually do not seek only finance capital, but also contributions, feedbacks and ideas that may increase the project value.

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The industry report by Massolution (2013) highlights that in 2012 \$2.7 billion was raised across 1.1 million campaigns posted on 800 crowdfunding platforms world-wide, with estimates that the flow of funding has grown to \$5.1 billion in 2013. Notable examples of successful projects funded by the crowd comprise the Pebble watch and the Ouya game console (more than \$10 million and \$8.5 million raised on Kickstarter.com, respectively). Curiously, the project collecting the largest commitment from the crowd at the moment has been the Ubuntu Edge project (more than \$12 million committed on Indiegogo.com) but still under the threshold requested, so the offer was withdrawn. In Europe, the Scottish beer maker BrewDog raised £4.25 million from 8124 investors through a direct crowdfunding campaign named ‘Equity for Punks’. The design-led housing development firm HAB has raised more than £1.9 million via the online platform CrowdCube. The crowdfunding platform Seedrs has closed its self-crowdfunding round having raised more than £2 million with 850 individual investors.

Harrison (2013) categorizes crowdfunding into five distinct models according to the quid-pro-quo offered to crowdfunders. First, donation models provide contributors with nothing: this is the typical framework for charitable and no-profit activities. Second, reward models offer the contributors a non-monetary benefit, like the possibility to have dinner with the favourite sport champions, or any other gift. Third, the pre-purchase model provides the contributors with a product or service that is the output of a business project. The benefit may be also a special discount on the future market price. Fourth, the lending model provides contributors with a monetary return on a loan (peer-to-peer borrowing). Last, equity crowdfunding offers investors an equity stake in a company, as they will become shareholders.

Lending and equity crowdfunding involve the sale of a security and typically fall under the regulatory regime of financial markets. Indeed, while donation, reward and pre-purchase models of crowdfunding are generally admitted in every country, lending and equity crowdfunding are allowed in some countries, while are forbidden in others. Nevertheless, general solicitations to the public for security offerings are subject to a number of restrictions, everywhere.

This chapter of the book focuses on equity crowdfunding, that involves raising equity capital in relatively small amounts from a large number of investors via the Internet, according to the definition given by Ahlers et al. (2013). Equity crowdfunding has the potential to represent the disintermediation of the equity issue market as funders and entrepreneurs get in touch directly, with no need to hire an underwriter or to seek for a professional investor like a venture capital fund. Such a quest for alternative funding is relevant as new ventures do not easily gain access to finance for their initial investments due to the lack of collaterals and to the risky nature of an early-stage business (Kerr and Nanda 2011). Due to the recent global financial crisis, financial constraints have risen even higher (Campello et al. 2010) this enhancing the attention of entrepreneurs and policymakers on the crowdfunding phenomenon.

In the following, we analyze the recent literature about equity crowdfunding (Sect. 20.2). Then in Sect. 20.3 we depict the situation of the regulatory framework

of equity crowdfunding around the world. In Sect. 20.4 the equity crowdfunding process is analyzed, focusing on the experience of a number of case studies. Finally Sect. 20.5 concludes.

20.2 The Literature on Equity Crowdfunding

The literature on crowdfunding, and to a larger extent on equity crowdfunding, is still seminal given the recent rise of the phenomenon.

A first stream of the literature is devoted to analyzing the effects of equity crowdfunding on the finance industry. The main research question is if crowdfunding will be synergic or alternative compared to other established source of finance for new ventures. Crowdfunders may be considered as an extension of the '4 F' investors, who provide the very first financial assets to a new ventures, i.e. founders, family, friends and fools. Giudici et al. (2013a) points out the differences between crowdfunding and traditional sources of finance for a start-up company. They argue that crowdfunding platforms share the characteristics of multi-sided markets, i.e. organizations that create value primarily by enabling direct interactions between two (or more) distinct types of affiliated customers. Basing on this definition, it is possible to distinguish crowdfunding from traditional forms of financing, where some of aforementioned requirements are lacking. Specifically, bank financing results from an intermediation between capital raised on the market and supplied to loan applicants. Private equity and venture capital (and in general all forms of private placements) lack an enabling structure, which in crowdfunding is represented by the crowdfunding platform. Stock markets, which guarantees the anonymity, exclude the direct interaction between the funders and the founded company.

Another stream of the literature explores the motivations that push investors to fund a project. Gerber et al. (2011) posit that crowdfunders like to feel part of the community of people supporting a project, to exchange ideas about it and discuss it on social networks. Proponents' decision to use crowdfunding for financing a project stems from the need for capital, from the possibility to obtain feedbacks and suggestions by crowdfunders, from the fact that posting a project on the Internet and opening it to the scrutiny of a large crowd can be perceived as a signal of quality, and from the possibility of relying on social capital to raise funds.

According to Schwenbacher and Larralde (2010) and Hemer (2011), crowdfunders are motivated by both financial goals and intrinsic motivations. Investors aim at participating into innovative projects, obtaining recognition and even fun, joining a community with similar priorities, being among the pioneers of a new business, and expand their personal network.

Finally, a series of papers look at the determinants of the success of crowdfunding campaigns. Ahlers et al. (2013) study a sample of projects published by the Australian platform ASSOBS and find that ventures with more board members, higher levels of education (as measured by the percentage of board members

holding an MBA degree), and better networks are more likely to attract investment. Moreover, startups that signal their intention to seek an exit by either an IPO or a trade sale are more likely to reach the target funding. Firms that have been in business longer prior to seeking equity crowdfunding are also more likely to be successful. Giudici et al. (2013b) show that the social capital of the proponents (measured by the number of contacts on social networks) is significantly correlated with the probability of success in fundraising. The authors also found an association with territorial social capital and crowdfunding projects' success. Specifically, projects which originate in geographical areas where individuals have comparatively more external social contacts, as measured by participation in non-profit associations, encounter less difficulties to raise capital. Conversely, projects which originate in territories where individuals have stronger family linkages have more difficulties to attract financing through crowdfunding, likely because their proponents can more easily rely on their family to obtain capital and devote less effort to their crowdfunding campaigns.

20.3 Equity Crowdfunding Around the World

The Massolution (2013) industry report lists 39 equity crowdfunding platforms around the world, and reports that \$116 million have been collected on the market in 2012, with an expectation of \$166 million in 2013. The average success ratio of equity crowdfunding campaigns is equal to 42 %. The statistics highlight that equity crowdfunding is truly a nascent industry. Moreover, due to different regulations of the security offerings in each country, the situation changes dramatically from one nation to the other.

In the US the JOBS Act in 2012 legalized equity crowdfunding, whose fundamental requirements are detailed in Title III. Individuals will be allowed to invest the greater of \$100,000 or 10 % of their annual income or net worth (\$2000 or 5 % for those with net worth of annual income lower than \$100,000) into privately held ventures. The latter may raise a maximum of \$1 million through a web portal which is subject to the SEC supervision. The law became partially effective in September 2013 (Title II) allowing equity offerings to be conducted over the Internet but limited to 'accredited' investors. Titles III and IV of the JOBS act are expected to become effective in 2015.

In Europe the European Commission adopted in March 2014 a communication on crowdfunding entitled "Unleashing the potential of Crowdfunding in the European Union", detailing an agenda for promoting the industry best practices, raising awareness, monitoring the development of crowdfunding markets and national legal frameworks and assessing whether any legislative action is necessary. In the communication equity crowdfunding is defined as a 'one of the newly emerging financing models that increasingly contribute to helping start-ups move up the "financial escalator" and contribute to building a pluralistic and resilient social market economy'.

In the UK equity crowdfunding is allowed through exemptions to the regulatory system promoted by the Financial Conduct Authority (FCA) that enabled equity crowdfunding platforms to offer securities even to unsophisticated investors. Recently, the FCA has proposed a new regulation that defines the legal framework in which platforms have to operate and clarifies regulations' exceptions in order to allow the development of equity-based crowdfunding. The regulation is currently under discussion and states that these platforms can accept funds from sophisticated investors, wealthy individuals and, finally, from all the people who declare to be informed of both investment's specifications and associated risks. Investors, also, are requested to certify that less than 10 % of their savings are invested into unlisted securities. The UK Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) allow investors to claim tax relief on investments made into qualifying businesses, including those investing through equity crowdfunding (Collins and Pierrakis 2012).

In Italy equity crowdfunding has been introduced in 2012 by a specific law and became effective in 2013. Only 'innovative' start-up companies may access to equity crowdfunding through portals authorized by the authority supervising the financial market (CONSOB). The first equity crowdfunding campaign has been launched in December 2013. Interestingly enough, in Italy a tax relief is granted to crowdfunders, as they can deduct 19 % of their investment from their personal tax burden (25 % in the case of social business ventures).

Equity crowdfunding is possible under certain limits in Australia, Austria, France, Germany, the Netherlands and Switzerland (European Crowdfunding Network 2013). A number of countries at the moment are contemplating ad-hoc legislation for equity crowdfunding (the provinces of Ontario and Saskatchewan in Canada, Denmark, Israel, New Zealand). Local authorities supervising financial markets issued guidelines for equity crowdfunding in Finland.

20.4 Lessons from Equity Crowdfunding

The first step of the equity crowdfunding process involves an entrepreneur submitting her proposal to a platform. The platform staff will then scrutinize the business plan and perform a 'soft' due diligence related to the business going-concern, the reputation of the entrepreneur, the quality of the product/service. If the feedback is positive, the pitch is published on the web site in the form of a video and/or a text. The rejection rate can be as high as 75 % for platforms like CrowdCube (Collins and Pierrakis 2012). In some cases (for example the Dutch platform Symbid) the due diligence is performed once the target capital has been successfully raised but before it is released to the entrepreneur.

Investors may browse through the published projects, examine the entrepreneurs' CVs, the business plans, the term of the offering (i.e. the target funding and the fraction of the equity capital offered) and eventually interact with the initiators leaving comments and feedbacks. Limitations about the maximum number of

potential investors and their accreditation (i.e. status of professional/sophisticated investor) may be at work according to the domestic regulation. A specific time allowed for the campaign is also set in advance. Most of the equity CFPs currently operate the ‘all-or-nothing’ system of funding. This means that the campaign is successfully closed only if the target funding is reached (or nearly met). If the target funding is not met, money is returned to investors. An alternative model is the ‘flexible funding’ system (or ‘take-it-all’), allowing the entrepreneur to accept the subscriptions even if the target funding is not met. The fees charged by the CFP in exchange for the service are generally comprised between 2.5 and 10 % of the capital raised. CFPs may also charge upfront administrative or legal fees.

Table 20.1 lists the equity crowdfunding platforms operating and active as at June 2014. The analysis does not consider inactive platforms that did not publish any project, and other funding models that may be deemed as forms of crowdfunding but restrict membership of the crowd or do not allow the direct subscription of equity securities. Most notably these includes platforms that allow only accredited investors to participate in investing or anyway impose restrictions on the potential audience of domestic investors (such as Seedups in Ireland and virtually all the US platforms, at the moment) and platforms that act as match-makers between entrepreneurs and potential investors (such as AngelList in the US, Socios Inversores in Spain or Siamosoci in Italy). We found 28 operating CFPs; a dozen of them are newly established portals with no significant track record.

Interestingly, so far, more than €180 million have been raised through pure equity crowdfunding around the world. The Australian CFP ASSOB, opened in 2005, is by far the most successful portal, followed by CrowdCube in the UK, SeedMatch in Germany and WiSeed in France. Other CFPs like AngelsDen and Seedrs are oriented to smaller entrepreneurial projects.

In the following some narrative case studies about successful stories of equity crowdfunding are reported.

20.4.1 *Jive Bike*

Jive Bike was awarded with the ‘product of the year 2013’ prize by the UK platform CrowdCube. The Jive Bike is ‘an electric, folding and chainless city bicycle that eliminates all the hassles faced by cyclists and urban commuters. Jive aims to take cycling into entirely new dimension: from an alternative to commuting to become a mainstream one’ (<http://www.crowdcube.com/investment/jive-bike-jam-vehicles-ltd-13528>). The bike has an electric motor in the hub of the front wheel, which provides a top speed of 15.6 mph when being used instead of pedal power, and has a range of 20 miles before needing recharging. It charges fully in 2 h, recharges smartphones and folds down to the size of a small suitcase.

The promoter of the project is a postgraduate student, Marcin Piatkowski. He established a company named JAM Vehicles Ltd in April 2012 investing £48,000 granted by founders, families and start-up competitions. The University College of

Table 20.1 Equity crowdfunding platforms operating around the world, as at June 2014

Platform	Country	Fee	Projects published so far	Capital raised so far
Afexios	France	2.5 %	24	€1 million
Angels Den	UK	5 % + admin. fee	69	€19 million
Assiteca Crowd	Italy	Undisclosed	2	€0.5 million
ASSOB	Australia	2.5 % + admin. fee	156	€93 million
Bank to the Future	UK	Upfront fee +5 %	19	€1.5 million
Bihoop	Spain	6 %	2	€0.75 million
Broota	Chile	5 % + admin. fee	12	€0.25 million
Companisto	Germany	10 %	30	€5.4 million
CrowdCube	UK	5 % + legal expenses	116	€28 million
CrowdMission	UK	5 % + admin. fee	4	New platform
Eureeca	UAE	7.25 % success fee	12	€0.9 million
FundedByMe	Sweden	6 %	31	€4 million
Growthfundrs	UK	5.5 % success fee	4	€0.1 million
Innovestment	Germany	10 %	29	€2.5 million
Invesdor	Finland	5 %	57	€1.9 million
Nestarter	Spain	5 % success fee	7	€0.1 million
Pocket Venture	Finland	5 %	3	New platform
Seedmatch	Germany	Range 5–10 %	60	€13.1 million
Seedrs	UK	7.5 %	62	€4.5 million
ShareIn	UK	Range 1–5 %	5	€0.1 million
StarsUp	Italy	Undisclosed	4	New platform
Symbid	Netherlands	Upfront fee +3 %	53	€3.8 million
SyndicateRoom	UK	5 %	8	€3.2 million
The Crowd Angel	Spain	2.5 %	6	€1.5 million
Unica Seed	Italy	Undisclosed	1	€0.16 million
United Equity	Germany	Range 8–10 %	5	New platform
Venture Crowd	Australia	5 %	36	New platform
WiSeed	France	Range 5–10 %	52	€7.8 million

Source: Collins and Pierrakis (2012), Ahlers et al. (2013), platforms' web sites

London also supported the project with a convertible loan equal to £25,000. The company used the money to build a prototype of the urban bicycle. In September 2013 the founder decided to collect finance through crowdfunding, offering 25 % of the equity capital. Web surfers had the opportunity to subscribe shares of the company, and have a discount on the purchase of the bicycle. The round was closed on January 2014, after collecting £160,000 from 57 investors.

20.4.2 *Antabio*

Antabio is a French start-up company established in 2009 in Toulouse in the life-sciences techno park Biostep, operating in the biotechnology business. In detail, the mission is to develop new pharmaceuticals to prevent antibiotic-resistant bacterial infections.

In October 2010 the company raised €300,000 from 207 investors in less than 2 months, through the platform WiSeed. The platform organized a poll between the 13,000 community members about the investment potential of a number of companies. Antabio was the winning candidate and entered the crowdfunding program.

One year later, the company organized a second financing round, subscribed by a business angel, who also took over the entire share capital previously subscribed by crowdfunders in 2012, who earned a 44 % return. The founders declared that crowdfunding has been fundamental in sustaining the initial growth and attracting the attention of professional investors.

20.4.3 *SelfWealth*

SelfWealth is a Melbourne-based company managing an on-line collaborative and self-directed community enabling investors to compare their portfolios with peers, professionals and the market via a flat fee monthly subscription. The community incorporates a research tool which allows to build investment strategies and back-test the results, as well as to research individual companies.

The company was founded by Andrew Ward in 2011. The founder, according to press interviews, firstly submitted his business plan to a few venture capitalists, but the valuation they put on the business was a lot lower than expected by Ward, who considered the alternative of crowdfunding. In 2012 SelfWealth successfully closed a AU\$1.6 million capital raising via the Australian Small Scale Offerings Board (ASSOB) crowdfunding platform over four rounds with the initial shares on offer at 3 cents and the round four shares offered at 10 cents. Notably, under the Australian law, a maximum of 20 non-sophisticated investors in any 12-month period are allowed to subscribe shares on the Internet. The funding allowed Self-Wealth to successfully release its website and tools. ASSOB also provides a platform for secondary sale, although with no market-makers.

What do the stories ahead teach about equity crowdfunding? First of all, the emotional component plays a fundamental part in crowdfunding. As the review of the literature highlights, crowdfunders are motivated by both monetary returns and emotional incentives. Equity CFPs integrated with social networks allow them to build up a community sharing interests and objectives. Dholakia et al. (2004) posit that both individual and social motivations influence the desire to join a community. Therefore we may assume that people participating in equity crowdfunding campaigns expect both a financial return and an ‘emotional dividend’, the latter

referring to the individual and social levels. Likely, funders of the Jive Bike project acknowledge that they contribute to reduce pollution and improve mobility in urban places. Probably most of them share the passion for cycling. The opportunity to be rewarded with a discount on the product is a further option that they enjoy. In the case of Antabio, a supportiveness sentiment might have been determinant in convincing investors to bid for the shares, since they acknowledge that the objective of the company is to preserve people's health and to improve the quality of life.

Then, equity crowdfunding is not necessarily in competition with traditional professional investors like venture capitalists and business angels. Given that it represents an alternative source of finance, as the SelfWealth case demonstrates, we believe that there are more synergies and complementarities with venture capital, than threats. Equity crowdfunding may bring at least two benefits for venture capitalists: sharing the costs of due diligence with the crowd (like the Antabio case shows) and nurturing potential candidates for follow-up investments letting the crowd to bear the risk (see the SelfWealth case). Interestingly, Kahneman and Tversky (1979) demonstrate that there are situations in which the small chance of large gains can lead to risk-seeking ('lottery effect'), in particular if the maximum loss can be very small, like in the case of crowdfunding.

Finally, we also have to note that the danger of moral hazard is very high in equity crowdfunding. Crowdfunders have no mean to monitor the venture company and their bargaining power is very low. Professional investors usually impose agreements and contractual provision in order to protect their investment. Crowdfunders do not have this guarantee and the moral hazard problem is faced by CFPs either through a due diligence process (like ASSOB) or by relying on the crowd's wisdom (like WiSeed) through a poll. The Internet heavily impacted on the process of reducing information asymmetries when consumers have to buy a product or a service. Before booking for a room, people have a look at TripAdvisor. Yet decisions about equity investments in start-ups are different because the company (and often the entrepreneur) has no track record that may be documented from other investors, and because the business of the new venture can be very specific and technology-based, out of the competences of the mass of the people.

20.5 Conclusion

The rapid diffusion of equity crowdfunding platforms and the introduction of new regulation around the world suggest that tapping the crowd for raising equity capital may be a new opportunity for start-up companies. Nevertheless this chapter showed that there are different models of equity crowdfunding. Sometimes equity CFPs just present opportunities for investing, and leave the parties to come to a separate agreement. In other cases, on-line investing is admitted but there are significant limitations imposed by the regulators on the maximum number and on the typology of investors that may be involved on the Internet.

When entrepreneurs have the possibility to approach the indistinct crowd of web surfers proposing to subscribe equity shares of a start-up company, the potential benefit of a collective contribution to the new venture is unleashed. Yet, while making a new source of financing potentially available to entrepreneurial activities, equity crowdfunding might have a series of pitfalls. First, crowdfunders are unsophisticated investors, and probably are not able to provide value-added activities typically brought by professional investors (business angels and venture capitalists). Second, investing in equity capital of small entrepreneurial ventures is very risky; crowdfunders must rely on the due diligence outcome made by web platforms (or cannot rely on any due diligence activity at all) and the risk of opportunistic behavior and moral hazard is very high. Third, the management of a crowd-backed start-up company is very complex, since the presence of a multitude of shareholders challenges the usual corporate governance rules. New ventures are not endowed with competences, time and resources to manage a wide plethora of investors. Fourth, while the ‘wisdom of the crowd’ has a clear positive impact in the development of innovation (Suroviecki 2005), there is no evidence at the moment that the crowd is able to efficiently select entrepreneurial ventures and bid their stock. Rather, the literature highlights that the crowd of retail unsophisticated investors may behave in chaotic and irrational manners on financial markets leading to a ‘cascade’ effect or what is termed ‘herding’ (Spyrou 2013).

Thus, future research is needed to assess the real effectiveness of equity crowdfunding in nurturing successful entrepreneurial start-ups.

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Chapter 21

Signaling Through Innovation in IPOs

Andrea Signori

Abstract This study addresses the signaling power of corporate innovation indicators in the IPO market. Innovation measures can convey considerably different signals to public investors, depending on whether they quantify the firm's commitment in innovative inputs, as in the case of R&D investments, or achieved outputs, as in the case of patents. This study aims at disentangling such effects. Using a sample of 382 high-tech entrepreneurial firms going public in Europe during 1998–2003, this paper studies the impact of a firm's R&D intensity and number of patents on stock liquidity. Results reveal that IPO firms with larger R&D investments benefit from greater liquidity in the aftermarket, while the size of the patent portfolio does not exert any significant effect. This suggests that investors tend to participate more in IPOs by firms embedding greater innovation potential, as suggested by their level of R&D investments, while the number of patents does not drive their behavior.

Keywords R&D intensity • Patents • IPOs • Liquidity

21.1 Introduction

Among the different ways in which private firms can fund their innovative activity, the decision to go public has received considerable attention. Beyond the infusion of fresh equity capital that can be invested to fund growth prospects, IPOs offer a number of benefits, such as the opportunity to reduce information asymmetry between the firm and other market participants, thereby enhancing firm profile and visibility in the eye of potential investors. Reducing information asymmetry can be particularly beneficial for specific categories of firms, such as high-tech entrepreneurial firms, whose value is largely dependent on the intellectual capital and growth opportunities they embed (Ragozzino and Reuer 2007). While these firms are typically hard to evaluate from outsiders as long as they remain private,

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the IPO process may mitigate this concern by providing firms with the possibility to convey quality signals to the public market.

There are different channels through which private firms can signal their quality when going public, such as by affiliating with reputable venture capitalists (Megginson and Weiss 1991), corporate partners (Stuart et al. 1999), and prestigious investment banks (Carter and Manaster 1990). While signaling through third-party affiliation has been widely investigated by the existing literature, relatively less effort has been devoted to understand the role of corporate innovation as signaling device. Since innovation is a key driver of future profitability (Geroski and Machin 1993), one could argue that more innovative firms are perceived by investors as those facing superior growth potential. In particular, there are two measures of a firm's innovative activity that can be conceptualized as signals according to Spence (1973), namely R&D intensity and the number of patents. Focusing on these two indicators is intriguing because, although they both proxy for a firm's propensity to innovate, the type of signal they convey may be substantially different. While R&D intensity quantifies the firm's effort in providing inputs to its innovative activity, proxying for the firm's innovation potential, patents are a measure of innovative outputs already achieved by the firm. The interpretation of these two signals by public investors may therefore be substantially different. Vismara and Signori (2014) show that firms with larger patent portfolios are more likely to be acquired, while R&D-intensive firms face a higher risk of delisting. The contribution of this paper is to investigate how these two distinct indicators operate as signals in the IPO market.

One of the measures of the success of an IPO is aftermarket liquidity. Liquidity is a valuable resource for firms, and is an important reason for companies to go public. Among other benefits, liquidity contributes to increase firm value (Amihud and Mendelson 1986), and facilitate the adoption of managerial incentive schemes that alleviate agency conflicts (Jensen and Meckling 1976). The extent to which the newly listed firm is able to develop stock liquidity in the aftermarket is a proxy for the investors' interest and participation in the IPO. Based on these arguments, this paper sheds light on the signaling power of an IPO firm's innovation inputs and outputs by investigating their influence on aftermarket liquidity.

The focus of this study is on IPOs by high-tech entrepreneurial firms, and is motivated by the following reasons. First, assessing the effectiveness of quality signals is of particular interest for this type of firms, who often face difficulties in accessing external capital due to the substantial information asymmetry they face (Ragozzino and Reuer 2007). Second, high-tech entrepreneurial firms are the ideal setting where to study signals based on corporate innovation, such as patents and R&D investments, as the success of these firms is strongly tied to the quality of their intellectual capital (Shane and Cable 2002). Third, aftermarket liquidity is sought after by entrepreneurs, gaining the option to easily liquidate their positions without excessively detrimental effects on stock prices (Massa and Xu 2013).

Using the population of 382 high-tech SMEs gone public in the period 1998–2003 on the stock markets of the four largest European economies (namely, Germany, United Kingdom, France, and Italy), I find that a firm's R&D intensity

significantly increases its aftermarket liquidity, as measured by post-IPO turnover velocity. This evidence documents that the signal conveyed by innovative inputs is interpreted as a valuable potential by investors, who show an increased attractiveness towards the firm. On the other hand, innovative outputs, as measured by the number of patents, do not exert any significant effect on liquidity.

The remainder of the paper is structured as follows. Section 21.2 presents the literature review. In Sect. 21.3, I describe the sample, the variables and the methodologies used. Results are presented in Sect. 21.4, and Sect. 21.5 concludes.

21.2 Literature Review

Early stage entrepreneurs often struggle to guarantee adequate financial resources to the survival and growth of their ventures (Stinchcombe 1965). As written by Stuart et al. (1999), “because the quality of young companies often cannot be observed directly, evaluators must appraise the company based on observable attributes that are thought to co-vary with its underlying but unknown quality. Resource holders therefore assess value by estimating the conditional probability that a firm will succeed, given a set of observable characteristics of the organization.” Since developing new technologies is a risky process, alleviating information asymmetry towards external capital providers is particularly relevant for entrepreneurial firms trying to bring new products to the market (Shane and Cable 2002).

A wide variety of firm characteristics has been investigated as informative signals, especially in the IPO setting where the level of information asymmetry between firms and other market participants is pronounced (Leland and Pyle 1977). Affiliation with reputable third-parties, such as inter-firm alliances (Reuer and Ragozzino 2008), venture capitalists (Megginson and Weiss 1991), underwriters (Carter and Manaster 1990), or universities (Bonardo et al. 2011), is a signaling strategy that drew considerable attention among researchers. Another stream of research has focused on the entrepreneurial experience and skills developed by the founder (e.g., Gompers et al. 2010). Direct measures of a firm’s intellectual capital can also serve as signals of firm quality. In particular, a number of studies document that IPO investors consider the amount of R&D investments and the number of patents held by a firm as a valuable resource (Deeds et al. 1997; Lee and Lee 2008).

Patents are publicized in IPO prospectuses by firms going public (Stuart et al. 1999). The intellectual property endorsed by patent authorities allows firms to benefit from a competitive advantage. By recognizing how human capital, corporate culture, and R&D investments have been successfully employed to produce an innovative output protected by the legal system, patents guarantee a sort of monopoly that generates extraordinary future cash flows for the firm (Audretsch and Lehmann 2008). Property rights can also create value for entrepreneurs through the sale of rights to third parties or through stronger bargaining power vis-à-vis other patent owners (Cohen et al. 2000; Ziedonis 2004). Therefore, patents are frequently used as quality signal to convince potential investors about a firm’s

capability to translate its knowledge base and technological skills into tangible innovative activity (e.g., Adegbesan and Higgins 2011; Arora et al. 2001). Hsu and Ziedonis (2013) document that the firm's advantage from patenting can be twofold, by isolating mechanism in the product market and by signaling device in early-stage capital raising. Lemley (2001) writes that "Venture capitalists use client patents (or more likely, patent applications) as evidence that the company is well managed, is at a certain stage in development, and has defined and carved out a market niche."

R&D intensity is another commonly used indicator of a firm's propensity to innovate (e.g., Lefebvre et al. 1998). Its power as signaling device in presence of information asymmetry is however far less explored. Signaling through R&D expenditures may lead to substantial different effects from those obtained by patenting. While patents are a tangible output of achieved innovation, R&D investments certify the firm's commitment towards innovation, but with no guarantees of positive outcomes. While costs are immediately borne by the firm, positive cash flows are still uncertain. Therefore, they may end up increasing the perceived riskiness associated with the firm towards potential investors. On the other hand, R&D projects provide firms with potential future commercial opportunities (Herath and Park 1999), and raise their profile by documenting the possession of promising technologies.

The use of liquidity as a measure to assess the effectiveness of signaling mechanisms in the IPO market is relatively new to the literature. Patents have been extensively studied within a signaling perspective, but using other outcomes of the IPO process. For instance, firms with greater patenting activity are associated with lower risk of failure (Wagner and Cockburn 2010), lower underpricing (Heeley et al. 2007), and higher likelihood of being targeted (O'Donoghue et al. 1998). Similarly, firms with greater R&D expenditures are more likely to be acquired (Lehto and Lehtoranta 2004) and to receive financing from venture capitalists (Haeussler et al. 2009). Vismara (2013) shows that firms with higher R&D investments are more likely to use IPO proceeds to pursue investments and to acquire participation in other companies, while those with more patents tend to invest less and to raise more debt capital.

21.3 Research Design

21.3.1 *Sample, Data and Variables*

This paper investigates the influence of innovative activity of high-tech entrepreneurial firms going public in Europe on their aftermarket liquidity. I use the population of 382 high-tech SMEs going public in the period 1998–2003 on the stock markets of the four largest European economies (namely, Germany, United Kingdom, France, and Italy). The list of IPO firms is from the EURIPO database

Table 21.1 Sample

	Sample	Electronics	IT	Pharma & Bio	Machinery	Communications
No. firms	382	54	172	69	30	57
(%)		(14.14)	(45.03)	(18.06)	(7.85)	(14.92)
France	65	20	8	14	13	10
(%)	(17.02)	(30.77)	(12.31)	(21.54)	(20.00)	(15.38)
Germany	171	25	92	21	0	33
(%)	(44.76)	(14.62)	(53.80)	(12.28)	(0.00)	(19.30)
Italy	19	4	6	3	5	1
(%)	(4.97)	(21.05)	(31.58)	(15.79)	(26.32)	(5.26)
UK	127	5	66	31	12	13
(%)	(33.25)	(3.94)	(51.97)	(24.41)	(9.45)	(10.24)

Percentages in the first column are relative to the whole sample

that provides the IPO prospectus as well as very detailed information on the companies and their management.¹ In line with other studies (e.g., Cloodt et al. 2006), I consider as high-tech sectors electronics (Electronics), information technology (IT), pharmaceutical and biotech (Pharma & Bio), industrial machinery (Machinery) and communications (Communications). The most numerous industry in the sample are Information Technology and Pharmaceutical and Biotechnological, thanks to the contribute of new stock markets. Companies operating in these intangible sectors are typically the most research-based ones, and their attitude to go public may signal their need to raise funds to be invested in research and development activities. Germany and UK are the most highly represented countries in the sample (45 % and 33 %, respectively), due to the larger size of the economy (Germany) and to the superior level of stock market development (UK) (Table 21.1).

Table 21.2 reports the definition of the variables used throughout the paper, while Table 21.3 describes the sample. Liquidity is defined as the annualized turnover velocity over the 5 years following the IPO. It is computed for each firm as the annual average ratio between the number of shares traded (turnover) and the number of shares outstanding. After an average value of 51 % for the first year of the IPO, liquidity becomes on average quite stable around 30 % during the following years, yielding an average 5-year value of 33.8 %, as shown in Table 21.3. This value is in line with that of alternative markets of the world, where turnover ranges between 15 and 50 % (Arcot et al. 2007).

¹ SMEs are defined according to the definition of the European Commission as firms with sales inferior to 50 million euros at the IPO. The industry classification is the official one adopted by the European stock exchanges, namely the ICB—Industry Classification Benchmark. The EURIPO database is managed by University of Bergamo (www.euripo.it) and contains data on more than 5,000 companies that went public in Europe since 1985. For a description of the database see Vismara et al. (2012). I focus on the four largest economies in Europe, namely Germany (Deutsche Börse), the United Kingdom (London Stock Exchange), France (Euronext) and Italy (Borsa Italiana).

Table 21.2 Variables definition

Variable	Definition
Liquidity (%)	Annualized turnover velocity (turnover/no. shares outstanding) measured over the 5 years post-IPO
<i>Panel A. Innovation</i>	
R&D intensity (%)	Ratio between R&D investments and sales
Patents (No.)	Number of patents registered at the European Patent Office
<i>Panel B. Firm characteristics</i>	
Market value (million euros)	Market capitalization at offer prices
Age (years)	Age of the firm
Leverage (%)	Ratio between debt and total assets
Profitability (%)	Return on assets
<i>Panel C. IPO characteristics</i>	
Market to book	Ratio between market capitalization plus debt over book value of total assets
Dilution ratio (%)	Number of newly issued shares over number of shares outstanding after the IPO
Participation ratio (%)	Ratio of existing shares divested at IPO-time relative to the number of pre-IPO shares (secondary shares %)
Substantial shareholders divestment (%)	Divestment at the IPO by substantial shareholders: shares sold, over pre-IPO stakes
TMT divestment (%)	Divestment at the IPO by TMT members: shares sold over pre-IPO stakes
<i>Panel D. Institutional affiliation</i>	
VC-backing (% of firms)	Dummy variable equal to 1 if venture-backed
University affiliation (% of firms)	Dummy variable equal to 1 for companies developed by faculty members based on their research, or companies created to capitalize on research carried out in universities

Concerning the set of explanatory variables, biotech companies are the most innovative both in terms of research input, as measured by R&D intensity, and research output, as measured by the number of patents. In the biotechnology industry, continuous innovation is a strategic priority in a firm's efforts to acquire and protect a competitive advantage. To succeed in science-based industries, a firm must innovate and protect its innovations from imitation by rivals (Grant 1998). Thus, in this sector, where successful product commercialization has been rare, companies have sought to protect their innovations through patents. Moreover, the speed of change of this sector is so rapid that companies can survive only if they acquire the capabilities that they do not have through alliances and technology acquisitions (Amir-Aslani and Negassi 2006).

High-tech SMEs going public in Europe are in median 7.5 years old and have an average market value at the IPO of 81 million euros. Size varies among industries, from an average of 44 million euros of market capitalization of machinery firms to

Table 21.3 Descriptive statistics

	Sample	Electronics	IT	Pharma & Bio	Machinery	Communications
Liquidity (%)	33.7	39.5	28.8	19.8	62.4	44.4
<i>Panel A. Innovation</i>						
R&D intensity (%)	11.89	15.51	10.56	17.16	10.15	7.01
Patents (No.)	14.71	32.37	5.25	35.33	12.00	2.95
<i>Panel B. Firm characteristics</i>						
Market value (million euros)	80.72	58.34	99.55	83.24	44.01	61.43
Age (years, median)	7.5	9	8	6	9	6
Leverage (%, median)	28.45	34.52	23.35	21.88	65.94	25.76
Profitability (%, median)	5.46	7.99	3.22	−1.31	15.31	7.49
<i>Panel C. IPO characteristics</i>						
Market to book	3.65	3.56	3.72	3.65	3.19	3.58
Dilution ratio (%)	29.86	27.43	30.74	31.67	28.07	28.07
Participation ratio (%)	8.98	13.24	8.33	5.84	9.97	8.67
Substantial share- holders divestment (%)	16.10	19.39	17.05	11.64	16.85	15.01
TMT divestment (%)	11.65	10.41	12.20	9.82	17.45	10.07
<i>Panel D. Institutional affiliation</i>						
VC-backing (% of firms)	54.65	57.14	53.45	63.23	36.01	55.32
University affilia- tion (% of firms)	29.58	29.63	25.01	62.32	3.34	17.54

Descriptive statistics of the sample of 382 high-tech SMEs going public in Europe during 1998–2003. Where not differently specified, mean values are reported. See Table 21.2 for variable definitions

100 million euros for IT firms.² The leverage, measured as ratio between debt and total assets, spans from an average of 22 % for biotech companies to 66 % for machinery firms. Machinery is also the sector with the highest median profitability (return on assets) and the lowest market-to-book ratio. On the contrary, biotech companies are the least profitable (most had no earnings prior to the IPO) and have highest market-to-book ratio. There are, therefore, two extremes in the industry

² According to the EU definition of SME, only companies with (pre-IPO) sales lower to 50 million euros are selected. As a consequence, the average market size in this sample is higher for industries with high relevance of intangible as-sets, such as IT and biotech, and lower for machinery and electronics. This is due to the higher price-to-sales ratio in more intangible industries. Similar considerations can be drawn for the market-to-book ratio.

composition of the sample. Machinery companies are the smallest, oldest, and most indebted and more profitable companies, while biotech and pharmaceutical companies are the youngest, (second) biggest, less indebted and less profitable firms. As for institutional affiliation, the proportion of companies with VC or university affiliation³ is particularly high in Pharma & Bio industry, suggesting that the pharmaceutical and biotech companies face great difficulties to start businesses without relationships with universities or research institutions. This indeed is the most science-based industry, where more than 60 % of innovative SMEs going public are university-affiliated.

21.3.2 Methodology

I test the effects of an IPO firm's innovative activity on its aftermarket liquidity by means of a cross-sectional OLS regression. The dependent variable is liquidity, defined as the annualized turnover velocity over the 5 years following the IPO. For firms delisted before the 5-year IPO anniversary, liquidity is computed till the delisting date. Explanatory variables about a firm's innovative activity are the IPO firm's R&D intensity and the number of patents, both measured at the IPO. These are defined as the natural logarithm of the ratio between R&D investments and sales, and the natural logarithm of the number of patents held by each firm scaled by the natural logarithm of market capitalization, respectively. An interaction term between the number of patents and the Pharma and Bio and Electro dummies ($\text{Patents} \times \text{Pharma \& Electro}$) is also included to capture the peculiar role played by patents in these industries, that are characterized by the highest patenting rate.

Control variables are selected according to previous studies on IPOs and innovation. These are grouped in three main categories, i.e. firm characteristics, IPO characteristics, and institutional affiliation. Firm characteristics include size, age, leverage, and profitability.⁴ IPO characteristics include a set of indicators that is representative of the capital raising and divestment decisions, such as market-to-book, dilution and participation ratios, substantial shareholders divestment, and TMT divestment. The effects of institutional affiliation are controlled for by employing two dummy variables identifying IPO firms that are affiliated with universities, and those that received venture capital financing.

³ University-based firms are identified as in Bonardo et al. (2010), based on information reported in the prospectus. Companies that were developed by faculty members based on their research, or companies created to capitalise on research carried out in universities, are considered as affiliated with universities.

⁴ Firm size is measured by the natural logarithm of market capitalization at the IPO; firm age is measured by the natural logarithm of company's years since incorporation at the IPO; firm profitability is measured by return on assets at the IPO; firm leverage is measured by the natural logarithm of the ratio between debt and total assets at the IPO.

The OLS regression model is then defined as follows (plus industry, stock exchange, and year fixed effects):

$$y_i = \overline{\beta}_0(\text{Innovation}) + \overline{\beta}_1(\text{Firm\_characteristics}) + \overline{\beta}_2(\text{IPO\_characteristics}) + \overline{\beta}_4(\text{Institutional\_affiliation}) + \varepsilon_i$$

21.4 Results

Table 21.4 presents the results of the cross-sectional regression on aftermarket liquidity. The coefficient of the R&D investments variable is positive and significant at the 1 % level, while the coefficients of the patents variable and of the interaction term between patents and Pharmaceutical and Electronics industries are not significant. IPO firms with larger R&D investments are able to develop greater liquidity in the aftermarket, while this is not the case for firms with a larger number of patents. The evidence suggests that R&D intensity is an effective signaling device in the IPO context with reference to aftermarket liquidity, consistent with investors being more attracted by firms embedding greater growth potential. On the other hand, patents do not significantly influence investor expectations about the firm. This evidence may be explained by the fact that information revealed through patents tends to be noisy and costly to verify (Hsu and Ziedonis 2013). An important fraction of patents indeed is characterized by low quality (Jaffe and Lerner 2004) or ends up bringing negligible economic benefits (Scherer and Harhoff 2000). While other signals such as prestigious third-party affiliations tend to be easily perceived by the investment community, the technical nature of patent disclosure may not be as immediately interpretable (Heeley et al. 2007). This leads to an inability of patents themselves to significantly reduce information asymmetry between the firm and uninformed investors.

Concerning control variables, firm characteristics such as age and leverage have negative effects on aftermarket liquidity, although significance levels are at 10 % and 5 %, respectively. This may reveal investors' cautiousness in getting involved in IPOs by younger and more indebted firms, for which future profitability may be affected by greater uncertainty. Among IPO characteristics, there is strong evidence of a positive effect of participation and dilution ratios on aftermarket liquidity. This suggests that complementing primary offers with secondary shares significantly helps to secure a sufficiently large free float, thereby allowing a higher level of aftermarket liquidity. Liquidity is also positively related to the level of divestment at the IPO by TMT members. Among institutional affiliation variables, evidence shows that firms affiliated with universities suffer from lower liquidity after the IPO. This result may be explained by the fact that university-based firms are typically less likely to generate profits than independent firms (Ensley and Hmieleski 2005), thereby reducing their attractiveness in the eye of potential investors.

Table 21.4 Cross-sectional OLS regression on aftermarket liquidity

Liquidity	
R&D intensity	1.65***
Patents	0.05
Patents $\times$ Pharma & Electro	0.09
Size	0.08
Age	-0.14*
Leverage	-0.45**
Profitability	-0.25
Electro	-0.18
Pharma	-0.16
IT	0.25*
UK	-0.26
Germany	0.14
Market to book	0.07*
Dilution ratio	1.35***
Participation ratio	2.28***
Substantial shareholders divestment	0.34
TMT divestment	1.35**
VC backing	-0.05
University affiliation	-0.57***
Constant	-0.85
Observations	382
R ² %	26.4

Cross-sectional OLS regression using liquidity as dependent variable, defined as the annualized turnover velocity (turnover/no. shares outstanding) measured over the 5 years post-IPO. Robust standard errors are computed using the White/Huber/sandwich estimator of variance. Coefficients and significance levels are reported (***1 % significance level; **5 % significance level; *10 % significance level)

21.5 Conclusions

Companies going public need to reduce information asymmetry towards potential investors in order to convince them about their quality. This issue is much more relevant for high-tech entrepreneurial firms, that are strongly dependent on intangible resources, such as intellectual capital, and are therefore more difficult to evaluate by outsiders. An extensively studied way in which IPO firms can mitigate information asymmetry is by signaling their quality to the market, for instance by affiliating with prestigious underwriters or venture capitalists. This paper complements this stream of literature by investigating whether a firm's innovative activity acts as market signal. The focus on corporate innovation is of interest because its signaling power can be substantially different depending on which indicator is evaluated. R&D intensity, for instance, proxies for a firm's innovative potential, which is however still unrealized; on the other hand, patents quantify achieved

innovation outputs, although they are sometimes economically worthless or hardly interpretable by the community. Using a sample of 382 high-tech SMEs going public in Europe during 1998–2003, I assess the signaling power of a firm's R&D intensity and number of patents by looking at their impact on stock liquidity. Empirical analyses reveal that firms going public with larger R&D investments benefit from a higher degree of aftermarket liquidity, while those with a larger portfolio of patents do not significantly differ from the average firm. Investors are therefore more attracted by firms embedding greater innovation potential, as suggested by their level of R&D intensity, rather than by firms having already codified innovation outputs, as pointed out by the number of patents. The main contribution of this paper is to the literature on IPO market signaling. While considerable attention has been devoted to third-party affiliations, this paper takes a less explored perspective by focusing on corporate innovation measures as signaling mechanisms. The evidence suggests that innovation is not always perceived as signal of firm quality per se, but depends on the way in which it is interpreted by other market participants. This contribution should however be evaluated in light of some limitations. For instance, the choice of stock liquidity as the outcome measure to assess the power of signaling devices in the IPO market may not be optimal. It is however of interest, since a minimum degree of aftermarket liquidity is required by stock exchanges authorities in order to avoid a firm's stocks being delisted. Furthermore, the analysis does not distinguish the ownership of patents. Whether patents are owned by the CEO or by the firm may affect to different extents the IPO firm's ability to develop liquidity in the aftermarket.

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