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Innovation and Knowledge: An Explorative Study of Entrepreneurial Firms in Germany

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Alma mater mea

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ABSTRACT

Entrepreneurial firms are considered to be vehicles for employment and growth and as such have become targets for public policy measures in all OECD countries. At the same time there is a lack of micro-level data about these firms, their characteristics, innovation activity, relationships with external sources of knowledge, links with universities, and the role of the entrepreneur in these, which renders public policy analysis difficult. Entrepreneurial firms, following the definition applied in this thesis, have as business foundation purpose the implementation of a radical innovation, and are characterised by an initial lack of existing repository of knowledge and capabilities, and a continuity of their innovation activity.

From an exploratory study of 86 entrepreneurial firms, located in the metropolitan areas of Munich and Berlin, and elsewhere in Germany, we found evidence of the dominant presence of the entrepreneur in organising the firm's innovation activity and in setting the search scope and the repertoire of external knowledge sources. Firms were undertaking multiple innovation projects in parallel, and firm characteristics, such as organisation in subunits, and multiple teams R&D teams spread across the firm, were found to positively influence the combination of new and incremental innovation projects. Firms selectively involved external sources of knowledge in their innovation activity, with involvement in new innovation projects being more frequent than in incremental projects.

We found evidence that relationships between firms and universities and other public research organisations differ from inter-firm and market relationships in that the former exhibit a much higher degree of creativity, novelty and reconfiguration. Young firms, in overcoming the double-constraint of organisational and environmental factors were active networkers and likely to revert to the entrepreneur's own networks to circumvent entry and establishment barriers in existing networks. For this, contacts maintained with the entrepreneur's alma mater were found to be of salient relevance.

We argued that science is organised in epistemic communities, which are built upon shared identities, and in which members share the same tacit and experiential knowledge, which is passed on through personal contacts, eliminating and punishing opportunistic behaviour. We found evidence that membership in these epistemic communities has lasting effects in that members will turn to other members as part of their search for related or new knowledge.

Key words: entrepreneurial firms, local development, universities, epistemic community, Germany, explorative study

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CHAPTER 1

INTRODUCTION

Entrepreneurial firms are considered to be vehicles for employment and growth and, as such, have become targets for public policy measures in all OECD countries. Public-private partnerships in the provision of venture capital and entrepreneurship centres in universities are commonly emerging practices (OECD, 2012). Colombo et al. (2010: 2-3) listed several arguments for why these firms should receive public support. First, access to finance is difficult for these firms because they lack a track record which would help them to overcome information asymmetries and thus suffer from adverse selection and moral hazard problems. Second, these firms may invest less in R&D because they cannot protect themselves sufficiently from unwanted knowledge spillovers and thus would face low appropriability of investments in their internal R&D capacity. Third, these firms would not be attractive for private sector financing because of the uncertainties associated with their technology and (future) products.

There is great interest from policy-makers to learn from the experiences of public support measures targeted at entrepreneurial firms in a cross-country context (OECD 2012). This is not confined to the national context but has significant weight at the sub-national level both in local economies, which already have a high concentration of government investment, industrial and university expenditures in R&D, and those which aim at increasing all of these (Laursen et al., 2011). Public pressure on universities has augmented to increase their

interaction with businesses, their role in local innovation systems, and, in particular, their activities to promote academic entrepreneurship (Etzkowitz et al., 2000).

Yet, there is a lack of micro-level data on entrepreneurial firms, their characteristics, the role of the entrepreneur, which is assumed to be crucial, but little is known about its manifestations, the innovation activity of these firms and their relationships with external sources of knowledge. This renders policy analysis difficult as the extant information gap prevents a distinction between effects related to institutional contexts and effects related to the subject of intervention, that is, the nature of the entrepreneurial firm.

Before we present the definition of entrepreneurial firms, which we applied in this thesis, the explorative nature of this research should be underlined. The research undertaken in this thesis is a response to the extant gaps in the micro-foundations (Felin and Hesterly, 2007; Foss and Klein, 2012) of entrepreneurial firms and the scarcity of empirical data that cover the entire bandwidth of phenomena and influencing factors related to the role of the entrepreneur, the innovation activity of these firms, their relationships with external sources of knowledge, and their links with universities. It is thus broad in its approach to review relevant theories and to identify areas for contributions. The reader will therefore miss narrowly defined hypotheses but receives an invitation to follow an exploratory research, which is guided by broad research questions and leads to the identification of influencing factors related to the institutional context of the firm, on the one hand, and the personal characteristics of the entrepreneur, on the other hand.

1.1 Definition of entrepreneurial firms

We use three aspects to define entrepreneurial firms. The first one is related to their initial purpose, that is, the reason for firm creation. Entrepreneurial firms are created for the purpose of implementing a radical innovation. Often, the foundation of these firms coincides with an expert-assessment – undertaken by venture capital providers and other organisations of local innovation systems, such as entrepreneurship centres of universities and expert juries of business plan competitions – of the novelty of the business conception and its appropriability potential. This expert-assessment is an important first step for these firms to build up a reputation and relationships with investors, and with larger firms in the value chain (Baum and Silverman, 2004).

The second aspect is systemic, in the sense that these firms were built upon the subjective means-ends framework of the entrepreneur. In the words of Langlois (2007: 1120), entrepreneurial firms are the result of "self-conscious design … they do not draw on existing unselfconscious repositories of knowledge and capability, whether these be existing market patterns or existing systems of rules of conduct within organizations … they are sources of systemic novelty". In particular, young entrepreneurial firms have to overcome the double-constrain of lacking internal sources and access to external resources. They simultaneously have to gain contacts, a position in existing networks, and build a firm internal structure (Stinchcombe, 1965). The third aspect is the continued existence of these firms underlining the continuity of the innovation process and its inherent demand for novelty triggers and permutations of existing resources.

Summarising, the definition of an entrepreneurial firm used in this thesis, depicts an entrepreneurial firm as a business organisation, which was founded in order to implement a radical innovation. Given the systemic novelty of the firm and the innovation process, and the inherent need of the latter for a continuous provision of triggers and permutations (Grupp, 1998), an entrepreneurial firm will be searching for external sources of knowledge. This requires an entrepreneur who is capable of fulfilling the three-fold function of a creator, organiser and market-maker (Schoonhoven and Romanelli, 2001).

1.2 Research questions

This thesis explores the characteristics, activities and relationships of entrepreneurial firms, particularly with regard to:

(1) The role of the entrepreneur in organising the innovation activity of the firm, and, as part of this, the relationships with external knowledge sources.

(2) The innovation activity of entrepreneurial firms in terms of type (product, process, marketing, organisational), the stage (new, incremental) as well as the number of contemporarily implemented innovation projects.

(3) The involvement of external knowledge sources in the innovation activity of the firm, that is, in which types and stages, who is involved, in terms of knowledge partners, such as public research organisations, universities, firms from the same sector, firms from other sectors, business support organisations, their geographical

location as well as the relevance of external knowledge sources for the innovation activity of entrepreneurial firms.

(4) The links with universities, in terms of the types, location and relevance of links.

For each of these a set of research questions was defined. These will be presented in the following.

1.2.1 The role of the entrepreneur

We adopt from the literature the assumption that the entrepreneur needs to demonstrate cognitive leadership in order to translate h/er subjective means-ends framework into a business conception and a shared cognitive focus that enhances the accumulation and utilisation of productive knowledge inside the firm (Witt, 2007). We argue, following Penrose (1959/1995), that both founders and firm managers can engage in this role of the entrepreneur.

To sustain the business conception over time, and to render it responsive to eventually necessary changes, the entrepreneur will continue to play an important role in core business activities (Witt, 2007). To measure this, we use the number of key tasks undertaken by the entrepreneur in the innovation process as an approximation of the intensity of the entrepreneur's involvement in the innovation process.[1]

[1] We constructed a summary variable of the eight tasks, for which we solicited information from the questionnaire: idea generation, idea evaluation, acquisition of financial, human and technology/knowledge resources, prototyping, production and marketing.

We expect the entrepreneur to play an important role in the innovation process of the firm and analyse what influences h/er involvement in the innovation process.

The following questions will guide the empirical research:

(1) Do firm characteristics influence the entrepreneur's involvement in the innovation process?

(2) Do personal characteristics influence the entrepreneur's involvement in the innovation process?

(3) Does the firm's innovation activity influence the entrepreneur's involvement in the innovation process?

1.2.2 Innovation activity

Combining exploitation, that is, the refinement and improvement of already existing products and processes, with the exploration and discovery of new areas of potential business activity, is considered, in general, difficult because it requires the combination of different cognitive frameworks and related changes to organisational structures (Nooteboom, 2009). Hence, firms are expected to focus their innovation activity and thus limit the number of innovation projects. However, since innovation rents tend to annulment over time, there is a continuous need for triggers and permutations in order to ensure novelty in inputs and outputs (Grupp, 1998).

Moreover, decision environments (Ocasio, 1997) are complex and constrain the entrepreneur as decision-maker to restrict h/er attention. The following research questions will guide the analysis:

(1) Do firm characteristics influence the type and stage of innovation activity?

(2) Do firm characteristics influence the number of contemporarily implemented innovation projects?

1.2.3 Relations with external knowledge partners

Relationships with external sources of knowledge may be assumed to follow a matchmaking approach because different sources of knowledge fulfil different needs, and firms are likely to choose external knowledge partners according to their needs.

As the cognitive focus of the firm changes through knowledge accumulation and learning, the firm's search scope will increase in order to satisfy the growing need for novelty, against decreasing returns on knowledge caused by lower marginal values of novelty (Nooteboom, 2009). The relevance of external knowledge partners is thus likely to vary according to the purpose of their involvement and the overall choice of external knowledge sources from which a firm can choose. Also, gatekeepers, that is, firm members who are keeping external relationships, as well as the organisational structure of a firm are key factors of influence for the search and selection activity of the firm.

We expect the involvement of external knowledge partners and the perceived relevance of their contributions to vary for different types of innovation activity. The following research questions guide the analysis:

(1) Does the entrepreneur influence the choice of external knowledge sources in terms of partner type and/or location?

(2) Does the entrepreneur influence the relevance of external knowledge sources for the innovation activity of the firm?

(3) Do firm characteristics influence the choice of external knowledge sources in terms of partner type and/or location?

(4) Do firm characteristics influence the relevance of external sources of knowledge for the innovation activity of the firm?

1.2.4 University links

Universities links can be an important source of knowledge for the innovation activity of firms. We may expect variations in the number, type and perceived relevance of university links. We distinguish between different types of university-business links (Perkmann et al., 2013) and assume that knowledge relationships between science and industry actors follow a complex interactive "chain-link" model of circular and two-way interactions around tacit knowledge as its core component (Rosenberg and Kline, 2010).

Furthermore we understand science, following (Knorr Cetina, 1999: 1), as epistemic culture, that is, an "amalgam of arrangements and mechanisms – bonded through affinity,

necessity, and historical coincidence – … that create and warrant knowledge". Hence, scientific disciplines can be understood as epistemic communities, within which knowledge exchange is facilitated by shared symbolic and theoretical frames. Members share the same tacit and experiential knowledge, which is passed on through personal contacts, eliminating and punishing any opportunistic behaviour. We argue that membership in epistemic communities is the result of studying and working at a university, and that it has lasting effects. We, thus, expect entrepreneurs with a university employment experience and/or completed doctoral studies to maintain links with their alma mater and to make these links available for the innovation activity of the firm.

The following research questions will guide the analysis:

(1) Do firm characteristics influence the number, type, location and relevance of university links?

(2) Does the entrepreneur's university history influence the type, location and relevance of university links?

(3) Do the entrepreneur's attitudes to firm internal and external networks influence the type, location and relevance of university links?

CHAPTER 2

RESEARCH DESIGN

This Chapter presents in two subsequent sections the methodology chosen for the empirical research, and the approach followed in defining the target population.

2.1 Methodology

The aim of this thesis is to respond to the lack of micro-level data on entrepreneurial firms by analysing their innovation activity and their relationships with external sources of knowledge from a two-level perspective: the firm, and the entrepreneur. A key methodological advantage of studying entrepreneurial firms is the predominant role of the entrepreneur in assembling the resources of the firm (Johannisson, 1998).

Sequential exploratory strategy, following Creswell (2003), was used to identify, collect and analyse both qualitative and quantitative data on entrepreneurial firms. This included a five-step approach, as Figure 1 depicts.

Figure 1. Sequential exploratory strategy approach adopted in the thesis

The review of extant studies made clear that an approach based only on case studies – although potentially best suited to provide the horizontal breath of information needed to

investigate above stated research questions – would not provide the vertical breath of information, which results from studying in a larger group of firms those factors which show signs of common relevance.

The decision was, therefore, to apply a mixed-method research design (Creswell, 2003), which included interviews with key informants and a survey of entrepreneurial firms. Interviews were conducted with venture capital providers, managers and staff of entrepreneurship centres at universities, and managers and jury members of business plan competitions. This led to the development of a questionnaire and the building of a database of entrepreneurial firms. The questionnaire was pilot tested with four firms, and the manager of one entrepreneurship centre. It was then administered in an online survey. Additional telephone interviews were conducted to complement the information on the investigated phenomena, and on the reasons of why respondents refused participation. We shall discuss in the following the different steps of the approach in more details and start with the choice of the location for the empirical research.

Germany was selected as location for the empirical research. This was motivated by several reasons. First, German firms have shown high levels of innovation performance in all Community Innovation Surveys (EC, 2013), start-up rates in innovation-intensive sectors (OECD, 2012) have been stable or increasing (Eurostat, 2014), and strong spatial and sectorial innovation systems are in place (Cooke and Morgan, 1994; Spielkamp and Vopel, 1998; Kaiser and Prange, 2004).

Second, universities are playing an active role in the spatial and sectorial innovation systems in the country, and growing numbers of universities have established internal support

structures to enhance the business start-up activity of students, graduates and researchers (Kulicke, 2015). Two locations have been standing out in this, during the last decade, particularly, in terms of start-up rates and the number of universities playing key roles in the innovation systems. These are the metropolitan areas of Berlin and Munich (May-Strobl, 2011; Kulicke, 2015).

Finally, also the prior knowledge of the author about the antecedents, processes and outcomes of academic entrepreneurship in Germany, from previously conducted institutional and ethnographic qualitative studies, and the resulting contacts with decision-makers and key actors in the innovation systems, were taken into consideration for the choice of the research location.

A presentation of the research context is provided in Chapter Five. It includes key recent figures of firm-level innovation in Germany and a comparison with other European countries for start-up rates in two innovation-intensive sectors in manufacturing and services (OECD, 2012). Further, the university system in Germany will be briefly presented as are the metropolitan areas of Berlin and Munich, which are the two local economies included in the empirical research.

2.2 Target population

The definition of entrepreneurial firms, applied in this thesis and introduced in Chapter One, has three aspects. The first one is that the firm was founded with the purpose to implement a radical innovation. The second aspect is systemic, in the sense that these firms were built upon the subjective means-ends framework of the entrepreneur and thus cannot

draw on already existing repositories of knowledge and capability. Search, selection and absorption of external knowledge are therefore crucial for these firms, at least in the early stages of their life cycle. The third aspect concerns the continuity of the firm and the implicit innovation pressure. Entrepreneurial firms, included it the target population had existed, at the time of survey, for a period of below one year up to a maximum of ten years.

An existing dataset that corresponds to these aspects is the regularly conducted Community Innovation Survey (CIS), which provides the basis for a large part of extant empirical studies. Since 1993, CIS surveys have been regularly conducted in all member countries of the European Union; initially recurring every four years, and since 2005 on a biannual basis, with questions covering a three- year period. The harmonised methodology is based on the Oslo Manual (OECD, 1993) and has been further developed by the European Commission and the Organisation for Economic Co-operation and Development.

With regard to the research questions of this thesis, the CIS data bears, however, three main limitations. First, the CIS survey data does not provide information regarding the organisational structure of the firm and the entrepreneur's role and personal characteristics, which this thesis, however, assumes to be of salient influence for the firm's innovation activity, and the decision to involve external sources of knowledge.

Third, the CIS data does not distinguish between different types of university links, and does not provide information, which would allow an analysis of whether and why universities play a particular role as external sources of knowledge.

Fourth – and for certain aspects of this thesis most important - firms with less than ten employees are excluded from the CIS target population. Although for the CIS survey in

Germany, the threshold was set lower and the sample contains firms with at least five employees, this would still exclude part of the target population of this thesis. The understanding gained from the interviews with venture capital providers and managers of entrepreneurship centres during the field work, is that entrepreneurial firms may start with an initial number of employees less than five and include a number of freelance collaborators during the first year. Even though these collaborators belong to the cognitive framework of the firm, it has become common practice to keep the organisational structure flexible, in particular during the first one or two years.

These four issues made the need for original data collection obvious. The main obstacle to overcome in operationalising the here used definition of entrepreneurial firms – i.e., (i) radical innovation as a business foundation purpose, (ii) initial lack of existing repository of knowledge and capabilities, and (iii) continuity – is to find information that a firm qualifies with regard to the radical innovation aspect.

There are three possible options to overcome this obstacle. The first one is to use self-reported data. This is often practiced, yet there are several issues, particularly if self-reported data is used to establish a key criterion of a definition. Most obviously respondents tend to overemphasise the novelty of their business idea. This, in combination with the third aspect of the here used definition of an entrepreneurial firm (i.e., continuity), would risk low reliability of the data, as possible overestimation is likely to be paired with the memory effect inherent to the recalling of events in the past. Even if one could argue that the entrepreneur is less affected by the memory effect, it would be difficult to ensure that only entrepreneurs complete the questionnaire.

A second option would be to rely on patents as external assessment of radical innovation. Applying patents as selection criteria for entrepreneurial firms, would, however, omit those firms, whose radical innovation is not patented or patentable (Arundel et al., 2004).

A third option is to constrain the target population to those firms whose creation coincides with an expert-assessment of the novelty of the business idea and its appropriability potential. In particular, financial intermediaries, such as venture capital firms, apply a rigorous investment readiness check, which is based on the innovativeness and growth potentials of firms (Baum and Silverman, 2004). Similar assessments, yet less rigorous, are conducted by large-scale business plan competitions and university entrepreneurship centres. They seek to attract and channel financing sources towards these firms, and thus need to build and keep up a reputation from having promising start-ups in their portfolio. Generally, these organisations keep detailed records of the selection processes and the results, which can be used to identify firms that qualify the criteria of innovativeness and age.

We have chosen this option to define the target population and will present the organisations chosen for the expert-assessment in Chapter Five, together with the research context.

CHAPTER 3

RELEVANT THEORETICAL PERSPECTIVES

In this Chapter, relevant theoretical perspectives are reviewed in order to build the conceptual framework for the empirical study undertaken as part of this thesis. This is organised in four sections. First, key aspects of the theory of the firm are reviewed and assembled in order to look into the role of the entrepreneur in organising the firm and its activities. The second section focuses on the innovation activity of firms from a process perspective. The review of the antecedents of firm knowledge and the role of external sources is started in the third section, and continued in the subsequent section, which analyses the role of universities as knowledge partners and the notion of epistemic communities. Each section ends with a summary of key issues.

3.1 Theory of the firm

Business firms, like all organisations, vary in their performance. The causes of this variation and ways to increase performance have motivated the research of scholars from different disciplines for more than a century. A common starting point was the aim to counter the view of the representative firm as "a set of supply and demand functions", (Penrose, 1985 c.f. Pitelis, 2009), and to look into the "system of selective connections" (Loasby, 2005: 17), which was assumed to be the key, yet largely ignored, characteristic of a firm.

From a transaction cost perspective, firms and markets can be understood as alternatives in organising production and trade.[2] Whereas market mechanisms entail costs for every transaction, such as, for example, "identifying trading partners, negotiating terms … and enforcing contracts" (Coase, 1937: 390), a firm bundles all of these costs under one organisational roof. Under stable conditions, this will reduce costs for search and contract execution. Under the dynamic conditions of innovation – which imply novelty and change – markets and firms assume more complementary functions, whereby markets are a source for firms to explore new knowledge, which they then transform into new products and processes (Nooteboom, 2009: 123).

Transaction costs provide a useful conceptual framework for explaining the existence of markets and firms as well as benefits from choosing one over the other in organising production and trade. What remains unexplained is what happens inside firms, that is, the interaction and allocation of human and non-human resources and the role of cognition and entrepreneurial judgement (e.g., Montresor, 2004; Foss and Klein, 2012; Sarasvathy and Dew, 2013). Also, the circumstances, antecedents and outcomes of novelty and change are only partly explained by transaction costs, because the search costs in the case of change and novelty are different from the transaction costs associated with constant relationships (Langlois, 2007).

There are two other aspects of real-world firms, which remain as well (largely) unexplained by transaction cost economics. First, capital stocks of firms are not homogenous but heterogeneous. The heterogeneity of resources is given by their attributes, which are

[2] In general, the superiority of firms over markets depends upon the nature of the adaptation problem and existing markets (Langlois, 2007). See Walker (2013) for an overview of the theory of the firm from the perspective of contemporary 'mainstream' of economics.

(largely) unknown at the time the resource is traded.[3] Second, because information is dispersed (Hayek, 1945), firms are constrained to act under uncertainty, and, on the long run, to establish networks to absorb information from different sources into their own productive knowledge (Winter, 2002). Hence, decision-making is more likely to be driven by heuristics and entrepreneurial experimentation than the result of carefully equating marginal costs and revenues of all possible options.

3.1.1 Resources and the services they render

Understanding the antecedents and outcomes of differences in the endowment and utilisation of resources have been central issues in the resource-based view of the firm (Alvarez and Busenitz, 2001). Two seminal contributions, which shall be mentioned here, are Edith Penrose's (1959), *The Theory of the Growth of the Firm*, and Richard Cyert and James March's book (1963) *A Behavioural Theory of the Firm*.[4] The main common assumption is that not the resources yield results, but the services, which they may render (Nooteboom, 2009: 8).

Penrose pointed out that "it is at the organization as a whole that we must look to discover the reasons for its growth" (1959/2009: 5). Besides the capabilities of the firm, which specialise over time, a major contingency for firm growth is managerial structure and its maintenance and adaption over time. Going beyond Penrose's focus on firm growth, Cyert

[3] The notion of heterogeneity of resources has been elaborated in details by Austrian economics (in particular, Ludwig Lachmann and Israel Kirzner); for an overview, see Foss and Klein (2012).

[4] Other classical contributions to the resource-based view include Philip Selznick (1957) and Alfred Chandler (1962). These were followed by quickly emerging large and heterogeneous stream of literature. This developed as a complement to the industrial organisation view, with Michael Porter as its main proponent. Whereas the latter saw the determinants for firm performance within its surrounding industry structure, the resource-based view focused on factors endogenous to the firm (Kraajenbrink, Spender and Groen, 2007).

and March (1963/1992) build on the concept of bounded rationality[5] in dismissing the objectively given means-ends framework on the basis that neither means nor ends can be assumed as *ex ante* given. Instead, firms are proactive organisations, which operate under conditions of uncertainty and bounded rationality.

Cyert and March argue that firms may also have (all) other goals than profit maximisation.[6] Moreover, the existence of goals *per se* does not result in firm behaviour but requires a decision-maker as well as a subsequent communication process within and outwith the firm. These have been absent in the orthodox economic theory, in which firms have "no complex organization, no problems of control, no standard operating procedures, no budget, no controller, no aspiring 'middle management'" (Cyert and March, 1963/1992: 8).

Information and knowledge are crucial for decision-making. As von Hayek (1945) points out, the knowledge needed for optimal planning does not exist in a concentrated or integrated form: "the 'man on the spot' cannot decide solely on the basis of his limited but intimate knowledge of the facts of his immediate surroundings ... to fit his decisions into the whole pattern of changes of the larger economic system" (524-525). Hence, there is a "consequent need for a process by which knowledge is constantly communicated and acquired" (530).

[5] Herbert Simon coined the concept of bounded rationality. Three types of bonds can be distinguished (Loasby (2005): logic and statistics are difficult for most human beings, logical operations are grounded on incomplete, often doubtful premises, and since cognition is a scarce resource, rationality is selective.

[6] Cyert and March have been spearheading the argumentation that profit maximisation is not the only goal. Whereas making profit is necessary for firm survival, it can also be a prerequisite for realising other or ultimate individualistic (e.g., creativity, power) or altruistic goals, such as, for example making the world a better place for everyone.

Hayek's findings have been incorporated in the resource-based view. Firms are considered to interact with their environment, screening it for resources, whereby applying an organisational filter. This results in productive opportunities. Recognising and acting upon these opportunities depend upon the internally available knowledge and the managerial structure. Eventually these opportunities will result in learning and additional resources. These "excess resources" (Penrose, 1959/1995), or "slack" (Cyert and March, 1963/1992), are important determinants of organisational structure, innovation performance and growth. They can facilitate rectification of failures, and provide opportunities for diversification and exploration, yet, if unutilised for a longer time, they may also risk becoming wasted (Nohria and Gulati, 1996).

A general model for resource utilisation and firm performance was developed by Peteraf (1993). She presents four "cornerstones", or basic criteria, which resources should meet in order to build a sustained competitive advantage for firms. These are: (i) "heterogeneity", as a basic condition for efficiency differences and rents, (ii) "ex post limits to competition", that is, forces that limit the competition for gained rents, such as property rights and quasi-rights related to time lags, information asymmetries and tacit knowledge, (iii) "imperfect mobility" of resources, which are tradable but because they are "somewhat specialized to firm-specific needs", they value more inside the firm than outside, and (iv) "ex ante limits to competition", that is, the resource is valued less by competitors (Peteraf, 1993: 180-185).

The resource-based view has introduced into the theory of the firm a window to look into firm internal processes and the factors steering them. However, two key limitations

should be noted here.[7] Firstly, the focus has been largely on the utilisation of existing resources and their appropriability rather than on the creation of new resources (Nooteboom, 2009). Secondly, resources have been mainly considered as individual entities, with less attention on their interplay (Foss, 1997).

These two issues have been taken up by scholars of Austrian and evolutionary economics (see Foss and Klein, 2012 for an overview). Building on the already inherent commonalities between these different streams of theory, a key focus has been on the notion of dynamic capabilities, which allow firms to adapt to, and to provoke change (Nelson and Winter, 1982).

We will look into this in a subsequent section of this Chapter, but shall anticipate the just mentioned interplay of resources, which is considered to be a key constituting element of the context-bounded nature of firm knowledge. This argument can be dismantled as follows. The knowledge of a firm can be partly observed in its technologies, operating rules, and its client list (Kogut and Zander, 1992). What cannot be observed, however, is what causes, enables and impedes their interplay.

How operating rules interact with the current selection of technologies in use or how the information in a client list is shared and utilised by the different units of a firm are examples of what Kogut and Zander (1992: 384) call "combinative capability", that is, the combination of internal learning (e.g., restructuring, training, use of technologies) and

[7] It should also be mentioned that the resource-based view was extensively criticized for its methodological and conceptual weaknesses (see Foss, 1997 for an early, and Kraajenbrink, Spender and Groen, 2007 for a later overview). A common critique concerns its tautological or circular reasoning (e.g., Porter, 1994; Mosakowski and McKelvey, 1995): firm success is defined by its rents, which are also used to delineate a firm's critical resources.

external learning (e.g., acquisitions, hiring, network partners). Since combinative capability can be easily replicated within the organisation but not beyond its borders, it allows a firm to gain and sustain a competitive advantage over other firms (and over the market as an alternative form of resource governance).

So far, we have introduced the firm as an organisational entity, which is seeking and employing resources in a proactive and adaptive manner. Next, we shall explore the role of the decision-maker, that is, the one who, ultimately, sets the firm-subjective means-ends framework.

3.1.2 The entrepreneur and the entrepreneurial firm

For a long time, the theoretical firm has been "entrepreneurless", as if, in the words of William Baumol (1968: 66) "the Prince of Denmark has been expunged from the discussion of Hamlet". In neo-classic economic theory, firms are assumed to always make their equilibrium choices of combinations of input and output levels, with all knowledge exogenously given, and readily applicable in production. This leaves, overall, no active role for the entrepreneur.[8] Yet, when present, the entrepreneur was treated as a stylised and rather abstract figure as "necessary analytical stepping stone to understanding other phenomena, typically at higher levels of analysis" (Foss and Klein, 2012: 7).

Also, much of contemporary entrepreneurship research contains only little discussion about why entrepreneurs choose the firm instead of the market. Two separate conceptual

[8] A partly explanation of why the entrepreneur remained largely unacknowledged in the theory of the firm, is related to the fact that the latter´s conceptual original falls together with the emergence of neoclassic microeconomics.

approaches seem to exist: either the entrepreneur is added to the firm or the firm is added to the entrepreneur. In both ways, the entrepreneur is explicitly or implicitly dissociated from the firm. As criticised by Foss and Klein (2012), "the entrepreneurial act … [is] often conceived as an independent, free-floating cognitive act, divorced from subsequent processes of exploiting the entrepreneurial insight by assembling resources and producing goods and services" (16).

This thesis attempts to bring these two approaches closer together by investigating the transformation of the initial entrepreneurial act of firm formation over time. In particular, the role of the entrepreneur as decision-maker in steering the innovation activity of the firm and its relationships with external sources of knowledge shall be examined in the empirical study of this thesis. We apply Penrose's definition (1959/1995) of the term 'entrepreneur' as:

> [i]ndividuals or groups within the firm providing entrepreneurial services … [which] are those contributions to the operations of a firm which relate to the introduction and acceptance on behalf of the firm of new ideas … Entrepreneurial services are contrasted with managerial services which relate to the execution of entrepreneurial ideas … and to the supervision of existing operations … The same individuals may … provide both types of services to the firm (31-32)

We also build in this thesis on the notion of the entrepreneurial firm, relatedly to Langlois (2007) and Foss and Klein (2012). Entrepreneurial firms are the result of "self-conscious design … they do not draw on existing unselfconscious repositories of knowledge and capability, whether these be existing market patterns or existing systems of rules of conduct within organizations … they are sources of systemic novelty" (Langlois, 2007: 1120).

For the purpose of this thesis, single-person firms are omitted from the discussion because – given the absence of workers – coordination only concerns external inputs and

excludes the more complex process of knowledge absorption involving different members of the firm.

The quest for profit – though not necessarily as overall, unique goal – and the dispersion of knowledge[9] are fundamental assumptions upon which the entrepreneur acts in designing and directing the firm. This requires judgement, which is "the (largely tacit) ability to make, under conditions of structural uncertainty, decisions that turn out to be reasonable or successful *ex post*" (Langlois, 2007: 1112; emphasis added).

The understanding that the essence of the firm lies in the specialisation of this judgement, which the entrepreneur offers as a non-tradable service (Foss and Klein, 2012), is central to the entrepreneurship perspective in the theory of the firm. There are at least three reasons for why judgment, in general, is non-tradable (Langlois, 2007). From a contract perspective, selling judgment, firstly, encounters the well-known problem of how to price unknown information, which supposedly traded judgment, is. Secondly, a problem of moral hazard arises because the contract over judgment may remain (partly) unfulfilled due to the opportunistic behaviour of the seller or bad luck. In addition, judgment results from a subjective means-end framework, which is tacit and novel, and cannot be communicated immediately because of conceptual barriers.

Two core elements of entrepreneurial judgement are alertness and creativity (Foss and Klein, 2012). Alertness, the distinguishing characteristic of Kirzner's (1973) entrepreneur, is understood as the interpretation of new information into a matching extant framework. The

[9] Because information is asymmetrically dispersed, individual decision-makers seek to access and possess different sets of information and knowledge. This understanding has been key to the work of Austrian economics (see Foss and Klein 2012 for an overview).

entrepreneur acts as an agent of equilibration, responding to a change that has already happened (Loasby, 2005). This is different to Schumpeter's entrepreneur, who acts upon imagination and creativity, which are both largely outside given frameworks. This sort of entrepreneurial judgement tends to raise resistance, which requires, "a new and another kind of effort of will … for conceiving and working out the new combination …" (Schumpeter, 1934/1961: 86).

Whereas Kirzner's alertness is "domain-limited", that is, what the entrepreneur recognises is congruent with h/er extant interests, the Schumpeterian entrepreneur acts under a "domain-linking" premise (Loasby, 2005: 14). Here, the new cognitive apparatus, due to prior or concurrent changes or differences intrinsic to the entrepreneur, leads to the imagination of opportunities.[10]

Common to both – domain-limited and domain-linking entrepreneurial judgement – is a means-ends framework, which is subjective to the entrepreneur. Consequently, the entrepreneur needs to translate this into a shared understanding or, at least, into an initial acceptance inside the firm and in the market, in order to create the basis of the firm (Loasby, 2005; Witt, 2000; Foss and Klein, 2012). We shall look now into this process.

3.1.3 Cognitive leadership

In establishing the firm, the entrepreneur, seeks to accomplish the three-fold function of a creator, organiser and market-maker (Schoonhoven and Romanelli, 2001). The creativity of the entrepreneur is thus constituted only in parts by the recognition and imagination of the

[10] For Loasby (2005: 15) this is "the most fundamental of Schumpeter's challenges to standard economics, because it is a challenge to the standard conception of human agency".

business idea, whereas the larger remainder lies in the ingenuity of organising the firm and its external relationships (Amabile, 1997).

During the process of venture creation, the "business conception", that is, the notion of what and how to produce and/or to trade, guides the entrepreneur, or the team of entrepreneurs, in establishing the firm (Witt, 1998, 2000, 2007).

The business conception is not a formal blueprint of business organisation, neither is it identical with a business plan, but, as Witt (2007: 3) noted, "a business plan is based on an (elaborate) business conception". We have operationalised this notion for the empirical part of this thesis, and used, as mentioned earlier, the expert-assessment of business plans by venture capitalists to constitute the study target population of entrepreneurial firms.

The business conception can be understood as the entrepreneur´s subjective means-ends framework, which needs to be translated into a common cognitive frame, which exists independent from intentional choice (Witt, 1998, 2000, 2007), and steers and motivates decision-making at all levels in the firm.

As Witt (2000), relating to Anderson (1990), explained, cognitive frames enhance the representation of knowledge in a meaningful way, whereby the meaning is stipulated by the cognitive frame. Although different cognitive tasks can be undertaken based on different cognitive frames, it is not possible for two cognitive frames to operatively coexist contemporaneously. Whichever cognitive frame acts, constrains mental activity and will therefore act as a bound.

Despite the idiosyncrasy of individual cognitive frames, intensive communication and learning processes within social groups can result in cognitive communalities, that is, a common cognitive frame (Witt, 1998, 2000, 2007). By communicating the subjective means-ends framework inside the firm, the entrepreneur assumes "cognitive leadership". This lies the foundation for higher-order principles, routines and dynamic capabilities (Zander, 2007). In this way, a shared cognitive frame is established, which enhances motivation and coordination inside the firm.

Cognitive leadership is thus salient to how individuals select and interpret knowledge. It is a determinant for discretionary or delegated decision-making, and the utilisation of dispersed knowledge through creativity and collective problem solving, due to the close relationship between how employees perceive their tasks, how their contributions are valued, and their intrinsic motivation (Witt, 2000; Zander, 2007).

Cognitive leadership is, however, not perpetual; its sustainability depends upon informal communication, the models of behaviour that are approved and rewarded by the firm, and upon the extent to which the entrepreneur influences and dominates social learning (Witt, 2007). Quality and appeal of the business conception – expressed in working conditions, career possibilities and social models (fairness, collaborative problem, etc.), have an impact on the effectiveness of cognitive leadership.

All of these are likely to change over time and workers may decide to leave the firm, if they are no longer satisfied with the business conception and its realisation by the entrepreneur. The question is then, how can cognitive leadership be sustained over time?

Langlois (1998, 2007) suggested that charismatic leadership can both establish and sustain effective cognitive leadership. Charismatic authority, understood in the Weberian tradition, "derives neither from traditionally nor rationally designed rules … it is a way of reducing dynamic transaction costs by packaging a bundle of complex knowledge and information[11] in a form that others can cheaply absorb" (Langlois, 2007: 1221). Whereas it is apparent how this type of authority could steer informal communication, intrinsic motivation, and certain forms of behaviour, it seems that, on the long-run, rewards influence the effectiveness of cognitive leadership more by raising extrinsic motivation (Witt, 2007). Charismatic leadership, on the contrary, tends to polarise radical change in rather rare and exceptional situations.

Cognitive leadership is sensitive to the size of an organisation as well as to its organisational structure (Witt, 1998, 2000, 2007). The size of a firm can be a key determinant of cognitive leadership, as the example of an idealised growth process of an entrepreneurial start-up firm, discussed in Witt (2007) shows. An entrepreneurial start-up firm is typically a very small organisation with face-to-face contacts of the entrepreneur and the workers. It therefore provides all favourable conditions for a regime of cognitive leadership, which would lead, if successfully applied, and given sufficient or increasing levels of revenues, to business growth. An increase in the number of employees is likely to challenge the effectiveness of cognitive leadership in a firm as the frequency of face-to-face contacts are likely to decrease and alternative cognitive frames – which may be in dissonance with the business conception – are likely to emerge.

[11] Information can only be understood by those individuals, who possess the capabilities to make sense of it; otherwise information is meaningless (Pavitt, 1998).

If the entrepreneur, at this turning point, continues as before, the firm will be less efficient, and growth will be impeded, even if the firm may continue to exist (Witt, 2007). Such deterioration of cognitive leadership can hardly be reversed, but requires a change of direction. One approach is to introduce a "monitoring regime", in which the "entrepreneur-organizer" (Alchian and Demsetz, 1972) continuously exercises fiat and monitors performance. Such a governance system requires an omnipresent entrepreneur, who acts, on the expense of the entrepreneurial service, as a manager, or, alternatively, the introduction of a hierarchy of managers. Both are likely to leave less or no room for discretion, exploitation of novel knowledge and innovation, unless specifically delegated. Hence, collaborative coordination, intrinsic motivation, and tapping into tacit knowledge – all prerequisites of acting under dynamic conditions – are impeded and cannot emerge under such conditions (Langlois, 1992, 2000; Witt, 2007; Foss and Klein, 2012).

However, if there is no immediate need for creativity and innovation, the introduction of such a monitoring regime can be an alternative form of governance as Witt (2007: 1133) suggested. Although we shall not dwell on this point, it should be mentioned that the effects of introducing such a monitoring regime are unlikely to be temporary, but may lead – depending on the degree of deviance from the original business conception – to a further deterioration of the firm as an organisation.

Another approach is to create subunits and to establish a "decentralised cognitive leadership regime … with 'subordinate entrepreneurs' " (Witt, 2007: 1135). This requires the establishment of the business conception of the entrepreneur in this entrepreneurial group and a sufficient degree of cognitive coherence.

Summarising, it can be said, relatedly to Witt (2000; 2007), Foss and Klein (2012) and Langlois (1998, 2007), that the ability of an entrepreneur to implement cognitive leadership, and to maintain it during the course of business growth, depends upon on the size and organisational structure of a firm, and upon the entrepreneur's personal characteristics, such as communicativeness, persuasiveness, persistence, appreciativeness and fairness and the ability to choose, in case of need, alternative organisational development routes.

3.1.4 Organisational structure, capabilities and attention

A key determinant of the innovation activity of firms is the ability to mobilise resources from various sources (Nooteboom, 2009). As said, not the resources *per se* but the services, which they may render, yield results. This is a central point in understanding and answering the question of why there is more knowledge inside than outside the firm.[12] The accumulation of productive knowledge inside the firm is the result of a certain set of capabilities, which can be easily replicated within the organisation but not beyond its borders, because "coordination, communication, and learning are situated not only physically in locality, but also mentally in an identity" (Kogut and Zander, 1996: 502).

We have already dwelled upon the concept of firm identity, related to the notions of business conception and cognitive leadership, and shall now focus on capabilities.

Nelson and Winter (1982) distinguished between two sources of capabilities. At the level of the individual members of a firm, capabilities are referred to as skills, whereas at the organisational level, capabilities are higher-level routines. Ordinary capabilities, which allow

[12] This question was asked by Nicolai J. Foss and answered by Kogut and Zander in their 1996 article on What Firms Do? Coordination, Identity and Learning.

firms to implement regular activities can be conceptually separated from dynamic capabilities, that is, systemic activities that permit firms to modify ordinary capabilities in order to improve performance, and to enact and adapt to changes.

Capabilities are embedded in, and largely constrained by, the firm's organisational structure (Teece and Pisano, 1994), which co-evolves over time together with its resource base into a set-up that is suitable for the day-to-day operations of the firm (Fagerberg, 2004). Any significant change in strategy is thus likely to require significant changes to a firm's organisational structure (Nelson and Winter, 1982).

Depending upon the nature of the firm' activity and its degree of novelty, on the one hand, and upon the characteristics of the firms technical and governance resources, on the other hand, these capabilities may either co-exist as dynamic capabilities next to the regular and predictable behavioural patterns of a firm, that is, its routines (Nelson and Winter, 1982), or transform into dynamic capabilities.[13]

Nooteboom (2009) provides a useful extension to the concept of dynamic capabilities with regard to the search and integration of knowledge that is cognitively distant to the current knowledge of the firm. In this case, the dynamic capability of a firm includes the capability to employ a cognitive focus that enables the firm to explore and exploit knowledge, the ability to search and find external knowledge, which is both novel and related to extant internal knowledge, and has thus optimal cognitive distance, and the management and governance capability to purposefully employ these in innovation activity. We will revert to some of these aspects in a subsequent section of this Chapter.

[13] Not all routines are therefore capabilities. Routines are self-referential and resilient to status quo (Tidd and Bessant, 2009) and as such not well suited for novelty and change.

Decision-makers act as “cognizers” (Calori et al., 1984). By applying their own mental maps as interpretation lenses of the environment, they define the firm’s search scope (Volberda et al, 2010). A conceptual model to investigate the role of the decision-maker in this process of co-evolution was introduced by Ocasio (1997).

Building on the work of Simon (1947), who analyses organisational behaviour as a complex network of attentional processes, both at the level of individuals and the organisation, Ocasio (1997) developed a process-based model of organisational attention with three interrelated premises. Firstly, what decision-makers do depends upon their “focus of attention”. Secondly, which issues and answers are central depends upon the specific actual context and situation, what Ocasio (1997: 188) calls “situated attention”. Thirdly, situations and issues are determined by the “structural distribution of attention” in the firm, which is the outcome of resources, rules and routines.

Attention can be defined as encompassing “the noticing, encoding, interpreting and focusing of time and efforts on both issues … and answers” (Ocasio, 1997: 189), instead of distinguishing between four separate activities. Further, Ocasio emphasised the distributive nature of organisational decisions, actions and cognitions, which can be common to or differ between firm leadership, management and employees (Simon, 1947; Witt, 2007; Nooteboom, 2009).

The firm in Ocasio’s (1997) model is an “open social system where, through attentional processing and decision-making, the inputs from the environment of decisions are transformed by the organization into a set of outputs – the organisational moves” (193). In the following, each of these elements shall be briefly presented.

The environment of decisions encompasses both firm internal and external factors related to markets, tradable and non-tradable resources, and institutions. Its infinite complexity requires selective decision-making, in which decision-makers "restrict their attention to a limited set of stimuli, while ignoring others" (Ocasio, 1997: 193). This selection is influenced by cultural and institutional processes. We argue that university education can establish such cultural and institutional processes and will develop our argumentation in the last section of this Chapter on university-firm links and the notion and relevance of epistemic communities.

Organisational moves are actions undertaken by the decision-maker either in reaction to changes that have occurred or in provocation of the latter. This includes "exchanges of resources and information with the firm's external environment as well as changes in the firm's own resources and attention structures" (Ocasio, 1997: 201).

Organisational moves may or may not be implemented. In both cases they are, however, an input for the construction of subsequent moves. We will discuss this further down in this Chapter in the section on the role of knowledge in the innovation activity of firms.

3.1.5 Summary

This section started by recalling the foundations of the theory of the firm, highlighting the role of the entrepreneur in organising the firm, whilst acting upon the heterogeneity of resources and the inherent continuous need of decision-making to acquire and communicate knowledge from different sources.

Two key issues emerged for the empirical study of this thesis.

First, the entrepreneur needs to demonstrate cognitive leadership in order to translate h/er subjective means-ends framework into a business conception and a shared cognitive focus that enhances the accumulation and utilisation of productive knowledge inside the firm. Firm characteristics, such as the age of an organisation, number of employees and its increase over time, market developments in the sector, and others, will all influence the cognitive focus of a firm, and thus impact on the maintenance of cognitive leadership. This is likely to result in organisational changes, such as the creation of subunits, which divides organisational processes whilst maintaining a shared business conception.

Second, environments of decisions are complex and thus constrain the entrepreneur as decision-maker to restrict h/er attention. Cultural and institutional processes are likely to influence the selection of influences taken into account by the decision-maker.

Next, we shall review relevant theories related to the innovation activity of the firm. A thorough review of the vast and quickly growing literature goes beyond the scope of this thesis. Thus, a limitation is applied to key aspects of innovation in terms definitions of different types of innovation activity and a conceptual model to review the organisation of the innovation process.

3.2 Innovation activity of firms

The innovation activity of the firm can be understood as a result-oriented process, whose ultimate goal is the generation of innovation rents (Grupp, 1998). Since these rents

tend to annulment over time, there is the need for continuous triggers and permutations to the process in order to ensure novelty. Key sources of novelty can be both internal to the firm, such as new employees, new organisational structures, learning from experience, and external to the firm. Especially in the early phases of an innovation project, openness to new ideas is essential (Fagerberg, 2004). This openness can be understood as a function of strategic choice, depending upon firm-internal dynamics and factors related to the firm's environment.

3.2.1 Types of innovation activity

Schumpeter (1934/1961) defines innovation as "[d]evelopment [and] the carrying out of new combinations", and distinguishes the following five cases or types: (i) introduction of a new product or new attributes, (ii) introduction of a new production method, not yet existing or being tested in the industry, including trading strategies for a product or service, (iii) opening new markets, (iv) new suppliers, and (v) organisation of the industry, such as, for example "the creation … or the breaking up of a monopoly position" (66). Traditionally, these five types have been summarised in the innovation literature as "new products, new methods of production, the exploitation of new markets, new sources of supply, and new ways to organise business" (c.f. Fagerberg, 2004: 6-7).

Innovations can be compared according to how different their outputs are from existing products and processes, and categorised as either radical or incremental innovations (Freeman and Soete, 1997; Slater el al., 2014). Another distinction can be made between an innovation and its imitations, that is, by establishing a reference category for the novelty of an innovation output, which can be new to the firm, the industry, the country or new at the global level (Unger, 2005).

These distinctions are relevant aspects for studies that analyse the economic outcome of innovative performance, yet they are less relevant for the purpose of this thesis, whose focus is on innovation processes instead of innovation performance.

The classification of innovation types, applied in this thesis, builds on Schumpeter's definition; specifications are added for market and organisational innovations (Table 1, below). Market innovation is understood as entering existing markets or building new markets by attracting and binding customers (Tidd and Bessant, 2009). Organisational innovation is focused on firm internal structures and processes, which are aimed at enhancing the utilisation of knowledge and skills.

A note shall be made here on why new sources supply of and the opening of new markets – although important and fundamental forms of innovation – have not been included in this study. These innovation activities imply utilisation or reliance on external sources of knowledge, which would confound the research design given the conceptual overlap between the involvement of external actors in the innovation activity and the opening of new sales or supply channels.

We assume that firms couple these innovation activities, that is, product with process development, introduction and improvement of market methods and organisational structures and procedures into what Freeman (1991: 500) called "internal networks" within the firm.[14]

[14] Freeman (1991) presented the results of the SAPPHO project a major international comprehensive empirical study about „innovation pairs". The coupling of development, production and marketing activities was found to be of six key success factors for innovation activity. Others are the (i) identification of user needs, (ii) the linkage with external sources of scientific and technical information and advice, (iii) the concentration of internal R&D resources as complementary to externally absorbed resources, (iv) high status, wide experience and seniority of the innovator, and (v) in-house performance of basic research.

Table 1. Types and stages of innovation activity

Product innovation	New development of products, which had not yet been part of the products of the firm. Further development of existing products with regard to product attributes and/or product use.
Process innovation	New development or introduction of new processes, which are crucial to the core activities of the firm, e.g., product development processes, test processes, production processes. Further development of existing processes.
Marketing innovation	New development or introduction of new marketing methods, e.g., product packaging, product placement, advertisement strategies, price strategies. Further development of existing marketing methods.
Organisational innovation	New development or introduction of organisational structures and processes, which are aimed at optimising the enhancement and utilisation of the knowledge and skills of employees. Further development of existing organisational structures and processes, which are aimed at optimising the enhancement and utilisation of the knowledge and skills of employees.

The introduction of two stages for each type of innovation activity, that is, "new" and "further", or incremental, development, is considered to bring five advantages to the empirical analysis undertaken as part this thesis.

First, it links with the exploration versus exploitation discussion in the literature, where, starting from March (1991), exploration is associated with variation, discovery, and innovation, that is new development, whereas exploitation or implementation, refinement and improvement concerns products and processes already existing in the firm. It has been argued that a combination of the two in the dual structure of an "ambidextrous" firm (Duncan, 1976) – that is an organisation, which is capable of exploiting with equal dexterity existing competencies as well as exploring new opportunities (Lubatkin et al., 2006) – is difficult because it requires the combination of different cognitive frameworks as well as reflection in organisational structure.

Exploitation requires stable roles and standards, whereas exploration implies uncertainty, lack of resources, and increased flexibility (Nooteboom, 2009). March (1991) proposed that exploitation and exploration are, initially, fundamentally different activities, which compete for the allocation of scarce resources. However, this may also constitute a basis for proactive change.

The potential competitive advantage, inherent to ambidexterity, was reflected in the literature, starting from the early view of ambidexterity as trade-off between status-quo or resilience and change (Levinthal and March, 1993), to the later understanding of ambidexterity as a necessary paradox for organisational survival and growth (e.g., Eisenhardt et al., 2000; Gavetti and Levinthal, 2000; for an overview see Raisch and Birkinshaw, 2008).

Second, distinguishing between a new and an incremental stage, provides room to acknowledge for feedbacks and loops, which characterise the non-linear conceptual understanding of the innovation process (Kline and Rosenberg, 2010), and, in this sense, also links with Abernathy and Utterback's (1978) three-stage model. These feedbacks and loops influence the allocation of search resources and thus are likely to condition also the involvement or non-involvement of external sources of knowledge.

We argue that the sources of knowledge or the modes of utilisation may vary between the types and stages of the innovation activity. For example, external sources of knowledge might be more relevant for the further development of existing products by identifying or testing novel product attributes or applications, than for the original product innovation. Here, the role of lead-users and early adopters (von Hippel, 1988) has been found salient for the

decision of whether further, incremental changes are needed to achieve greater market success.

Third, the introduction of an incremental stage also contrasts the techno-centric focus on new product and market innovations, which dominates extant research and excludes innovation activity that is internally focused (Adams et al., 2006), such as process and organisational innovation.

Fourth, the two stages can be understood as being interlinked, in that incremental innovations are subsequent to or anticipating new developments. They can also be distinctive from each other, for example when the product or service, which is further developed, is of extra-mural origin.

Fifth, having two stages for each innovation type, facilitates data collection in the empirical study of this thesis as it renders questionnaire-based soliciting of information easier. The innovation process, due to its complexity, is often not directly observable and thus complicates the establishment of a common understanding of an innovation output (Unger, 2005: 22). The two stages, each meticulously described, therefore facilitate the recalling of information concerning, firstly, the innovation activity itself, and, secondly, the eventual involvement of external sources of knowledge.

3.2.2 Organising innovation activity

In order to analyse the role of the entrepreneur in organising the firm's innovation activity, and the involvement of external knowledge partners, the process nature of the innovation activity needs to be operationalised. It can be argued that above presented types of

innovation activity already form part of a process, in which, for example the further development of a product succeeds the new development of it. This, however, does not reveal the underlying organisational structure, which we are interested in.

Consequently, the innovation process was structured from an organisational point of view into key tasks, treating new and incremental innovation as discrete projects. Each innovation is understood as an organisational move (Ocasio, 1997), which is the output of attentional processing and decision-making with regard to the allocation of resources.

We apply Tidd and Bessant's (2009: 79-86) model, which describes the innovation process in four phases, and defined for each phase key tasks, which were included in the questionnaire (Table 2, below).

In addition to the key tasks, the following aspects of entrepreneurial judgement were included and associated to the overall process: (i) relevance of communication with other members of the firm, (ii) knowledge in one's own and (iii) in other disciplines, and membership in a (iv) wide or (v) narrow network with individuals and organisations outside the firm.[15]

The first phase in Tidd and Bessant's model is search. It includes the detection of signals from both known and unknown environments. Examples are technological change processes in the sector, legal frameworks, and behaviour of competitors. The search space is mainly confined by the combinative capability of the firm. Here, prior knowledge and experience (Cohen and Levinthal, 1990) plays an important role; we will discuss this in the

[15] Respondents were asked to rate each of these on a 1-5 point scale in terms of the relevance for their activity area in the firm.

following section of the Chapter. The key task that we associated with this phase is idea generation.

Table 2. Phases of the innovation process and key tasks and attitudes

Phase	Search	Selection	Implementation	Capturing value
Tasks	• Idea generation	• Idea evaluation • Financial resources • Human resources • Technology and knowledge resources	• Prototyping • Production	• Marketing
Attitudes of the entrepreneur towards …	• Communication with other members of the firm • Knowledge of own discipline • Knowledge of other disciplines • Wide network • Narrow network			

Source: Phases drawn from Tidd and Bessant (2009: 80)

The second phase is selection; it includes the evaluation and appraisal of ideas, taking into account available and accessible resources. Not all of the knowledge needed to assemble these resources may be already available to the firm (Foss and Klein, 2012). Adding and integrating additional sets of knowledge require management skills and involves communication between different teams and units in the firm. There are three key determinants to the selection space. Firstly, the signals detected in the first phase, secondly, the current knowledge base and the knowledge base accessible for the firm, and thirdly, the overall fit with the business activity. The following tasks were associated to this phase: idea evaluation, acquisition of financial resources, human resources, and technology and knowledge resources.

Implementation – the third phase – is turning the different inputs into outputs, such as new products or processes. We associated the tasks of prototyping and production to this phase, which is characterised by a steep learning curve from prototypes to the final product.

The final phase is capturing value from the innovation process. It is closely linked with the other phases and it sets the path direction and reference framework for future innovation processes. The associated key task is marketing.

3.2.3 Summary

This section focused on the innovation activity of firms. It started with a presentation of the different types of innovation activities typically found in the literature and justified the decision taken in this thesis to distinguish between the new and further, or incremental, development of products, processes, marketing methods and organisational structures and procedures. Next, the innovation process was presented in four interlinked phases – search, selection, implementation, and appropriability or capturing value – for which key tasks and attitudes towards knowledge and internal and external networks were introduced to analyse the role of the entrepreneur in organising the innovation activity of the firm.

Four key issues emerged from this for the empirical study of this thesis.

First, since innovation rents tend to annulment over time, there is a continuous need for triggers and permutations to ensure novelty. Key sources of novelty can be both internal and external to the firm.

Second, combining exploitation, that is, the refinement and improvement of already existing products and processes, with the exploration and discovery of new areas of potential business activity, is considered difficult because it requires the combination of different cognitive frameworks and related changes to organisational structures.

Third, the need for external sources of knowledge is likely to vary for different types of innovation activity. For example, external knowledge partners might be more relevant for the further development of existing products by identifying or testing novel product attributes or applications, than for the new development of a product.

Fourth, it can be assumed that the involvement of the entrepreneur will vary across the different phases of the innovation process, focusing on those phases, which require the most organisational attention. This may differ between the different types and stages of the innovation activity.

The choice of an innovation strategy is affected by several factors, which are in parts external and in parts internal to the firm. Besides demand and market structure, the availability of knowledge, the choice of external sources of knowledge, and the firm's absorption capacity are key determinants (Unger, 2005). We will review these in the following section.

3.3 The role of knowledge in innovation

Different approaches have been introduced to categorise the knowledge of firms. We take as a basic general starting point, Fritz Machlup's (1980: 108f.) distinction between five classes of knowledge as (i) practical knowledge, which includes professional knowledge, business knowledge, workman's knowledge, political knowledge, household knowledge and other forms of other practical knowledge; (ii) intellectual knowledge; (iii) small-talk and pastime knowledge; (iv) spiritual knowledge; and (v) unwanted knowledge. Central to this

thesis are practical knowledge, mainly professional and business knowledge, and intellectual knowledge, in particular, the one that is acquired at universities.

The knowledge of firms has different dimensions, which can be delineated by the question of whether knowledge creation is an activity of the firm or its individual members. Proponents of the latter often base their argumentation on Simon's (1991) point that "[a]ll learning takes place inside individual human heads; an organization learns in only two ways: (a) by the learning of its members, or (b) by ingesting new members who have knowledge the organization didn't previously have" (125). For example, Grant (1996) argued that knowledge creation is an individual activity, and that the primary role of firms is the application of existing knowledge to the production of goods and services.

The other line of argumentation is that knowledge creation results from a socialised and contextualised process, in which individuals contribute to the creation of knowledge that is larger than individually-held knowledge (Kogut, 2008 for an overview). We adopt this understanding, acknowledging, however, the potential salient influence of knowledge hold by individuals, in particular when this knowledge is offered entirely to the firm, as, presumably, it is the case for the entrepreneur.

3.3.1 Knowledge of firms

A common distinction is the one between the explicit and tacit components of knowledge.[16] These two components are complementary. Explicit knowledge is considered a key source of major technological and scientific shifts and their global diffusions, whereas

[16] The distinction between tacit and explicit knowledge goes back to Michael Polanyí's (1967/1983) book *The Tacit Dimension.*

tacit knowledge enables the translation of knowledge into economically viable innovations (Lissoni, 2001).

Explicit or encoded knowledge exists in the form of written information and other forms of recordings (Foray, 2004). Examples are text books, scientific and professional journals, as well as conference presentations and other forms of audio and video transmissions. The information transferred through these means is accessible for everyone, who understands both content and context (e.g., language). Tacit knowledge, instead, can only be acquired through experience and cannot be transferred in separation from the latter. Moreover, the exchange and diffusion of tacit knowledge requires the willingness of the knowledge holder to share (Foray, 2004). Once shared and interpreted, tacit knowledge can, partly, be encoded, for example in protocols of experiments.

In the case of technology knowledge – a form of practical knowledge – an example of the tacit component is the working experience acquired in a laboratory. Whereas the explicit component of technological knowledge is relatively stable, its tacit component is continuously updated. This renders privately held tacit knowledge, which is not regularly updated through continuous involvement in scientific research and laboratory work, subject to decay (Witt and Zellner, 2007).

For the purpose of this thesis, we find most suitable the definitory approach proposed by Kogut and Zander (1992: 386), to distinguish between information as "knowledge that can be transmitted without loss of integrity once the syntactical rules … for deciphering are known", and know-how, which is "a description of how to do something". Information and know-how have different degrees of codifiability and complexity. Applying this to the above

example of technological knowledge, information includes all explicit and codified knowledge, whereas know-how is its tacit component, that is, the procedural knowledge, which is continuously built.

Generalising this approach to the knowledge of a firm, it can be stated, relatedly to Arrow (1962a), that knowledge is growing over time, and that it is acquired in a learning process, which is based on experience (Nonaka, 2000).

Knowledge as a resource of firms has complex issues of appropriability. Since information is in principle tradable, it does not constitute *per se* the firm's potential for superior performance, but requires higher-order capabilities, which allows for the value of knowledge to be appropriated, either by increasing the ease of firm internal replication or by limiting the risk of external imitation (Teece, 1986). Tacit knowledge, which cannot be directly transferred, can only be appropriated through the revenues from the productive activity it has contributed to. Also, explicit knowledge *per se* is inappropriable by means of market transactions, except for the case of declared property rights, such as, patents (Grant, 1996).

Montresor (2004: 410) provides a useful conceptual summary of the enabler-asset nexus between knowledge and higher-order capabilities, including competences: "the firm is a set of "resources" … both tangible (e.g. machinery) and intangible (e.g. patents), it has specific "capabilities" … to configure, exploit and possibly renovate (i.e. dynamic capabilities), and idiosyncratic "competences" … to set at work into actual problem-solving activities and routines". These idiosyncratic competences emerge from procedural knowledge, in the sense that "we all know what to do" (Kogut, 2008: 35). Procedural knowledge is

common to the firm, or its subunits, which are organised around specific task areas. It is largely tacit and thus hardly codifiable and shareable with contexts other than the original.

Learning has inherent forms of myopia, which narrow the focus of learning to what is already known to the learner. Hence, myopia tends to limit the organisational attention (Ocasio, 1997) in general, and the exploration capability of firms in particular (Levinthal and March, 1993).

Levinthal and March (1993) distinguished between the following three forms of myopia. The first one, temporal myopia, implies that learning sets a focus on distinctive competencies, which are relevant for a particular purpose at a given point in time. A change of purpose may render irrelevant the accumulated competencies. The second form, spatial myopia, occurs in proximity to the location of former learning processes and may therefore impact only or mainly certain units of a firm and not on the entire firm. Finally, failure myopia, concerns the general tendency that failures get eliminated by success, which "produces confidence and confidence produces favourable anticipations and interpretations of outcomes" (ibid. 110).

In a certain sense the contrary of myopia is the absorptive capacity of a firm (Cohen and Levinthal, 1990). As said above, the search and identification of knowledge, which is new to the firm, is crucial for variation and thus for the pace of innovation (March, 1991). However, access to novel knowledge is only the first step in a longer process, which, on its own, may be insufficient for success (Spender, 1996). Whilst access to novel knowledge can enhance innovation activity, the inability to absorb and utilise it – in combination with extant knowledge – is likely to repress innovation activity. A bridge between extant and novel

knowledge is constituted by what Cohen and Levinthal (1990: 128) referred to as the "level of prior related knowledge", and what Nooteboom (2009: 41-43) re-introduced as "background knowledge".

A certain degree of related diversity is likely to increase absorptive capacity, in that "[s]ome portion of that prior knowledge should be very closely related to the new knowledge to facilitate assimilation, and some fraction of that knowledge must be fairly diverse, although still related, to permit effective, creative utilization of the new knowledge" (Cohen and Levinthal, 1990: 136). Understanding of scientific developments in a discipline and membership in an epistemic community are examples of manifested prior related technological knowledge.

Absorptive capacity enables innovation activity, but it is mainly the "imagination of new connections from existing patterns to elements that lie *outside* these patterns" (Loasby, 2005: 13, emphasis added) that will push innovation. It is the decision-maker and h/er role in setting the organisational attention (Ocasio, 1997) and the governance competence (Nooteboom, 2009) that set patterns and possibilities for permutations.

Depending upon the degree of novelty, a firm might have to "be free of memory in order to imagine the future in a new way" Langlois (2007: 1119), in order to achieve permutation and a novel recombination of its resources. From a systemic point of view, changes to the performance of a system require either modifying (some of) its constituting elements or rearranging its internal and external connections (Loasby, 2005).

Different measures have been developed to account for the absorptive capacity of a firm; a review would be beyond the scope of this thesis (see Zahra and George, 2002 for an

overview). Instead, we shall focus on measurements of firm internal research and development (R&D). A typical measure is the ratio between expenditure and some expression of output (Adams et al., 2006). For small firms or service firms, this is, however, not a useful or feasible measure, because these firms may not have formal R&D activities for which they calculate and/or report expenditures.

Alternative measures disaggregate R&D related inputs in people, tools, physical and financial resources (Adams et al., 2006). People factors have been measured as the (absolute and relative) number of employees committed to innovation activities. We build upon this approach and specify people in R&D as those employees that are tasked with the acquisition of knowledge that is new to the firm and/or the unit h/she works in. Following Salter and Martin (2001), we limit research to application-oriented research and exclude curiosity-oriented research, which is undertaken, pursuing a private motivation, to acquire new knowledge for its own sake. In addition, we also introduce as measure of the organisation of R&D activities, the number of firm subunits to which these employees belong to.

The R&D capacity of a firm is considered to be a necessary complement to the openness to external sources of knowledge (Cassiman and Veugelers, 2006). A potential substitution effect exists as firms may compensate internal R&D activity with external knowledge (Chesbrough, 2003), following a transaction cost logic. A substitution effect of external sources may also occur with the increase of firm internal R&D activity, resulting in a more focused scope and depth of search (Dahlander and Gann, 2010). Furthermore, as Nooteboom (2009) points out, firms, as a result of experience, are likely to extend their scope of search by increasing the cognitive search distance for novel knowledge. This is a point to which we will return later in this Chapter.

3.3.2 External sources of knowledge

Firms do not innovate in complete isolation (Foss and Klein, 2012), but selectively involve external sources of knowledge. This selection occurs at the categorical level of whether or not to co-operate as well as concerning the types of innovation activities (Dahlander and Gann, 2010).

Much of extant research has focused more on the role of external knowledge during opportunity recognition than during opportunity realisation. Foss et al. (2013) attribute this to the emphasis in the strategic management literature on the entrepreneurial process, which is seen as largely self-contained and leaves little room for interaction with external sources of knowledge. The realisation of opportunities other than the identification and creation of opportunities, however, requires multiple complementary resources, for which firms typically tend to complement what is already internally available with what can be sourced from market or hybrid relations (Foss and Klein, 2012).[17]

Particularly when firms act upon a novel or complex opportunity, which requires the deployment of specialised knowledge and/or contextual information, for example about industry-specific standards and regulations, this is likely to be sought from external sources, such as suppliers or individuals and organisations providing business development support (Foss et al., 2013).

The permeable nature of firm boundaries has been reviewed by a growing stream of literature, spinning off from the concept of open innovation (see West et al., 2014 for an

[17] This thesis adopts the nature of opportunities as inferred from subsequent market behaviour in contrary to the assumption of the *ex ante* existence of opportunities, consequently, opportunities, become manifest in the actions of firms (Foss and Klein, 2012).

overview). Chesbrough (2003) introduced this concept as a two-side flow of knowledge between a firm and external actors, which forms an integral part of the firm's innovation process.

Dahlander and Gann (2010) introduced a useful taxonomy, distinguishing between inbound and outbound forms of open innovation with pecuniary and non-pecuniary flows. Inbound forms of innovation include the acquisition of knowledge, under a pecuniary setting, and the sourcing of knowledge as a form of non-pecuniary flow. Outbound forms of innovation relations include different forms of selling knowledge (pecuniary) and revealing knowledge (non-pecuniary). The focus of this thesis is on inbound links in general, and on knowledge sourcing in particular.

Inbound knowledge flows can be measured through the linkages maintained. Such linkage measures are typically dichotomous and measure whether or not a firm maintains external relationships and only rarely imply also a qualitative assessment (Adams et al., 2006). This thesis also focuses on a dichotomous measure whilst undertaking, in addition, a qualitative assessment of the relevance of the relationship for the innovation activity of the firm.

Openness implies various issues of appropriability. Different mechanisms exist to decrease the risk of imitation and unwanted knowledge spillovers (Dahlander and Gann, 2010). Formal mechanisms, such as patents, registrations of designs, and trademarks, can be distinguished from more informal ways, of which common forms are secrecy related to product complexity and lead times. Formal mechanisms have been found in extant research to

be less effective than informal mechanisms or a combination of both (Laursen and Salter, 2014).

Negative implications of an overly demonstrated focus on appropriability have been pointed out, for example, by Nelson (1990), Chesbrough's (2003) and von Hippel (2005), who argue that firms, in this way, limit their discovery capacity, including both opportunistic and deliberate forms of search and interaction activity.

Individuals, organisations, documentary repositories, conferences and alike can be external sources of knowledge for firms. As shown in various empirical studies, the sources of knowledge may vary for the different types of innovation activity (e.g., Laursen and Salter, 2006; Tödtling et al., 2008; Freel and de Jong, 2009; Varis and Littunen, 2010). Codified knowledge can be accessed from various sources, whereas tacit knowledge "requires the pre-existence of a community of people, rich of social links and endowed with a common cultural background" (Lissoni, 2001: 1480), and is therefore available only from certain sources and not accessible to anyone.

Mostly researched, starting with von Hippel's (1988) conceptualisation of the lead user, has been the role of customers in defining and prototyping innovations; particularly in the case of novel and complex innovations and poorly defined markets (Tether, 2002). Collaboration between firms in the same supply chain has also been studied as closely related to firm internal innovation processes. Also, cooperative arrangements with competitor firms can be considered as relevant sources for both technological and business knowledge, following the assumption that firms do not compete across their entire portfolio of activities (Hamel et al., 1989). Another frequently studied group includes business support

organisations and consultants, which provide more applied information and specialist skills, often related to specific strategic and organisational challenges of the firm (Tether, 2002).

Finally, the relevance of public research institutes and universities as knowledge partners of firms have been studied for a long time (Perkmann et al., 2013 for an overview). Brostöm and McKelvey (2009) have argued that research institutes are organised in a different way from universities and have a different rewards system. The presence of a clear mission to interact with private businesses, with clear objectives and a managerial structure gives research institutes a more similar organisational set-up to firms, which begs the assumption of lower interaction barriers than in the case of universities and firms, which differ greatly in terms of work organisation, hierarchies and reward systems.

In this thesis we will examine the role of the following external sources of knowledge: firms from the same sector, firms from other sectors, business support organisations, research organisations and universities.

Given the particular role of universities, mainly with regard to the notion of epistemic communities – which we assume to act as continuous bonds between alumni entrepreneurs and their alma mater – we will review the vast literature on the relationships between universities and businesses separately in a subsequent section of this Chapter.

3.3.3 Path-building effects

External knowledge relationships are a form of learning to which above mentioned forms of myopia apply (Levinthal and March, 1993). Such relationships also have a more general path-building function in that they "lead to structures, and structures lead to repeated

relationships", as Kogut (2008: 26-26) pointed out. Positive or negative experiences related to such relationships are therefore likely to have an imprinting effect on the future search activity and relationship building of the firm, in the sense that actions and related experience build a repertoire which results in cognitive structuring, and provide a new basis for action (Nooteboom, 2009; Bruneel et al., 2010). Gatekeepers, that is, individual members of the firm, who are keeping external relationships on behalf of the firm, play a key role in building institutional memory which is applied to subsequent choices.

The organisational structure of a firm also matters for knowledge partnerships. Small firms are considered to have a number of advantages (Rothwell, 1989), mainly related to their organisational flexibility and close contacts with customers and suppliers. Such cohesiveness may, however, be more suitable for exploitation, or static processes, than for the introduction of novelty and change through means of explorations (Nooteboom, 2009).

Young firms have to overcome the double-constraint of lacking internal sources and access to external resources (Stinchcombe, 1965). They simultaneously have to gain contacts, get established in existing networks, and organise the firm. It can therefore be assumed that young firms are active networkers, whilst having to overcome eventual entry and establishment barriers in existing networks. Moreover, it can be assumed that these firms are likely to revert to own existing networks, such as for example university links or membership in epistemic communities.

Knowledge accumulation and learning have an impact on the cognitive focus of a firm. According to Nooteboom (2009: 105) they enhance the ability to collaborate, widen the scope of technological competence, but at the same time, they also lower the marginal value

of novelty, which leads to decreasing returns on knowledge. This, what Nooteboom (2009) calls “boredom effect”, continuously increases the search scope of firms to look for more distant sources of knowledge.

At the same time, firms are also likely to reuse knowledge (Katila and Ahuja, 2002). Which elements of knowledge are reused may change over time, for example, when certain knowledge loses its relevance. From extant research little is known about the different depth levels of exploiting existing knowledge. Routines repeat knowledge results and thus render search easier and more successful; they set starting points for new search based on extant experience, and reference frameworks to reduce errors (Levinthal and March, 1981). Whereas the reuse of knowledge opens associations between knowledge elements and facilitates access and understanding of the (more) tacit components, it can also lead to a lock-in situation with rigidity and a halt on the technological trajectory (c.f. Argyris and Schön, 1978; Dosi, 1988), when most of the dynamic capabilities, built earlier in the search process, have turned into ordinary capabilities.

A high search scope adds new variations, distinctive from the existing ones, and enhances re-combinatory search (Nelson and Winter, 1982). However, integrating new knowledge has dynamically increasing costs because it requires new communication relationships both within and outside of the firm, and a reallocation of resources to build new organisational capabilities whilst maintaining reliability, that is, the “ability to respond to new information correctly” (Katila and Abuja, 2002: 1185).

There is also the possibility of over-search (Koput, 1997). This can be due to (i) wrong timing, that is, the firm cannot utilise the information when it is acquired and also cannot

"store" it for later utilisation, (ii) attention-levels are insufficient to prioritise and allocate resources, or (iii) the absorptive capacity of the firm insufficient to utilise the information. Relatedly, Laursen and Salter (2006) argued that decision-makers shall focus on a limited number of search activities below the point at which external search breath becomes disadvantageous.

3.3.5 Summary

In this section, we reviewed key aspects of the knowledge of firms and the different sources of origin. We first adopted the distinction between information, which includes knowledge that can be entirely transmitted and know-how, or procedural knowledge, which is largely tacit and context bound. We then adopted the understanding that the knowledge of a firm creation is the result of a socialised and contextualised process, in which individuals contribute to the creation of knowledge that is larger than individually-held knowledge. In this, we acknowledged the dominant role of the entrepreneur.

Next, starting from the statement that firms do not innovate in complete isolation but selectively involve external sources of knowledge, we briefly reviewed the concept of open innovation, issues related to the appropriability of knowledge, and different groups of external knowledge partners.

From this, three key issues emerged for further analysis in the empirical study of this thesis.

First, the firm internal accumulation of knowledge through learning is likely to be constrained by myopia, reducing the focus of learning to what is already known to the learner.

This also applies to learning from external sources. Gatekeepers, that is, firm members who are keeping external relationships, as well as the organisational structure of a firm are key determinants for the institutional memory which impacts on the future search and selection activity of the firm.

Second, firms are likely to choose external knowledge partners according to their needs. Different sources of knowledge fulfil different needs.

Third, as the cognitive focus of the firm grows through knowledge accumulation and learning, the firm' search scope will also increase in order to satisfy the growing need for novelty, against decreasing returns on knowledge caused by lower marginal values of novelty.

The ambiguous relationship between path-building, forms of myopia and organisational attention has been analysed in this section under the perspective of cognitive proximity. We will further develop this in the next section, particularly with regard to the role of proximity for knowledge links between firms and universities, and the notion of epistemic communities.

3.4 Universities as knowledge partners

Universities are crucial for the development of contemporary societies by performing a three-fold role, which encompasses education, creation of scientific knowledge, and sharing of knowledge (Perkmann et al., 2013).

In particular, knowledge sharing with private businesses has received high levels of attention of public policy actors. As Etzkowitz et al. (2000: 314) noted, "[d]espite industrial

and academic systems at varying stages of development, governments in virtually all parts of the world are focusing on the potential of the university as a resource to enhance innovation environments". In Europe, university-business links have moved into the centre of policy initiatives – both at supra-national and national levels – because public universities are one of the few actors in national and regional innovation systems, whose institutions and funding can still be steered by public policy (Howells et al., 2012).

In the recent Community Innovation Survey, implemented across the 28 member countries of the European Union and covering the three-year reference period 2010-2012[18], universities ranked third as sources of external knowledge, accounting for 13% of the sample, after suppliers (18.3%) and firms within the same enterprise group (12.5%). For countries, where data was available on the most relevant source of external knowledge, firms from the same enterprise group ranked again first with 13.6% of the sample firms, and only 2.8% of respondents stated that universities were their most relevant source for external knowledge. This was followed by consultants (2.2 %), firms from the same sector (1.7%), and public research institutes (1.5%) (EC, 2015).

Reasons and motivations to collaborate with universities vary across sectors and firm size; often universities are only one of several knowledge partners of a firm (Perkmann et al., 2011; Kim, 2013). Sharing costs and risks of research, was found to be a common reason for collaboration. Participation in collaborative research projects, gives firms the possibility to share the costs of research, and to eventually benefit from government funding. Larger firms, given their greater resource availability, are more likely to use this option. To close this

[18] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis8_sou&lang=en

access-gap, a growing number of government programmes target young and small innovative firms.

University links provide knowledge, which firms need to continue on-going R&D efforts (Jaffe, 1989; Cohen et al., 2002). In particular high-technology firms are keen to access scientific knowledge to update and enlarge their internal knowledge base, and to established long-term links, even at a low level of intensity, in order to stay informed about the research activities in university.

Although scientific knowledge is, in principle, as Arrow (1962b) argues, freely available to everyone, there are various barriers to accessing it. The most fundamental ones are access to education and experiential forms of learning. The latter is considered essential for building tacit knowledge, which constitutes a large part of scientific and technological knowledge, and requires long years of continuous experience to form (Rosenberg, 1990, and Pavitt, 1991). Furthermore, transforming scientific knowledge, research and technology from different disciplines involve substantively distinctive time scales, uncertainties and appropriability regimes (Markman, et al., 2008; Meyer-Kramer and Schmoch, 1998).

Appropriability of scientific knowledge and research results are governed by a complex system, on which the Bayh-Dole Act, enacted 1980 in the United States, has had imprinting effects (Geuna and Rossi, 2010). The Bayh-Dole Act prescribes all intellectual property rights over inventions resulting from government funded research to the university. This approach has been followed by most European countries since the end of the 1990s, with Italy, Sweden, and to some extent Finland, being current exceptions. In these countries

scientists have an entitlement for primary utilisation, which is widely referred to as "professor's privilege".

Scientific knowledge can be accessed through journals, conferences and other forms of information repositories or through personal contacts. Such an understanding follows a simple linear model, which pushes science out onto users. During the last three decades, this "science push" model has been replaced by a more complex interactive "chain-link" model (Kline and Rosenberg, 2010), which acknowledges the existence of circular and two-way interactions, and the central role of tacit knowledge. The interactive model also suggests a salient role for cognitive and geographical proximity in knowledge sharing, which we shall look into next.

3.4.1 Geographic proximity

The role of geographical proximity for innovation and learning is discussed in a substantive body of literature. Key strands include studies on knowledge spillovers as a result of spatial concentration of firms (e.g., Audretsch and Feldman, 1996), networks formation based on social capital and trust (e.g., Powell et al., 1996; Powell, 1998), innovative milieu which are nurtured by a shared local culture and manifested in informal contacts (e.g. Camagni, 1991), and the literature on innovation systems with their umbrella function of shared institutions, and organisations that produce and share knowledge, such as universities and research organisations. In all of these, the role of institutions is eminent. These can be defined, following Hodgson (2006: 2), as "systems of established and prevalent social rules that structure social interactions".

Firms locate in proximity to universities, public research institutes and infrastructure, such as science parks, in order to benefit from geographical spillover effects. Technology transfer from universities to firms has been practiced for a long time. Early case studies date back to the nineteen century. For example, the early developments of the chemistry industry in Germany happened under the influence of university scientists (Meyer-Thurow, 1982). Since then a long list of theory building work and empirical studies has built up to capture and measure the geographical and sectorial spillover effects of public research (e.g., Lundvall, 1992; Cooke and Morgan, 1993; Varga, 1998; Mansfield and Lee, 1996; Saxenian, 1994 ; Feldmann and Florida, 1994; Feldman and Desrochers, 2003; Collinson and Gregson, 2003; Cohendet et al., 2014).

In general, time is a determining factor for the relevance of geographical proximity for science industry relationships (Mowery and Shane, 2002). During certain stages of a relationship co-location can have positive lasting effects on the exchange of tacit knowledge (Asheim and Gertler, 2005). This is also relevant for spatial clusters, whose development path, according to Malmberg and Maskell (2001), is influenced by three factors. First, spin-offs stay in close proximity to their parent organisation; second, they become embedded into the "local milieu", often also contributing to its co-evolutionary nature; and third, inertia sustains the local milieu, in that firms find locally what they need, and draw additionally from non-local sources, when they need to. The latter is, however, not an inherent feature of inertia but requires firms to be open to the outside world. A continued lack of openness – which was found to be a risk of highly specialised and locally concentrated industries – may cause stagnation and lock-in situations (Boschma, 2004).

Direct contacts may also last despite geographic distance, if there is a given purpose of collaboration (Rappa and Debackere, 1992; Yli-Renko et al., 2001). For example, when licensing instrumentation and technology from universities, both university scientists and firms tend to maintain close contacts in order to benefit from the further development of the research tools and emerging new areas of scientific research (Rosenberg, 1992, Nelson et al., 1996 c.f. Martin and Salter, 2000). Generally, it was found that technologies, resulting from university research and transferred to industry, often require continued collaboration to develop from little more than "proof of concepts" into commercial products (Gittelman, 2007).

3.4.2 Epistemic communities as a form of cognitive proximity

Perceptions of shared identity positively influence the knowledge sharing behaviour of individuals in professional environments (Kane et al., 2005). Geographical proximity can thus be (partly) substituted by other forms of proximity, such as cognitive, organisational, social and institutional proximity (see Boschma, 2005 for an overview). In particular, communities of practice (Brown and Duguit, 2001) and epistemic communities (Knorr Cetina, 1999; Gittelman, 2007; Cohendet et al., 2014) may act, to a certain degree, as substitutes for geographic co-location in the creation and diffusion of tacit knowledge.

For the formation of scientific communities, geographical and cognitive proximity are complementary factors (Gittelman, 2007). There are discipline-specific differences regarding the lasting relevance of local links. For engineers, face-to-face interactions are more important than for scientists, which refer to status hierarchies and common membership in research communities without the necessity of spatial collocation. This relates to Merton's (1973: 375)

understanding of a "community of scientists [as] a dispersed rather than a geographically compact collectivity … [its] structure … cannot, therefore, be adequately understood by focusing only on the small local groups of which scientists are a part". Merton underlines that scientists, even when working independently from each other and remote in space, "are responding to much the same social and intellectual forces that impinge on them all" (ibid).

For certain sciences, such as biotechnology, information and computer technology, larger cosmopolitan networks exist, which include professionals and scientists that share common research interests, even if they do not share a history of direct professional or social links (Murray, 2004; Gittelman, 2007).

We relate to Knorr Cetina (1999: 1), who argues that science can be understood as an epistemic culture, that is, an "amalgam of arrangements and mechanisms – bonded through affinity, necessity, and historical coincidence – … that create and warrant knowledge". From this follows that scientific disciplines can be understood as epistemic communities, within which knowledge exchange is facilitated by shared symbolic and theoretical frames. Epistemic communities are built upon shared identities, which are expressed in symbolic and theoretical frames (Hakanson, 2010). Members share the same tacit and experiential knowledge, which is passed on in personal contacts, eliminating and punishing any opportunistic behaviour.

The notion of epistemic communities was suggested first in 1968 by Burkart Holzner, a German sociologist, as a contextual conceptualisation of knowledge residing in groups of practitioners, who share "frames of reference" and cognitive "orientation systems" (c.f. Hakanson, 2010). Holzner did not confine his definition of epistemic communities to

academia – which is delineated by shared principles of the scientific method – but used it more widely.

This tradition has continued. Knorr Cetina (1999), for example, applied the concept to science, which is based in laboratories. Hakanson's (2010) interpretation of Holzner's work focused on the firm as the locus of an epistemic community, whereas Nooteboom (2006 c.f. Hakason) applied the concept to groups that engage in transdisciplinary and/or transfunctional activities, and thus focuses the interstices between the various disciplines. For Lissoni (2001) the epistemic communities in the mechanical industry cluster in Brescia, are centred around mechanical engineers working in local firms which are linked with a selected number of suppliers' and customers' technicians. Cohendet et al. (2014) used the diffusion of Cubism, a radically different whilst extremely influential art movement in the early 20th century, to exemplify knowledge sharing and adaption in an epistemic group, which firstly involved only artists in Paris before it spread across Europe.

Cowan et al. (2000: 234) provided a general definition of epistemic communities as groups, which may be small in size and "comprise knowledge-creating agents who are engaged in a mutually recognized subset of questions, and who (at the very last) accept some commonly understood procedural authority as essential to the success of their collective activities".

We argue in this thesis that epistemic communities may exist in universities either as entire groups or in the form of local units, each including one or more individual, which belong to larger groups that are spread across different locations. These epistemic communities can be organised as single-discipline groups or spanning different disciplines.

Further, we distinguish between passive and active membership (Coleman, 1990). The former applies to students, who acquire the codified knowledge of an epistemic community during formal studies. Involvement in scientific research, related to the recognised subset of questions of an epistemic community, for example in form or a doctoral dissertation, may eventually transform a passive membership (student) into an active membership (researcher). We assume that also work experience in research at a university or a public research institute leads to membership in an epistemic community. We assume that membership in an epistemic community has lasting effects, and that members will turn to other members as part of the search process for related or new knowledge.

An example of an epistemic community, in which the author of this thesis is a member, is the German engineers association VDI (*Verein Deutscher Ingenieure*). Traditionally, engineering research in Germany has been an area of excellence with close collaboration with industry and organised in well-resourced large research groups (Grimpe and Fier, 2010). The VDI is an important network with close links into universities and local chapters in each university that offers engineering studies. Engineer students usually become a member of the VDI during their studies or upon graduation.

3.4.3 Different forms of university business collaboration

Martin and Tang (2006) provide a useful summary of seven different types of contributions that university research can make to business performance. These are (i) increasing the stock of useful knowledge; (ii) increasing the capacity for scientific and technological problem solving (iii) creating new scientific instrumentation and

methodologies; (iv) training skilled graduates; (v) forming networks and stimulating social interaction; (iv) forming social knowledge; (vii) creating new firms.

We have already addressed the first three possible outcomes of knowledge relationships, and shall only add here on the further education offer of universities, before we review the remaining three types of contributions.

Universities offer various further education activities both to maintain contacts with their alumni and as a source of additional revenues (Abreu et al., 2008; Cosh and Hughes, 2010). Typical education offers include technical courses on new instrumentation and methodologies as well as so-called Masters or Doctorates of Business Administration, which are targeted at managers.

At the same time, also universities seek to include lecturers with industry experience into their education offer, in particular for courses that have practical elements and build on experiential learning. This is often the case for business administration, project management as well as for the fast growing area of entrepreneurship education (OECD, 2008).

Employing students in apprenticeships, supervising scientific research assignments, which students undertake as part of their studies, and the employment of graduates are commonly practiced by firms to increase their internal stock of knowledge (Salter and Martin, 2001). Skilled students and graduates as transmitters of scientific knowledge can also help to update the privately held scientific knowledge of the entrepreneur and other firm members.

Scientific knowledge is, however, not the only knowledge, which is shared through links between people in the university and businesses. University researchers may offer a

wide range of consultancy services based on applied knowledge, such as advice on organising health services provision (Martin and Tang, 2006), or support for drafting local development strategies. Interaction is bidirectional whereby academics gain reputation, financing, and knowledge and thus act upon extrinsic as well as intrinsic motivations (Meyer-Kramer and Schmoch, 1998; Grimpe and Hussinger, 2013).

As mentioned above, firms often maintain informal ways of collaboration with university researchers to learn about the areas and progress of university research and technology development (Salter and Martin, 2000). Callon (1993: 413) argues that the relationships between firms and universities and research institutes differ from inter-firm or market relationships in general in that the former exhibit a much higher degree of creativity, novelty and reconfiguration, with "each of the elements drawn into the collective plays an active role".

The inclusion of university members in firm boards is a common practice in university spin-offs (Markman et al., 2007). University members bring reputations and capabilities, which help to establish the credibility of the firm and enhance the scope and depth of search for external knowledge.

3.4.4 Technology transfer and academic engagement

We distinguish in this thesis between technology transfer and academic engagement. The former includes patenting, licensing and spin-off ventures as ways of transferring knowledge resulting from public research into private firms through ways, which are regulated by intellectual property rights.

University spin-offs, according to the definition proposed by Wright et al., (2007), are a particular form of technology transfer. In this sense, spin-offs are new ventures that are dependent upon licensing or assignment of a university research for initiation, in which a university may own equity shares. We have opted for this strict definition, mainly because of the advantages in operationalising the concept for the empirical study of this thesis, acknowledging, however, the substantive number of university spin-offs that draw only on the tacit knowledge of university scientists (Markman et al., 2008).

University spin-offs, also referred to as science-based entrepreneurial firms (Colombo, Mustar and Wright, 2010), have seen a steep increase in numbers across the OECD area (Wright et al. 2007). Firm organisation and access to finance often pose key challenges for former scientists, and are often associated with conflicts arising from the involvement of non-academic stakeholders, such as venture capital providers, in firm boards (Clarysee et al. 2007).

Patenting and licensing are forms of formal technology transfer, which regularly involve the need for pacifying conflicting demands from academic scientists, university administrators and actors in firms (Siegel et al., 2003). To this end, universities often establish dedicated units with personnel that have either worked in industry before or accumulated close industry links in order ways. These units are widely referred to as technology transfer offices, and their employees are perceived as "boundary spanners, acting as a bridge between 'customers' (entrepreneurs/firms) and 'suppliers' (academic scientists), who operate in distinctly different environments and have different norms, standards, and values" (Markman et al., 2008: 1405).

Technology transfer activities vary between universities (Genua and Muscio, 2009). Some of this variation can be explained by specific country effects, however much lies within the characteristics of individual researchers and the research environment. Ponomarinov (2007) found that researchers were positively influenced by the availability of private R&D funding and negatively influenced by the academic quality of the institution. Overall, however, these were smaller effects than individual characteristics (i.e., tenure achievements and aspirations) and disciplinary affiliation.

The increasing amount of data available from technology transfer offices in universities tends to set the focus of empirical studies on patents, trademarks, licenses, and spin-offs. Such a focus is, however, likely to distort the overall picture of university-business interactions, as noted, *inter alia*, by Genua and Muscio (2009), only a small fraction of university research can be codified in patents, trademarks and copyrights.

Academic engagement is a much broader concept than technology transfer. It includes – following the definition by Perkmann et al., (2013: 424) – all other forms of formal and informal knowledge-related collaboration between academe, researchers and non-academic organisations and individuals. Examples of formal knowledge-related collaboration are collaborative research, contract research, and consulting, whereas informal activities include networking and ad-hoc collaboration with business practitioners (Abreu et al., 2009; Bonaccorsi and Piccaluga, 1994; D'Este and Patel, 2007; Meyer-Krahmer and Schmoch, 1998; Perkmann and Walsh, 2008). Conference, meetings and informal contacts, at the level of individuals, were found crucial for university-business contacts (Cohen et al., 1998; Ponomariov and Boardman, 2008), and often anticipate more formal contacts (Genua and Muscio, 2009).

From the extant literature, we summarised twelve forms of university-business collaboration, and included these in the questionnaire, classified as formal and informal links (Table 3, below). Collaborations were considered as formal if it can be assumed that they are governed by a contractual agreement between the firm and the university.

Table 3. Forms of university-business collaboration

Type of university link	Formal	Informal
Contacts maintained with alma mater		
Contract regulated research co-operation with university or individual scientists		
Informal contacts with individual scientists		
License utilisation of HEI-owned patents		
Utilisation of HEI-owned laboratories and research infrastructure		
Contacts with TTOs, entrepreneurship centre or similar		
Members of the firm are educators in HEIs		
Members of the firm participate in the educational offer of HEIs		
Supervision of Bachelor, Master and doctoral theses		
Employment of students as trainees		
Involvement of members of the firm in HEI internal boards		
Involvement of HEI researchers in firm internal boards		

Given that universities and firms have two – sometimes fundamentally – different systems of knowledge production, conflicts in the collaboration are likely (Bruneel et al., 2010).

The main difference perhaps is, as pointedly paraphrased by Brown and Duguid (2000), that firms prefer to create sticky knowledge, which remains with them and generates revenues, whereas academic researchers aim to create knowledge that is leaky and which spreads quickly in their community. Also, the choice of research topics appears to follow different motivations. Academics choose topics, which interest their peers, whereas firms aim

to establish unique selling point positions whilst orienting themselves with reference to their current customer preferences (Bruneel et al., 2010).

Trust plays a crucial role, in the relationships between universities and firms, as it does for inter-firm relationships (Nooteboom, 2002; Santoro and Saparito, 2003). Intellectual property rights are key area of conflict. A vast body of literature exists, which will not be reviewed in this thesis (see Azoulay et al., 2007; Bradely et al., 2013 for an overview).

In a large-scale survey of scientists in the United Kingdom, Abreu et al. (2009) found that only a minor part of respondents, around 10%, perceived cultural differences and disputes over intellectual property rights as main constraints for collaboration, whereas lack of time, bureaucracy and inflexibility within university administration were stated by more than half of the more than 22 000 participants.

3.4.5 Summary

In this section, we reviewed different aspects of why universities play a particular role as potential knowledge partners of firms. We started from the understanding that knowledge relationships between science and industry actors follow a complex interactive "chain-link" model of circular and two-way interactions around tacit knowledge as core component.

Geographical and cognitive proximity are assumed to be of key relevance for the effectiveness of these relationships. We reviewed the extant theories and empirical studies for both, and focused then on the role of science, and its organisation in universities, in the formation of epistemic communities. Finally, we summarised the different forms of contributions of university knowledge to firm performance, and various methods of

technology transfer and academic engagement, as we have operationalised them for the empirical study of this thesis. From this, the following three issues emerged:

First, geographic proximity matters for some firms more than others, especially spin-offs and science-based firms are more likely to stay in close proximity to their main external sources of knowledge as this enables face-to-face contacts and continuous exchange of tacit knowledge.

Second, the existence of epistemic communities, which are built upon shared identities and expressed in symbolic and theoretical frames, promote the sharing of tacit knowledge amongst its members. We argue that epistemic communities exist at universities either in the form of unidisciplinary or multidisciplinary groups, and that individuals assume membership by studying and working at a university. There are different degrees of membership, related to an individual's intensity with engagement on the mutually recognized research issues and the contribution to knowledge creation. It is argued that membership in an epistemic community has a lasting effect, and that members will turn to other members as part of the search process for related or new knowledge.

Third, there are different forms of university-business links, which firms will rate differently in terms of their contributions to the innovation activity.

CHAPTER 4

OVERVIEW OF EXTANT EMPIRICAL RESEARCH

In this Chapter extant empirical studies are reviewed in light of their findings regarding the characteristics and determinants of firms collaborating with external sources of knowledge. These are discussed in two sections, of which the first one focuses on knowledge partnerships in general, and the second one on links with universities.

4.1 Characteristics and determinants of knowledge partnerships

4.1.1 Firm size and resources

Firm size has been discussed in extant research as a key determinant for the involvement of external partners into the innovation activity of the firm. The assumption is that the larger the firm, the greater its capability to draw from university research. Tether (2002), for example, found that firm size matters, in general, for the collaboration with external partners, and in particular, for the choice of partners. Co-operations with universities, other research organisations, and consultants were more practiced by larger firms. Tether (2002: 956) attributes this to the availability of greater resources and the tendency to "have greater awareness of the capabilities of these research orientated organisations". Whereas this might apply to small traditional firms, it can be doubted that this explanation holds also for small innovative firms.

Fontana et al. (2006) also found that firm size was a determining factor in that larger firms with more screening activities had the highest propensity to collaborate with public research organisations.

Tether (2002) found an interaction between age, size and origin of the firm. Newly established firms with more than ten employees[19] were found to have a higher propensity to collaborate with universities. Speculatively this was explained by the origin of these firms in or in close proximity to universities, suggesting that these firms are "likely to maintain links with their 'parent' at least for the first few years" (Tether, 2002: 962).

The human capital endowment of firms seems to matter for the link intensity. Tether and Tajar (2008) found that the share of science and engineering graduates of the firm's human capital stock has a positive impact on the relationship with universities and public research organisations.

Fritsch and Lukas (2001) analysed firms with more than ten employees in three German territories – Baden, Hanover-Brunswick-Göttingen, and Saxony – for their propensity to maintain different forms of R&D cooperation with customers, suppliers, other firms, and public research organisations.[20] They found that customers were the most common partners (61.6%), followed by suppliers (49.5%) and "other" firms (32.5%); 33.8% of the respondent firms collaborated with public research organisations and universities.[21]

[19] Only firms with ten or more employees are included in the Community Innovation Survey. There are exceptions to this; for example the threshold for sample inclusion is five employees.

[20] Respondents were asked if "in the last three years their enterprise had maintained relationships with customers, manufacturing suppliers or "other" firms which in character went beyond "normal" business interaction" (Fritsch and Lukas, 2001: 299).

[21] The study did not distinguish between universities and public research institutes.

An interesting finding from the Fritsch and Lukas (2001) study is that collaboration intensity, measured as the actual number of collaborative activities, with research organisations is less influenced by size than collaboration with customers, suppliers and other firms. Size was found, however, to matter for the first establishment of contacts with a public research organisation. This pattern was found to apply to all types of partners included in the study, except for "other" firms where size mattered more for collaboration intensity than collaboration establishment.

Tether (2002) found that firms, which heavily invested in internal R&D, or which introduced innovations new to the market, were more likely to have innovation collaboration with universities.

Fritsch and Lukas (2001) measured R&D intensity as the percentage of R&D employees in firm, and introduced furthermore the notion of a gatekeeper, assuming that the latter's existence increases the probability of R&D cooperation. They apply the definition provided by Tushman and Katz (1980: 1071) and consider gatekeepers as "those key individuals who are both strongly connected to internal colleagues and strongly linked to external domains". The existence of a gatekeeper was found to explain establishment but not intensity, mainly for relationships with customers but also with public research organisations. Fritsch and Lukas (2001: 310) found that firms that collaborate on R&D "tend to be relatively large, have a comparatively high share of R&D employees, spend resources for monitoring external developments relevant to their innovation activities … [have] a relatively high aspiration level of their product innovation activities".

Tether and Tajar (2008), using the CIS-4 dataset for the United Kindom, focused on the role of specialist knowledge providers as information sources in innovation activities, that is, consultancies, private research organisations, universities and public research laboratories. The underlying assumption is that specialist knowledge providers can substitute other sources information and, therefore, reduce search costs. The study found that relationships with specialist knowledge providers tend to complement rather than substitute the information from other sources; signs of complementarity between consultancies and universities were, however, lower. They also found that size matters for all types of specialist knowledge providers, in that the larger the firm, the more likely links were. No difference was found between new and established firms. Interesting are the results for industry sectors: high-tech firms were more likely to have strong links with consultants. Overall, firms in service sectors had fewer and weaker links with universities and public research institutes.

4.1.2 Search behaviour of firms

Katila and Ahuja (2002) examined in a longitudinal study based on the patenting activity in the global robotics industry[22], the search and problem-solving processes in firms for and during the creation of new products. Martin and Mitchell's (1998) definition of a new product as a change of design characteristics that are new to the firm was followed.

Their findings suggest that exploration and exploitation are two distinct dimensions of search and problem-solving processes, of which one describes how deeply a firm reuses its

[22] Kathila and Ahuja (2002) sampled industrial robotics companies from Europe, Japan and North America, covering entire populations.

existing knowledge ("search depth"), and the other, how widely it explores new knowledge ("search scope").

Katila and Ahuja (2002) expanded the view of organisational learning, which spans a uni-dimensional search space from exploitation to exploration (March, 1991). They argue that scope, that is, the degree to which a firm moves with its search along the continuum from local search (i.e., related to existing knowledge) to distant search (i.e., new, unrelated knowledge) is incomplete. Scope alone does not take into account the "degree to which existing knowledge is reused or exploited", in other words, "firms may use some of their existing elements of knowledge repeatedly while others may use them only once" (1184). Relatedly with Winter (1984), Katila and Ahuja (2002) state that "combining firm-specific accumulated understanding of certain knowledge elements (depth) with new solutions (scope), firms are more likely to create new, unique combinations that can be commercialized" (1186).

4.2 Universities as external knowledge partners

Studies of the relationships between businesses and universities are undertaken from different perspectives: (i) university perspective, (ii) firm perspective, (iii) comparative perspective. Most relevant for this thesis are the latter two. In the following, key findings from recent empirical studies are summarised.

4.2.1 Types of university links

Agrawal and Henderson (2002) found, investigating the departments of electrical and mechanical engineering of the Massachusetts Institute of Technology, that researchers use a variety of channels, other than patents, to collaborate with firms. The study followed earlier work of Mansfield and Lee (1996), which argued that R&D collaboration with universities allows firms to update their knowledge base and to recruit new employees, which, in turn, enlarges their explorative as well as their exploitative capabilities.

D'Este and Patel (2007), using a large-scale survey of university researchers in the United Kingdom, investigated the factors underlying their choices in industry interactions. They analysed various forms of knowledge transfer, going beyond the focus on patents, licenses and spin-offs. These forms of knowledge transfer can be traced more difficult than patents and spin-off activities, but, as D'Este and Patel (2007) argued, they "can be equally as (or even more) important both in terms of their frequency and economic impact" (1297).

Interaction was found to vary across disciplines, with engineers having the highest levels of interaction. Certain individual characteristics, namely academic status (reputation) and previous experience in industry collaboration, increased collaboration, whereas age had a negative effect. Institutional characteristics, related to the department and the university, had a much smaller influence. Interestingly, although the study did not find any significant difference between low and high quality research activities on the likelihood of business interaction, a lower research quality seem to lead to an increased variety of interactions.

A commonly used distinction in empirical studies is that of formal and informal links. Several studies have highlighted a possible relationship between informal and formal university links (Cohen et al., 2002; Meyer Krahmer and Schmoch, 1998; Link et al., 2007). A recent study in Germany by Grimpe and Hussinger (2013) found, using the Germany CIS 2003 data, that consulting is the most common form of collaboration, whereas licensing and technology acquisition were least often practiced. They found, similar to other studies, that informal and formal links mostly occur together and that the situations where formal links occur without any type of informal relationship can be delineated to extreme forms of contract conditionality that ban any form of extra contacts at employee level. Often informal and formal technology transfer activities occur simultaneously and even enhance each other.

Understanding more about this relationship between formal and informal link and other antecedents of formal relationships, is a key prerequisite for those overseeing and implementing formal relationships and the wider intellectual property regime. Grimpe and Fier (2010), in a comparative study[23] of the interactions between university scientists and industry employees in Germany and the United States with a focus on informal technology transfer mechanisms, found that patents have a much higher signalling effect to industry partners than scientific publications.

This contradicts the findings of extant empirical studies on the biotechnology industry in the United States (Zucker et al., 2002), which found that "star"[24] scientists, with a high

[23] The large-scale dataset of 2 797 responses (17.2% response rate) was obtained from a survey of German scientists implemented on behalf of the German government as part of a 6th European Union Research Framework Programme. The survey was carried out in 2008 and covered a period of twelve months.

[24] According to the definition of Zucker et al. (2002: 138-139), start scientists are "those cumulatively reporting more than 40 genetic-sequence discoveries or on 20 or more articles reporting any genetic-sequence discoveries in the GenBank [database]".

number of peer-reviewed relevant publications, were more attractive partners for firms. However, as also pointed out by Grimpe and Fier (2010), this might be a sector-specific finding of the biotechnology industry, which maintains, generally, close relationships with universities and public research organisations. Also, it is worth recalling that Zucker et al., 2002: 152) found in their study that the technology transfer relationships of star scientists were "typically … 'vertically integrated' into the firm in the sense of receiving equity compensation and being bound by exclusivity agreements".

4.2.2 Factors influencing the knowledge partner choice

Bekkers and Freitas (2008) argued that firms "define their own strategy of interaction with a university after having reflected on their present and future knowledge needs". In particular, two strategies were observed: one that is centred on collaborative and contract research, and another one on patents, licensing and specific activities. The former applies mostly to firm links with biomedical sciences and computer sciences, whereas the latter to material sciences and engineering. The study also found that respondents working in small firms were less often involved in collaborative and contract research or rated this at a low level of importance. The caveat of this study is that entrepreneurs were not included, which however, can be expected to play a crucial role in defining in the firm's strategy.

In a study of 45 large research-intensive firms in Canada, Bercovitz and Feldman (2007) addressed the question of how the innovation strategy of a firm, in terms of focus and organisation, influences the decision to engage in R&D alliances with universities. Their starting point was that firms, when engaging in innovation, need to make decisions about their innovation strategy and the resources they want to allocate. Firms will need to decide between

exploring new and exploiting existing opportunities, and how to best allocate resources to this, taking into consideration the firm internal resources and the option of external alliances.

Since universities are not the only possible knowledge partner of a firm, collaboration with universities is the result of a selection process, which, according to Bercovitz and Feldman (2007), is more likely the case if a firm (i) emphasises exploration and the development of new capabilities, (ii) is concerned with appropriability and/or engages in long-term exploratory projects regulated by strict intellectual property regimes. Also, the more centralised the firm's R&D function, the more likely it chooses a university as knowledge partner.

The main underlying assumption in Bercovitz and Feldman's (2007) study is that universities are in a "unique position as R&D partners … [because] they … *lack the complementary assets* to compete directly in commercial markets" (937, emphasis added). In their conclusion, Bercovitz and Feldman (2007) point to the ongoing changes in university-industry relationships, which may challenge this assumption in the future. The tightening of the intellectual property rights framework in favour of universities could influence the partner choice for those firms that base their decisions largely on the appropriability of knowledge.

Also, in more general terms, this assumption needs to be revisited in light of the increasing number of universities that are establishing support structures for their students and staff members to commercialise the results of academic research (Rasmussen and Borch, 2010). These efforts might establish bonds, such as for example, premium channels for people belonging to the same epistemic community. For example, some academics may choose to share their research results first with former colleagues and students. Former colleagues and

students may as well, when having to decide with whom to enter in a strategic alliance, refer in the first place to former professors and colleagues. Such premium collaboration channels would not concern the uniqueness part of above Bercovitz and Feldman's assumption, but they may not necessarily apply to all firms. Other differentiating factors will play a role. In the Bercovitz and Feldman (2007) study, which investigated strategic alliances between universities and the largest private R&D spenders, these might have been pecuniary reasons – e.g., additional revenues from research contracts, scholarships for students – to outweigh eventual epistemic community bonds.

Laursen and Salter (2004) explored the factors that influence why firms collaborate with universities for their innovation activities. Advancing the above mentioned study by Katila and Ahuja (2002), they investigated what role do links with universities play in firm's search strategy, using the CIS 2001 data for the United Kingdom. They approximated the scope of search of a firm with the number of different knowledge sources used in innovation activity, under the assumption that the higher the number of sources, the higher the "openness" of the firm's innovation search strategy (ibid. 1204).

The work of Laursen and Salter (2004, 2006) has been one the first attempts in the extant empirical work on university-firm relations that goes beyond structural factors, such as size, industry sector, R&D intensity and type of innovation, and investigates the type of links to universities (see also Fontana et al., 2006; Tether and Tajar, 2008), and the search strategy of firms.

Laursen and Salter (2004) used three structural variables in their estimation model: R&D intensity, age and size. They found that the higher a firm's R&D intensity, the more

likely are innovation-related links with universities. With regard to firm age, science-based start-ups were found to be more likely to have innovation relevant links with universities, since other start-ups tend to be too small, thus lacking the necessary capabilities, to build and utilise such links.

Fontana et al. (2006) used the KNOW Survey[25], carried out in seven European countries in 2000, to investigate the determinants of research co-operation between firms and public research organisations. They distinguished three components in the process of information gathering and application – searching, screening and signalling and found that searching was not a significant factor for collaboration, whereas screening and signalling were.

4.2.3 Geographical links

Fritsch and Lukas (2001) analysed the collaboration patterns of firms and public research organisations in three different local economies (i.e., Baden, Hanover-area, and Saxony). The study reveals surprising results: firms in Saxony, a region in eastern Germany, had a higher propensity to collaborate with public research organisations than firms in the two western German regions, despite the presence of long established innovation systems.

In the late 1990s, when Fritsch and Lukas (2001) conducted their survey, a fundamental reform process was underway in eastern German universities and other higher education institutions, which caused a great outflow of academics into industry (Fuchs, 1997).

[25] The KNOW Survey was carried out in Denmark, France, Germany, Greece, Italy, the Netherlands, and the United Kingdom. It was limited to food and beverages, chemicals (excluding pharmaceuticals, communications equipment, telecommunications services and computer services, in order to include a variety of technology intensity. The firms sampled had an employee range from ten to 999.

It can be assumed that those, who took on R&D positions and/or gatekeeper roles, referred, in the first instance, to the sources of information encountered during previous work and education, that is, scientific literature an expertise in universities (Gibbons and Johnston, 1974: 238). This could be a plausible explanation of the different propensities between the regions.

This is also reckoned in the interpretation by Fritsch and Lukas (1999), who furthermore point to the possibility that also universities and research organisations could be proactively looking for collaboration, given their historical past where "research institutions in the socialist innovation system, even if engaged in basic research, were characterised by a pronounced orientation towards the application of their results and this attitude of research might be still widespread in Saxony" (173-174).

The above mentioned study by Grimpe and Hussinger (2013) also included in their analysis regional data from the year 2000 on the number of university scientists in proximity to the firm and found that the density of university scientists in the NUTS-3 region, where the firm was located, is an important determinant for both formal and informal relationships with universities.

Murray (2004) argued that the relationship between an academic scientist and a firm is not solely about the exchange of human capital (Stephan, 1996) but that it is the scientist's social capital that can bring value to a firm and that this social capital has a spatial dimension. Murray distinguished between the "local laboratory network" and the "broader cosmopolitan network of colleagues, collaborators and members of the invisible college", which both result from the scientist's previous or contemporary work in a university (Crane, 1968; Merton,

1973; Friedkin, 1978; David, 1998, Knorr Cetina, 1999). If embedded into the firm, the social capital of the scientist can be a key salient factor for firm development.

Scientific inventors offer their human and social capital through different, distinct mechanisms to the firm, which are mainly shaped through the kind of relationship the inventor has with the firm. Murray (2004) distinguished between (i) moving from academia to the firm, either retaining a formal university affiliation or not, and (ii) remaining in academia with either a formal, informal or no relationship with the firm. Each of these have different impacts on the willingness or ability of the inventor to make available h/er social capital in addition to the human capital, whose transfer is task-specific and regulated by the contractual relationship between the academic inventor and the firm.

Firms locate in geographical proximity of universities for various reasons, as discussed in Chapter Three. For new ventures, location in close proximity to universities may mean access to internally not (yet) available human resources, infrastructure and technology (Lerner, 2004). As Murray (2004) pointed out that a newly founded firm starts with a lack of capital, defined as "a combination of the firm's scientific team, the scientific advisory board, and the broader scientific community outside the formal (hiring) boundaries of the firm who are engaged in collaborative research with the firm" (646). Resources in spatial proximity may be of salient importance to overcome this lack.

For example in biotechnology, spin-off firms have shown strong spatial location patterns in proximity to their former universities or research laboratories (e.g., Audretsch and Stephan, 1996; Zucker et al. 1998). Only geographical proximity allows for the continuity of face-to-face contacts and laboratory collaboration, which are of salient for knowledge transfer

in these technology regimes (Murray, 2004). On the contrary, the global robotics industry does not show these signs of intensive local connections (Katila and Ahuja, 2002).

Empirical studies on the impact of location effects have not yet reached global coverage. Extant country-wide studies cover mainly the United States and the United Kingdom and vary in their findings. Whereas similar significant impacts were found for most of the regions in the United States, in the United Kingdom these were found only for the area around Cambridge (Varga, 1998).

Variations were also found cross sectors and for different types of firms. In parts, these sectorial variations can be explained by the difficulty of measuring the economic gains from publicly funded research infrastructure (Salter and Martin, 2000). For many industries, with the possible exceptions of pharmaceuticals, university links are often informal or indirect and thus intangible and hard to capture with the currently used metrics.

Bonaccorsi and colleagues (2013) found in a recent study on Italian provinces that university specialisation contributes to new firm formation. Universities, which have specialised in applied sciences and engineering, were found to have a broad effect in science-based manufacturing industries. Also, for the Italian context, Colombo et al. (2010) found that universities play a significant role for the growth of knowledge-based firms. An interesting finding of this study is that a greater commercialisation orientation of universities may negatively impact the availability of scientific knowledge for these firms as the number of competitors for knowledge partnerships with universities increases.

Johannisson's (1998) research on entrepreneurial networks also showed that geographical proximity was particularly relevant for knowledge-based ventures, whose

founders have a qualified formal education, that is, a university degree and eventually also possess work experience at a university. He found that over time these entrepreneurs become detached from their academic commitment and attached to the local business community.

CHAPTER 5

PRESENTATION OF THE RESEARCH CONTEXT

This Chapter provides a presentation of the research context. It is organised in three sections, of which the first one presents key recent developments of firm-level innovation in Germany and a comparison with other European countries for start-up rates in two innovation-intensive sector groups. Next, a brief presentation of the university system in Germany is provided highlighting the role of universities as key players in geographical and sectorial innovation systems. The concluding section is dedicated to the presentation of the metropolitan areas of Berlin and Munich.

5. 1 Firm-level innovation in Germany

Germany, together with Denmark, Finland, and Sweden, are currently the leading countries in the European Union in terms of their innovation performance (EC, 2014). Firms in Germany and Sweden have the highest levels of investment in both science-based R&D and non-R&D innovation activities, including investments in advanced equipment and machinery. Germany is a leading country concerning the amount of intellectual assets hold by firms, and the overall leader in terms of innovation outputs.

The two indicators with the highest growth rates, for the country were community trademarks (7.9%) and innovative SME collaborating with others (7.2%), whereas a weakness of the German innovation system is the relative low level of venture capital investments in

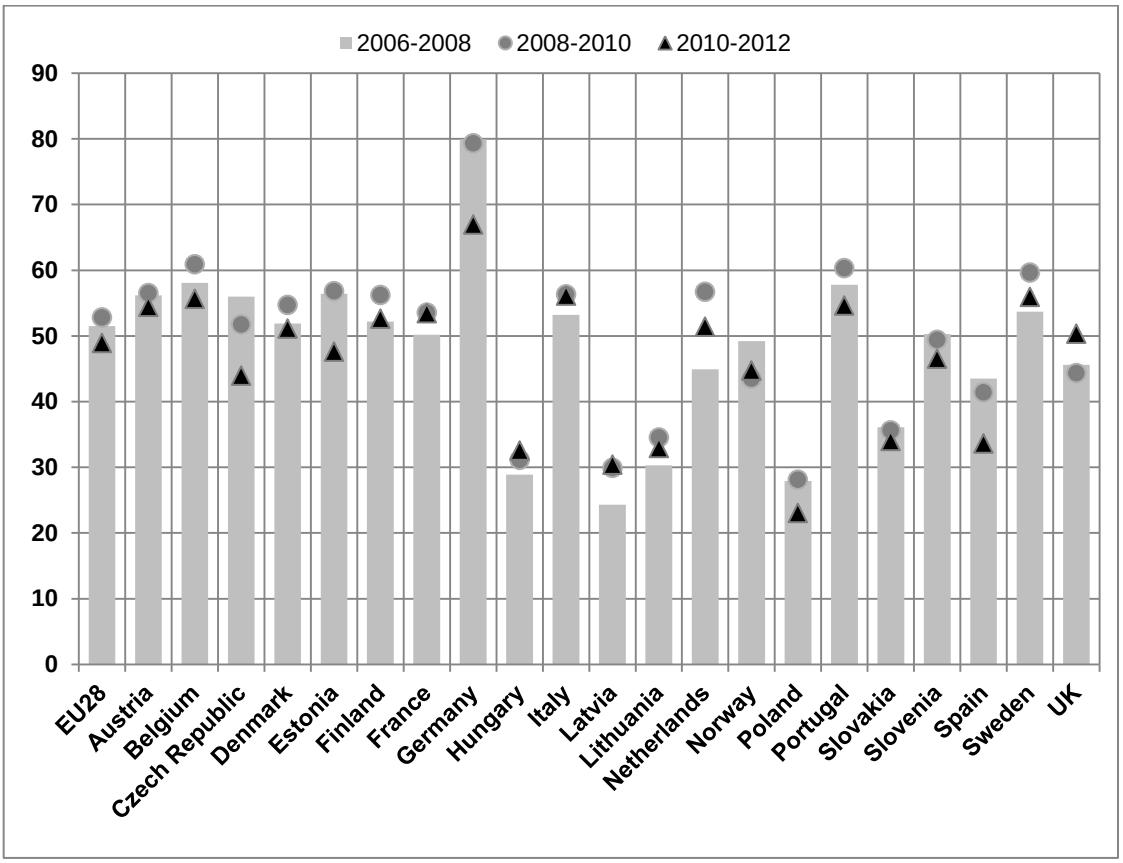
innovative firms, which is below the EU-average (80 of 100) and on a decreasing trend (-1.6%) (EC, 2014).

For the three last editions of the Community Innovation Survey, Germany has been the country with the highest share of innovator firms (79.9%; 79.3%; 66.9%). It should be noted that the last survey in 2012 has shown decreasing shares for most of the participating countries, with an average of -3.9% for the EU-28 area; exceptions were the United Kingdom with an increase of 6.0%, Hungary (1.4%), Norway (1.2%) and Latvia (0.5%) (EC, 2015). Figure 2 (below) provides an overview of these developments for Germany and selected countries.

In the period 2010-2012, German firms had been the most active innovators in product innovation with 55.0% of firms having had introduced during this period a new product and/or service (EU-28 average: 36.0%). Germany was leading in the sub group product innovation (35.8%; EU-28: 23.7%) but ranked only 12th (25.5%) in process innovation, which was led by Portugal (33.5%; EU-28: 21.5%).

The group of organisational and/or marketing innovators was led by firms from Luxemburg, with more than half having had introduced a new organisational form or a new marketing method (53.5%; EU-28: 37.1%). Second and third ranked Ireland and Germany (47.6%). The sub-groups organisational innovation and marketing innovation, were led respectively by Luxemburg (46.8%; EU-28: 27.5%) and Austria (39.5%; EU-28: 24.3%). Germany ranked 10th (32.2%) in terms of organisational innovation, and 6th (34.4%) for marketing innovation.

Figure 2. Innovator firms in selected countries (CIS 2006-08; 2008-10; 2010-12)



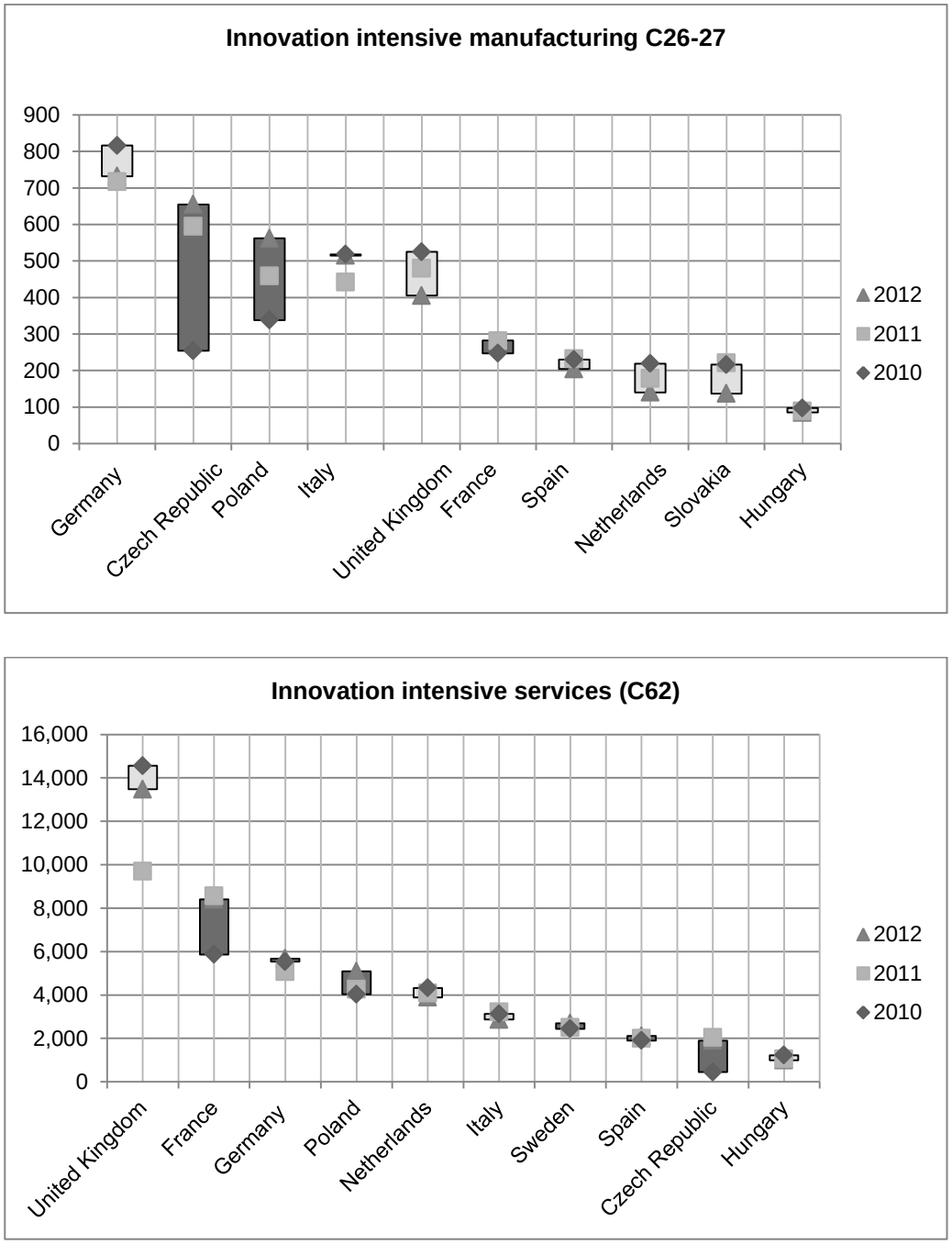
Source: EC, 2015; own elaboration.

A closer look into two innovation-intensive sectors (OECD, 2012), shows that business start-up rates in Germany remain stable or increase. Figure 3 (below) shows the number of enterprises newly born in t-2 having survived to t for the period 2008-2012 for the sectors manufacture of computer, electronic and optical products; and manufacture of electrical equipment (NACE 2rev C26-27), and computer programming, consultancy and related activities (NACE 2rev C62).

In the period 2008-2012, Germany was the leading country for start-ups and incumbent firms for manufacture of computer, electronic and optical products and

manufacture of electrical equipment. It ranked third, after the United Kingdom and France, for computer programming, consultancy and related activities.

Figure 3. Start-up rates in innovation-intensive sectors (2008-2012)



Source: Eurostat, 2014; [bd_9bd_sz_cl_r2].
Notes: Number of enterprises newly born in t-2 having survived to t. Dark grey shading shows increase over time, light grey shading decrease.

Overall, in the period 2011-2012, young high-technology firms in Germany have been performing well, in terms of turnover, profits, and employment rates (Bretz et al., 2013). Around 11% of firms, created in the period 2009-2012, have introduced in 2012 a radical innovation. For 3% this was new to the world, 5% were new to the German market and the rest were new to the region, in which the firm was located. Radical innovations were highest for firms in high-tech manufacturing and lowest in construction (Bretz et al., 2013).

5.2 Universities as key players in innovation systems

Universities[26] in Germany play a central role in the country's geographical and sectorial innovation systems (Kaiser and Prange, 2004; Koch and Stahlecker, 2006). In addition to universities, the Max-Planck-Society, Fraunhofer-Gesellschaft, Leibniz Association and the Helmholtz Centres are leading semi-public research institutes, each with a broad network of local research units, covering almost all NUTS-3 units in the country (Spielkamp and Vopel, 1998).

In 1997, the German federal government started an initiative to support universities to establish infrastructure and education activities to promote academic entrepreneurship. The EXIST programme, which is still operative, has provided financial support for 167

[26] The term university, as used in this thesis, includes both universities and universities of applied sciences. The difference in the German system is that entry barriers to university of applied sciences are lower, study programmes are at Bachelor, Master and Diploma levels, and include high share of experiential learning (e.g., internships, applied problem solving) (EURASHE, 2012).

universities to establish professorships for entrepreneurship, entrepreneurship centres and other initiatives; several universities benefited from multiple projects.[27]

The overall objective of the programme has been to enhance the translation of scientific knowledge and the findings of scientific research into economic value, and, in particular, to increase the number of innovative start-ups (Kulicke, 2014).

In 2002, business start-up scholarships for individual academics were introduced. Applications have always been received from a broad area of disciplines, however, with a focus on engineering studies, and business ideas related to software development, internet and communication technologies. In ten years, more than 1 500 start-up projects received scholarships (Kulicke, 2013).

All universities in Germany, which are undertaking basic and applied research activities, have their own technology transfer offices, which are expected to act as central points of contact for scientists and external actors. As mentioned in Chapter Three, the Bayh-Dole Act, enacted 1980 in the United States, has had imprinting effects on the current appropriability regimes in Europe (Geuna and Rossi, 2010). In Germany, the system switched from the professor´s privilege to institutional ownership in 2002. The current system distinguishes between "service inventions", which result from the activity stipulated by the employment contract, and other inventions. Whereas the former fall under the automatic ownership of the university or research institute, rights for the latter are assigned to the inventor whilst the organisation can commercialise them under a non-exclusive license (Geuna and Rossi, 2010: 13).

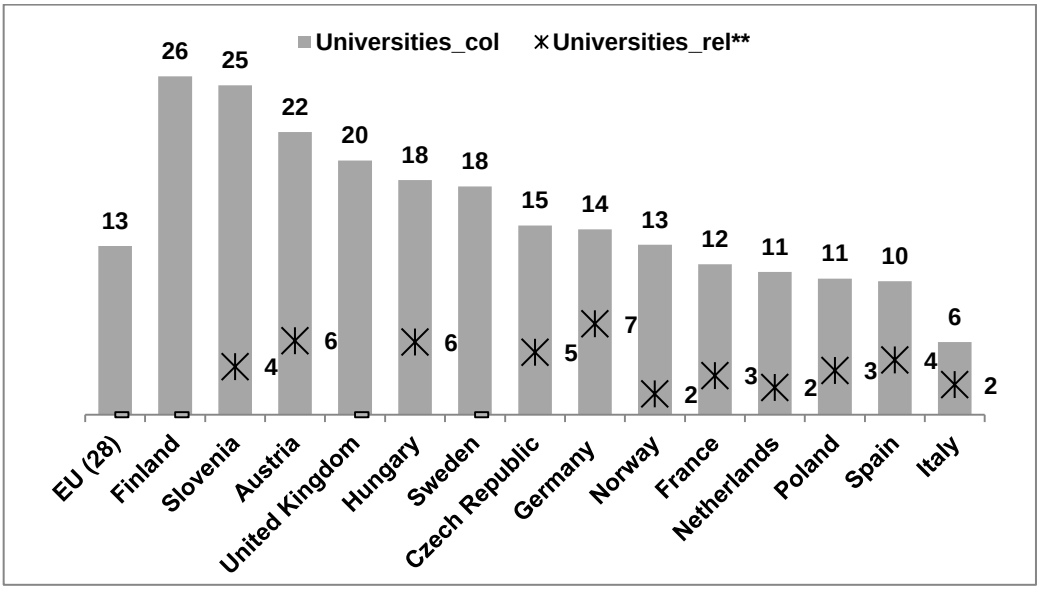
[27] Germany has currently 428 higher education institutions of which 108 are full universities and 216 universities of applied sciences.

In addition to the technology transfer offices in universities, so-called patent exploitation agencies or "*Patentverwertungsagenturen*", were created during the last decade at the level of regions to assist universities and academic inventors in choosing and implementing appropriate regimes of intellectual property protection (Geuna and Rossi, 2010). Since 2000, the number of academic inventor-owned patents has decreased in Germany, whereas university-owned patents have increased as a result of the new intellectual property rights regime (von Ledebur et al., 2009; Frietsch et al., 2012).

For innovator firms in Germany, universities are key external knowledge partners; in particular technical universities play an important role (Rammer and Hünermund, 2013). Key barriers for collaboration, found in the 2012 Community Innovation Survey, are the fear of unwanted knowledge spillovers (35%), followed by a lack of suitable partners (32%), no need to collaborate (30%), and high associated costs or a lack of time (26%).

In comparison with other European countries, the share of German firms collaborating with universities as external knowledge partners is above the EU-28 average, but below the leading countries Finland, Slovenia, Austria and the United Kingdom (Figure 4).

Figure 4. Universities as external knowledge partners (2010-2012, in %)



Source: European Commission, 2015, CIS 2012; own elaboration.
Notes: Stars indicate the percentage of firms, who stated that universities were their most relevant external source of knowledge.

However, in terms of the relevance of universities as knowledge partners, half of the German firms, which stated to have collaborations with universities, also stated that universities were their most important knowledge partners (Figure 4, above). This is highest share of all 28 countries in the sample.

5.3 Regional hubs of entrepreneurial start-up activities

The metropolitan areas of Berlin and Munich are key agglomeration economies in the country, both in terms of demographics and the density of local business support offers (May-Strobl, 2011).

5.3.1 Brief overview of recent economic development

Traditionally, Munich has been one of Germany's number one high technology regions (Sternberg and Tamasy, 1999; Lückgen et al., 2006). It has the broadest specialisation of high technology industries, with automotive industry (BMW), aerospace (headquarters of German Aerospace), electronic engineering (Siemens). These industries show the highest concentration rate in the Munich metropolitan area (Sternberg and Tamasy, 1999).

Table 4. Socio-economic indicators for Berlin and Munich (2011)

			Unemployment rate		Firms in sectors B, N, P-S	
	Inhabitants	HEI graduates	Youth	Total	Total	Per 10.000 inhab.
BMA	3.332.600	692.490	13.4%	13.3%	171.157	514
MMA	1.685.775	422.760	2.75%	4.0%	124.793	740

Source: Destatis (2014), Regionalstatistiken; own elaboration. Number of inhabitants and firms per 10.000 inhabitants are shown for the 2011 census data.

During the last decade, Berlin has seen a rapid increase in venture capital investment deals, reflecting its increasing economic development path (Metzger et al., 2010). In 2012-2013, around 600 firms in Berlin received around two billion EUR of private venture capital investment (Scheuplein et al., 2014). Key sectors are information and communication technology, software development and E-commerce. More than half of the VC funds came from foreign investors, based in London, Moscow, and the Silicon Valley.

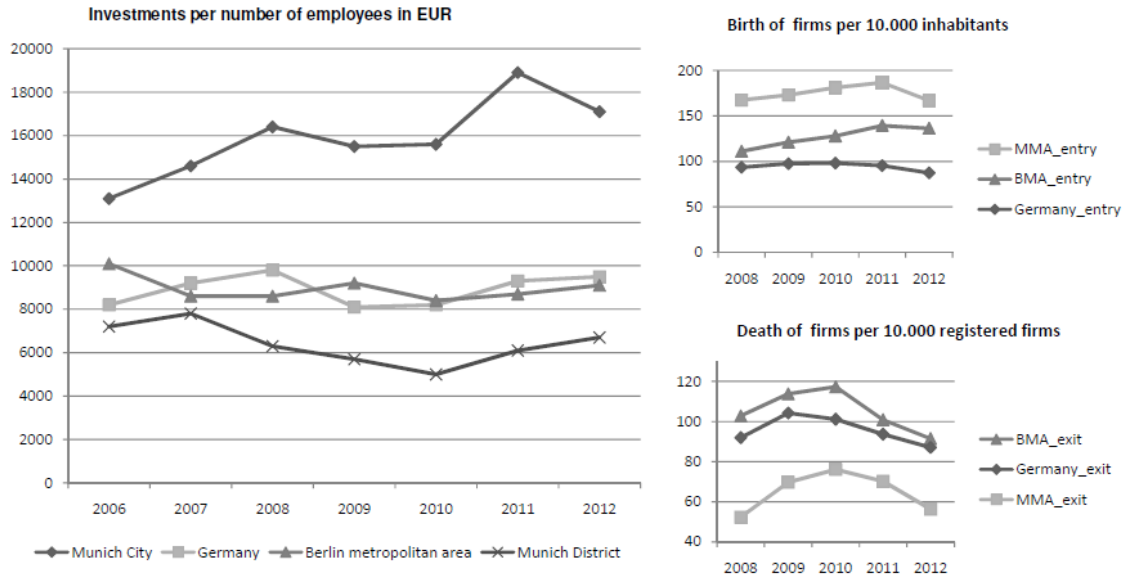
Since 2010, Berlin became also one of the key locations in Germany for venture capital companies holding close to 10% of all German VC deals in the country. This is only superseded by Munich, which still accounts for approximately 27% (Scheuplein et al., 2014).

From the latest data, covering the period 2008-2012), firm birth rates are following downwards trends in both locations. The same trends are noted for death rates, thus leading to a rather stable business sector (Figure 5, below).

In both local economies birth rates were above the national average. In Berlin business death rates were slightly above the national average but with a converging trend. Business death rates for Munich are significantly below the national average, with an increase in the period 2008-2010 and a continuous decrease since then.

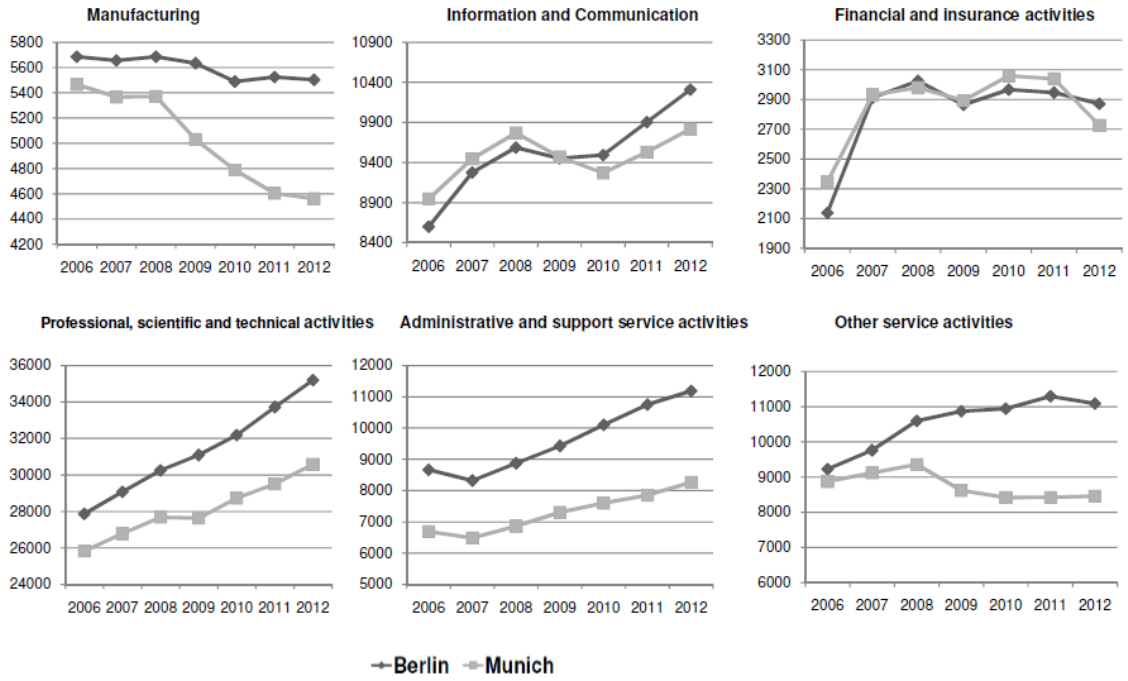
Looking at the business investment rates per number of employees (Figure 6, below), a significant difference between the City of Munich and the district of Munich can be noted (both are considered in this thesis as constituting the Munich metropolitan area). Over time, the business investments rates in Munich City are almost double the national average, whereas they are one-third below for the district area.

Figure 5. Business statistics for Berlin, Munich and Germany (2006-2012)



Source: Destatis (2014), Regionalstatistiken for several years; own elaboration.

Figure 6. Sector statistics for Berlin, Munich and Germany (2006-2012)



Source: Destatis (2014), Regionalstatistiken for several years; own elaboration.

Investment rates in Berlin have been developing stable along with the national average. Absolute numbers of incumbent businesses in various sectors are higher in Berlin. The two-fold size difference in numbers of inhabitants between the two local economies, is, however, only reflected in service sectors (Figure 6 above).

Manufacturing sectors have seen a steep decline in Munich since 2008. For both local economies, the year 2008 has been a turning-point for research in the sectors "Information and Communication, and "Financial and Insurance", which have shown signs of decline until a reverse development as of 2010. Instead, business activity in professional, scientific and technical activities and the sector administrative and support services has increased in both places since 2006/2007. As for manufacturing, we can see a gap between the local economies

also for the sector "Other Service Activities", which has declined in Munich since 2008, but increased in Berlin.

5.3.2 Entrepreneurship promotion in universities

The metropolitan areas of Berlin and Munich have the highest concentration of universities and higher education institutions (HEIs) in Germany. There are 49 public and private HEIs in Berlin and 24 in Munich (Kulicke, 2014).

All main public universities in Berlin and Munich have established dedicated organisational units to promote entrepreneurship. The majority of these centres were created during the last five to seven years. At the main public universities systematic activities to promote and support business start-ups date have been offered to academic staff and students for up to 15 years (Table 5, below).

Table 5. Entrepreneurship promotion at public universities in Berlin and Munich

University	Entrepreneurship education since	Start-up support*	Manager in 2012 since
Free University of Berlin	1999	1998	2004
Humboldt University of Berlin	2006	1998	2006
Technical University of Berlin	2006	1998	2004
Ludwig Maximilian Univ. (Munich)	1998	1998	2004
Munich University of Applied Sciences	2003	2000	2006
Technical University of Munich	2003	1998	2003

Source: Own interviews with entrepreneurship centre managers; November 2012 – February 2013.

Notes: *Start-up support started as part of the university´s technology transfer activities and where later integrated into the entrepreneurship centre, sometimes also providing a justification for the latter´s creation.

All managers, except for one, have been in their job since the establishment of the centres. They have played a key role in shaping the centres's mission and activities. Personal

interviews conducted for this thesis revealed that the managers play a central selective role in connecting start-ups with investors. The managers of the entrepreneurship centres are involved in large networks of business support organisations, maintaining key positions. All entrepreneurship centres maintain databases of contact details and brief company profiles.

5.3.3 Venture capital providers and business plan competitions

In this thesis, we utilised an expert-assessment of the novelty of the business conception and its appropriability potential as the main source to identify the target population for this study.

The following organisations, providing such expert-assessment, were chosen:

(1) High-Tech Gründerfonds (HTGF);

(2) Public and private venture capital firms in Berlin and Munich;

(3) Business idea and business plan competitions in Berlin and Munich; and

(4) Entrepreneurship centres at the main public universities in Berlin and Munich.

Three reasons motivated this choice. The first reason was the general coverage of the organisation; in this regard the HTGF as the largest semi-public venture capital provider in Europe (Debackere et al., 2014) has the greatest scope. The second reason was the geographical coverage of organisation; since the HTGF has a German-wide portfolio, it was decided to choose as locations for the business plan competitions and the university entrepreneurship centres the metropolitan areas of Berlin and Munich, in order to have a target population with three major geographical coverage areas, that is, Berlin, Munich and Germany elsewhere.

The third, and most important reason, was the comparability of the criteria, which these organisations apply to assess the innovation potential of business ideas. In order to gather confirmatory information about this, a two-step approach was undertaken. In a first step, the information provided on the Internet about eligibility criteria, assessment criteria and portfolio firms was analysed. In a second step, interviews were conducted, either face-to-face or by telephone[28] with the directors and chief executive officers of these organisations to gather additional information about the assessment criteria, and primarily, to build a database of entrepreneurial firms. In this way, the names of 309 firms and their chief executive officers were retrieved. A subsequent research of firm websites and entries in the federal Germany business register revealed that 18 firms had ceased activity. These firms were excluded from the final study population, which included 291 firms.

Assessment criteria

All expert-assessment organisations included in the study, apply a similar set of assessment criteria (Table 6, below). Common assessment criteria are the personal profile of the applicant/s, new markets, business models, and growth potential of the business idea. Instead, technology intensity, attractiveness of financing, and the proposed organisational structure of the firm, are only assessed by some of the organisations.

[28] The interviews were conducted in the period November 2012 to January 2013. Face-to-face interviews lasted between 60 minutes and 120 minutes, and telephone interviews approximately 45 minutes.

Table 6. Evaluation criteria applied by the selected expert-assessment organisations

Organisation	Personal profile	New markets	Business model	Techno-logy	Growth potential	Financial attractive-ness	Firm organi-sation
HTGF	xx	xx	xx	xx	xx	xx	xx
VC Fonds Berlin	xx	xx	xx	x	xx	xx	xx
Venture Capital Club Munich	xx	xx	xx		xx	xx	
EXTOREL	xx	xx	xx	xx	xx	xx	xx
BPC Berlin-Brandenburg	xx	xx	xx	x	x	x	xx
BPC Munich	xx	xx	xx	x	x	x	
Entrepreneurship centres	xx	xx	xx		x		

Source: Own interviews; November 2012 – February 2013.
Notes: xx denotes key assessment criteria, x additional assessment criteria. Missing x indicates that these were not part of the criteria applied to assess the novelty and appropriability of a business idea.

The HTGF favours technology-based over non-technology based business ideas, as does EXTOREL, a private venture capital firm located in Munich. The entrepreneurship centres of the public universities in Berlin and Munich apply a non-discriminatory approach, which assesses primarily the potentials to reach or create new markets, for example through a new business model, regardless of the technology intensity of the business idea. A similar approach is applied by the business plan competitions (BPC) in Berlin and Munich.

A central criterion for venture capital providers is the financial attractiveness of a business idea, that is, how much private financing a business idea is expected to attract. The proposed organisation of the firm was included into the assessment criteria, as an approximation of the entrepreneurial capacity to plan, organise and delegate, by the HTGF, the VC Fonds Berlin and the BPC Berlin.

In the following, these expert-assessment organisations are briefly presented. The entrepreneurship centres of the public universities in Berlin and Munich have been presented earlier in this Chapter.

High-Tech Gründerfonds

The High-Tech Gründerfonds (HTGF) is the largest semi-public venture capital provider in Europe (Debackere et al., 2014). It was established by the German federal government as a public-private partnership in 2005. The Ministry of Economics and Technology and the KfW Banking Group are the main public investors, overseeing up to a dozen private investors from various industries, such as Deutsche Telekom, Siemens, BASF, Deutsche Post, Daimler, Metro Group and others.

Key partners of the HTGF are universities, research organisations, and business plan competitions (HTGF, 2014a).To increase the deal flow, the HTFG works closely with the technology transfer offices of universities across Germany and maintains a large network of professors and scientists, who act as coaches (Debackere et al., 2014). Networking and access to knowledge are key support elements offered in addition to financial investment.

Eligible firms are at maximum one year old and have their headquarters or a subsidiary in Germany. During the seed phase, the HTGF provides up to EUR 500 000 risk capital for a share of 15% without valuation and a possible follow-up funding of 1.5 million. Investees have to provide 20% of the HTGF seed risk capital; 10% if firms are located in the eastern Länder and Berlin. Up to half of the amount can be financed through business angels, government loans and private investors (HTGF, 2014a).

HTGF's key investment areas are (i) automation and electronics, (ii) cleantech, (iii) enabling technologies, (iv) information and communication technology, (v) and life sciences. The assessment of a financing proposal focuses on the technological basis of the business idea, a convincing business plan which explains how the management team seeks to implement the business idea, and the presence of an able management team (HTGF, 2014b).

The assessment and appraisal process has three stages (HTGF, 2014b). First, the applicants submit their documentations after eventual contacts with a HTGF investment manager. The documentation is reviewed by a group of technology and financing experts, and successful applicants are invited for a personal interview. Upon successful completion, the business plan undergoes a so-called due diligence check by external financing experts.

Business plan competitions in Berlin and Munich

The first editions of the business plan competitions in Munich and Berlin were organised in 1996/97. Both competitions follow a three-stage model, which lasts up to seven months, usually from January to July every year. The focus in the first phase is on the business idea and future clients. In the second phase, this is deepened by identifying market potentials and marketing approaches. The third phase focuses on financing. During each phase, applicants get expert coaching, which is often supported by local universities. Winners are awarded in each phase.

The jury includes technical and financial experts, who rate the applications for their growth potentials and attractiveness for financing. The Business Plan Berlin-Brandenburg

introduced as additional criteria the proposed internal organisation of the firm and offers, to this end, seminars and individual coaching (BPW, 2015).

Other venture capital providers in Berlin and Munich

To balance the study population for an eventual bias towards firms with their origins in university environments, other public and private venture capital providers, located in Berlin and Munich, were included as expert-assessment organisations. These are the VC Fonds Berlin, the Venture Capital Club Munich, and EXTOREL. In the following, their portfolios and selection criteria are briefly described.

The VC Fonds Berlin was created in 2004 as full subsidiary of the public investment bank of Berlin (Investitionsbank Berlin). To date more than 150 investments have been made into innovative technology start-ups and incumbent firms located in Berlin. The focus is on creative industries, information and computer technology, life sciences, and industrial technologies (IBB, 2014). The evaluation criteria are similar to those of the Business Plan Competition Berlin-Brandenburg, that is, novelty of the business idea, personality profile, proposed firm organisation, and attractiveness for additional financing.

The Venture Capital Club Munich, founded in 2006, is an association of more than 30 local venture capital and private equity providers, banks and local firms. Membership is open to individuals and organisations. Every six weeks, meetings are organised during lunch time with short expert presentations on various aspects of venture capital investments, followed by two pitch-style presentations of innovative start-up and incumbent firms. If interest is raised, longer presentations are organised with potential investors. Central assessment criteria in the

first round are the novelty of the business idea and the personality of the presenter, whereas a rigorous check of the growth potential follows in the second assessment phase.

EXTOREL is a private investment fund located in Munich. It is listed in international venture capital ratings and has a highly selective portfolio of high technology firms in laser and nanotechnology, Internet technology and new media, and clean technology. Investing primarily as a minority shareholder, key selection criteria for EXTOREL are the financial attractiveness and the growth potential of a business idea.

CHAPTER 6

PRESENTATION OF THE SAMPLE

In this Chapter, the study sample is presented in three sections, of which the first explains the sampling approach and the administration of the survey, and provides an overview of the responses. The second section provides a brief overview of the sample firms in terms of key characteristics, such as age, size, growth, and firm organisation. The concluding section provides a comparison of these characteristics for the three geographical sample locations.

6.1 Sampling frame, survey administration and response

Given the relative small size of the study population, the applied sampling frame included the entire target population of 291 firms.

Data collection was done through an online questionnaire[29] and complementary telephone interviews. In the beginning of April 2013, all chief executive officers of the 291 firms were contacted with a personal email, which explained the purpose of the study and the time requirements for participation. To increase the response rate, an individual report was offered on the firm specific information, solicited from a fully completed questionnaire. A report on anonymised data from a firm located in Munich, which participated in the pilot test

[29] The questionnaire was programmed on Sosci, an open-source questionnaire software, which was developed by the Ludwig-Maximilian University in Munich. The questionnaire was accessible at https://www.soscisurvey.de/Berlin_kmandlearning_2a from it was functional from 15 April 2013 to 15 July 2013.

of the questionnaire, was available for downloading on the website, which hosted the questionnaire. In addition a raffle was announced.[30]

Between April and July 2013, two personal follow-up emails, reminding about the survey were sent, each with approximately three weeks distance; 53 questionnaires were collected in response. Although the telephone interviews served primarily to increase the survey response rate, however, complementary information was gathered from firm managers regarding the relationships with external sources of knowledge.

The average completion time was below ten minutes (M = 9.36; SD = 3.03). Respondents were given the possibility to return at a later point in time to continue with or to complete the questionnaire; 20 questionnaires were only partly completed and thus excluded from the analysis. In total 106 (36.4%) firms participated in the survey, 185 (63.6%) did not participate.

6.1.1 Non-response bias

In order to detect sample selection bias, the participation status was used as the dependent variable in bivariate tests, using Mann-Whitney U tests to compare participants and non-participants (Cuddeback et al., 2004). Results indicated no differences between participants and non-participants in terms of sample source, sector, firm age, nor in the 2012 sectorial reference values for R&D investments and turnover percentages due to product innovation. A sample bias was detected for location: firms in Berlin were less likely to

[30] Amongst all fully completed questionnaires, three "Du&Ich" vouchers of Jochen Schweizer were raffled, each with a market value of EUR 110.

participate and firms from elsewhere in Germany were more likely to participate then their expected values (See Annex A for the test statistics).

6.1.2 Respondents

Respondents were either part of firm management in the end of 2012 (77; 89.5%) or employees (9; 10.5%). The majority in the firm management respondent group (68; 88.3%) were firm founders. Managers had entered the firm either in the 2-3 year of existence, and employee respondents had joined the firm on average during the third year (M = 3.26, SD = 2.04), and carried out half of the key innovation tasks (Mdn = 3; IQR = 2). Hence, it can be assumed that the respondents have been sufficiently informed to respond to the questionnaire. Respondents in the firm management group carried out on average six tasks (Mdn = 6; IQR = 1). A Mann-Whitney U test shows that the difference between the two groups is statistically significant (Z = 4.378; p = 0.000; r = 0.47).

6.2 Brief overview of sample firms

The average/typical sample firm belongs to the knowledge-intensive service industry.[31] In 2012, sample firms have been, on average, in their third year of existence (M = 2.58; SD = 0.988) and have undertaken five parallel innovation projects (Table 7, below).

[31] We built on Pavitt's (1984) taxonomy of innovative firms, and adopted the classification from the Oslo Manual (OECD 1993; 2006), which distinguishes between High-technology (HT), Medium-high-technology (MHT), Low-technology (LT), Knowledge intensive services (KIS), and Less-knowledge intensive services (LKIS).

The average size of sample firms, measured in the total number of full-time and part-time employees in the end of 2012, is nine (IQR = 10); the smallest firm had one employee and the largest 70 employees.

Table 7. Key characteristics of sample firms

Characteristics	**Absolute numbers**	**%**
Location		
Berlin metropolitan area	21	24.4
Munich metropolitan area	27	31.4
Germany elsewhere	38	44.2
Sector (1)		%
High-technology (HT)	7	8.1
Medium-high-technology (MHT)	15	17.4
Knowledge intensive services (KIS)	46	53.5
Less-knowledge intensive services (LKIS)	18	20.9
Firm age		
1st year	12	14.0
2-3 year	31	36.0
4-5 year	24	27.9
6-8 year	19	22.1
Firm size		
1-5 employees	24	29.9
6-9 employees	23	26.7
10-19 employees	24	27.9
20-49 employees	11	12.8
≥ 50 employees	4	4.7
R&D intensity	**M**	**SD**
Share of employees tasked with the acquisition of new knowledge	0.59	0.275
Innovation activity in 2012		
Total number of innovation projects(2)	5.22	2.209

Notes:

(1) HT: NACE 2-rev 21 (number of firms: 1); 26 (6); MHT: 20 (1); 27 (1); 28 (3); 32 (6); 35 (4); KIS: 62 (21); 71 (5); 72 (15), 58 (1), 63 (1), 70 (1); LKIS: 46 (5); 47 (3); 82 (4); 94 (1); 96 (5)

(2) Maximum number of innovation projects was set at eight, i.e. four types of innovation activity with a new and incremental stage each.

If we compare the number of employees with the age of the firm in the end of 2012, we can see an increase of the number of employees over time (Table 8 below). Sample firms in their first year of existence had on average five employees (IQR = 5), with a minimum of

one employee and a maximum of 25 employees. The average number of employees in the age group 2-3 year was nine (IQR = 7), also the age group 4-5 year (IQR = 11); firms in the age group 6-8 years had 15 employees (IQR = 20).

Table 8. Firm size and growth across age groups

		Descriptive statistics			
		Median	**IQR**	**Minimum**	**Maximum**
Number of employees					
	1st year	5	5	1	25
	2-3 year	9	7	1	30
	4-5 year	9	11	2	70
	6-8 year	15	20	2	67
	All	*9*	*10*	*1*	*70*
Employment change					
	1st year	0.0	0.0	-0.25	1.67
	2-3 year	1.0	2.83	-0.50	9.00
	4-5 year	2.0	3.15	-0.64	16.50
	6-8 year	4.4	3.70	-0.67	12.40
	All	*1.33*	*4.00*	*-0.67*	*16.50*

Employment growth follows the from extant research expected increase. Firms had, on average, achieved a 100%-increase in their number of employees by their 2-3 year of existence (Mdn = 1.0; IQR = 2.83) and quadrupled by when they had reached their 7th year (Mdn = 4.4; IQR = 3.70). A Kruskal-Wallis test shows that these variations are statistically significant $\chi^2(3, N = 86) = 19.605$, $p = 0.000$. Mann-Whitney post-hoc tests with Bonferroni corrections, show significant differences for all firm age groups, except for the groups 2-3 year and 4-5 year.

More than half of the firms (46; 53.5%) had a simple organisation with no subunits headed by managers other than the entrepreneur. Firms, which were organised in subunits, had on average three units with separate managers (SD = 1.148). Firm organisation varied in terms of firm age and the number of employees, but a statistically significant difference was only found for firm size, $\chi^2(4, N = 86) = 27.885$, $p = 0.000$. Follow-up tests to the Kruskal-

Wallis test, applying Bonferroni corrections, showed significance for the differences between groups 6-9, 10-19 and 20-49 employees. Figure 7 (below) provides an overview.

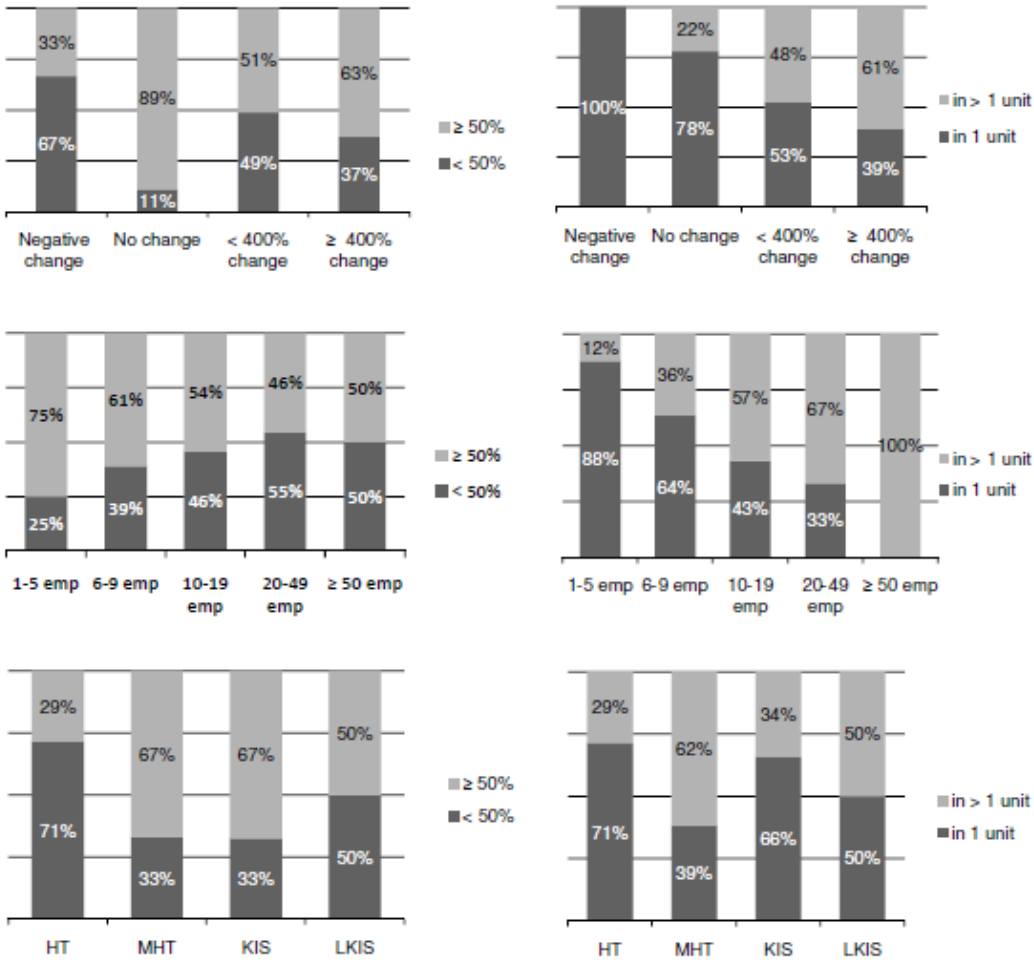
As a metric for the R&D intensity of a firm, we used, as introduced in Chapter Three, the share of employees tasked with the acquisition of knowledge that is new to the firm and/or the unit the employee works in. We limited research to application-oriented research and exclude curiosity-oriented research, which is undertaken, pursuing a private motivation, to acquire new knowledge for its own sake (Salter and Martin, 2001). Furthermore, information was collected on the organisation of R&D activities in one central unit versus different R&D teams working across the firm.

The average share of R&D employees in the sample was 0.59 (SD = 0.275); organisation in a central team was more practiced than having different R&D teams spread across the firm (M = 0.41; SD = 0.496). We found, using a Mann-Whitney test, that the organisation of R&D employees in teams is different from the organisation of the firm in subunits in that firms had more R&D units than subunits (Mean ranks $35.16_{\text{R\&D units}} - 18.20_{\text{subunits}}$; Z = 3.297, p = 0.001, r = 0.364). This suggests a dominant role of the entrepreneur in organising the key activities of the firm, which includes specialised teams, such as, for example R&D teams.

The share of R&D employees and the organisation of R&D activities varied with firm size and firm growth (Figure 7, below). The effect of firm growth on the share of R&D employees is higher ($\chi^2(3, N = 86) = 17.392$, $p = 0.001$) than the effect of firm size ($\chi^2(4, N = 86) = 14.826$, $p = 0.005$), as Kruskal-Wallis tests show. This could also be expected as firms absorb new knowledge with new employees, i.e., firm growth. Also, the smaller the firm is,

the higher the share of employees, which are tasked with the exploration of new knowledge. For the presence of R&D teams spread across the firm, the effect of firm size is greater ($\chi^2(4, N = 82) = 18.454$) than firm growth ($\chi^2(3, N = 82) = 10.332$, $p = 0.016$).[32]

Figure 7. Key R&D features of sample firm



[32] Post hoc Mann-Whitney tests, with Bonferroni corrections, confirm these results for the size groups 1-5 and 6-9 employees for both R&D intensity (Mean ranks $31.17_{1\text{-}5\ emp.} - 17.83_{10\text{-}19emp}$; $Z = 3.324$, $p = 0.001$, $r = 0.48$) and R&D organisation (Mean ranks $18.94_{1\text{-}5\ emp.} - 29.28_{10\text{-}19emp}$); $Z = 3.150$, $p = 0.002$, $r = 0.46$). For the R&D organisations differences are also statistically significant for the size groups 1-5 and 20-49 employees, and 1-5 and ≥ 50 employees, but not for the share of R&D employees. Firms, whose number of employees did not change since the end of their first year up to the end of 2012, had a higher share of R&D employees than firms with a positive increase in staff (Mean ranks $45.28_{No\ change} - 25.02_{\leq 400\%}$; $Z = 4.076$, $p = 0.000$, $r = 0.52$), this also holds for the last category, i.e. ≥ 400% change.

We also observed differences across the sectors. High-technology intensive firms in the sample have a lower share of employees, who are tasked with the acquisition of new knowledge, suggesting that these firms are more focused on exploiting knowledge which is already existing inside the firm. Also, R&D employees tend to be organised in few groups, rather than spread across the firm. In knowledge-intensive service firms, we can see a tendency towards a concentration in the organisation of R&D activities. However, it should be noted that due to the small sample size, we cannot go beyond speculations.

With regard to the intensity and organisation of R&D activities, we found no differences between spin-off firms and non-spin-off firms; also no statistically significant differences were found related to firm age.

6.3 Firm characteristics in the three spatial sample groups

In the following, a brief overview is provided of the above discussed key firm characteristics for the three spatial sample groups.

Sample firms, located in the metropolitan areas of Berlin (M = 2.86, SD = 1.66) and Munich (M = 2.96, SD = 1.99) were younger than firms located in Germany elsewhere (M = 3.66, SD = 2.31).

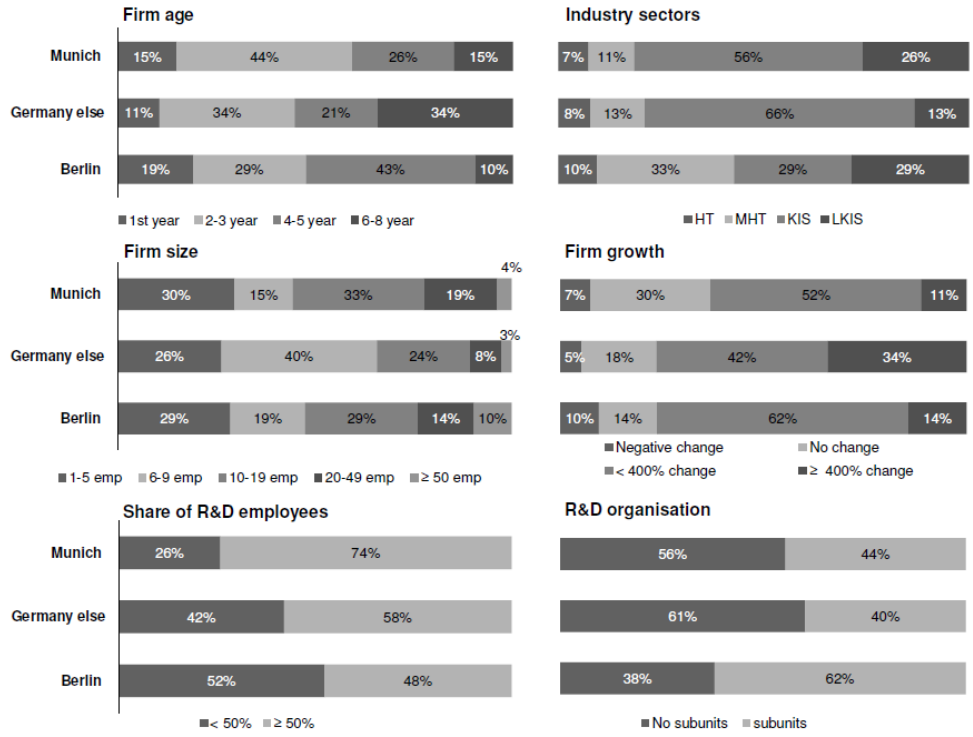
In terms of industry sectors, the largest share of firms, located in Munich and elsewhere in Germany, are part of knowledge-intensive services (56%; 66%). Regarding the size of firms, we see similar shares of the group 1-5 employees for the three geographical samples and also the other size groups are similarly distributed, except for the group 6-9

employees, which has a higher share in the groups of firms located elsewhere in Germany. This group also has a higher share of firms, who have increased their number of employees more than four times since the end of the first year.

The share of R&D employees is higher for firms located in Munich (M = 0.68; SD = 0.26), whereas firms in Berlin have more R&D teams spread across the firm.

Figure 8 below provides an overview. Descriptive statistics of key variables for the geographical samples can be found in Appendix A.

Figure 8. Key features of sample firms for geographical locations



CHAPTER 7

RESULTS FROM THE EMPIRICAL RESEARCH

This Chapter presents the results from the empirical research undertaken as part of the thesis, and is organised in five sections. After a brief presentation of the data analysis strategy applied in this thesis, the role of the entrepreneur in the innovation process is explored and the factors, which are influencing the intensity of h/er involvement and the types of tasks carried out, are identified and analysed. In section three, the innovation activity of the sample firms in 2012 is presented and examined for influencing factors. The fourth section is looking into the relationships of sample firms with external sources of knowledge, and the factors that influence the choice of partners and the perceived relevance of such partnerships for the innovation activity of the firm. The last section analyses the university links of the sample firms regarding influences related to firm characteristics and the university background of the entrepreneur.

Each section ends with a discussion of the results in light of the research questions and the assumptions derived from the review of relevant theories and extant studies earlier in Chapters Three and Four. Summary tables of test statistics are presented in these sections.

7.1 Data analysis approach

The approach to data analysis was chosen in response to the explorative nature of the research undertaken in this thesis. Regression modelling for categorical data was excluded,

after initial trials with (i) count data models for the role of the entrepreneur (inotask variable summing the number of tasks as dependent variable), and the number of parallel innovation projects, and (ii) ordered logit models for the share of innovation projects with external knowledge partner involvement (Tutz, 2012).

The main reason was the small size of the dataset (86 firms) and the breath of variables. To overcome the first obstacle, various summary variables were constructed; they will be introduced in the subsequent sections along with the analysis of the data. To respond to the second characteristic of the sample, i.e., the wide range of variables, and to analyse which of these influence our four areas of research – i.e. the entrepreneur's involvement in the innovation process of the firm, the innovation activity of the firm, relationships with external sources of knowledge, and university links – we decided to apply nonparametric statistical methods. These are based on statistical tests of the ranks of the data, associated estimates and confidence intervals (Hettmansperger and McKean, 1998). The main advantages of using nonparametric procedures are that they are distribution-free and relatively insensitive to outlying observations as they are based on the ranks of observations (Hollander et al., 2013).

We used three types of non-parametric tests for the bivariate analyses. To test for differences between two groups on a single, binary variable, we used the Mann-Whitney U test, which is the non-parametric version of the parametric t-test (Hollander et al., 2013). It is applied when data does not meet the assumptions of the t-test. For ordinal variables with more than two levels, we used the Kruskal-Wallis test, which is an extension of the two-group Mann-Whitney U test. It is the nonparametric version of the one-way ANOVA (Hollander et al., 2013). Our sample fulfils the assumptions of these tests, namely: distributions of the test

variable are continuous and have identical form and that cases represent random samples from the population, and scores on the test variable are independent from each other.

As post-hoc tests to a Kruskal-Wallis test, we undertook Mann-Whitney U test and applied Bonferroni corrections using a simple sequential rejective multiple test procedure (Holm, 1979) with adjusted p-values, corresponding to a 0.5 threshold p-value.

For comparing variables in dependent samples, we used Kendall's coefficient of concordance W to assess agreement in the rankings of multiple raters. It is a measure to evaluate the degree of agreement between a sets of ranks for several subjects (Sheskin, 2011). We applied this to analyse, for example, the preferences of knowledge partners across different types and stages of innovation projects.

7.2 The role of the entrepreneur

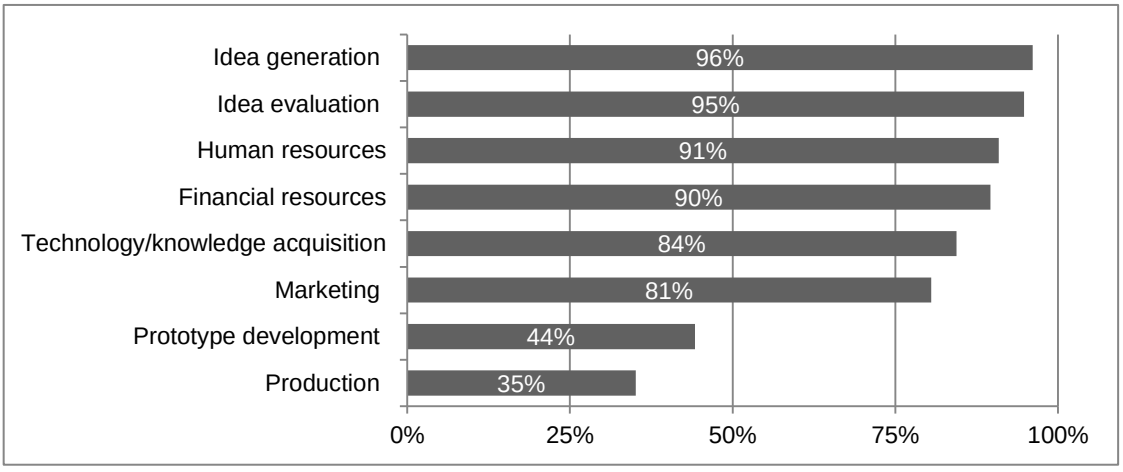
In this section, we will explore the role of the entrepreneur in the innovation process and identify factors, which influence the intensity of involvement and the type of tasks carried out.

We adopted from the literature the understanding that entrepreneurial firms are based on cognitive leadership, which the entrepreneur exerts by translating the subjective means-ends framework into a business conception and, over time, into a sustained shared cognitive focus, which is expected to enhance the accumulation and utilisation of productive knowledge inside the firm.

Hence, we expect the entrepreneur to play an important role in the innovation process of the firm. We measured this with the number of key tasks undertaken by the entrepreneur in the innovation process as an approximation of the intensity of h/er involvement in the innovation process and constructed a summary variable of the eight tasks, for which we solicited information from the questionnaire: idea generation, idea evaluation, acquisition of financial, human and technology/knowledge resources, prototyping, production and marketing. The summary variable *inotask* has an acceptable level of reliability at $\alpha = 0.615$ (Christmann and van Aelst, 2004).

Firms in the sample showed a high intensity of the entrepreneur's involvement in the innovation process (M = 6.16, SD = 1.405). On average, entrepreneurs undertook six of the eight tasks. With regard to single tasks, involvement was highest for idea generation (M = 0.96, SD = 0.195) and idea evaluation (M = 0.95, SD = 0.223), followed by the acquisition of human resources (M = 0.91, SD = 0.289), and financial resources (M = 0.90, SD = 0.307). Less than half of the entrepreneurs in the sample were involved in prototype development (M = 0.44, SD = 0.500) or production (M = 0.35, SD = 0.480) (Figure 9).

Figure 9. Key tasks of the entrepreneur in the innovation process



7.2.1 Influences on the entrepreneur's involvement in the innovation process

In the following, we will analyse different sources of influence on role of the entrepreneur in the innovation process, and its intensity. We distinguish between influences related to:

- *Firm characteristics*: location, sector, size, employment growth, firm organisation, R&D intensity and organisation, and whether the firm is a university spin-off;
- *Personal characteristics of the entrepreneur*: age, gender, university history – including university degree, university employment experience, doctoral degree, and contacts maintained with the alma mater since firm foundation – and attitudes towards knowledge in one's own and other disciplines, communication in the firm, and membership in networks;
- *Innovation activity*: number of innovation projects, types and stages of innovation activity.

Influences of firm characteristics

We found that R&D intensity and R&D organisation seem to influence the entrepreneur's involvement in the innovation process. In firms, with more than half of their employees tasked with the acquisition of new knowledge, the entrepreneur was more likely to be involved in the acquisition of financial resources than firms with lower R&D intensity. In firms with a centralised organisation of R&D activities, entrepreneurs were more likely to be

involved in production. In university spin-off firms, the intensity of the entrepreneur's involvement in the innovation process was lower than in other firms.

Influence of the entrepreneur's personal characteristics and attitudes[33]

Before analysing whether the personal characteristics of an entrepreneur influence h/er role in the innovation process, we shall briefly present key aspects of the entrepreneur respondents in the sample.

Entrepreneurs belong, on average, to the age group 35-44 years (SD = 0.903), and, except for two, all have a university degree. The most frequent university discipline groups were engineering (35%) and natural sciences (21%), followed by economics and business (14%), medical and health sciences (8%); last ranked humanities and social sciences (5%; 4%).[34] All entrepreneurs had maintained contacts with their alma mater, and almost two-thirds (47; 61%) had gained working experience at a university.[35]

The median time difference between graduation and firm entry/foundation is seven years (IQR = 12) with approximately one-third of the entrepreneurs had graduated less than five years ago, and another one-third more than ten years ago.[36] We found indications that the age of the respondent influences the timing of venture creation: the younger the respondent, the shorter the time distance between university graduation and firm foundation ($\chi^2(3, N = 61)$

[33] The analysis of personal characteristics was carried out only for the respondents who were part of the firm management in the end of 2012, either as a firm founder or a hired manager. This group includes 77 respondents.

[34] Study disciplines were classified following OECD (2011), Frascati Manual.

[35] The questionnaire did not specify which type of employment experience this involved.

[36] The maximum time difference between university graduation and firm foundation was 38 years. One respondent was still studying.

= 36.476, p = 0.000). Entrepreneur-founders in the age group 25-34 years (N = 18) had created the business, on average, within four years after graduation (M = 2.39; SD = 1.189), founders in the age group 35-44 years (N = 22) within ten years (M = 9.00; SD = 5.106).

With regard to the entrepreneur's role in the innovation process, we found no indication that the intensity of h/er involvement is influenced by age or gender. Looking into the eight key tasks separately, we found that age is influencing the involvement in marketing in that younger entrepreneurs were more involved in marketing than older ones. Male entrepreneurs (67) were more often involved in idea evaluation than female entrepreneurs (10) in the sample.

The two main sources of influence related to the personal characteristics of the entrepreneur were found in the university background of the entrepreneur and h/er attitudes towards knowledge, communication in the firm and membership in external networks. In particular, the involvement of the entrepreneur in idea generation was found to be influenced by several aspects of the entrepreneur's university background.

- *Contacts maintained with alma mater*: Entrepreneurs, who had maintained contacts with people from their alma mater, belonging to different disciplines than their own, were more likely to be involved in idea generation than entrepreneurs without such links.
- *University employment*: Entrepreneurs with university employment experience were more likely to be involved in idea generation than other entrepreneurs.
- *University discipline*: Entrepreneurs with a background in engineering were more likely to be involved in idea generation than others.

As introduced in Chapter Three, we measured the following attitudes of the entrepreneur: communication in firm, knowledge in own discipline, knowledge in other disciplines, wide network and narrow network with individuals and organisations outside of the firm. We found that the relevance assigned to internal and external knowledge networks influenced the entrepreneur's involvement in the innovation process. In particular, entrepreneurs, who attributed a high relevance to firm internal communication, were more likely to be involved in the acquisition of technology and knowledge resources, and of financial resources. Entrepreneurs, for who being part of a wide external network was highly important to their work, were more likely to be involved in marketing than others.

Influences of the firm's innovation activity

Both the different types and stages of the firm's innovation activity seem to influence the intensity of the entrepreneur's involvement in the innovation process and the tasks he/she carries out.

In firms, whose innovation activity included incremental product innovation, the intensity of the entrepreneur's involvement was higher than in other firms. In particular, the entrepreneur was more likely to be involved in marketing, and prototype development. Also, process innovations, in form of development or introduction of new processes, which are crucial to the core activities of the firm, seem to require a higher intensity of the entrepreneur's involvement in the innovation process. This was particularly reflected in the entrepreneur's involvement in the acquisition of technology and knowledge resources, whereas in firms, whose innovation activity included new product innovation, entrepreneurs were more likely to be involved in idea generation. We also found evidence that in firms

which were undertaking new or incremental marketing innovation, the entrepreneurs were more likely to be involved in marketing tasks themselves.

Also the development, introduction or further development of organisational structures, which aim at optimising the enhancement and utilisation of the knowledge and skills of employees, seem to require a higher intensity of the entrepreneur's involvement in the innovation process. In particular, entrepreneurs were more likely to be involved in the acquisition of new knowledge and technology resources.

7.2.2 Discussion of results

The sample firms showed a high intensity of the entrepreneur's involvement in the innovation process (M = 6.16, SD = 1.405). We measured this by the number of tasks carried out by the entrepreneur, which we computed as a sum variable from the following single tasks – idea generation, idea evaluation, acquisition of financial resources, human resource and technologies and knowledge, involvement in prototype development, production and marketing.

We thus assumed the entrepreneur to play a key role in organising the firm's innovation activity and formulated the following research questions: (i) Do firm characteristics influence the entrepreneur's involvement in the innovation process?; (ii) Do personal characteristics influence the entrepreneur's involvement in the innovation process?; (iii) Does the firm's innovation activity influence the entrepreneur's involvement in the innovation process?. We found confirmatory evidence for both questions.

Our starting point has been the assumption from extant literature that the entrepreneur seeks to accomplish the three-fold function of a creator, organiser and market-maker (Schoonhoven and Romanelli, 2001). The greater intensity of involvement related to organisational innovation, process innovation and marketing seems to support this assumption, which requires a greater role of the entrepreneur in building organisational structure, aligning tasks, and maintaining a governance competence that promotes the interplay of resources (Kogut and Zander, 1992). This does, however, not hold for spin-off firms, where entrepreneurs are involved in a lower numbers of tasks (M = 5.41, SD = 1.575).

We found no evidence that the firm characteristics or the personal characteristics of the entrepreneur influence the intensity of h/er involvement in the innovation process, but we found influences on single tasks. A higher R&D intensity seems to be related to the involvement of the entrepreneur in the acquisition of financial resources, and in firms were R&D activities were centralised in one unit, the entrepreneur was involved in production. Multivariate tests are needed to detect eventual correlations with the size and organisation of firms. Younger entrepreneurs were more likely to be involved in marketing than older entrepreneurs.

Finally we found influences related to the university history of the entrepreneur related to h/er active participation in idea generation; namely contacts maintained with people from other disciplines and university employment. Table 9 (below) provides an overview of the results.

Table 9. Influences on the entrepreneur's involvement in the innovation process

		Test statistic			
	Influence	**Mean ranks**	**Z**	**p**	**r**
inotask	Spinoff	$31.91 - 21.31_{\text{Spin-off}}$	2.351	0.019	0.31
M = 0.77	ProdF	$41.70_{\text{ProdF}} - 27.30$	2.220	0.026	0.25
SD = 0.181	ProcN	$42.52_{\text{ProcN}} - 30.20$	2.249	0.025	0.26
	OrgN	$43.59_{\text{OrgN}} - 33.78$	1.978	0.014	0.23
	OrgF	$43.91_{\text{OrgF}} - 33.69$	2.065	0.039	0.24
Idea generation (tidea)	Alma mater contacts	$39.50_{\text{otherdisc}} - 35.48$	2.275	0.028	0.26
M = 0.97	University employment	$40.50_{\text{uempl}} - 36.65$	2.197	0.028	0.25
SD = 0.162	Discipline	$16.50_{\text{Engineer}} - 12.63_{\text{other}}$	2.598	0.009	0.47
	ProdN	$39.93_{\text{ProdN}} - 32.80$	2.803	0.005	0.32
Idea evaluation (ideaev)	Gender	$39.85_{\text{M}} - 33.30_{\text{F}}$	2.247	0.025	0.26
M = 0.96					
SD = 0.162					
Financial resources (tfr)	R&D intensity	$41.36_{\text{RD>50\%}} - 35.30$	2.194	0.028	0.25
M = 0.89	Firm int. communication	$40.17_{\text{high}} - 30.17_{\text{low}}$	2.385	0.017	0.27
SD = 0.311					
Technology and knowledge (ttec)	Firm int. communication	$40.47_{\text{high}} - 27.89_{\text{low}}$	2.524	0.012	0.29
	ProcN	$41.50_{\text{ProcN}} - 32.72$	2.486	0.014	0.28
M = 0.84	OrgN	$43.12_{\text{OrgN}} - 34.31$	2.746	0.014	0.31
SD = 0.369					
Prototyping (tprot)	ProdF	$41.25_{\text{ProdF}} - 29.70$	2.086	0.037	0.24
M = 0.44					
SD = 0.500					
Production (tprod)	R&D organisation	$8.00_{\text{mult. R\&D teams}} - 3.50$	2.484	0.013	0.29
M = 0.36					
SD = 0.483					
Marketing (tmark)	Age	$22.49_{\text{35-44y}} - 12.33_{\text{55-65y}}$	2.759	0.006	0.50
M = 0.81	Wide network	$42.22_{\text{high}} - 31.43_{\text{low}}$	2.823	0.005	0.32
SD = 0.392	ProdF	$41.53_{\text{ProdF}} - 28.53$	2.943	0.005	0.36
	MarkN	$42.13_{\text{MarkN}} - 34.83$	2.063	0.039	0.24
	MarkF	$42.22_{\text{MarkN}} - 34.47$	2.185	0.014	0.25

Notes: Mann-Whitney U Tests; r calculated as $r = \frac{Z}{\sqrt{N}}$

7.3 Innovation activity

In this section, we will present the innovation activity of the sample firms in 2012, and discuss the factors that we found to influence the number and types of innovation projects.

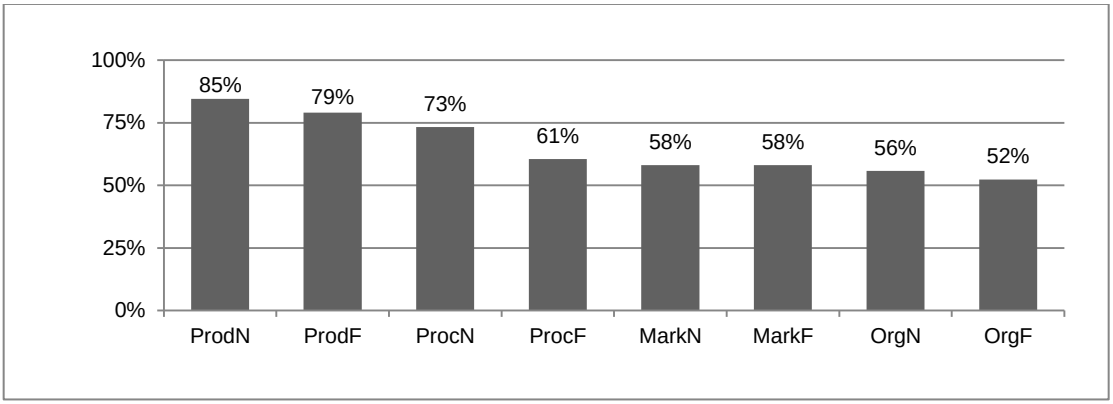
We distinguished between new innovation projects and incremental innovation projects, assuming that the new development of a product, process, marketing method or

organisational structure is likely to require different resources than the incremental or further development of already existing products, structures and practices.

To overcome difficulties in analysing data from a small sample as ours, we constructed three sum variables: (i) *inopro* for the total number of innovation projects (α = 0.74), (ii) *inopron* for the total number of new innovation projects (α = 0.61), and (iii) *inoprof* for the total number of incremental innovation projects (α = 0.72). The reliability, measured with Cronbach's Alpha, of all three variables is acceptable (Christmann and van Aelst, 2004).

In 2012, sample firms undertook several innovation projects in parallel (Mdn = 5; IQR = 5; Min = 1; Max = 8). Most frequently practiced was product new development (ProdN) (73; 85%), followed by the further development of existing products (ProdF) (68; 79%), and the new development of processes (ProcN) (63; 73%). Existing processes were further developed (ProcF) by 52 firms (61%), marketing innovation, both new and incremental innovations, by 50 firms (58%). Least practiced, yet still by more than half of the sample, was the new development of organisational structures (OrgN) (48; 56%) and its further development (OrgF) (45; 52%). Figure 10 provides an overview.

Figure 10. Innovation activity of sample firms in 2012



In the following, we will analyse influences on the innovation activity of firms related to the characteristics of the firm, in particular firm location, sector, age, size, firm growth, R&D intensity and organisation, and whether the firm is a university spin-off.

7.3.1 Influences on the innovation activity of firms

The number of innovation projects – both in total and in its new and incremental forms – did not vary across the three geographical sample location groups. Looking into the different innovation types, we found that the further development of organisational structures and processes was more practiced by firms located in Berlin, than other firms in the sample.

The practice of incremental organisational innovation also showed variations across the industry classification groups. Post hoc tests showed that firms in high-technology sectors are more likely to further develop their organisational structures than medium-high technology firms. Firms in knowledge-intensive sectors were more likely to practice organisational innovation than firms in less knowledge-intensive sectors.

We found no statistically significant difference in the total number of innovation projects related to the age of firms, but found that more younger firms in the sample undertook new organisational innovation projects than older firms.

Firm size was found to influence both the total number of innovation projects: the more employees, the higher the number of innovation projects. The effect on new projects was smaller than on further innovation projects. Post hoc tests show the greatest difference between firms with 1-5 employees and firms with 10-19 employees.

Firm growth rates were found to influence new product innovation, incremental process innovation, and marketing innovation. Post-hoc tests show that firms with negative growth rates were less likely to undertake product and marketing innovation activities. Firms, which did not increase their number of employees since the end of the first year, were less likely to further develop processes related to their core business activities or to change their marketing methods.

Firms, which were organised in subunits, were more likely to have a higher total number of innovation projects, and of incremental innovation projects than firms with no subunits. In terms of the different types of innovation activity, the following were more likely in case of a firm organisation in subunits: incremental process innovation; new organisational development, and its further development.

R&D intensity was found to have an ambiguous influence on the number of innovation projects. Firms, in which only up to 50% of their employees were tasked with the acquisition of new knowledge, had a higher number of total innovation projects, and of incremental innovation projects than firms with a higher R&D intensity. Instead, a decentralised organisation of the R&D activity, with R&D teams spread across the firm, was found to increase the total number of innovation projects, and the number of incremental innovation projects. In particular, the development of existing processes was more likely for firms with a decentralised R&D organisation, as well as new organisational innovation and further organisational innovation.

Spin-off firms in the sample had a lower total number of innovation projects in 2012 than other firms, and a lower number of new innovation projects. In particular, spin-off firms were less likely to undertake product innovation, and process innovation.

7.3.2 Discussion of results

We started our analysis from the understanding that because innovation rents tend to annulment over time, there is a continuous need for triggers and permutations to ensure novelty. Key sources of novelty can be both internal and external to the firm.

Firms are likely to couple innovation projects, that is, product with process development, introduction and improvement of market methods and organisational structures and procedures, into "internal networks" (Freeman, 1991).

At the same time, combining exploitation, that is, the refinement and improvement of already existing products and processes, with the exploration and discovery of new areas of potential business activity, is considered difficult because it requires the combination of different cognitive foci and related changes to organisational structures (Nooteboom, 2009).

Hence, there is a trade-off situation between combining innovation projects and focusing on given cognitive frameworks. We can assume two sources of influence. Firstly, firm characteristics, such as the age of an organisation, number of employees and its increase over time, market developments in the sector, and others, will influence the cognitive focus of a firm (Witt 2000, 2007).

We formulated this in two research questions: (1) Do firm characteristics influence the type and stage of innovation activity?; (2) Do firm characteristics influence the number of innovation projects?.

In 2012, sample firms conducted innovation several projects in parallel (Mdn = 5; IQR = 5; Min = 1; Max = 8). We found confirmatory evidence for both research questions. The parallel undertaking of innovation projects would correspond with the assumption that firms couple innovation projects (Freeman, 1991).

Firm characteristics influenced both the types and stages, and the total number of innovation projects. Firm growth, organisation in subunits, which are headed by managers or sub-entrepreneurs (Witt, 2007), and the organisation of R&D activities in decentralised teams spread across the firm, positively influenced the number and type of innovation projects.

R&D intensity, which we measured as the share of employees tasked with the acquisition of knowledge that is new to the firm or their unit was, however, found to have an inverse effect. Firms with a higher share (cut-point 0.5) had a lower number of innovation projects and less likely to undertake new product and process innovation. Also, university spin-off firms had a lower number of innovation projects, with the same pattern of innovation types.

These findings would support the assumption that implementing contemporaneously a higher number of (diverse) innovation projects is difficult because it requires the combination of different cognitive foci and related changes to organisational structures. Table 10 (below) provides an overview of the results.

Table 10. Influences on the innovation activity of firms

		Test statistic				
	Influence			**Z**	**p**	**r**
inopro	Firm size	K-W:	χ^2 (4, N = 86) = 15.398		0.004	0.43
M = 5.12	Firm organisation	M-W:	$50.54_{subunits}$ – 37.38	2.476	0.013	0.27
SD = 2.205	R&D intensity	M-W:	$51.12_{\leq 50\%}$ – $38.52_{>50\%}$	2.324	0.020	0.25
	R&D organisation	M-W:	$49.69_{R\&D\ teams}$– 35.70	2.666	0.020	0.29
	Spin-off	M-W:	$34.67_{Spin\text{-}off}$– 47.54	2.255	0.024	0.24
inopron	Firm size	K-W:	χ^2 (4, N = 86) = 10.466		0.033	0.35
M = 2.67	Spin-off	M-W:	$34.20_{Spin\text{-}off}$– 47.75	2.426	0.015	0.26
SD = 1.245						
inoprof	Firm size	K-W:	χ^2 (4, N = 86) = 12.529		0.014	0.38
M = 2.45	Firm organisation	M-W:	$52.13_{\leq 50\%}$ – $37.86_{>50\%}$	2.676	0.020	0.29
SD = 1.369	Firm organisation	M-W:	$50.20_{subunits}$ – 37.67	2.395	0.017	0.26
	R&D organisation	M-W:	$49.21_{R\&D\ teams}$ –36.04	2.538	0.011	0.28
ProdN	Firm growth	K-W:	χ^2 (3, N = 86) = 13.216		0.004	0.39
M = 0.85	Spin-off	M-W:	$37.26_{Spin\text{-}off}$– 46.36	2.527	0.012	0.27
SD = 0.360						
ProdF	R&D intensity	M-W:	$49.97_{\leq 50\%}$ – $39.29_{>50\%}$	2.785	0.006	0.30
M = 0.79						
SD = 0.409						
ProcN	Spin-off	M-W:	$35.89_{Spin\text{-}off}$– 46.98	2.494	0.013	0.26
M = 0.73						
SD = 0.445						
ProcF	Firm growth	K-W:	χ^2 (3, N = 86) = 7.988		0.046	0.31
M = 0.60	Firm organisation	M-W:	$49.75_{subunits}$ – 38.07	2.556	0.011	0.28
SD = 0.492	R&D organisation	M-W:	$49.56_{R\&D\ teams}$– 35.79	3.036	0.002	0.34
MarkF	Firm growth	K-W:	χ^2 (3, N = 86) = 9.979		0.020	0.34
M = 0.58	R&D intensity	M-W:	$51.38_{\leq 50\%}$ – $38.35_{>50\%}$	2.770	0.006	0.29
SD = 0.496						
OrgN	Firm age	K-W:	χ^2 (4, N = 86) = 7.950		0.047	0.31
M = 0.56	R&D organisation	M-W:	$46.94_{R\&D\ teams}$– 37.65	2.032	0.042	0.22
SD = 0.500						
OrgF	Firm location	M-W:	29.79_{B} – 20.39	2.672	0.008	0.29
M = 0.36	Sector	K-W:	χ^2 (4, N = 86) = 7.950		0.002	0.41
SD = 0.483	R&D organisation	M-W:	$47.03_{R\&D\ teams}$– 37.58	2.044	0.011	0.23

Notes: M-W: Mann-Whitney U Tests; r calculated as $r = \frac{Z}{\sqrt{N}}$

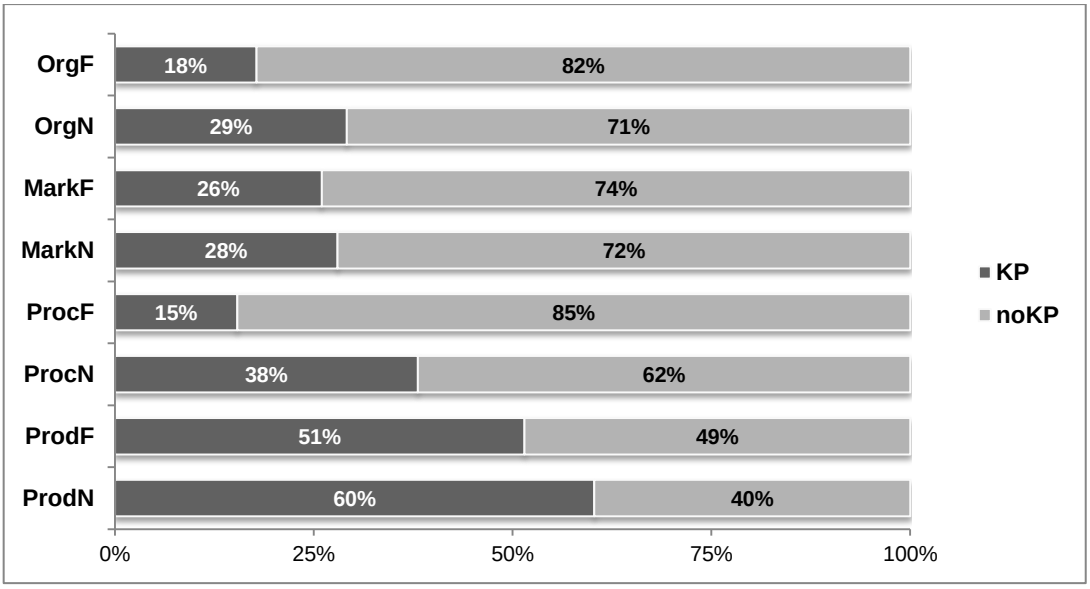
K-W: Kruskal-Wallis Tests; eta-squared values calculated as $\eta^2 = \frac{\chi^2}{N-1}$ and converted into r values following the method proposed in Borenstein et al. (2009).

7.4 Collaboration with external knowledge partners

In this section, we will present the relationships of the sample firms with external knowledge partners, and analyse which factors influence the choice of partners, in terms of type and location of partner, and perceived relevance of their contributions for the firm's innovation activity.

More than two-third of sample firms (62; 72.1%) collaborated in 2012 for their innovation activity with external knowledge partners. Involvement varied by type and stage of innovation activity (Figure 11, below). The highest involvement rate with was noted for new product innovation (ProdN), followed by incremental product innovation (ProdF), whereas the lowest rate of external knowledge partner involvement (KP) was noted for incremental process innovation (ProcF), which was practiced by 52 firms in the sample, but only eight (15%) stated to involve external knowledge partners (Figure 11).

Figure 11. Involvement of external knowledge partners in innovation activity



External knowledge partners were more likely to be involved in new innovation projects than in incremental innovation projects.[37] With a Kendall's W Test, we compared the preferences of knowledge partner involvement across multiple innovation projects, as most sample firms implemented multiple innovation projects in 2012. We found that the sum of external knowledge partner involvement in product new development ranked highest (6.27), followed by incremental product innovation (ProdN: 5.48), new and incremental marketing innovation and new organisational innovation, which ranked the same (MarkN, MarkF: 4.39), and ahead of process new development (ProcN: 4.20) and further development of organisational structures (OrgF: 3.66); last ranked incremental process innovation (ProcF: 3.48).[38]

With regard to the perceived relevance of external knowledge partner involvement, Kendall's W Test results showed that firms rate most relevant contributions to product new development (6.30), followed by ProdF (5.61), MarkN (4.25) and MarkF (4.25), OrgN (4.36), ProcN (4.23), OrgF (3.61), and ProcF (3.39) ranking last.[39]

More than half of the sample firms (46; 53.5%) had knowledge collaborations with universities, half (43; 50.0%) with firms from other sectors. Firms from same sector (39; 45.3%), business support organisations (37; 43.0%), and research institutes (36; 41.9%) were less frequent partners.

[37]A Wilcoxon Signed Rank Test for multiple related samples, shows statistical significance for product innovation ($Z = 2.111$, $p = 0.035$, $r = 0.28$), process innovation ($Z = 2.828$, $p = 0.005$, $r = 0.42$), and organisational innovation ($Z = 2.449$, $p = 0.014$, $r = 0.43$).

[38]Test statistics for Kendall's W Test: $\chi^2(7, N = 22) = 45.228$, $p = 0.000$.

[39]Test statistics for Kendall's W Test: $\chi^2(7, N = 22) = 52.363$, $p = 0.000$.

Firms stated to have multiple knowledge partners. When comparing the involvement rates of the 59 firms, who collaborated with external knowledge partners for their innovation activity, we found that firms from other sectors rank highest as external knowledge partners (3.53), followed by firms from the same sector (3.17), business support organisations (2.92), research organisations (2.87), and, last, universities (2.52).[40] A possible explanation for this is that collaboration with external knowledge partners is likely to serve multiple purposes. Universities and research organisations, however, provide knowledge and technology resources for specific purposes. Hence, these partnerships are likely to be more focused, with the transferred information being less likely to serve multiple purposes. Instead, relationships with other firms and business support organisations can serve multiple purposes.

We found that knowledge partners vary by type and stage of innovation activity (Table 11).

Table 11. Preferred knowledge partners across innovation projects

	Research org.	Univ.	Firms same sector	Firms other sectors	Bus. sup. org.	Test statistic
ProdN	2.86	2.42	3.12	3.60	3.00	$\chi^2(4, N = 50) = 24.593, p = 0.000$
ProdF	2.88	2.41	3.25	3.52	2.93	$\chi^2(4, N = 46) = 19.460, p = 0.001$
ProcN	2.88	2.39	3.11	3.61	3.01	$\chi^2(4, N = 44) = 22.176, p = 0.000$
ProcF	2.81	2.47	3.15	3.60	2.97	$\chi^2(4, N = 34) = 15.187, p = 0.004$
MarkN	2.71	2.69	3.40	3.33	2.88	$\chi^2(4, N = 24) = 7.897, p = 0.095$
MarkF	2.87	2.50	3.23	3.66	2.74	$\chi^2(4, N = 35) = 17.362, p = 0.002$
OrgN	2.80	2.49	3.03	3.61	3.07	$\chi^2(4, N = 35) = 16.808, p = 0.002$
OrgF	2.67	2.41	3.21	3.74	2.96	$\chi^2(4, N = 35) = 23.347, p = 0.000$

Involvement rates of KP groups in innovation activity per type

Notes: Mean rank values from Kendall's W Test.

Comparing the involvement rates of the different knowledge partner groups for the different types and stages of innovation activity, we found that firms from other sectors rank

[40] Test statistics from Kendall's W Test: $\chi^2(4, N = 59) = 21.597, p = 0.000$).

first for new product innovation, followed by firms from same sectors, and business support organisations; universities rank last. This pattern applies more or less to all types and stages of innovation activity.

Looking at the spatial dimension of the involvement of external knowledge partners, we found that the firm's local proximity was the preferred area for collaboration for all types and stages of innovation activity, except for incremental organisational innovation, where knowledge partners from elsewhere in Germany were preferred (Table 12). We should, however note that the sample sizes are very small and results should be treated with caution.

Table 12. Spatial preferences for knowledge partners

	Local proximity	Germany	Europe	Outside Europe	Test statistic
ProdN	3.15	2.83	2.10	1.92	$\chi^2(3, N = 44) = 42.106, p = 0.000$
ProdF	3.19	2.84	2.16	1.81	$\chi^2(3, N = 35) = 37.895, p = 0.000$
ProcN	3.21	2.71	1.96	2.13	$\chi^2(3, N = 24) = 22.865, p = 0.000$
ProcF	3.44	2.94	1.69	1.94	$\chi^2(3, N = 8) = 13.552, p = 0.004$
MarkN	3.32	2.89	2.04	1.75	$\chi^2(3, N = 14) = 19.286, p = 0.000$
MarkF	3.08	2.92	2.15	1.85	$\chi^2(3, N = 13) = 13.769, p = 0.003$
OrgN	3.18	2.61	2.32	1.89	$\chi^2(3, N = 14) = 13.154, p = 0.004$
OrgF	2.44	3.44	2.19	1.94	$\chi^2(3, N = 8) = 9.222, p = 0.026$

Notes: Mean rank values from Kendall's W Test.

After having presented the knowledge relationships of the sample firms in terms of types and stages of innovation activity and location, we shall next analyse two groups of influences: influences related to the characteristics of the firm, and influences related to the role of the entrepreneur in the innovation activity of the firm and h/er personal characteristics.

7.4.1 Influences on external knowledge partnerships

Influences of firm characteristics

Firms located in the metropolitan area of Berlin (BMA) were found to have more external knowledge partners from elsewhere in Germany than the other firms in the sample. One plausible explanation for this is the geographic position of Berlin, which is a City state and two of its boroughs have industry settlement areas, which belong to the neighbouring state of Brandenburg. Other than this, we see from a Kendall's W Test that knowledge partners in local proximity to the firm dominate for all three sample groups. Table 13 presents the results.

Table 13. Spatial preferences for knowledge partners per sample location

	Local	Germany	Europe	Outside Europe	Test statistic (Kendall's W Test)
BMA	2.93	3.25	2.04	1.79	χ^2 (3, N = 21) 17.139; p = 0.001
MMA	3.28	2.95	2.10	1.68	χ^2 (3, N = 27) 26.447; p = 0.000
GERelse	3.14	2.78	2.16	1.92	χ^2 (3, N = 38) 18.553; p = 0.000

Notes: Mean rank values from Kendall's W Test.

We also noted differences for the perceived relevance of the contributions of different external knowledge partners to the innovation activity of firms across the three geographical samples. Firms in Berlin rated collaboration with firms from other sectors highest and collaborations with firms from their own sector lowest. Firms located in Munich (MMA) rated universities highest, followed by firms from the same sector, and rated lowest the collaboration with business support organisations. Firms located elsewhere in Germany (GERelse) rated research organisations highest and universities lowest (Table 14, below). Statistically significant results were only obtained for the metropolitan area of Berlin.

Table 14. Preferences for knowledge partner type per sample location

	Res.org	Univ.	Firms same sector	Firms other sectors	Bus. sup. org.	Test statistic (Kendall's W Test)
BMA	2.57	3.59	1.71	4.07	3.36	χ^2 (4, N = 15) 10.262; p = 0.036
MMA	2.78	3.44	3.17	2.89	2.72	χ^2 (4, N = 18) 1.494; p = 0.828
GERelse	3.67	2.50	2.83	3.25	2.75	χ^2 (4, N = 13) 2.280; p = 0.684

Notes: Mean rank values.

The age of sample firms was found to influence the choice of external knowledge partners. Younger firms had more collaboration with business support organisations than older firms. Also, universities were more frequent knowledge partners for younger firms, whereas collaboration with research organisations was more practiced by older firms. The effect of age is the highest for university collaborations.

Firms, whose numbers of employees had not changed since the end of their first year of existence, had more often involved firms from other sectors and business support organisations in their innovation activity than firms, which had a positive employment growth rate. A possible explanation could be that business consultants were understood by respondents as firms from other sectors.

Firms, who had more than half of their employees tasked with the acquisition of new knowledge, rated the relevance of research organisations and universities as external knowledge partners higher than firm with a lower internal R& intensity. No effect was found related to the organisation of R&D activities.

Spin-off firms involved external knowledge partners more often in their innovation projects than other firms in the sample; in particular they collaborated more often with universities and also rated this collaboration higher than other firms.

Influences related to the entrepreneur

Firms, with a high intensity of the entrepreneur's involvement in the innovation process – that is, the entrepreneur was involved in more than five of the eight key innovation tasks – had a higher number of innovation projects with external knowledge partners than other firms. The effect on the involvement rate of universities was, however, invers. We found that firms, in which the entrepreneur was involved in less than five tasks, had a higher share of universities as external knowledge partners. This could be related to the just mentioned effect created by spin-off firms, who collaborated more often with universities and whose entrepreneurs undertook fewer tasks than in other firms.

Firms, whose entrepreneur was involved in the acquisition of technology and knowledge resources, involved external knowledge partners more often in their innovation projects than other firms. They also had more knowledge partners in their local proximity.

With regard to the personal characteristics of the entrepreneur, we found that younger entrepreneurs were more likely to go beyond their local economy in searching for external knowledge partners. Firms with an entrepreneur in the age group 25-34 years had more knowledge partners from elsewhere in Germany, than firms with an entrepreneur in the age group 45-54 years.

We found several influences related to the university background of the entrepreneur, in particular employment experience gained at universities, and contacts maintained with the alma mater. Firms, whose entrepreneurs had gained employment experience at a university had a higher rate of external knowledge partner involvement, and also rated the contributions

of external knowledge partners as more important for the innovation activity of the firm than others. Similarly, firms, whose entrepreneurs, had maintained contacts with h/er alma mater, in particular with people from the same discipline, had a higher share of external knowledge partners, and rated their contributions to the innovation activity higher than others.

We also found that the attitudes of the entrepreneur towards communication inside the firm, knowledge in other disciplines, and participation in networks have an influence on the firm's relationship with external sources of knowledge.

- *Communication in firm*: Firms, whose entrepreneurs rated firm-internal communication as highly important for their own work had more knowledge partners from elsewhere in Germany.
- *Knowledge in other disciplines*: Firms, whose entrepreneurs considered knowledge in other disciplines as highly important were also found to have more knowledge partners from elsewhere in Germany.
- *Narrow network*: Firms, whose entrepreneurs rated membership in narrow networks as highly important had a higher share of firms from the same sector amongst their external knowledge partners.
- *Wide network*: We found an inverse effect for the perceived relevance of wide networks. Firms, whose entrepreneurs assigned low importance to the membership in wide networks rated the contribution of universities as external knowledge partners higher than other firms. This also applied for the relevance rating of firms from other sectors, and business support organisations.

7.4.2 Discussion of results

Our results confirm findings from extant research that firms do not innovate in complete isolation, but selectively involve external sources of knowledge (Foss and Klein, 2012).

From the review of extant literature we assumed that relationships with external sources of knowledge follow a matchmaking approach because different sources of knowledge fulfil different needs; firms are likely to choose external knowledge partners according to their needs and the level of "prior related" (Cohen and Levinthal, 1990) or "background" (Nooteboom (2009) knowledge.

Furthermore, accumulation of knowledge through learning is likely to be constrained by myopia, reducing the focus of learning to what is already known to the learner (Levinthal and March, 1993). This also applies to learning from external sources. Hence, decision-makers act as "cognizers" (Calori et al., 1984); they apply their own mental maps as interpretation lenses of the environment, and, in this way, define the firm's search scope and build a repertoire which results in cognitive structuring and provides a new basis for action (Nooteboom, 2009; Bruneel et al., 2010).

To capture these different sources of influence on the relationships of entrepreneurial firms with external sources of knowledge, we formulated four research questions: (1) Does the entrepreneur influence the choice of knowledge partners in terms of partner type and/or location?; (2) Does the entrepreneur influence the perception of relevance of the contributions of external knowledge partners to the innovation activity of the firm?; (3) Do firm

characteristics influence the choice of knowledge partners in terms of partner type and/or location?; (4) Do firm characteristics influence the perception of relevance of the contributions of external knowledge partners to the innovation activity of the firm?. For all four, we found confirmatory evidence.

We found that the role of the entrepreneur influences the choice of knowledge partners. Firms, with a higher intensity of the entrepreneur's involvement in the innovation process, had also higher involvement rates of external knowledge partners; particularly the entrepreneur' involvement in the acquisition of technology and knowledge resources.

With regard to the personal characteristics of the entrepreneur, we found that younger entrepreneurs were more likely to go beyond their local economy in searching for external knowledge partners. We found several influences related to the university background of the entrepreneur, in particular related to employment experience gained at universities and contacts maintained with the alma mater. We also found that the attitudes of the entrepreneur towards communication inside the firm, knowledge in other disciplines, and participation in networks influence the relationships of the firm with external knowledge sources. Firms, whose entrepreneurs had gained university employment experience had higher involvement rates of external knowledge partners and rated their contributions higher than other firms. The same pattern holds for firms, whose entrepreneurs, had maintained contacts with their alma mater, in particular with people from the same discipline.

Hence, we can support from our findings the assumption from the literature and findings from extant studies that the entrepreneur acts as cognizer and defines the firm's search scope.

We found that the following firm characteristics were influencing the choice of knowledge partners, in particular firm age, employment growth, and the origins of a firm as a university spin-off.

In particular, younger firms more often involved business support organisations than older firms. This could be related to the need of these firms for information and access to financing or public support measures due to a lack of internal resources.

Younger firms were also more likely to collaborate with universities than older firms. This could be related to the shorter time difference between university graduation and firm foundation, which we observed for these founders, or the existence of prior related knowledge. Older firms involved research organisations more often in their innovation activity than younger firms. This could be also interpreted with the existence of prior related knowledge, and with path-building effect of former relationships, for which we, however, do not have information from the survey.

Firms whose numbers of employees had not changed since the end of their first year of existence, had more often involved firms from other sectors and business support organisations than firms with a positive employment growth rate. A possible explanation could be that business consultants were understood by respondents, as mentioned above, as firms from other sectors.

Spin-off had a higher number of innovation projects, in which they collaborated with external knowledge partners than other firms. They also involved universities more often than other firms.

We also found that R&D intensity influences the perception of relevance of the contributions of external knowledge partners to the innovation activity of the firm. Firms with a higher share of employees tasked with the acquisition of new knowledge rated the relevance of external knowledge partners higher than other firms. This supports the assumption that firms are likely to extend their scope of search by increasing the cognitive search distance for novel knowledge (Nooteboom, 2009).

Table 15. Influences on the involvement of external sources of knowledge

		Test statistic				
	Influence			**Z**	**p**	**r**
KPinv	Spin-off	M-W:	$53.31_{\text{Spin-off}} - 39.01$	3.100	0.002	0.33
M = 0.39	inotask [1]	M-W:	$43.54_{>5\text{tasks}} - 26.08_{\leq 5\text{tasks}}$	3.080	0.002	0.42
SD = 0.341	ttec [2]	M-W:	$41.15_{\text{ttec}} - 27.38$	2.010	0.044	0.23
	University employment	M-W:	$43.43_{\text{uempl}} - 32.03$	2.790	0.005	0.32
	Alma mater contacts	M-W:	$43.54_{\text{samedisc}} - 28.70$	3.014	0.003	0.35
KPrel	University employment	M-W:	$43.27_{\text{uempl}} - 32.32$	2.125	0.034	0.24
M = 2.75	Alma mater contacts	M-W:	$42.23_{\text{samedisc}} - 30.89$	2.214	0.027	0.25
SD = 0.841						
kploc	ttec	M-W:	$30.50_{\text{ttec}} - 12.50$	4.351	0.000	0.59
M = 0.77						
SD = 0.425						
kpnat	Age entrepreneur	M-W:	$16.67_{\text{25-34y}} - 8.67_{\text{45-54y}}$	2.597	0.009	0.50
M = 0.71	Firm communic.	M-W:	$28.43_{\text{high}} - 13.30_{\text{low}}$	2.150	0.032	0.30
SD = 0.457	Knowledge other disciplines	M-W:	$30.00_{\text{high}} - 20.65_{\text{low}}$	2.122	0.034	0.29
kpeur	Firm location	M-W:	$28.24_{\text{Munich}} - 18.89$	2.786	0.005	0.42
M = 0.37						
SD = 0.486						
bspinv	Firm age	K-W:	χ^2 (3, N = 59) = 9.918		0.019	0.41
M = 0.37	Firm growth	M-W:	$27.57_{\text{No change}} - 17.59_{\text{Incr}}$	2.636	0.008	0.41
SD = 0.442						

bsprel	Wide network	M-W:	$34.53_{low} - 24.79_{high}$	2.717	0.007	0.37
M = 2.53 SD = 1.206						
foinv	Firm growth	M-W:	$29.18_{No\ change} - 16.76_{Incr}$	3.276	0.001	0.51
M = 2.47 SD = 1.230						
forel	Wide network	M-W:	$33.93_{low} - 25.03_{high}$	2.360	0.018	0.32
M = 2.94 SD = 1.174						
fsinv	Narrow network	M-W:	$30.93_{high} - 20.03_{low}$	2.594	0.009	0.35
M = 0.45 SD = 0.470						
resinv	Firm age	K-W:	χ^2 (3, N = 59) = 10.073		0.018	0.41
M = 0.38 SD = 0.441						
resrel	R&D intensity	M-W:	$33.56_{>50\%} - 25.78_{\leq 50\%}$	2.326	0.020	0.30
M = 2.83 SD = 1.361						
uinv	Firm age	K-W:	χ^2 (3, N = 59) = 28.009		0.000	0.69
M = 0.51 SD = 0.456	Spin-off	M-W:	$37.67_{Spin\text{-}off} - 26.65$	2.490	0.013	0.32
	inotask[1]	M-W:	$40.83_{\leq 5tasks} - 23.69_{>5tasks}$	3.706	0.000	0.50
urel	R&D intensity	M-W:	$32.91_{>50\%} - 24.78_{\leq 50\%}$	2.305	0.021	0.30
M = 2.94 SD = 1.161	Spin-off	M-W:	$51.80_{Spin\text{-}off} - 39.70$	2.120	0.034	0.23
	Wide network	M-W:	$33.67_{low} - 25.13_{high}$	2.539	0.011	0.35

Notes: M-W: Mann-Whitney U Tests for non-parametric data; r calculated as $r = \frac{Z}{\sqrt{N}}$

K-W: Kruskal-Wallis Tests for non-parametric data. Eta square values were calculated as $\eta^2 = \frac{\chi^2}{N-1}$

(1) inotask = number of key tasks undertaken by the entrepreneur in the innovation process
(2) ttec = entrepreneur is involved in the acquisition of new knowledge and technology

Legend: **KPinv**: Share of innovation projects in 2012 with ext. knowledge partners; **KPrel**: Mdn relevance of KP involvement in all innovation projects in 2012; **kploc**: Firm has knowledge partners in local proximity; **kpnat**: Firm has knowledge partners elsewhere in Germany; **kpeur**: Firm has knowledge partners elsewhere in Europe; **bspinv**: Share of ext. knowledge partners being business support org.; **bsprel**: Mdn relev. of business sup.org.; **foinv**: Share of ext. knowledge partners being firms other sectors; **forel**: Mdn relev. of firms other sectors; **fsinv**: Share of ext. knowledge partners being firms same sector; **resinv**: Share of ext. knowledge partners being research org.; **resrel**: Mdn relev. of research org.; **uinv**; Share of ext. knowledge partners being universities; **urel**: Mdn relev. of universities.

7.5 University links

In this section, we will present the links of sample firms with universities and analyse the factors, which influences the type of links and their perceived relevance for the innovation activity of the firm.

In 2012, all sample firms maintained some types of links with universities. We distinguished between formal links, which are governed by some kind of contractual relationship between the firm and the university or individuals associated with it, such as for example scientists and students, and informal links. Table 16 (below) provides an overview of the types of university links included in the study.

We draw from extant empirical studies (Abreu et al., 2008; Perkmann et al., 2013) in the selection of link types, and added teaching activities of firm members at universities, and the participation of employees in the education offer of universities as two activities, which have received increased attention and support from public policy to enhance the so-called "third mission" of universities, that is, their productive interaction with their surrounding local economy (Etzkowitz, et al., 2000).

Table 16. Formal and informal types of links with universities

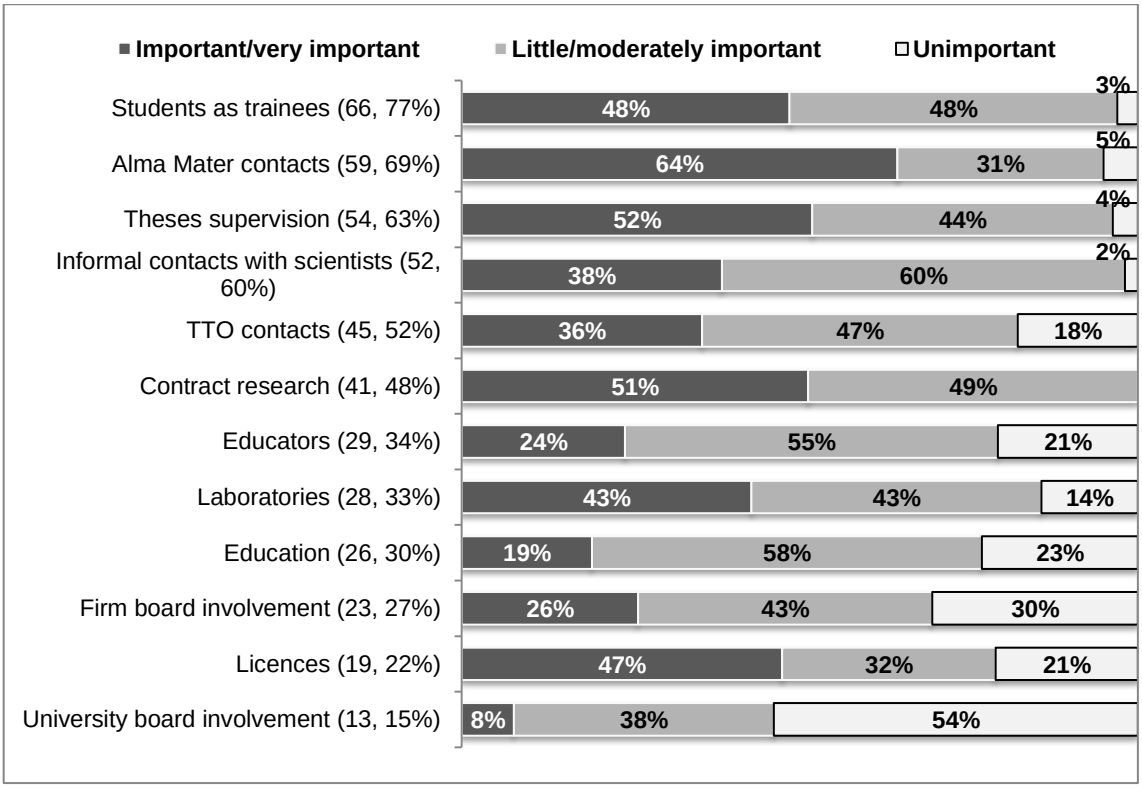
Formal links	Informal links
• Contract regulated research co-operation between the firm and a university or with individual scientists (Contract research) • License utilisation of HEI-owned patents (Licences) • Utilisation of HEI-owned laboratories and research infrastructure (Infrastructure) • Supervision of BA, MA and doctoral theses (Theses supervision) • Involvement of members of the firm in HEI internal boards (University boards involvement) • Involvement of HEI researchers in firm internal boards (Firm board involvement)	• Informal contacts with individual scientists (Informal contacts with scientists) • Contacts with technology transfer offices, entrepreneurship centres or similar (TTO contacts) • Members of the firm participate in the educational offer of HEIs (Education) • Members of the firm are educators in HEIs (Educators) • Employment of students as trainees (Students as trainees) • Contacts maintained since firm entry (Alma mater contacts)

In 2012, sample firms had, on average, five links with universities (IQR = 3). The number of informal links was higher (Mdn = 3, IQR = 2) than the number of formal links

(Mdn = 2, IQR = 2). Most practiced was the hosting of students as trainees (66; 77%), followed by contacts the respondents (both entrepreneurs and employees) had maintained with h/er alma mater since firm entry/foundation (59; 69%). Least common was the involvement of firm members in governing boards of universities (13; 15%).

The highest relevance rating was given to contract research co-operation (Mdn = 3.54, SD = 1.051), followed by the supervision of academic work of students (Mdn = 3.54, SD = 0.985) and the employment of students as trainees (Mdn = 3.36, SD = 1.104). As least relevant perceived was the involvement of firm members in university boards (Mdn = 1.0, IQR = 4). Figure 12 provides an overview.

Figure 12. Occurrence and relevance of university links in 2012



7.5.1 Influences on the university links of firms

Influences of firm characteristics

Firms located in Munich had more informal university links than other firms in the sample. With regard to particular types of university links, firms located in Munich had more student internships and supervised more students than firms located elsewhere. Firms in Berlin had more links with universities in their local proximity than firms located elsewhere. An explanation could be the number of local universities and higher education institutions (49), which is the highest in the country.

We found indication that firms in their first year had more contacts with universities, and also rated their relevance for the firm's innovation activity higher, than older firms. In particular, younger firms had more contacts with former professors, more contacts with people from their own discipline, and more contacts with people from other disciplines. Younger firms also assigned higher relevance to alma mater contacts and a higher relevance of informal contacts with university scientists.

We found no influence of firm size on the type of university links and their perceived relevance, but an influence of the firm organisation. Firms with no subunits were less likely to supervise students in their academic work than firms with subunits.

The R&D intensity of firms was found to result in a higher number of formal university links, and a higher relevance of contract research cooperation. Firms with a high R&D intensity were also more likely to supervise academic theses. This was also more likely in firms with multiple R&D teams.

University spin-offs had a higher total number of university links than other firms in the sample, and a higher number of formal links. Spin-offs also rated the relevance of the following types of university links higher than other firms: university researchers in firm internal boards; license utilisation; contract research cooperation; and utilisation of laboratories.

Influences of the entrepreneur

As likely to be expected, we found that the university background of the entrepreneur has an influence on the university links of the firm. In particular, the university employment experience of an entrepreneur has an impact on the personal contacts maintained with the alma mater and on the firm's total number of university links.

Entrepreneurs with university employment experience were more likely to maintain contacts with their alma mater after firm foundation. In particular, with their former professors, people from their own discipline and with the technology transfer office. They also had a higher total number of university links than other firms. This also applies to the sum of informal and formal links, with the effect on formal links being higher than for informal links. Firms whose entrepreneur had worked at a university were more likely than other firms to utilise the laboratories and research infrastructure of universities, and to supervise Bachelor, Master and doctoral theses of students.

We found that entrepreneurs with a PhD degree act as a link builder for their firms. The share of links initiated by these entrepreneurs was higher than by the other entrepreneurs in the sample. Firms, whose entrepreneur had a PhD degree, had a higher total number of university links than other firms. This was particularly reflected in a higher share of formal

links. These firms were also more likely to have links with universities outside Europe, and they valued the potential relevance of research activities carried out at local universities higher than other firms.

The time difference between graduation and venture creation was found to influence the perceived relevance of informal university contacts. Entrepreneurs, who had founded the firm within five years after their graduation, rated the relevance of informal contacts higher than entrepreneurs for who this time period was more than ten years.

The location of an alma mater in geographical proximity, also seem to matter for the university links of the firm. Interestingly, we found no statistically significant difference in the links the entrepreneur had maintained with people from the same or other discipline explained by geographical proximity. Instead, there is an influence on the links maintained with technology transfer offices, both the entrepreneur's alma mater, and, with a smaller effect size, for technology transfer offices in general. Firms, in geographical proximity to the entrepreneur's alma mater also had a higher number of informal university links than other firms.

We also found that the entrepreneur's attitudes towards membership in narrow networks and firm internal communication influenced the university links of the firm. Firms, whose entrepreneurs attributed high importance to the membership in narrow networks, had a higher total number of university links than other firms, and in particular of informal links. They were also more likely to have contacts with technology transfer offices. Firms, whose entrepreneur rated firm internal communication as highly relevant for h/er work, were more likely to have links with universities in their local proximity than other firms.

7.5.2 Discussion of results

Our starting point was that different forms of university links exist and that firms will rate them differently in terms of their contributions. We found that sample firms maintained several university links in 2012, with a preference for informal, that is, non-contractual relationships. Most common practiced were hosting students as trainees and contacts which entrepreneurs had maintained with their alma mater university. Perceived as most relevant for the innovation activity of the firm were contract research co-operation, supervision of the academic work of students and the employment of students as trainees, whereas the involvement of firm members in university boards received the lowest relevance rating.

We understand science in this thesis, following (Knorr Cetina, 1999: 1), as an epistemic culture, that is, an "amalgam of arrangements and mechanisms – bonded through affinity, necessity, and historical coincidence – … that create and warrant knowledge". Hence, scientific disciplines can be understood as epistemic communities, within which knowledge exchange is facilitated by shared symbolic and theoretical frames. Consequentially, we argued that epistemic groups may exist in universities either as entire groups or in the form of local units, including one or more individuals, which belong to larger groups that are spread across different locations. These epistemic groups can be organised as single-discipline groups or spanning different disciplines. Further, we distinguished between passive and active membership. The former applies to students, who acquire the codified knowledge of an epistemic community during their formal studies. Involvement in scientific research, related to the recognised subset of questions of an epistemic community, for example in form or a doctoral dissertation or work experience, may transform a passive

membership (student) into an active membership (researcher). We also assumed that membership in an epistemic community has a lasting effect in that members will turn to other members as part of the search process for related or new knowledge.

We formulated three research questions: (1) Do firm characteristics influence the number, type and relevance of university links?; (2) Does the entrepreneur's university history influence the number, type and relevance of university links?; (3) Do the entrepreneur's attitudes to firm internal and external networks influence the number, type and relevance of university links?.

For all three research questions, we found confirmatory evidence; in particular intensity and organisation of R&D activities, and the firm's origin as university spin-off are influencing the number and types of university links.

Firms in their first year had more contacts with universities, and also rated their relevance for the innovation activity of the firm higher than older firms. In particular, younger firms assigned higher relevance to informal contacts with university scientists than older firms. This is related to the role of the entrepreneur, as we will discuss below.

We found no influence of firm size on the type of university links and their perceived relevance, but we found an influence of firm organisation, R&D intensity and R&D organisation on the number and types of links and their perceived relevance. University spin-offs had a higher total number of university links and rated these higher than other firms, in particular with regard to formal links. The use of laboratories and research infrastructure was significantly higher in the spin-off group.

This supports the assumptions, advanced in literature and extant research, that firms often maintain links with university researchers to learn about the areas and progress of university research and technology development, and to update the firm internal technology knowledge through continuous involvement in scientific research and laboratory work, in particular its tacit component (Witt and Zellner, 2007).

We found that the university background of the entrepreneur is of salient influence for the university links of the firm. In particular, the university employment experience of an entrepreneur has an impact on the personal contacts maintained with the alma mater and for the university links of the firm. We found that entrepreneurs with a PhD degree act as a link builder for their firms. The share of links initiated by these entrepreneurs was higher than by the other entrepreneurs in the sample.

The time difference between graduation and venture creation was found to influence the perceived relevance of informal university contacts. Entrepreneurs, who had founded the firm within five years after their graduation, rated the relevance of informal contacts higher than others. Also, geographical proximity of the alma mater matters for university links, however, not, as it might be expected, for eventual bonds with the entrepreneur's epistemic community but for contacts with technology transfer offices.

We also found that the relevance attributed by the entrepreneur to membership in narrow networks influences the number and types of university links, in particular links with technology transfer offices. Interestingly, for knowledge partnerships in general, we found that, on the contrary, membership in wide networks mattered for the intensity and relevance of these partnerships.

Table 17. Summary of influences on the university links of firms

			Test statistic			
	Influence			**Z**	**p**	**r**
KPinv M = 0.39; SD = 0.341	Spin-off	M-W:	$53.31_{\text{Spin-off}} - 39.01$	3.100	0.002	0.33
	inotask [1]	M-W:	$43.54_{>5\text{tasks}} - 26.08_{\leq 5\text{tasks}}$	3.080	0.002	0.42
	ttec [2]	M-W:	$41.15_{\text{ttec}} - 27.38$	2.010	0.044	0.23
	University employment	M-W:	$43.43_{\text{uempl}} - 32.03$	2.790	0.005	0.32
	Alma mater contacts	M-W:	$43.54_{\text{samedisc}} - 28.70$	3.014	0.003	0.35
KPrel M = 2.75; SD = 0.841	University employment	M-W:	$43.27_{\text{uempl}} - 32.32$	2.125	0.034	0.24
	Alma mater contacts	M-W:	$42.23_{\text{samedisc}} - 30.89$	2.214	0.027	0.25
resinv M = 0.38; SD = 0.441	Firm age	K-W:	χ^2 (3, N = 59) = 10.073		0.018	0.41
resrel M = 2.83; SD = 1.361	R&D intensity	M-W:	$33.56_{>50\%} - 25.78_{\leq 50\%}$	2.326	0.020	0.30
uinv M = 0.51; SD = 0.456	Firm age	K-W:	χ^2 (3, N = 59) = 28.009		0.000	0.69
	Spin-off	M-W:	$37.67_{\text{Spin-off}} - 26.65$	2.490	0.013	0.32
	inotask	M-W:	$40.83_{\leq 5\text{tasks}} - 23.69_{>5\text{tasks}}$	3.706	0.000	0.50
urel M = 2.94; SD = 1.161	R&D intensity	M-W:	$32.91_{>50\%} - 24.78_{\leq 50\%}$	2.305	0.021	0.30
	Spin-off	M-W:	$51.80_{\text{Spin-off}} - 39.70$	2.120	0.034	0.23
	Wide network	M-W:	$33.67_{\text{low}} - 25.13_{\text{high}}$	2.539	0.011	0.35
fsinv M = 0.45; SD = 0.470	Narrow network	M-W:	$30.93_{\text{high}} - 20.03_{\text{low}}$	2.594	0.009	0.35
foinv M = 2.47; SD = 1.230	Firm growth	M-W:	$29.18_{\text{No change}} - 16.76_{\text{Incr}}$	3.276	0.001	0.51
forel M = 2.94; SD = 1.174	Wide network	M-W:	$33.93_{\text{low}} - 25.03_{\text{high}}$	2.360	0.018	0.32
bspinv M = 0.37; SD = 0.442	Firm age	K-W:	χ^2 (3, N = 59) = 9.918		0.019	0.41
	Firm growth	M-W:	$27.57_{\text{No change}} - 17.59_{\text{Incr}}$	2.636	0.008	0.41
bsprel M = 2.53; SD = 1.206	Wide network	M-W:	$34.53_{\text{low}} - 24.79_{\text{high}}$	2.717	0.007	0.37
kploc M = 0.77; SD = 0.425	ttec	M-W:	$30.50_{\text{ttec}} - 12.50$	4.351	0.000	0.59
kpnat M = 0.71; SD = 0.457	Age entrepreneur	M-W:	$16.67_{\text{25-34y}} - 8.67_{\text{45-54y}}$	2.597	0.009	0.50
	Firm communic.	M-W:	$28.43_{\text{high}} - 13.30_{\text{low}}$	2.150	0.032	0.30
	Knowledge other disciplines	M-W:	$30.00_{\text{high}} - 20.65_{\text{low}}$	2.122	0.034	0.29
kpeur M = 0.37; SD = 0.486	Firm location	M-W:	$28.24_{\text{Munich}} - 18.89$	2.786	0.005	0.42

Notes: M-W: Mann-Whitney U Tests for non-parametric data; r calculated as $r = \frac{Z}{\sqrt{N}}$

K-W: Kruskal-Wallis Tests for non-parametric data. Eta-squared values were calculated as $\eta^2 = \frac{\chi^2}{N-1}$

(1) inotask = number of key tasks undertaken by the entrepreneur in the innovation process

(2) ttec = entrepreneur is involved in the acquisition of new knowledge and technology

CHAPTER 8

CONCLUSION

The aim of this thesis has been to contribute to the micro-foundations of entrepreneurial firms and to gather empirical evidence about the intensity and organisation of their R&D activity, the role of the entrepreneur, their innovation activity, the relationships with external sources of knowledge and their links with universities.

The attention of public policy on entrepreneurial firms is increasing; they are considered to be vehicles of employment and growth (OECD, 2012). Universities have been assigned key roles in promoting business start-up amongst their graduates and researchers (Etzkowitz et al., 2000) and have thus become a major source of origin for the entrepreneurial firms.

The need for public policy intervention to enhance the start-up and growth rates of entrepreneurial firms has been discussed widely in the literature (see Colombo et al., 2010 for an overview), and public policy has been responding to this. Yet, the lack of micro-level data is rendering policy analysis difficult as effects related to the institutional context cannot be distinguished from effects related to the nature of entrepreneurial firms.

We found evidence for a dominant presence of the entrepreneur in the organisation of the firm's innovation activity and in setting the search scope and the repertoire of external knowledge sources. For example, younger entrepreneurs were more likely to go beyond their

local economy in searching for external knowledge partners, and they also reverted to the contacts they had gained during their university employment experience.

Sample firms, in general, were undertaking multiple innovation projects in parallel. Employment growth, the organisation in subunits, and the organisation of R&D activities in multiple teams spread across the firm were found to positively influence the combination of new and incremental innovation projects. This suggests the need of further empirical studies to investigate the trade-off situation between combining innovation projects and focusing on given cognitive frameworks, as assumed in the current literature.

We found confirmatory evidence that firms selectively involve external sources of knowledge. This selection occurs at the categorical level of whether or not to co-operate and concerning the types of innovation activities. In our sample, external knowledge partners were more involved in new than in incremental innovation projects. Our questionnaire did not distinguish different activities on the continuum from opportunity recognition to opportunity realisation. This would, however, be needed as suggested by Foss et al. (2013) to investigate which steps require multiple complementary resources and who provides these. We will add this in a replication of this study.

We have argued in this thesis, following Callon (1993), that the relationships between firms and universities and other public research organisations differ from inter-firm or market relationships in general in that the former exhibit a much higher degree of creativity, novelty and reconfiguration. We found evidence for this. Formal and informal university links occurred together. University links were used to enhance internal R&D capacity by updating

technology knowledge through continuous involvement in scientific research (supervision of theses) and laboratory work (Witt and Zellner, 2007).

Young firms, in overcoming the double-constraint of organisational and environmental factors (Stinchcombe, 1965), are active networkers and likely to revert to the entrepreneur's own networks to circumvent entry and establishment barriers in existing networks. Contacts maintained with the entrepreneur's alma mater were found to be of salient relevance.

The empirical research of this thesis was focused on one particular context – Germany – and although it sought to include different local economies, our findings remain limited to this specific context and its institutions. However, we have aimed at providing a detailed exploration of the organisation, activities and relationships of these firms, and their entrepreneurs. Further studies are needed to test our findings in a more robust setting with a larger sample size and varying institutional contexts. This will also provide more evidence on whether the metrics we introduced in this thesis to measure the entrepreneur's involvement in the firm's innovation activity, and the distinction between new and incremental innovation projects proof to be useful also in different contexts.

From the results of the empirical research in this thesis, we propose the following two contributions to extant research.

Firstly, the inclusion of a measurement of the organisation of R&D activities in addition to intensity of R&D, measured by the ratio between expenditure and some expression of output or R&D related inputs in people, tools, physical and financial resources (Adams et al., 2006). We found evidence that a decentralised organisation of R&D activity in multiple

teams is enhancing the innovation capacity of a firm (higher number of projects), its search capacity (more external knowledge partners), and its absorptive capacity (higher relevance of external knowledge).

Secondly, universities can be a primary source of external knowledge for firms which emerged from them. Young firms have to overcome the double-constrain of lacking internal sources and access to external resources (Stinchcombe, 1965). They simultaneously have to gain contacts and a position in existing networks, and build the firm's organisational structure. We found evidence of the existence of epistemic communities, which are built upon shared identities, and in which members share the same tacit and experiential knowledge, which is passed on through personal contacts, eliminating and punishing any opportunistic behaviour. In particular, membership in these epistemic communities has lasting effects: members will turn to other members as part of the search process for related or new knowledge. For example, some academics may choose to share their research results first with former colleagues and students. Former colleagues and students may as well, when having to decide with whom to enter in a strategic alliance, refer in the first place to former professors and colleagues. This is mostly relevant in light of the tightening of the intellectual property rights framework in favour of universities, and the increasing number of universities that are establishing support structures for their students and staff members to commercialise the results of academic research. This is likely to limit the partner choice of firms that base their decisions mainly on the appropriability of knowledge.

To nurture epistemic communities, universities have to involve students more into research and academic practice in order to build these bonds. Much will depend upon individual professors and researchers, but universities can set the framework conditions to

change passive membership in epistemic communities, which is gained through codified knowledge, into active membership, based on the member's contributions to the creation of tacit and codified knowledge.

APPENDIX A. DESCRIPTIVE STATISTICS

		Descriptive statistics			
Variable	**Definition and measurement**	**Mean**	**SD**	**Min**	**Max**
Entrepreneur					
inotask	Share of key tasks undertaken by entrepreneur	0.77	0.181	0	1
ageres	Age of respondent in categories(1)	2.01	0.105	1	3
gender	Gender of respondent (binary; 0 = male)	0.16	0.371	0	1
unidgr	University degree (binary; 0 = no)	0.97	0.162	0	1
tduf	Time difference university degree and firm entry in years	7.0(Mdn)	9.10	0	38
tdufc	Time difference university degree and firm entry in categories(2)	1.94	0.892	1	3
uempl	University employment (binary; 0 = no)	0.61	0.490	0	1
conal	Contact maintained with alma mater (binary; 0 = no)	0.75	0.434	0	1
conalr	Mdn relevance of contacts with alma mater; single items on 1-5 point scale.	3.15	1.162	1	5
alfiloc	Alma mater located in geo. proximity to firm (binary; 0 = no)	0.73	0.445	0	1
know	Perceived relevance of knowledge in own discipline for activity area in firm (1-5 point scale) binary high low	4.40	0.735	3	5
knowot	Perceived relevance of knowledge in other disciplines for activity area in firm (1-5 point scale)	4.03	0.854	2	5
comfirm	Perceived relevance of firm-internal communication for activity area in firm (1-5 point scale)	4.48	1.018	1	5
widnet	Perceived relevance of a wide external network for activity area in firm (1-5 point scale)	3.99	1.133	1	5
narnet	Perceived relevance of a narrow external network for activity area in firm (1-5 point scale)	3.92	1.062	1	5
tidea	Idea generation as task (binary; 0 = no)	0.97	0.162	0	1
tideaev	Idea evaluation as task (binary; 0 = no)	0.96	0.197	0	1
tfr	Acquisition of financial resources as task (binary; 0 = no)	0.89	0.311	0	1
thr	Acquisition of human resources as task (binary; 0 = no)	0.91	0.293	0	1
ttec	Acquisition of technology & knowledge as task (binary; 0 = no)	0.84	0.369	0	1
tprot	Involvement in prototype development (binary; 0 = no)	0.44	0.500	0	1
tprod	Involvement in production development (binary; 0 = no)	0.36	0.483	0	1
tmark	Marketing as task (binary; 0 = no)	0.81	0.392	0	1

Notes: (1) Categories of time difference between university degree and firm entry: 1 = less than 5 years; 2 = between 6 and 10 years; 3 = more than 10 years. (2) Categories of respondent age: 1 = 25-34 years; 2 = 35-44 years; 3 = 45-54 years; 3 = 55-65+ years.

Firm characteristics

Variable	Definition and measurement	Mean	SD	Min	Max
agefirm	Firm age in years	3.126	2.095	0.08	8.67
agefirmc	Firm age in categories[(1)]	2.52	1.005	1	4
emp1	Number of employees in the end of the first year	4.71	3.965	1	25
emp12	Number of employees in the end of 2012	12.12	12.396	1	67
emp12c	Number of employees end 2012 in categories[(2)]	2.31	1.351	1	5
empch	Change of employment in period end year1-end 2012	2.267	3.028	-.067	16.5
empchc	Change of employment y1-end 2012 in categories[(3)]	2.83	0.844	1	4
funits	Binary reaches unity if firm is organised in subunits	0.43	0.198	0	1
rdint	Share of employees with the task to acquire knowledge. which is new to the firm and/or their subunit	0.593	0.260	0.06	1.00
rdintc	More than 50% of employees have new knowledge acquisition as task (binary; 0 = less than 50%)	0.61	0.240	0	1
rdorg	Employees with new knowledge acquisition task are in different units of the firm (binary; 0 = all in one unit)	0.38	0.488	0	1
spinoff	Binary reaches unity if firm is a spin-off from a university	0.33	0.475	0	1
Berlin	Binary reaches unity if firm is located in Berlin	0.23	0.421	0	1
Munich	Binary reaches unity if firm is located in Munich	0.35	0.479	0	1
GerE	Binary reaches unity if firm is located elsewhere in Germany	0.43	0.498	0	1

Notes: (1) Categories of firm age: 1 = 1st year; 2 = 2-3 year; 3 = 4-5 year; 4 = 6-8 year. (2) Categories of number of employees in end 2012: 1 = 1-5 employees; 2 = 6-9 employees; 3 = 10-19 employees; 4 = 20-49 employees; 5 = more than 50 employees. (3) Categories of change of employment in period end year1-end 2012: 1 = negative change; 2 = no change; 3 = less than fourfold increase; 4 = more than fourfold increase.

Innovation activity

Variable	Definition and measurement	Mean	SD	Min	Max
inopro	Number of innovation projects carried out in year 2012	5.12	2.205	1	8
inopron	Number of “new” innovation projects carried out in year 2012	2.67	1.245	0	4
inoprof	Number of “further” innovation projects carried out in year 2012	2.45	1.369	0	4
ProdN	New product developed in 2012 (binary; 0 = no)	0.85	0.360	0	1
ProdNK	External knowledge partners in ProdN (binary; 0 = no)	0.68	0.478	0	1
ProdF	Existing product further developed in 2012 (binary; 0 = no)	0.79	0.409	0	1
ProdFK	External knowledge partners in ProdF (binary; 0 = no)	0.55	0.510	0	1
ProcN	New process developed in 2012 (binary; 0 = no)	0.73	0.445	0	1
ProcNK	External knowledge partners in ProcN (binary; 0 = no)	0.23	0.429	0	1
ProcF	Existing process further developed in 2012 (binary; 0 = no)	0.60	0.492	0	1
ProcFK	External knowledge partners in ProcF (binary; 0 = no)	0.05	0.213	0	1
MarkN	New marketing method developed in 2012 (binary; 0 = no)	0.58	0.496	0	1
MarkNK	External knowledge partners in MarkN (binary; 0 = no)	0.27	0.456	0	1

MarkF	Existing marketing method further dev. in 2012 (binary; 0 = no)	0.58	0.496	0	1
MarkFK	External knowledge partners in MarkF (binary; 0 = no)	0.27	0.456	0	1
OrgN	New organisational structure dev. in 2012 (binary; 0 = no)	0.56	0.500	0	1
OrgNK	External knowledge partners in OrgN (binary; 0 = no)	0.27	0.456	0	1
OrgF	Existing organisational structure further dev. 2012 (binary; 0=no)	0.52	0.502	0	1
OrgFK	External knowledge partners in OrgF(binary; 0 = no)	0.09	0.294	0	1

External knowledge partners

Variable	Definition and measurement	Mean	SD	Min	Max
KP	Involvement of external knowledge partners in innovation activity (binary; 0 = no)	0.71	0.457	0	1
KPinv	Share of innovation projects in 2012 with ext. knowledge partners	0.39	0.341	0	1
KPrel	Mdn relevance of KP involvement in all innovation projects in 2012; single items were measured on 1-5 point scale.	2.75	0.841	1	4
resinv	Share of ext. knowledge partners being research organisations	0.38	0.441	0	1
resrel	Mdn relevance of research org. as knowledge partners across all innovation projects in 2012; single items on 1-5 point scale.	2.83	1.361	1	5
uinv	Share of ext. knowledge partners being universities	0.51	0.456	0	1
urel	Mdn relevance of universities as knowledge partners across all innovation projects in 2012; single items on 1-5 point scale.	2.94	1.161	1	5
fsinv	Share of ext. knowledge partners being firms same sector	0.45	0.470	0	1
fsrel	Mdn relevance of firms same sector as knowledge partners across all innovation projects in 2012; single items on 1-5 point scale.	2.47	1.230	1	5
foinv	Share of ext. knowledge partners being firms other sectors	0.47	0.466	0	1
forel	Mdn relevance of firms other sector as knowledge partners across all innovation projects in 2012; single items on 1-5 point scale.	2.94	1.174	0	1
bspinv	Share of ext. knowledge partners being business support org.	0.37	0.442	0	1
bsprel	Mdn relevance of business sup.org. as knowledge partners across all innovation projects in 2012; single items on 1-5 point scale.	2.53	1.206	1	5
kploc	Firm has knowledge partners in local proximity (binary; 0 = no)	0.77	0.425	1	0
kpnat	Firm has knowledge partners elsewhere in Germany (binary;0=no)	0.71	0.457	1	0
kpeur	Firm has knowledge partners elsewhere in Europe (binary;0=no)	0.37	0.486	1	0
kpglo	Firm has knowledge partners outside Europe (binary;0=no)	0.17	0.382	1	0

University links

Variable	Definition and measurement	Mean	SD	Min	Max
ulink	Sum of university links in 2012	6.37	2.706	12	2
ulinkr	Mdn relevance of all university links for innovation activity in 2012; single items on 1-5 point scale.	3.14	0.889	1	5
ufols	Share of formal university links	0.43	0.134	0	1
ufolr	Mdn relevance of formal university links; single items on 1-5 scale.	3.29	1.059	1	5
uinfols	Share of informal university links	0.60	0.134	0	1
uinfolr	Mdn relevance of informal university links; single items on 1-5 scale.	3.25	0.823	1	5
ulent	Share of university links initiated by the entrepreneur	0.64	0.325	0	1
ulman	Share of all university links initiated by unit managers	0.05	0.137	0	1
ulemp	Share of all university links initiated by employees	0.18	0.257	0	1
uluni	Share of all university links initiated by university	0.06	0.127	0	1
ulelse	Share of all university links initiated by someone else	0.07	0.147	0	1
locpres	Potential relevance of local university research in categories(1)	3.07	1.031	1	4
uloc	Firms has links with local university (binary; 0 = no)	0.88	0.327	0	1
unat	Firms has university links elsewhere in Germany (binary; 0 = no)	0.56	0.500	0	1
ueuro	Firms has university links elsewhere in Europe (binary; 0 = no)	0.11	0.311	0	1
uglo	Firms has university links outside Europe (binary; 0 = no)	0.07	0.251	0	1
conal_rel	Relevance of contacts with alma mater	3.15	1.146	1	5
inf_rel	Relevance of informal links with university scientists	3.54	1.051	1	5
labinf_rel	Relevance of utilisation of university-owned laboratories	3.21	1.449	1	5
license_rel	Relevance of license utilisation	3.11	1.487	1	5
prof	Contacts with former professors	0.43	0.498	0	1
pdisc	Alma mater contacts with people same discipline	0.63	0.485	0	1
pdisco	Alma mater contacts with people other disciplines	0.59	0.493	0	1
students	Employment of students as trainees	0.77	0.425	0	1
theses	Supervision of theses	0.63	0.486	0	1
tto	Contacts with technology transfer offices	0.52	0.502	0	1
tto_al	Contacts with technology transfer alma mater	0.52	0.502	0	1
ufbo_rel	Relevance of involvement of university members in firm board	2.43	1.273	1	5

Notes: (1) The item was measured on a 1-5 scale. as all other point-scale measured items in the questionnaire. It was then recoded into 1 = no importance; 2 = low importance; 3 = medium importance; 4 = high importance.

Descriptive statistics of key variables for geographical locations

	Descriptive statistics			
Age firm	Mean	SD	Min	Max
Berlin metropolitan area	2,86	1,66	0,25	5,75
Germany elsewhere	3,66	2,31	0,17	7,67
Munich metropolitan area	2,96	1,99	0,18	7,67
Firm size	Mdn	IQR	Min	Max
Berlin metropolitan area	10	18	2	70
Germany elsewhere	7,5	48	2	50
Munich metropolitan area	10	66	1	67
Firm growth	Mdn	IQR	Min	Max
Berlin metropolitan area	1,0	3,58	-0,64	7,33
Germany elsewhere	2,17	5,00	-0,67	16,5
Munich metropolitan area	0,80	3,17	-0,50	12,4
Number of subunits in firm	Mdn	IQR	Min	Max
Berlin metropolitan area	0	2	0	6
Germany elsewhere	0	2	0	6
Munich metropolitan area	1	3	0	7
R&D intensity	Mean	SD	Min	Max
Berlin metropolitan area	0.53	0.31	0.08	1.0
Germany elsewhere	0.55	0.24	0.06	1.0
Munich metropolitan area	0.68	0.26	0.17	1.0

Characteristics of survey participants and non-participants

	Non-participants	Participants	Test statistic (1)	*p*
Characteristic	%	%		
Location			2,014	0,044*
Berlin metropolitan area	34,6	26,4		
Munich metropolitan area	40,5	37,7		
Germany elsewhere	24,9	35,8		
Sample source			1,093	0,274
Venture capital providers	82,2	77,4		
Entrepreneurship centres	9,7	9,4		
Business plan competitions	8,1	13,2		
Sector			1,0001	0,317
High-technology	9,2	6,6		
Medium-high-technology	9,2	15,1		
Low technology	2,2	-		
Knowledge intensive sectors	68,1	58,5		
Less-knowledge intensive sectors	11,4	19,8		
Firm age			1,234	0,217
1st year	23,8	27,4		
2-3 year	16,2	19,8		
4-5 year	26,5	27,4		
6-8 year	30,8	20,8		
9-10 year	2,7	4,7		
R&D investment as percentage of turnover (2)			0,432	0,666
1-24%	16,8	27,4		
25-49%	48,1	33,0		
50-70%	34,6	39,6		
Perc. of turnover due to product innovation (3)			1,262	0,207
1-14%	46,5	54,7		
15-24%	43,8	37,7		
25-30%	3,2	0,9		
≥ 31%	5,9	6,6		

Notes: (1) Mann-Whitney test; *significant test value. (2) Sector values for 2012, based on representative innovation panel data for firms with five or more employees (Rammer et al., 2014). (3) Sector values for 2012, based on representative innovation panel data for firms with five or more employees (Rammer et al., 2014).

APPENDIX B. QUESTIONNAIRE

Translated into the English language from the original version in the German language.

Data collection as part of a doctoral dissertation research on "Learning processes in Young Innovative Firms: The Role of External Knowledge Partners" at the University of Trento/Italy, Graduate School on Local Development and Global Dynamics.

Thank you very much for having taken **10 minutes** of your time to complete this questionnaire.

The questions regard mostly the time period **January to December 2012**.

One focus is on the innovation activity of the firm in terms of **new and further development** of:

- Products
- Processes, which are crucial to the core activities of the firm
- Marketing methods
- Organisational structures and procedures, which are targeted at an optimal knowledge management

The other focus is on **contacts to external knowledge providers**, that is, individuals or organisations, which possess knowledge that is of relevance for the innovation activity of the firm.

The information you provide will be treated **entirely confidential** and is utilised solely for scientific research.

To **thank you** for a fully completed questionnaire you will receive an individual report on the analysis of the results for the firm. In addition, there will be a raffle for three "Du&Ich" vouchers of Jochen Schweizer.

For any questions and comments you can contact me at andrea.hofer@unitn.it and 089/66660317.

Andrea-Rosalinde Hofer

[FS02] **To which sector does the firm belong?**
Please select

[FS11] **Is the firm an academic spin-off?**
An academic spin-off is a firm which was founded by employees of higher education institutes or public research organisations in order to commercialise technologies and research results, which were developed in these organisations.
- Yes
- No

[FS08] **When was the firm founded?**
Please state month and year in which the firm was founded.
Month (e.g. 12) [FS08_01]
Year (e.g. 2012) [FS08_02]

[FS04_01] **How many employees – including both full- and part-time employees – were employed at the end of the first financial year of the firm?**

[FS03_01] **How many employees – including both full- and part-time employees – were employed at the end of 2012?**

[FS05] **How many units/departments did the firm have in the end of 2012?**

A unit/department is the grouping of several jobs, which have common or directly linked tasks, under one leader.

In case the firm has more establishments, please complete this questionnaire for the main establishment in Germany.

Please select

The firm has no units/departments	[1]
2 units/departments	[2]
3 units/departments	[3]
4 units/departments [	[4]
5 units/departments	[5]
6 units/departments	[6]
More than 6 units/departments	[7]
Not answered	[-9]

[FS06_01] **How many employees – including both full- and part-time employees – had at the end of 2012 tasks aimed at contributing to the research and development activity of the firm?**

The research and development activity of the firm includes all systematic activities which are aimed at the acquisition and application of new knowledge, that is, new to the organisation.

[FS09] **In the end of 2012, in how many units/departments were employees with tasks related to the research and development activity of the firm?**

In case the firm has more establishments, please complete this questionnaire for the main establishment in Germany.

Please select

The firm has no units/departments	[1]
2 units/departments	[2]
3 units/departments	[3]
4 units/departments [	[4]
5 units/departments	[5]
6 units/departments	[6]
More than 6 units/departments	[7]
Not answered	[-9]

[IA88] **Which of the following activities were part of the innovation activity of the firm in the period January to December 2012?**

	Yes	No		
New development of products, which had not yet been part of the products of the firm	•	•	IA88_01	→*IA89 ff*
Further development of existing products with regard to product attributes and/or product use	•	•	IA88_02	→*IA90 ff*
New development or introduction of new processes, which are crucial to the core activities of the firm, e.g., product development processes, test processes, production processes	•	•	IA88_03	→*IA49 ff*
Further development of already existing processes of this type	•	•	IA88_04	→*IA50 ff*
New development or introduction of new marketing methods, e.g., product packaging, product placement, advertisement strategies, price strategies	•	•	IA88_05	→*IA51 ff*
Further development or already existing marketing methods	•	•	IA88_06	→*IA52 ff*
New development, or introduction of new organisational structures and processes, which are aimed at optimising the enhancement and utilisation of the knowledge and skills of employees	•	•	IA88_07	→*IA53 ff*
Further development of such structures and processes	•	•	IA88_08	→*IA54*

ff

IA89 **You´ve stated above that, in the period January-December 2012, the new development of products was part of the innovation activity of the firm.**
Were external knowledge providers involved in development of new products?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA38 **Were the following external knowledge providers involved in the new development of products? If yes, how important was this for the new development of products?**

	No involvement	
Non university research institutions		IA38_01
Higher education institutions (universities and universities of applied sciences)		IA38_02
Firms from the same sector		IA38_03
Firms from other sectors		IA38_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)		IA38_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA37] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA37_01]
- Elsewhere in Germany [IA37_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA37_03]
- Outside of the European Economic Area [IA37_04]

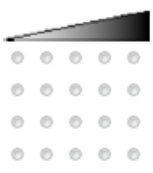
[1: not selected; 2: selected]

IA90 **You´ve stated above that, in the period January-December 2012, the further development of existing products was part of the innovation activity of the firm.**
Were external knowledge providers involved in the further development of existing products?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA70 **Were the following external knowledge providers involved? If yes, how important was this for the further development of existing products?**



	No involvement	
Non university research institutions		IA70_01
Higher education institutions (universities and universities of applied sciences)		IA70_02
Firms from the same sector		IA70_03
Firms from other sectors		IA70_04

	Business support organisations (e.g., Chamber of Commerce and Industry, etc.)	IA70_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA55] **Where were the involved external knowledge providers located?**

Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA55_01]
- Elsewhere in Germany [IA55_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA55_03]
- Outside of the European Economic Area [IA55_04]

[1: not selected; 2: selected]

IA49 **You´ve stated above that, in the period January-December 2012, the new development or introduction of new processes, crucial to the core activities of the firm, was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA63 **Were the following external knowledge providers involved? If yes, how important was this for the new development or introduction of new processes?**

	No involvement
Non university research institutions	IA63_01
Higher education institutions (universities and universities of applied sciences)	IA63_02
Firms from the same sector	IA63_03
Firms from other sectors	IA63_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)	IA63_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA69] **Where were the involved external knowledge providers located?**

Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA69_01]
- Elsewhere in Germany [IA69_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA69_03]
- Outside of the European Economic Area [IA69_04]

[1: not selected; 2: selected]

IA50 **You´ve stated above that, in the period January-December 2012, the further development of existing processes, crucial to the core activities of the firm, was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA64 **Were the following external knowledge providers involved? If yes, how important was this for the further development of existing processes?**

	No involvement	
Non university research institutions		IA64_01
Higher education institutions (universities and universities of applied sciences)		IA64_02
Firms from the same sector		IA64_03
Firms from other sectors		IA64_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)		IA64_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA56] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA56_01]
- Elsewhere in Germany [IA56_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA56_03]
- Outside of the European Economic Area [IA56_04]

[1: not selected; 2: selected]

IA51 **You´ve stated above that, in the period January-December 2012, the new development or introduction of new marketing methods was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA65 **Were the following external knowledge providers involved? If yes, how important was this for the new development or introduction of new marketing methods?**

	No involvement	
Non university research institutions		IA65_01
Higher education institutions (universities and universities of applied sciences)		IA65_02
Firms from the same sector		IA65_03
Firms from other sectors		IA65_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)		IA65_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA58] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA58_01]
- Elsewhere in Germany [IA58_02]

- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA58_03]
- Outside of the European Economic Area [IA58_04]

[1: not selected; 2: selected]

IA52 **You´ve stated above that, in the period January-December 2012, the further development of existing marketing methods was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA66 **Were the following external knowledge providers involved? If yes, how important was this for the further development of existing marketing methods?**

	No involvement
Non university research institutions	IA66_01
Higher education institutions (universities and universities of applied sciences)	IA66_02
Firms from the same sector	IA66_03
Firms from other sectors	IA66_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)	IA66_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA59] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA59_01]
- Elsewhere in Germany [IA59_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA59_03]
- Outside of the European Economic Area [IA59_04]

[1: not selected; 2: selected]

IA53 **You´ve stated above that, in the period January-December 2012, new development, or introduction of new organisational structures and processes was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA67 **Were the following external knowledge providers involved? If yes, how important was this for the new development, or introduction of new organisational structures and processes?**

	No involvement

Non university research institutions	IA67_01
Higher education institutions (universities and universities of applied sciences)	IA67_02
Firms from the same sector	IA67_03
Firms from other sectors	IA67_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)	IA67_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA60] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA60_01]
- Elsewhere in Germany [IA60_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA60_03]
- Outside of the European Economic Area [IA60_04]

[1: not selected; 2: selected]

IA54 **You´ve stated above that, in the period January-December 2012, further development of existing organisational structures and processes was part of the innovation activity of the firm.**
Were external knowledge providers involved in this?

External knowledge providers are individuals and organisations, who possess knowledge which may be of relevance to the innovation activity of the firm. The involvement of external knowledge providers may take different forms and can include one, several or all phases of the innovation process.

- Yes
- No

IA68 **Were the following external knowledge providers involved? If yes, how important was this for the further development of existing organisational structures and processes?**

	No involvement	
Non university research institutions		IA68_01
Higher education institutions (universities and universities of applied sciences)		IA68_02
Firms from the same sector		IA68_03
Firms from other sectors		IA68_04
Business support organisations (e.g., Chamber of Commerce and Industry, etc.)		IA68_05

[1: unimportant; 5 very important; -1 no involvement; -9 no answer]

[IA61] **Where were the involved external knowledge providers located?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [IA61_01]
- Elsewhere in Germany [IA61_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [IA61_03]
- Outside of the European Economic Area [IA61_04]

[1: not selected; 2: selected]

[UL03] **How to you assess the potential contribution of education and research at higher education institutions for the innovation activity of the firm?**

Education at higher education institutions [UL03_01]

Research at higher education institutions [UL03_01]

[1: unimportant; 5 very important]

[UL05] **For this assessment you have in mind higher education institutions, which are located in …?**
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [UL05_01]
- Elsewhere in Germany [UL05_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [UL05_03]
- Outside of the European Economic Area [UL05_04]

[1: not selected; 2: selected]

[UL02] **During the year 2012, was the firm in contact with one or more higher education institutions? Which of the following types of contacts apply and how important were they for the innovation activity of the firm?**

	No link
Contract regulated research co-operation between firm and HEI or between firm and individual researchers	UL02_01
Informal contacts with individual researchers	UL02_02
License utilisation of HEI-owned patents	UL02_03
Utilisation of HEI-owned laboratories and research infrastructure	UL02_04
Contacts with TTOs, entrepreneurship centre or similar	UL02_05
Members of the firm are educators in HEIs	UL02_06
Members of the firm participate in the educational offer of HEIs	UL02_07
Supervision of BA, MA and doctoral theses	UL02_08
Employment of students as trainees	UL02_09
Involvement of members of the firm in HEI internal boards	UL02_10
Involvement of HEI researchers in firm internal boards	UL02_11

[1: unimportant; 5 very important; -1 no link; -9 no answer]

[UL06] **How was the cooperation established – who <u>initiated</u> the <u>first contact</u>?**
[NB: only items which were rated at 1-4 are shown]

Contract regulated research co-operation between firm and HEI or between firm and individual researchers [UL06_01]

Firm management [1]	Middle management [2]	Employees [3]	Someone from university [4]	Someone else [5]	Don't know [6]
•	•	•	•	•	•

[-9 no answer]
…
Informal contacts with individual researchers [UL06_02]
License utilisation of HEI-owned patents [UL06_03]
Utilisation of HEI-owned laboratories and research infrastructure [UL06_04]

Contacts with TTOs, entrepreneurship centre or similar [UL06_05]
Members of the firm are educators in HEIs [UL06_06]
Members of the firm participate in the educational offer of HEIs [UL06_07]
Supervision of BA, MA and doctoral theses [UL06_08]
Employment of students as trainees [UL06_09]
Involvement of members of the firm in HEI internal boards [UL06_10]
Involvement of HEI researchers in firm internal boards [UL06_11]

[UL04] **Where were the higher education institutions, with which above mentioned contacts existed, located?**

Reference period: January – December 2012
Please tick all that apply. Multiple answers are possible.

- Same location as the firm [UL04_01]
- Elsewhere in Germany [UL04_02]
- Elsewhere in the European Economic Area, that is, EU-member countries (except Germany), Island, Liechtenstein, Norway [UL04_03]
- Outside of the European Economic Area [UL04_04]

- [1: not selected; 2: selected]

[PD04] **Are you the founder or co-founder of the firm?**

- Yes
- No

[PD01] **Since when have you been working for the firm?**

Please state month and year in which you started working for the firm.
Month (e.g. 12)
Year (e.g. 2012)

[PD02] **In which position have you been working during the year 2012***?*

If your position has changed during the year 2012, please state the position you had in the end of 2012.

- Part of firm management
- Middle management
- Employee without leadership function

[PD16] **Have the following tasks been part of your activity-area in the firm?**

Reference period: January – December 2012

	Yes	No	
Generation of new ideas	•	•	PD16_01
Evaluation/appraisal of new ideas	•	•	PD16_02
Planning / acquisition of financial resources	•	•	PD16_03
Planning / acquisition of human resources	•	•	PD16_04
Planning / acquisition of technologies	•	•	PD16_05
Development and testing of prototypes	•	•	PD16_06
Production	•	•	PD16_07
Marketing	•	•	PD16_08

[PD07] **Do you have a university degree?**

- Yes
- No

[PD06] **Have you ever been an employee of a higher education institution?**

- Yes
- No

[PD08] **Please state your highest academic title, its discipline, the higher education institution, which awarded the title, and the year in which it was awarded.**

Academic title	_____[PD08_01]
Discipline	_____[PD08_02]
Higher education institution	_____[PD08_03]
Year in which title was awarded	_____[PD08_04]

[PD13] **Have you been in contact with persons from the higher education institution at which you have earned above stated academic title since you have started working for the firm? If yes, how important have these contacts been for your activity-area in the firm?**

	No link	
Your former professors		PD13_01
Persons from your discipline		PD13_02
Persons from other disciplines		PD13_03
Persons working in technology transfer offices, entrepreneurship centres and alike		PD13_04

[PD17] **How important are communication in the firm, expert knowledge and networking for your activity-area in the firm?**

Regular communication with colleagues from other units/departments in the firm	PD17_01
Expert knowledge in own discipline	PD17_02
Expert knowledge in other disciplines	PD17_03
Broad as possible network with persons/organisations outside the firm	PD17_04
Small, but narrow network with persons/organisations outside the firm	PD17_01

[1: unimportant; 5 very important; -9 no answer]

[PD18] **How old are you?**

Please select

<20years	[1]
20-24 years	[2]
25-29 years	[3]
30-34 years	[4]
35-39 years	[5]
40-44 years	[6]
45-49 years	[7]
50-54 years	[8]
55-59 years	[9]
60-64 years	[10]
65 and older	[11]
No answer	[-9]

[PD05] **Are you…?**

- Female
- Male

- I would like to take part in the tombola. Five “Du&Ich” vouchers of Jochen Schweizer will be raffled off amongst all fully completed questionnaires. I agree that my email address will be saved for this purpose and until its completion. The information provided in this survey remains anonymous and will not be accessible for third parties.

- I am interested in the results of this study and would like to receive a summary by email.

Thank you for your participation! The information you provide will be treated **entirely confidential** and is utilised solely for scientific research.
Andrea-Rosalinde Hofer

For questions and comments: Andrea-Rosalinde Hofer, andrea.hofer@unitn.it; Graduate School on Local Development and Global Dynamics

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