Chapter 19
What Type of Companies Benefits from University Spillovers?

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19.1 Introduction

Over the last decades firms have broken away from purely internally oriented innovation activities to more interactive and open innovation processes (Chesbrough 2003; Christensen et al. 2005), because they recognize that the development and the production of their products has to rely on a wide range of external ideas, component technologies, and complementary capabilities. In a dynamically changing technological and economic environment it is virtually impossible for any single firm to stay abreast of all relevant advances; each and every single one of these advances can be a valuable opportunity for the firms' development of new goods, services or processes which are so important for the firms' competitiveness, the economy's growth, and the society's well-being.

Consequently, firms' success depends on their ability to create and maintain interfaces, which transcend the corporate walls (Nicholls-Nixon and Woo 2003), and it is strongly affected by the firms ability to interconnect these interfaces with their internal processes—especially with those processes that accumulate knowledge and develop capabilities (Van den Bosch et al. 1999; Kogut and Zander 1996).

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In the mid and late 1980s the introduction of the innovation system concept (Freeman 1987, 1988; Lundvall[1] 1988, 1992; Nelson 1988, 1993) made these increasingly interactive innovation activities accessible to academics and policy makers alike. Among other contributions such as the evolutionary theory of the firm (Nelson and Winter 1982) or the chain linked model of the innovation process (Kline and Rosenberg 1986) the concept of the innovation systems provided the foundation for a more systemic view on the innovation process since it emphasizes that innovation is an uncertain, disorderly, and complex process (Sharif 2006).

In general a system comprises a set of components which serve a common end. Thus, an innovation system is composed of a multitude of interconnected heterogeneous actors, such as firms, research institutes, funding organizations, policy-making bodies, and—most importantly for the context of this research—universities, which jointly and interactively create, accumulate and disseminate knowledge, skills, and artifacts. They thereby contribute to the development, the diffusion and the utilization of innovations and new technologies (e.g. Freeman 1987; Lundvall 1992; Nelson 1993; Metcalfe 1994; Kuhlmann 2001) on a national level (Lundvall 1992; Nelson 1993; Freeman 1987), on a sectoral level (Malerba 2002), on a technological level (Carlsson 1995; Callon 1992), and on a regional level (Cooke et al. 1997).

This research investigates the role of universities in the innovation system in their function as an informal source of inspiration for corporate innovation activities. It, hence, mirrors the evolving context and mission of universities as knowledge hubs and sources of inspiration (Shapira and Youtie 2008). Not unlike Laursen and Salter (2004) or Mohnen and Hoareau (2003) this analysis investigates what factors affect the firms' utilization of universities as inspiration for their innovation processes.

19.2 Theory

Innovations tend to originate from firms that continuously recognize and connect codified and scientific knowledge with their particular market insight and their specialized, often tacit, problem-solving capabilities within and outside their value chain (Jensen et al. 2007; Danneels 2002; Hargadon and Sutton 1997; Katila 2002; Katila and Ahuja 2002). The external networks of firms and the learning processes therein represent the microfoundations for interactive knowledge development and learning embedded in a larger innovation system (Giuliani and Bell 2005; Graf 2010).

In the innovation system, knowledge development and learning are the main activities lying at the core of the innovation system concept (e.g. Hekkert et al. 2007; Lundvall 1992). Herstad et al. (2011) classify the knowledge development

[1] Both Lundvall and Freeman attribute the first usage of the term 'national innovation system' to the other.

and learning activities crossing the corporate boundaries along four dimensions: labor market interactions, sourcing, collaboration, and inspiration through search. These are particularly important for the overall performance of the innovation system, its capability to support corporate innovation success as they strongly determine the innovation performance of firms (e.g. Laursen and Salter 2006; Ebersberger et al. 2012; Ebersberger and Herstad 2012). In addition, universities play a crucial role in each one of these dimensions.

First, labor market transactions lead to an inflow of workers from other firms or of newly graduates and extend the firms' stock of specialized knowledge and expertise with complementary competences (Boschma et al. 2009; Maliranta et al. 2009; Mason et al. 2004). This inflow also extends the firms' access to networks (Agrawal et al. 2006).

Second, firms may source component knowledge or technologies or fully fledged solutions from other corporate actors in the system (van de Vrande et al. 2006). Knowledge may also be sourced as embodied in various forms of software and hardware (Hauknes and Knell 2009) or as contract R&D services (Fey and Birkinshaw 2005; Grimpe and Kaiser 2010; Schmiedeberg 2008) from universities or higher education organizations (Perkmann and Walsh 2008).

Third, due to knowledge being tacit and sticky and due to the complexity and the uncertainty of the innovation process, firms often cannot access knowledge resources of universities by means of the two above-mentioned mechanisms (Hoopes and Postrel 1999). Collaboration for innovation or alliances with scientific partners may be an option in this case. However, this involves specific organizational requirements and challenges. In order to make sure the knowledge is comprehended, assimilated and integrated, firms require internal competences that are complementary to those of the scientific collaboration partners (Nooteboom et al. 2007). For beneficial knowledge exchange with science partners, firms have to allocate sufficient resources (Lam 2000) and management attention (Ocasio 1997) to the effort. Consequently, collaborative linkages are selective and dependent on firm level and context conditions such as the firms' corporate innovation strategy (e.g. Dachs et al. 2008), the firms' structure of the network of affiliates and ownership (e.g. Asheim et al. 2011), and the firms' location and access to labor market flows (e.g. Herstad et al. 2011).

Forth, new market and technology opportunities available externally have to be identified by the firm itself. In contrast to the above-discussed collaboration for innovation this process of inspiration through innovation search (Ahuja and Katila 2004; Katila and Ahuja 2002; Fleming 2001) does not require formal interaction between the firm and the university. The effect of innovation search is contingent on targeting knowledge fields without joint experiences (Hargadon and Sutton 1997; Majchrzak et al. 2004), which puts universities and its knowledge domains in a central role here. Search processes with universities may include the intentional use of information sources such as scientific publications, databases, and science collaboration partners. Yet, search activities often draw heavily on information about research efforts or findings (Cohen et al. 2002) which spills over through layers of personal ties (Agrawal et al. 2006) within networks or

communities (Maskell et al. 2006), or in the local environment surrounding the firm (Almeida and Kogut 1999). These knowledge spillovers are crucial for the regional impact of universities.

The knowledge spilling over from universities to firms using this as a source of inspiration for innovation projects is vital for the regional and national impact of universities. For university management, it is crucial to understand the characteristics of the firms utilizing this spillover to be able to identify where this important impact of the university occurs. For governments and funding organizations it is important to identify this as one of the incidences of public spending for universities. Hence, the overall research question is about the firm-specific and context-specific characteristics that influence the firms' use of universities as sources of inspiration.

19.3 Data and Methodology

The data used in this analysis originate from the Community Innovation Survey (CIS). The CIS is a periodic survey of firms' innovation activities to measure innovation. It is carried out by the national statistical offices of (current) EU member states including those of Norway and Iceland. The survey is based on a common set of guidelines for the collection and use of data on innovation activities; in particular, it is based on the Oslo Manual (OECD 1992) and its recent revisions (OECD 1997, 2005).

The strength of the survey is that it is conducted across countries according to a harmonized approach. The CIS includes information about the firm (including ownership), product and process innovation, innovation activity and expenditure, effects of innovation, innovation co-operation, public finding of innovation, sources of search and inspiration, and IP protection.

CIS data is used primarily for three different purposes. First and foremost, CIS data is used as a basis for official innovation statistics of the EU and its member states. Second it is used for policy-driven research and analysis, and is used extensively for analysis in economics (e.g. Veugelers and Cassiman 2006; Cassiman and Veuglers 2002; Cefis and Marsili 2005; Czarnitzki et al. 2007) in management studies (e.g. Laursen and Salter 2004, 2006), and in economic geography (e.g. Simmie 2003; Ebersberger and Herstad 2012).

The overall data set available for the analysis consists of 129,357 observations taken from the innovation surveys of the years 2004 (CIS4) and 2006 (CIS2006). The data are provided by Eurostat and available only at the premises of Eurostat in Luxembourg. It contains the national data set of 20 European countries. It is important to mention here that the available weights are used to extrapolate the results to the level of the economy. A detailed distribution of the national coverage is reported in Table 19.1.

Table 19.1 Composition of the sample

Country	Sample Size
BG	5,046
CY	194
CZ	6,830
DK	3,389
EE	983
ES	30,451
FI	2,472
FR	18,175
GR	3,428
HU	5,201
IT	25,950
LT	1,979
LV	1,683
MT	109
NO	2,768
PT	8,099
RO	3,907
SE	5,795
SI	1,282
SK	1,617
Total	129,357

19.3.1 Dependent Variable

The key variable here is a dichotomous indicator that firms use and appreciate universities as sources of information and inspiration for their innovation activities. The dichotomous variable is constructed from the ordinal survey question about the assessment of universities as sources of information for innovation activities. Companies assessing the importance of universities with the level 'medium' or 'high' on the four-level scale are regarded as appreciating universities as sources of inspiration. In the whole data set only slightly more than 13 % of the innovation active firms appreciate universities in this way. Additionally, we use a dichotomous indicator to identify companies, which are innovation active ($N = 50{,}270$).

19.3.2 Independent Variables

A number of country-specific, sector-specific, and firm-specific variables are included in the regression model to investigate the determinants for firms' utilization of universities as sources and inspiration for innovation. *First and foremost*, following the empirical tradition we capture the *firm size* by the natural logarithm of the number of employees.

19.3.2.1 Country and Sector Characteristics

Even the informal industry-science interaction may be influenced by the national framework conditions and the economic and scientific development of the economy. We use *the country groups* developed in Reinstaller et al. (2010) which classifies each of the countries in the data set into one of four groups: The group of Technology Leader Countries (SE, FI, DK, NO, FR, LU), the group of Technology User Countries (HU, EE, CZ, SK, SI), the group of High Income Low R&D Countries (IT, ES, PT, GR, CY, MT), and the group of Low Income, Low R&D Countries (BG, LT, LV, RO).

In addition to the development of the country captured by the country group the use of universities might depend on the size of the science system, which can be approximated by the *country size*. The size distribution of European countries (EU27 + NO + IS) yields a mean of 16 million inhabitants. All countries below this threshold are classified as small countries and all countries above it are classified as large countries.

Appropriability conditions can be operationalized on the sector level. It relates to how well intellectual property can protect new knowledge generated in a given sector to spill over into its environment. In certain industries the conditions are more favorable to protecting intellectual property, whereas in other sectors the conditions are such that spilling over of information, ideas, and knowledge is rather valuable to competitors and cannot be prevented. As in Ebersberger and Herstad (2012) we measure the appropriability regime indirectly employing the spillover approach utilized in Belderbos et al. (2004). There horizontal spillovers are measured directly as the importance firms assign to the information spilling over from competitors. As an indicator for the weakness of the appropriability regime in a sector we measure the fraction of innovating companies assessing information from competitors as important for their innovation activities. We will assume that the appropriability conditions do not only apply to corporate firms but also to universities.

19.3.2.2 Innovation and Knowledge

The innovation intensity is captured by the fraction of turnover spent on innovation activities; that is, the innovation expenditure divided by the turnover. We use the information on search channels to build in indicator of the *cumulativeness* of the knowledge base. We assume that the relative importance of external and the internal search captures the degree to which firm specific knowledge is accumulated and serves as a crucial ingredient to the current innovation process. Consequently, if a firm assigns higher importance to internal sources than to all other external sources, cumulativeness of the knowledge base is assumed (see Peneder 2007).

19.3.2.3 Internationality

Multinationality of a corporate network a firm is affiliated with may have an impact on the access to resources, directly impacting on the immediate need for informal external interfacing with the science system. On the other hand, multinationality of the network might be a precondition to lower the cost for external interfacing with international partners. A firm can be affiliated with a multinational network in basically two different ways—through foreign ownership or through being a *domestic multinational* (Ebersberger and Herstad 2012). The indicator for foreign ownership can be directly derived from the innovation survey as it inquires whether the firm is affiliated with a corporate group. If so, the survey inquires about the country, where the headquarters of the group is located. A dichotomous variable indicating affiliation to a corporate group, which is not headquartered domestically serves as all indicator for *foreign ownership*. The data set contains about 11 % of foreign-owned companies.

We follow Ebersberger and Herstad (2012) in determining the multinationality of a domestically headquartered corporate group and derive it from the information about innovation collaboration. About 1.5 % of the companies in the data set are affiliated to a domestic multinational network.

The effect of internationalization of firms on their innovation activities and their sources of inspiration have been discussed in the literature: Incentives to innovate are related to the size of the market on which the firm can commercialize the innovation. The decision to innovate also seems intensely intertwined with the companies' international orientation. We capture the *international orientation* by a dichotomous variable, which takes the value one if the firm reports that the most important markets are international. The most prominent indicator for international orientation, i.e. share of exports cannot be used as the export is not consistently surveyed as a firm demographic characteristic in the Community Innovation Surveys available.

19.3.2.4 Openness

As Laursen and Salter (2004) show the overall openness of the innovation process is a strong determinant of firms' utilization of knowledge spillovers from universities. We include three measures of openness in the regressions: the *diversity of search* with other corporate actors in the innovation system, the *diversity of collaboration*, and the diversity of the *protection strategy* of the firms. An extensive discussion of these indicators can be found in Ebersberger et al. (2011).

19.3.3 Method

Since the dependent variable is dichotomous we use a probit regression model to determine the effect of the characteristics on the use and appreciation of universities as sources of inspiration. Yet, the dependent variable can only be observed with firms that carry out innovation activities. Hence, we have to control for this selection bias and model the firms' decision to carry out innovation activities by a probit regression model. Including the Mills' ratio of the latter as an independent variable in the first regression model we control for the selection bias in a two-step estimation process.

19.4 Results

The results of the second step of the regression model, that is, the regression of the use and appreciation of universities as sources of inspiration for innovation, are reported in Table 19.2. To investigate the robustness of the models the same regression models are applied to all observations (Model I), to small and medium-sized firms (Model II), to firms in high technology (Hatzichronoglou 1997; OECD 2001) sectors (Model III), to firms in knowledge-based service (Hatzichronoglou 1997; OECD 2001) industries, and to firms from small countries (Model V). Table 19.2 reports the marginal effects rather than the coefficient estimates.

First we find that regardless of the subsample analyzed firm size determines the firms' usage and appreciation of universities as sources of inspiration. The size effect is smallest with knowledge-based services. A particularly strong effect can be found both among firms in high technology sectors and among firms in small countries. The larger the firms the more they seem to use and appreciate universities as sources of inspiration. As discussed above to be able to make good use of the inspiration firms have to comprehend, assimilate, and integrate the inspiration into their business. This absorptive capacity can be assumed to be more fully developed the larger the firm is.

For the total set of firms and for the subsample of SMEs and for the subsample of firms from small countries the openness of the innovation process is a strong determinant of the use and appreciation of external inspiration by universities. It can be assumed that in companies that already pursue an open innovation strategy, the receptiveness for external ideas, and inspiration is higher. Commonly, it is argued that the largest challenge in implementing open innovation strategies is to overcome the not-invented-here-syndrome. Given that, companies already use open innovation strategies it is plausible to assume that the syndrome is no strong obstacle for external ideas. The appreciation of inspiration is of course higher in these firms. Both in high technology industries and in knowledge-based services only the openness towards other—more industry related—inspiration is no determinant for the appreciation of science inspiration.

Table 19.2 Results of the outcome regression (model I–V)

	I	II	III	IV	V
me/se	ALL	SME	High tech	KIBS	Small country
Firm size	0.041***	0.045***	0.073***	0.025***	0.075***
	0.003	*0.004*	*0.018*	*0.006*	*0.006*
Openness of the innovation strategy					
Collaboration diversity	0.031***	0.029***	0.051***	0.044***	0.038***
	0.002	*0.003*	*0.010*	*0.005*	*0.004*
Industrial search	0.023***	0.024***	−0.007	0.007	0.032***
	0.003	*0.003*	*0.020*	*0.007*	*0.006*
Protection strategy	0.014***	0.014***	0.000	0.031***	0.016*
	0.003	*0.003*	*0.014*	*0.009*	*0.007*
Internationality					
Internat. orientation	0.042***	0.041***	0.135***	0.016	0.078***
	0.007	*0.007*	*0.039*	*0.017*	*0.013*
Dom. multinational	0.012	0.004	−0.047	0.027	0.019
	0.013	*0.016*	*0.044*	*0.033*	*0.024*
Foreign owned	−0.028***	−0.029***	−0.050	−0.051***	−0.013
	0.005	*0.006*	*0.027*	*0.012*	*0.011*
Knowledge and innovation					
Innov. intensity	0.089***	0.087***	0.087	0.128***	0.068*
	0.013	*0.013*	*0.080*	*0.021*	*0.030*
Cumulativeness	−0.058***	−0.054***	−0.109***	−0.089***	−0.086***
	0.005	*0.005*	*0.033*	*0.011*	*0.010*
Country and sector characteristics					
Appropriability (weak)	0.238*	0.313**	0.935	0.258	0.315
	0.100	*0.105*	*0.714*	*0.201*	*0.196*

(continued)

Table 19.2 (continued)

	I	II	III	IV	V
Techn. user country	−0.048***	−0.048***	−0.115**	0.008	−0.069***
	0.007	*0.007*	*0.039*	*0.024*	*0.015*
High R&D, low income cntry	0.036***	0.033***	0.06	0.062***	0.098***
	0.007	*0.007*	*0.039*	*0.016*	*0.017*
Low R&D, low income cntry	−0.024*	−0.020*	−0.118**	0.069	−0.073***
	0.010	*0.010*	*0.039*	*0.038*	*0.017*
Small cntry	0.083***	0.080***	0.108*	0.087***	–
	0.007	*0.007*	*0.042*	*0.017*	–
N	50,270	40,769	2,743	10,585	21,220
ll	-1.70E + 04	-1.32E + 04	−1302.561	−3962.581	−9308.18
R2	0.133	0.123	0.084	0.176	0.093
Chi2	2198.0***	1555.0***	121.7***	763.4***	860.3***

Note: Table reports marginal effects. Standard errors in italics. ***, (**, *) indicates significance at the 1 %, (5, 10 %) level. Regression include 17 sector dummies, one time dummy, indicators for opportunity conditions, and for model I–V the inverted Mills' ratio derived from the selection equation not reported here. The results of the selection equation can be obtained from the authors upon request

Internationality of the firm does have in effect on the use and appreciation of the university spillovers. We observe that domestically headquartered firms with an international network do not use university spillovers more intensively. Yet, firms with an international network of affiliates, which are headquartered abroad, report less use, and appreciation of the university spillovers. This can be caused by two phenomena. First, a branch plant syndrome causes reduced embeddedness of the firm in its immediate environment as the mandate of the firm does not extend into knowledge generation and innovation. Hence, these firms will be less likely to use and appreciate university knowledge spillovers. Second, the international network and the international headquarters also serve as sources of inspiration and knowledge spillovers. Although the absorption of these spillovers requires less attention than the management of a collaborative project, attention is a scarce resource, which might be allocated to accessing intra-MNC spillovers and easily transferable knowledge assets where appropriability is less of an issue (Markusen 1995).

The regression results also show that innovation intensity heavily affects the use and appreciation of the university spillovers. Yet, firms that face a high cumulativeness of their knowledge base are less likely to use and appreciate external information; this is also the case for university spillovers.

In sectors with weak appropriability regimes the inspiration by universities is generally more used and appreciated. As the appropriability is generally speaking not strictly determined by the sector it self but rather by the predominant knowledge and technology used in the sector the weak appropriability also refers to the knowledge developed by universities. Where appropriability is weak universities will generally create more spillovers.

Our regression results also show that the technological frontier of the science system and the development of the economy, measured by the level of income, have a strong effect on the use and appreciation of university spillovers. In countries that are not classified at the technological and scientific frontier, that is, the technology-using countries and the low R&D countries, we find a significantly lower likelihood to use and appreciate university spillovers. Yet, in the high R&D and low-income countries the use and appreciation of the university spillovers is between 3 and 10 % points higher than in the technologically leading countries. A strongly developed science system coincides with the need for further economic development. University spillovers seem to be a valuable but rather economical source of inspiration. We also observe that firms in small countries have an 8 % points higher likelihood to use and appreciate university spillovers than firms in large countries.

19.5 Discussion

In this analysis, we have generally confirmed for a data set of European firms what Laursen and Salter (2004) have found for a data set of firms from the UK. The structural dimensions of firms such as size and innovation intensity strongly influence the use and appreciation of the university spillovers. To firmly establish the university in its new role as a knowledge hub university management should

not only be interested in strengthening the science-industry collaboration and strategic alliances of the universities and corporate partners, university management should also be interested in the informal interaction generating spillovers and inspiration. In broadening the corporate audience, which benefits from the university spillovers, activities to reduce the dependence on size and absorptive capacity seem required. This can be achieved through provision of low-level access to research results and findings, for instance, by establishing a science fair particularly tailored to the needs and requirements of local and regional SMEs. Also the provision of technical advisory infrastructure such as a technology help desk which is open for external consultation can help companies to get in touch and to get inspired more easily. Supporting the universities publication effort in applied science, business practioneer, or applied science journals can increase the visibility of university research to corporate actors in the innovation system. Generally, the exchange of knowledge and inspiration across institutional boundaries requires the implementation of new methods of communication and tools focusing on mutual participation (Guston 2001).

Additionally, not unlike the findings in Laursen and Salter (2004), we find that managerial decisions as reflected in the overall search behavior and the openness of the innovation strategy heavily affect the use of universities as sources of inspiration for innovation. This indicates that primarily companies with distinct innovation strategy are interested in and receptive for the university spillovers. These are the companies, which have the strongest capacity to use the inspiration beneficially for the regional economy. This entails that this self-selection of firms reduces the university management's need for efforts to select the recipients of the spillovers or to channel these spillovers. As discussed above, providing broad access and broadcasting the research through a number of different channels will be sufficient to attract interested and capable companies to get inspired.

In addition to the findings in Laursen and Salter (2004), we established that the use and appreciation of the university spillovers depend on the regional and national context of the science system and the economic system. Overall our findings do not challenge the results obtained earlier. Yet, they highlight the particular role the university spillovers play in regional and national economies with a low innovation performance and the low growth prospects.

We find that a substantial fraction of 13 % of the innovation-active companies appreciate university spillovers, which is well above the 10 % reported in Laursen and Salter (2004). This, in combination with the findings in the analysis and with our own experience, tempts us to agree with Cohen et al.(2002): Although in the wake of the Bayh-Dole Act and in the wake of the reform of some of the employee invention regulations (e.g. in Germany and Austria) and with substantial investment in the management of university IP in most of the European countries, transfer of IP, nevertheless, seems to be a minor channel of how the innovation system and the corporate actors therein benefit from the findings of university research. Knowledge spillovers informing and inspiring corporate innovation activities tend to be a more relevant channel and require at least as much university management attention than IP issues do.

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