ANALYSIS OF INNOVATION DRIVERS AND BARRIERS IN SUPPORT OF BETTER POLICIES

Economic and Market Intelligence on Innovation

Open Innovation in Europe: effects, determinants and policy

Report

Prepared for:

European Commission
Directorate-General Enterprise
Unit D1 Policy Development for Industrial Innovation

Prepared by:

Bernd Ebersberger

Management Center Innsbruck
Innsbruck, Austria

Sverre J. Herstad

NIFU
Oslo, Norway

Eric Iversen (WP Coordinator)

NIFU
Oslo, Norway

Eva Kirner

(previously) Fraunhofer ISI

Karlsruhe, Germany

Oliver Som

Fraunhofer ISI

Karlsruhe, Germany

Oslo, July 19 2011

www.proinno-europe.eu/innogrips2

European Commission
Enterprise and Industry

Project consortium

- Austrian Institute of Economic Research, WIFO, Vienna, (coordination).
- Fraunhofer Institut für System- und Innovationsforschung, ISI, Karlsruhe.
- Greenovate! Europe, Brussels.
- NIFU, Oslo.
- UNU-Merit, Maastricht.
- MCI Innsbruck, Innsbruck, (subcontractor).

Authors (in alphabetical order)

Bernd Ebersberger, Management Center Innsbruck, Innsbruck, Austria
Sverre J. Herstad, NIFU, Oslo, Norway
Eric Iversen (Coordinator), NIFU, Oslo, Norway
Eva Kirner, (previously) Fraunhofer ISI, Karlsruhe, Germany
Oliver Som, Fraunhofer ISI, Karlsruhe, Germany

Referees for this report

Carter Bloch

Anthony Arundel

Note: The referees have provided highly valuable comments that have led to a substantial improvement of this report. The authors are responsible for any remaining mistakes.

Acknowledgements

The team would like to acknowledge the valuable input of the group of experts who participated at the Validation Workshop in Brussels on 19 May, 2011.

Suggested citation

Ebersberger, B.; Herstad, S.; Iversen, E.; Som, O.; Kirner, E. (2011). Open Innovation in Europe. PRO INNO Europe: INNO-Grips II report, Brussels: European Commission, DG Enterprise and Industry.

Foreword

"INNO-Grips" (short for "Global Review of Innovation Policy Studies") supports policy makers in adopting appropriate policy responses to emerging innovation needs, trends and phenomena. It analyses framework conditions, barriers and drivers to innovation and innovation policy and offers intelligence on international developments in these fields.

Over a period of three years (2010-2012) INNO-Grips will conduct studies and orgaise workshops to exchange views, ideas and best practices with innovation stakeholders in order to optimise innovation policy Europe-wide. These key activities will be complemented by a news service about international innovation policy developments, covering about 40 countries worldwide, and further dissemination activities such as newsletters. Target audiences are invited to discuss the results of studies and related issues in an interactive online environment (the INNO-Grips blog). INNO-Grips is thus a platform for all stakeholders involved in the practice of innovation and in innovation policy, in particular innovation policy makers at the EU, national and regional levels; innovation intermediaries such as innovation agencies and knowledge transfer centres; innovation practitioners and academia conducting research on innovation dynamics.

Technically, INNO-Grips consists of two lots. The first one – "Innovation policy research and intelligence" – gathers evidence on innovation policy developments worldwide and analyses specific aspects and trends in detail. The second lot – "Economic and market intelligence on innovation" – analyses framework conditions (e.g. implications of socio-economic trends), barriers and drivers to innovation at firm level. This report is the third in a series of six studies in the context of the second lot which will investigate the following topics[1]

1. Barriers to internationalisation and growth of EU's innovative companies
2. Socio-economic trends for innovation policy
3. Open innovation and other new forms of collaboration
4. Social attitudes to innovation and entrepreneurship
5. The role of multinational companies and supply chains in innovation
6. The new nature of innovation

These studies will be delivered in close coordination with the representatives of the European Commission and in close interaction with the service providers of the other PRO INNO Europe activities. All studies are of high relevance to the activities set in the context of the Flagship Initiative "Innovation Union" carried out as part of the new Strategy Europe 2020.

WIFO is the lead partner of the "Economic and market intelligence on innovation" studies and is also responsible for the coordination of activities with the European Commission. The partner institutions in this project are NIFU based in Oslo, UNU-Merit based in Maastricht, the Fraunhofer

[1] See http://www.proinno-europe.eu/inno-grips-ii/page/studies for more details.

Institute for Systems and Innovation Research (ISI) based in Karlsruhe, and the Management Center Innsbruck. Greenovate! Europe will support all dissemination activities. Each study will be presented and discussed at workshops organised by the Consortium in close cooperation with the European Commission. The workshops will serve to present the findings and conclusions as well as the derived policy recommendations to a qualified audience of stakeholders, representatives of the business community, policy makers, and leading academics for external validation.

The present report focuses on open innovation in European companies. In particular it sheds light on the performance effects of open innovation and on the determinants of open innovation practices.

Executive summary

Background

As modern industrial products become increasingly complex, their development and production must draw on a wide range of external ideas, component technologies and complementary capabilities. In this landscape it is virtually impossible for any single firm to keep abreast of all relevant technological advances. This means that 'what firms do' involves the targeted development of specialized knowledge assets, using inputs from a wider range of other science and non-science knowledge areas. Additionally firms also make some of their specialized knowledge assets available to other actors. These activities are referred here to as their open innovation practices.

The networks maintained by individual firms located within a national or regional economy represent the micro-foundations for learning and knowledge embedding at the larger system level. Knowledge development and accumulation at the firm-level enrich the wider economy by laying the basis for labor market mobility and personal network formation and by promoting collaborative ties. Territorial (national, regional) economies therefore represent potential melting pots for on-going experimental diffusion, recombination and transformation of specialized industrial and scientific knowledge.

In the report we explore these aspects of open innovation practices. The point of departure is the current notion of open innovation and the subsequent attempts made at transforming this firm-level management concept into more global perspectives on innovation and growth. While contributing to a more nuanced theoretical conceptualisation of open innovation, our main contribution is the large-scale empirical analysis (130,000 firms from 22 European countries) of open innovation impacts and determinants which have been conducted based on the pan-European Community Innovation Survey. In light of this material, an extensive survey of current and relevant policy measures is provided. The overall aim of the conceptual, empirical, and policy components of the report is to promote the emergence of a new policy discussion in the area of open innovation.

Key Findings

Dimensions and impacts of open innovation

The report conceptually identifies different dimensions of open innovation. It demonstrates that open innovation is not a singular best practice but rather involves a set of practices which we find to be empirically distinct. Around these distinct dimensions (introduced below), three distinct research topics are explored. First, we investigate the effects of the various practices on innovation performance at the firm level; second, we identify factors that are important determinants of these various practices, including public funding; and finally, we explore the national and European innovation policy landscape in order to discuss what our findings might mean for future innovation policy development.

Search and Screening – Finding Ideas and Inspiration Outside of the Firm

The first dimension of open innovation involves mechanisms that expose firms to new information and novel ideas from outside sources. Innovation is conditioned by the individual firm's exposure to information from various outside sources and by the attention paid by the firm to these. The combination of exposure and attention define the search spaces, in which corporate enterprises search and screen in order to find new inspiration, novel ideas and unrealized opportunities on a systematic basis. In this context, the report supports the theoretical argument that firms and economies need to develop search spaces which not only extend beyond their individual boundaries (organizations, sectors, territories) but also beyond their current network linkages.

The empirical evidence confirms that both the systematic screening of surrounding industrial actors (Industry Search) and of universities and other scientific institutes (Science Search are conducive to innovation. Evidence is also found that the search process itself is dependent on the strength of internal competences and capabilities. We emphasize that we find no indication that a focus on this intramural R&D leads to the not-invented-here syndrome. The indication that building internal knowledge bases supports broad external search has policy implications which are discussed.

Innovation Collaboration –Innovating together

The search process may lead to deeper interaction with external actors, depending on what is found. The individual firm may find that it lacks sufficient tacit knowledge to pursue a promising idea or it might confront unanticipated problems in exploiting these. If these challenges cannot be overcome internally, the firm may actively engage in collaborations with external actors. The second dimension involves these collaborative processes. In them, actors engage in the mutual exchange of knowledge, encouraging the exchange of tacit knowledge among partners to lesser or greater degrees. Collaborative relationships at the domestic level serve to diffuse and recombine knowledge actor and sector groups, whereas international collaborations may serve important technology transfer functions.

In terms of this dimension of open innovation, the empirical evidence of the report shows that collaboration diversity and internationalisation is determined by internal competences. This evidence tends to contradict the prevailing notion that strongly emphasizing the build-up of internal capacity results in 'closed' innovation processes. This suggests that strengthening the internal competence bases of firms more broadly tends to strengthen the propensity of firms to engage in innovation collaboration. Policy implications are discussed on this background.

External Innovation Expenditure – Purchasing embodied knowledge

The third dimension of the open innovation is what we will call "external innovation expenditure". External innovation expenditure involves arms-length contracting related to the procurement of technology 'embodied' in machinery and components, the purchase of problem-solving capabilities through contract R&D, or the acquisition of technology and capabilities in the form of patents or licenses. The purchase of knowledge and technology in this way is generally considered important to the expansion of global trade because it entails large flows of product-embodied knowledge between firms, sectors, and countries. It is distinct both from intramural R&D expenditures and from external innovation collaboration in several important ways. External innovation expenditure is for example less contingent on a firm's internal capabilities or absorptive capacity than the other two dimensions. Another key distinction is that this dimension leads to less knowledge accumulation for the sourcing firm, which is also left without control over those knowledge assets in which it invests. A strong reliance on it over time may lead to a 'hollowing out' of internal competencies.

In terms of this dimension of open innovation, our findings align well with other empirical studies which point to problems in coordination and integration, increased costs of innovation and long-term hollowing out of firm competences due to an over-reliance on external innovation expenditure. Overall, the impact of external innovation expenditure is found to be negative, especially for large enterprises. However, a negative impact is not present in small economies while a positive impact is found in those countries which are the farthest away from the technological frontier. This suggests that external innovation expenditure may serve to compensate for weaknesses for certain types of firms in market situations. These results are also discussed in the policy-oriented section of the report, which we turn to now.

Policy Impact & Implications

To complement the extensive empirical investigation of open innovation practices, the report also conducted a survey of relevant national and European innovation policy areas. This effort is used to introduce a discussion of what our findings might mean for future innovation policy development, especially at the EU level. Here, the message that emerges is that the future EU innovation programs might do well to focus far more explicitly on i) harnessing synergies between diverse industrial competences and capabilities present within Europe and ii) on linking these competences to extra-European global innovation networks; while at the same time focusing less on iii) forcing linkages between industry and the science system.

The report introduces a policy assessment framework in order to structure the more general policy discussion. This framework consists of three different yet complementary categories of policy instruments. The first set of instruments, Set 1, focuses on the build-up of specialised knowledge within corporate enterprises. These instruments predominantly involve measures to increase intramural R&D efforts. Their broader purpose is to ensure the embeddedness of firms in the economy, to strengthen their absorptive capacity, and to ensure a steady stream of spillovers from these R&D efforts. The second set of instruments, Set 2, involves promoting the dynamics of regional and national innovation system. These instruments are directed towards encouraging knowledge to diffuse more efficiently within the economy. The third set of instruments, Set 3, seeks to establish linkages between a given economy, other economies, and international innovation networks more broadly.

The Impact of Public Funding on Open Innovation Practices

The report distinguishes between the overall impact of national and European funding schemes. In the analysis, National funding schemes are found to increase domestic vertical and science system collaboration. This holds regardless of the specific country context. The picture becomes more mixed regarding industry search, in that both negative and positive effects of national funding are found for different country groups. This clearly warrants policy attention. The same applies for the apparent inability of national funding programs to trigger international collaborative linkages.

EU funding is shown to have a distinctive impact in reorienting search away from customers and suppliers (i.e. negative impact on industry search) and towards research institutes and universities (positive impact on science search). This suggests that while EU funding strengthens university-industry linkages in accordance with defined objectives, it weakens the attentiveness of firms towards information and inspiration from industrial sources. This effect is most distinct for small (<21 employees) SMEs. In contrast to national public funding which predominately broadens the collaboration patterns of medium-sized and large firms, the positive impact of EU public funding on collaboration in general is demonstrated throughout all firm size groups. On the other hand, EU funding is not found to affect innovation collaboration in small countries.

EU funding clearly triggers national and international science system collaboration. In certain contexts it also affects international vertical collaboration positively. This lends support to the concern (see search, above) that the behavioral additionality of EU funding is limited to the establishment of science system linkages. The analysis indicates that EU programs do not sufficiently contribute to linking industrial actors across national boundaries. This raises the question of the extent to which the predominant impact of existing EU funding schemes is to incorporate science system actors into collaboration networks already (largely) determined by firm characteristics and by their prior search activities.

Implications for EU Level Innovation Policy

Much of the recent open innovation literature postulates a contradictory relationship between internal R&D and open innovation. However, our analysis finds no evidence of this negative relationship. On the contrary, we find that strong internal corporate knowledge bases, as measured directly R&D intensity and indirectly by size and sector classes, drive complementary processes of external search and collaboration. This indicates that the Set 1 instruments remain highly relevant in the era of global open innovation. In this respect, our findings depart radically from the original formulation of the 'open innovation' concept by Chesbrough, who focused heavily on the virtues of external technology sourcing. Our analysis indicates that such arms-length sourcing may impact innovation positively in those countries which are farthest away from the technological frontier. But in advanced countries, and demanding sector groups, our analysis shows that a strong orientation towards external innovation expenditure may undermine innovation and competitiveness. This works by way of hollowing out.

We also find that the degree— and the nature—of corporate internationalisation matter. In Particular, the report emphasises the distinct impact that one type of linkage has for innovation performance; this is the set of linkages that a given firm has with industrial partners in other countries. This type of international industrial network can indeed be built up within the EU so as to capitalize on the diverse industrial competences and capabilities already present in its member and associated states. As the policy review section of the report indicates, there is scope for EU level innovation policies to further look into ways to exploit the innovation potential that exists at the interface between these diverse industrial competences. At the same time, it should be recognized that the potential positive effects of industrial linkages extend to other countries, where they may even be stronger. Efforts to further link Europe to innovation networks extending into emerging economies such as India and China may therefore be worth exploring further from this point of view. In sum this indicates that domestic **Set 3 instruments** should supplement EU level **Set 2 instruments** to build stronger intra-union *industria*l search spaces and collaboration networks which are linked to competences outside the Union. Whereas much policy has been directed on strengthening ties industry and the science system, the analysis suggests that these ties are can come at the expense of industrial linkages. If so, the combination of Set 2 and Set 3 instruments should arguably be prioritized in future to promote innovation performance in the EU.

In sum, the report demonstrates that open innovation matters for innovation performance and can potentially play a stronger role in the European Union. The diversity of industrial competences and capabilities in the European countries make the EU a potentially unique arena for open innovation processes. This study has indicated some areas of innovation policies at the level of member states and of the Union where adjustments may help to realize this potential.

Table of Contents

Tables

Figures

Open Innovation in Europe

Preface

This report summarizes the findings and the discussions of WP 3 of the InnoGrips Project. It was jointly conducted by researchers from NIFU (NO), Fraunhofer ISI (DE) and Management Center Innsbruck (AT). Please note that NIFU STEP simplified its name to NIFU during the course of the work.

Researchers from NIFU and Management Center Innsbruck (Ebersberger, Herstad and Iversen) are responsible for the general discussion, the empirical analysis and the policy discussion which is presented in chapter 1 through chapter 13. The empirical design and its operationalization were primarily carried out by Management Center Innsbruck (Ebersberger). Researchers from Fraunhofer ISI (Som and Kirner) are responsible for the policy analysis (Appendix chapter 15), which extends and contextualizes the implications for policy discussed earlier in chapter 13.

Introduction

As modern industrial products become increasingly complex, their development and production must draw on a wide range of external ideas, component technologies and complementary capabilities. In this landscape it is virtually impossible for any single firm to keep abreast of all relevant technological advances. This means that 'what firms do' (Kogut and Zander, 1996) involves the targeted development of specialized knowledge assets, that are integrated from a wider range of other science and non-science knowledge areas (Kessler, Bierly, and Gopalakrishnan, 2000). Growth and competitiveness become contingent on the ability of firms to compose, establish and maintain external interfaces (Nicholls-Nixon and Woo, 2003) ; to choose the right mode of governance, (Fey and Birkinshaw, 2005) and to link these effectively to internal knowledge accumulation and capability development (Bosch, Volberda, and Boer, 1999; Kogut and Zander, 1996). The way firms do this can be called their 'open innovation' practices.

In the changing environment, there is a need to better understand Open innovation (OI) activities. Policy makers in particular need an informed basis on which to consider different policy options. There are a number of challenges to improving our understanding of these activities. The ways in which corporate innovation processes link with external partners and to external knowledge sources are potentially heterogeneous and highly contextual. OI activities are likely to differ structurally in these different sectorial and geographic contexts. Bettering our understanding therefore requires an empirical study that is broad-based enough to cover different firm-types in different contexts but fine-grained enough to pick up important patterns in the way these activities are carried out.

The objective of this report is to address the need for this type of empirical analysis of OI activities. We set out to go beyond the scope and scale of current empirical studies. Research in this area, where empirical, has tended to rely on individual cases or populations for support. The report conducts an empirically based study of OI activities in the diverse European context. It addresses a need for a robust empirical study of these activities across a variety of contexts. The premise is that this will improve policy-making processes that aim to improve the way corporate innovation processes link with external partners and to external knowledge sources. a robust empirical basis is needed.

1. Scope

The empirical analysis is designed to promote evidence-based policymaking. To accomplish this the analysis builds on an extensive data set of more than 130,000 firms from 22 European countries. The analysis of this firm level innovation survey data sheds light on the implementation of open innovation practices in these firms and on the effects these practices exert on the firms' innovation performance. In particular the analysis informs the reader about potential leverages to strengthen innovation performance by fostering and furthering open innovation in European enterprises.

It is however crucial that the nature of this evidence is understood. The analysis is based on pooling two-waves of survey results (as described in Chapter 2). Although being extensive it still provides a snap-shot. The unit of analysis is the enterprise rather than, say, an individual innovation project. Thus, the survey does not provide project-level data nor does it provide explicit information about the commercialization strategies or business models of the reporting firms.

According to our definition of open innovation processes, this approach allows us to compare a range of different types of innovative firms in a wide range of different technological and geographical contexts. But, while the survey is extremely broad-based, it constrains us in what we can say about the observed open innovation activities. For example, the approach cannot link an individual product innovation (as opposed to a process innovation) to a specific type of collaborator; it cannot test the sensitivity of the different firms to a 'funding gap' during the commercialization process of a specific innovation; and it does not include the role of other policy tools (such as procurement) in promoting open innovation practices. That said, it does provide a rich and diverse body of information about the effects of open innovation practices on innovation performance of firms and the determinants of the firms' use of open innovation practices.

2. Research questions

In this context, the objective of the study is to address the need for a robust empirical analysis at the European level and to relate results from that exercise to the changing policy-landscape in Europe. More specifically, the aim of the study is to address three fundamental questions: (1) What are the effects of open innovation practices on the innovation performance of firms?; (2) What are the determinants for adopting open innovation practices?; (3) What are the consequences of the findings for innovation policy?

In terms of the first two questions, the study builds on earlier approaches. On this basis, the approach here goes considerably farther in scale and scope than earlier work in order to analyze OI activities across Europe. The empirical work is based on a comprehensive set of cross-country empirical material (i.e. different waves of the Community Innovation Survey for EU countries): a thoroughgoing empirical approach was developed in order to analyze this material in a rigorous and consistent manner. The work focuses primarily on the way innovative firms in different (national and sectoral) contexts i.) gain access to information from external sources, ii.) the way they collaborate with external partners, and iii.) the way they engage with external linkages given that these are affected by the companies' protection of its intellectual property. This allows the analysis to differentiate effects and determinants for different populations (for example low-tech manufacturing or medium-low-tech manufacturing firms). For example, we differentiate between whether innovative firms primarily search for ideas and inspiration in other industrial firms or from the science sector; and whether they primarily collaborate with partners along the value chain (such as customers and supplier) or with scientific partners; whether they primarily engage in domestic or international innovation collaborations.

To address the findings from this exercise to innovation policy, the study also takes stock of relevant policy initiatives both at the national and European level. A range of policy documents from both levels are screened and discussed in terms of their relevance for OI activities. There are several challenges to this work, not least that such activities are not clearly identifiable in the policy documents; that national and European measures may differ; and that policies change over time. The report tries to tackle these challenges. With a particular focus on the European dimension, the survey of policy documents is then considered in light of the findings from the empirical analysis.

The report culminates with a discussion of the implications of this exercise for ongoing and future policy development.

3. Report Structure

This report covers a vast territory and a variegated terrain. It is thus a comprehensive document because many details are necessary to understanding the different facets of the study. The report attempts to put a lot of this detail into annexes: the report will along the way refer readers who are specifically interested in, for example, the underlying technical approach or in the details of the policy-survey to the relevant annex. We include here a brief overview to help the reader navigate the report itself. This overview is based on the study's underlying research questions.

a. What are the effects of open innovation practices on the innovation performance of firms?

In Chapter 4 we start the analysis with the overall question whether open innovation practices have an effect on the innovativeness of firms at all. We focus only on the effect open innovation practices have on innovation performance, without exploring other interesting relationships such as how other firm level characteristics such as foreign ownership or public funding affect innovation performance. Moreover, this preliminary section does not explicitly distinguish between individual open innovation practices but rather concentrates on their joint effect. It is important to establish at the outset that the open innovation practices do jointly affect the innovation performance of firms: absent such a joint-effect, it would make little sense to pursue the individual factors in terms of a wider-set of OI practices.

Having established this joint-effect in Chapter 4, the subsequent chapters then unpacks the individual effects of open innovation practices. Chapter 5 investigates the effect of search activities on innovation performance. This investigation distinguishes between search activities targeted at industrial actors and search activities targeted at sciences actors. In Chapter 6 the effects of collaboration on innovation performance are presented. Here we report the effects that different collaboration patterns have on innovation performance, while distinguishing between vertical collaboration and science collaboration. We also distinguish between domestic collaboration and international collaboration. Chapter 7 moves on to explore the effects that IPR protection has on the innovation performance of firms. The premise here is that the way that the innovative firm controls unintended spillovers will affect the likelihood that they engage in different forms of collaboration. In Chapter 8 we investigate the effects of external innovation expenditure on firms' innovation performance.

b. What are the determinants for adopting open innovation practices?

Having established the effects of open innovation practices on innovation performance in the preceding chapters, we turn to the adoption of open innovation practices starting with Chapter 9. There we investigate firm level determinants of open innovation practices. In particular we investigate the effects of firm size in section 9.1, the effects of the firms' innovation intensity in section 9.2, and the effects of foreign ownership and of domestic multi-nationality in sections 9.3 and 9.4 respectively. Chapter 10 reports how public funding for innovation affects the use of and the intensity of the use of open innovation practices. There we distinguish between the effects of national domestic funding and EU funding. Chapter 11 addresses a question closely related to the adoption. It investigates the interdependence of the adoption of the open innovation practices.

c. What are the consequences of the findings for innovation policy?

In chapters 12 and 13 we summarize the findings and distill consequences for innovation policy from our findings. Building on a policy analysis framework introduced in section 12.1 we maintain the main structure of the analysis in this chapter as well. We discuss the findings and policy conclusions related to search activities in section 12.2, related to collaboration in section 12.3, related to protection in section 12.4, and related to external innovation expenditure in section 12.5. The report culminates in Chapter 13 with a discussion of the overall policy implications of open innovation in Europe. The final chapter takes shape in the light of the substantial policy annex (see below). It discusses a range of policy implications that might be taken from the empirical findings. It discusses implications in terms of the policy framework introduced above. The intention is to introduce a discussion of future innovation policy in this area.

4. Setting the stage and the appendix

Prior to the analysis of effects we discuss the overall context of the analysis in Chapter 1. The data used for the analysis is briefly introduced in Chapter 2. Chapter 3 discusses the measures and the methods employed in the quantitative analysis. In particular in section 3.2 we discuss in detail how open innovation practices are operationalized in the empirical analysis.

The Appendix contains an analysis of policy measures related to open innovation in Europe. The reader that is interested in the underlying regression tables from the quantitative analysis in Chapter 4 to Chapter 11 is asked to contact the primary author.

PART I

Setting the Stage

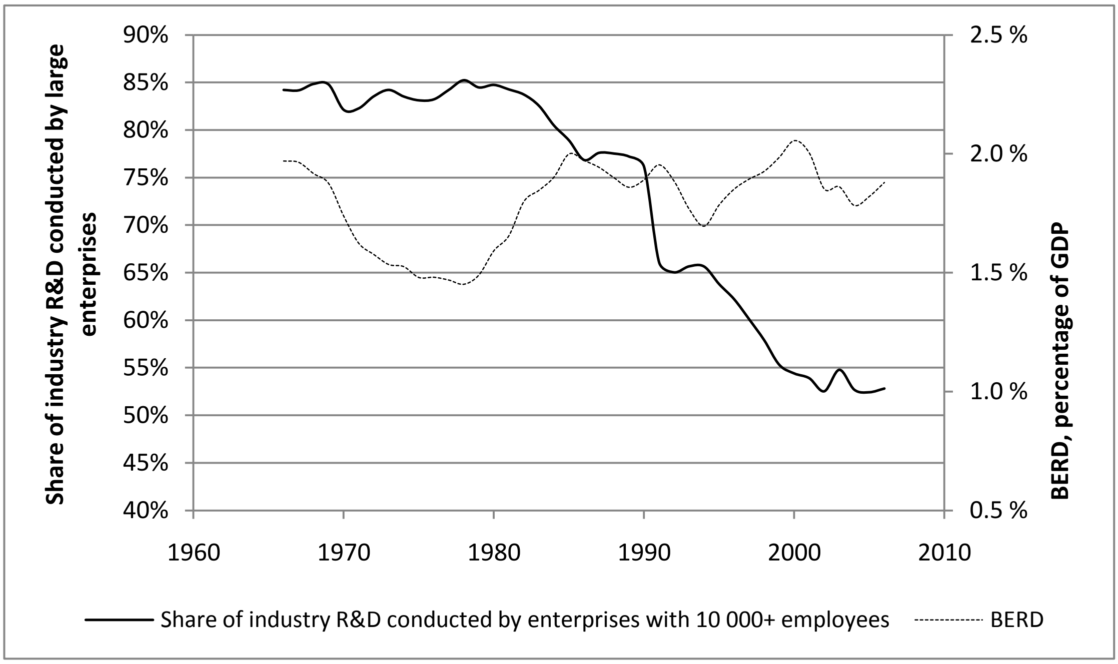
1. The context of open innovation

From economic growth follows specialization. With specialization follows diversification of the stock of knowledge available, from which the opportunities for new technology development exponentially grow. In the following we will disentangle how this process of diversification has a functional dimension – which entails that information, technology and knowledge relevant for any given firms becomes more and more distributed on numerous external actors; and a geographical dimension, which refer to the spatial structuring of this specialization and diversification process. Both have strong implications for management, and for public innovation policy. The result of these two processes combined is that the locus of innovation is shifting away from the individual firm (functional dimension) and national innovation system (geographical dimension), towards the more and more globally distributed knowledge networks which are forming when firms seek out and attempt to harness complementarities (Grandori & Soda, 1995; Smith, 2000).

At the firm level, this has been described as intensifying 'outside in' open innovation strategies, which impact innovation success but are differentiated by different structural characteristics of players involved. Firms also have stronger incentives to engage in controlled processes of external technology commercialization such as licensing out technology or selling patents that they hold but do not actively use (Lichtenthaler & Ernst, 2007). At the level of products and technologies, the result is increased complexity and more rapid rates of change, which in turn translate into increased technological opportunity and uncertainty. At the level of the firm, the result is the increasing reliance on 'absorptive capacity, integrative capabilities, and complexity in organizational structures which must be designed for the purpose of simultaneous exploration and exploitation. At the level of territorial economies, the result is that innovation systems 'deconstruct' as sets of user-producer collaborative relationships traditionally claimed to be at the core of well-functioning innovation systems (Fritsch, 2003). The immediate collective action outcome of this appear to be more firms seeking more intensively for technological inputs externally. Firms carry out searches in markets where an increasing amount of 'surplus' technology is available for purchase or licensing in (Chesbrough, 2006) or in industrial agglomerations where knowledge and information is available in the form of spillovers.

Before we consider the two primary aspects of open innovation (actors and geography) and before we discuss its various dimensions (search, collaboration, sourcing and external commercialization) in more detail, we briefly consider the larger processes which have been transforming the international landscape of trade and production and which have brought us to where we are today. These date back at least to the 1970s, but have accelerated with trade liberalization, the rapid rates of technological change following in the wake of the ICT paradigm, and the emergence of new players such as India and China on the arena of global production and trade. In the 1950s and 1960, the hegemonic US economy grew and consolidated the 'Fordist' regime of standardized mass production, with its strong emphasis on intramural R&D in so-called "first generation R&D organizations" (Roussel et al, 1991). Several conditions were critical to the growth of the regime. A key condition was continuously expanding consumption markets and managed international trade regimes. This was linked to large public incentives for industry investments in R&D; low external mobility of labor, and long-term governance of corporate enterprises by managerial elite who operated independent of shareholder demand for returns (Herstad, forthcoming). This established large conglomerate enterprises as the dominant private sector R&D players in the US (see figure 1).

Figure 1 The decline of Fordism in the US.



The Fordist regime was severely challenged by the economic downturn of the 1970s. Throughout the 1980s, overall market saturation forced flexibility, responsiveness and product diversification. At the same time, the connotation of 'best practice' industrial organization shifted away from the US and towards Japan and certain regions of Europe. According to observers from different traditions (Jensen, 1993; Jensen & Meckling, 1976; Piore & Sabel, 1984), the second industrial divide that was unfolding would create a landscape of smaller, networked and thus more 'open' modes of production and innovation – such as those found e.g. in certain regions of Germany and Northern Italy. Alfred Marshall's concept of 'external economies' in 'industrial districts', inspired by modes of industrial organization found prior to the growth and consolidation of Fordism (Marshall, 1920), was not only used to label these new best practice regional economies but they also paved the way for later concepts such as clusters, learning regions and regional innovation systems (Asheim, 1996). In industry, the breakdown of Fordism came with a shift away from the "first generation" R&D-lab oriented organization, through the intermediate second generation model which largely served to legitimize short-termism (Porter, 1992) and financial market driven downsizing of former conglomerate strongholds (Lazonick & O'Sullivan, 2000), towards a "third generation mode" in which internal R&D was to operate in integration with other knowledge communities internal and external to the corporate enterprise (Roussel et al., 1991, Lam, 2002, 2003). Building on this legacy, different innovation system approaches emerged and gained increasing currency in both academic and policymaking communities. Drawing additional insights from disciplines such as evolutionary economics and economic geography, these came to emphasize the interactive (later known as open) path-dependent and spatially differentiated nature of technological development and growth (Edquist, 1997; Lundvall, 1992).

During the last two decades, this ongoing transformation accelerated with the diffusion and consolidation of the ICT paradigm (Perez, 2002). This has had the effect of providing the technological basis for a set of new industries to emerge while also expanding seed and venture capital directed to new technologies. This in turn opened up new opportunities for established industries to improve production and supportive functions and to increasingly develop radically new consumer products. It also provided the technological foundation for the establishment and coordination of globally distributed production and innovation networks (Gereffi, Humphrey, & Sturgeon, 2005; Sturgeon, 2003; Sturgeon, Biesebroeck, & Gereffi, 2008), which has enabled the process of innovation-based growth to accelerate even further.

This has contributed to a landscape of intense, technology-based competition. In this landscape, firms have tended to focus more on intellectual property and protecting proprietary knowledge while reducing commitments to long-term cumulative R&D programs. A stronger emphasis has been placed on flexibility and receptiveness for ongoing changes in external conditions and opportunities. Some intellectual paradigms have emerged to try to account for the new developments taking place outside the realm of large corporations, including that of the "experimentally organized economy" (Carlsson & Eliasson, 2002). Similarly, the concept of 'open innovation' is in its original formulation heavily influenced by the US 'New Economy' economic landscape of the late 1990s and early 2000s, with its intense exploration of new technologies by means of entrepreneurship fuelled by increasingly available venture capital (Aglietta & Breton, 2001; Herstad, forthcoming; Lazonick, 2006, 2007). In knowledge-intensive organizational or geographical environments (Cohen, March, & Olsen, 1972), new solutions continuously emerge that preceed problems being identified or decisions concerning their development being taken. An indication of such 'surplus technology' is the differences between patents held by industrial firms, and patents used. Approximately 17 percent of European patents are not used by the applicant, nor are they licensed out.

This has been claimed to necessitate a stronger focus in industry on alternative means for commercialization (Lichtenthaler, 2005; Lichtenthaler & Ernst, 2007), with the result that more or less organized markets for IPR will emerge. With such markets would follow increasing opportunity not only to commercialize own technology by other means, but also to tap into technologies developed by others. Yet, organized markets for IPR remain an under-investigated phenomenon. Recent large scale surveys have helped to provide a baseline against which one can understand changing usages of IPRs. In Europe, the Patval survey has spawned several relevant studies. They reveal that patents which are exclusively licensed out by applicants make up about 6.4 percent of the patents in Europe (Gambardella 2005; 40: Gambardella et al 2007; Guiri et al 2007: 1118). This type of licensing, which may be facilitated by third party intermediaries with little involvement of the developer, varies considerably by applicant type and by technological field: the incidence is lowest for firms, especially larger firms, and highest for research institutions. A slightly larger proportion of European patents (7%) are both used by the applicant and licensed out, for example through cross-licensing arrangements.

Several factors tend to constrain the potential expansion of a 'market' for new technological knowledge to flourish along the lines forecasted, among which are the nature of knowledge (Arrow, 1962a) and the often severe limitations that happen codification and 'commodification' of complex technologies which result. Sourcing and commercialization within organized markets for IPR, and transactions in the equity market involving small technology-intensive firms, are therefore processes which only constitute a minor component of open innovation. Industrial firms may also collaborate for innovation, with universities or research institutes (Bailetti & Callahan, 1992; Balconi & Laboranti, 2006; Bekkers & Freitas, 2008; Conway, 1995; Lhuillery & Pfister, 2009), 'extend their enterprises'(Dyer, 2000) so that denser linkages form towards with suppliers and customers (Helper, DacDuffie, & Sabel, 2000; Lettl, Herstatt, & Gemuenden, 2006); form alliances or joint ventures with other industrial firms holding complementary knowledge and engage in consortia within which competitors may participate (Caloghirou, Ioannides, & Vonortas, 2003; Chiesa & Manzini, 1998; Hagedoorn, 1993). These various aspects of open innovation practices will all be discussed in the following but have the common characteristic that they entail direct (as opposite to indirect through market intermediaries) interaction, knowledge transfer and interactive learning. As we will also see, other open innovation activities which are far more predominant than IPR sourcing, and presumably more important for firm performance and territorial system dynamics, are information search (Grimpe & Sofka, 2009; Katila, 2002; Katila & Ahuja, 2002; Sofka & Grimpe, 2010), and external sourcing (Frenz & Ietto-Gillies, 2009; Grimpe & Kaiser, 2010; Howells, Gagliardi, & Malik, 2008; Weigelt, 2009).

This leads to the recognition that open innovation has several primary dimensions: screening of external information (search); interactive knowledge development and transfer (collaboration); market-based sourcing (e.g. external innovation expenditure); and external technology commercialization (e.g. licensing out or spinning out new firms). It should be noted that we use the term 'external innovation expenditure' rather than the simpler term 'sourcing' used by the literature in hopes that this will make clear the difference between it and collaboration in particular.

Although much is known about the roles played by different actor groups (customers, suppliers, research institutes), the question remains about the extent to which the phenomena as a whole can and should be conceptualized in terms of specific practices decoupled from the larger organizational context into which they are set. Firms are 'bundles' of different activities, which include – simultaneously - different forms of interaction with external actor groups. This recognition alone should lead one to question the fruitfulness of a search for single-dimension best management practices; and warn against excessive policy emphasis on specific aspects of industry organization and strategy. Various collaboration partners and information sources may supply inputs which are complementary rather than contradictory, and the overall openness towards external information and knowledge may be more important than the ability to use specific sources. Supporting this line of reasoning is contributions pointing to dense relationships between the use of various external actor groups (Laursen & Salter, 2004; Roper, Du, & Love, 2008); studies finding positive impacts on innovation from the simultaneous use of different information sources (Laursen & Salter, 2006) and collaboration partners (Grimpe & Kaiser, 2010), and studies finding that the impact of either one dimension (e.g. R&D sourcing) is conditioned by the nature of activity along others (ibid, Ebersberger & Herstad, 2010).

We now turn from this functional dimension of open innovation to its spatial dimensions. Economic geography has firmly established how regions serve as containing social structures in which information sharing and collective knowledge development is nurtured by personal network formation, labor market mobility (Agrawal, Cockburn, & McHale, 2006; Dahl & Pedersen, 2004; Lam, 2000) and the formation of trustful collaborative ties (Helper, DacDuffie, & Sabel, 2000; Storper, 1997). Such localized linkages give rise to territorial specialization, and tie innovation behavior as well as output to the properties of places. Similar arguments have been made at the level of nation states, based on research within evolutionary economics and the 'national innovation systems' tradition which has unveiled interdependencies at play in the evolution of industry and the supportive institutional frameworks which develop around it. These include innovation policy traditions, research system set-up and content (Narula, 2002), labor market practices and the – often highly nationally distinct – nature of financial systems and venture capital markets (Allen & Gale, 2000; Black & Gilson, 1998; Demirgüc-Kunt & Maksimovic, 2002; ECMI, 2006; Porter, 1992). The flip side of this coin is the danger of over-embeddedness of actors and lock-in to diminishing return paths, stemming from high cost of establishing extra-regional linkages and low marginal cost of continuing to use existing ones (Narula, 2002). This may cause actors to over-search those environments they already know (Katila & Ahuja, 2002) and to focus excessively on established collaborative linkages (Bathelt, Malmberg, & Maskell, 2004).

There follows from territorial specialization, therefore, a need for firms to look beyond their immediate regional and national environments and harness complementarities between knowledge assets which are specific to different places for the reasons described above. It also follows that open innovation practices will vary substantially in form and impact i) across different regional economies (Asheim & Coenen, 2006), and across national economies with ii) different institutional frameworks, industrial and political legacies (Whitley, 1992, 1999), and that they will be conditioned by iii) the overall level of economy development and its location within the global hierarchy of production, trade and technology. We are also forced to recognize that territorial economies not only contribute to the structuring of open innovation practices but also how these are conditioned by the activities of individual firms, their external effects and the collective action outcomes and economy level dynamics which follow. The production and reproduction of structural incentives and constraints by means of collective action games—and the existence of external effects from knowledge development within individual firms—are explicitly recognized within different innovation system approaches but remain largely neglected by work within the emerging 'open innovation' tradition.

With this we enter the landscape of open innovation in Europe.

2. Data

The Community Innovation Survey (CIS) is a periodic survey of enterprises to measure innovation which is carried out by the national statistical offices of (current) EU member states— as well as Norway and Iceland. The survey is based on a common set of guidelines for the collection and use of data on innovation activities in industry.[1] This harmonized approach evolved within the longstanding Frascati family of reference works at the OECD in the area of R&D and innovation indicators. It is specifically based on the Oslo Manual (1992) and its revisions (1997; 2005) which have expanded the survey's focus to include forms of market and organizational innovations as well as technological innovation. Six waves of the survey have been conducted in an increasing number of countries since the first pilot run in 1993. The most recent round was in 2008.

The initial strength of the survey is that it is conducted across countries and that it is periodic (allowing for comparisons through time) according to a harmonized approach. In this context, it further provides a rich set of information about industrial innovation. The CIS includes information about the enterprise (including ownership), product and process innovation, innovation activity and expenditure, effects of innovation, innovation co-operation, public finding of innovation, information source for innovation, and patents. It produces a broad set of indicators on innovation activities, innovation spending, effects of innovation, public funding, innovation co-operation, sources of information for innovation, main obstacles on innovation activity and methods of protecting intellectual property rights.Insight into the knowledge sources and collaboration activities that are important to different types of innovating firms in different contexts are of special application in the study of open-innovation.

2.1 Use of CIS data

CIS data have been used primarily for three different purposes. First and foremost CIS data are used as a basis for official innovation statistics of the EU and its member states. Second they are used for policy driven research and analysis (e.g. Cassiman & Veugelers, 2006; Cassiman & Veuglers, 2002; Cefis & Marsili, 2006; Czarnitzki, Ebersberger, & Fier, 2007), and have been used extensively for analysis in economics in management studies (e.g. Laursen & Salter, 2004, 2006), and in economic geography (e.g. Simmie, 2003, 2004; Ebersberger & Herstad 2011.)

2.2 National coverage of the data

The overall data set available for the analysis consists of 130,274 observations taken from the innovation surveys of the years 2004 (CIS4) and 2006 (CIS2006).

- CIS4, reference year 2004 and observation period from 2002-2004
- CIS2006, reference year 2006 and observation period from 2004-2006.

[1] CIS http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis : it is based on random sampling of manufacturing and service enterprises, stratified by firm-size, region, and industry. See above for an introduction.

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 1.

Table 1 Distribution of the observations across countries

Country	Total	Share
BG	19,394	0.149
CY	625	0.005
CZ	7,495	0.058
DK	2,305	0.018
EE	2,703	0.021
ES	32,290	0.248
FI	3,184	0.024
FR	10,088	0.077
GR	636	0.005
HU	5,960	0.046
IS	164	0.001
IT	10,154	0.078
LT	2,480	0.019
LU	752	0.006
LV	2,241	0.017
MT	419	0.003
NO	5,955	0.046
PT	5,881	0.045
RO	6,380	0.049
SE	5,013	0.038
SI	2,833	0.022
SK	3,322	0.026
Total	130,274	1.000

Note: Available weights used.

Although both surveys are conducted in all 27 EU member states only a reduced number of national statistical offices or national data owners granted access to the data through the Safe Center at the premises of EUROSTAT in Luxembourg. It is unfortunate that major European economies are not represented in the analysis, as data access has not been granted. In particular the UK, Germany, Poland and the Netherlands are not represented in the analysis. Although Iceland and Norway are not member states of the EU27, their data was made available and therefore included in the analysis. Figure 2 illustrates the geographical coverage of the available data. To generate interpretable results for the remainder of the economies we split the analysis into different contexts, which are represented by subsamples of the overall available data.

Figure 2 Geographical coverage of the available data

Note:The gray scale indicates the availability of the data.

3. Measures and Methods

In this section we document the development of the indicators used in the analysis below. Here, the development of all indicators used in the analysis is described, regardless of whether or not the indicators are reported. In some instances, indicators—although part of the analysis—have been included in the Tables found in the sections below. The full set of regression tables comprising all variables in the analysis can be obtained from the authors upon request.

3.1 Innovation Activities and Innovation Performance

We operationalize innovation performance in three different ways in order to analyze the innovation performance effects of open innovation practices. In addition to the performance measures introduced below, the structure of the problem and the design of the questionnaire require us to identify innovation active companies to be able to correct for a selection process. It is obvious that innovation performance and innovation related behavior—such as open innovation practices—can only be found in companies that carry out innovation activities. Measuring innovation performance and open innovation activities with firms that are not actively involved in innovation activities would severely distort the findings.

3.1.1 Innovation Activities

We follow the tradition of Tether (2002), Veugelers & Cassiman (2005), Cassiman & Veugelers (2006), and Rammer et al. (2009) and others to define a dichotomous variable for innovation activities. If the firm has introduced a new product or service, implemented a new process, carried out innovation projects or reports positive innovation expenditure the dichotomous innovation activity variable takes the value one. This variable is used in the first step of the regression analysis, which will correct for selection bias.

3.1.2 Innovation Performance

Innovation performance and innovation success can be approximated by a number of indicators (e.g. OECD 2005). Innovation performance measures range from innovation inputs—such as R&D expenditure to measures of innovation output such new technologies or patents, new products or services. Here we use the latter and operationalize innovation performance in three different variables, each capturing a slightly different aspect of innovation performance.

All three variables are consistent with the metrics for innovation performance used in the literature. First we approximate the companies' ability to bring a new product to the market by a dichotomous variable capturing that the company has successfully launched a new product in the reporting period. The dichotomous variable takes the value one if the new product is considered to be new to the market by the firm. The variable takes the value zero otherwise. This variable has been used previously for instance by Czarnitzki, Hanel & Rosa (2011), Herstad, Bloch, Ebersberger & van De Velde (2008), or Hipp & Grupp (2005). This variable builds the background for the second variable that we use to capture innovation performance: The share of sales generated by new products (market novelties) has frequently been used as a measure of innovation performance (e.g. Aschoff & Soffka 2009; Cassiman & Veugelers 2006; Grimpe & Kaiser 2011; Laursen & Salter 2006; Loshkin, Hagedoorn & Letterie 2011; Tether & Tajar 2008). This variable, although strongly influenced by the length of the product life cycle in the respective industries, captures the value of innovation for the companies' product portfolio. The third measure captures the innovation performance by the log of sales from new products (market novelties). This has recently been used by Cuijpers, Guenter & Hussinger (2011).

Although we do not discuss all findings in terms of each of the three innovation performance variables, we do report results from each in order to illustrate the robustness of the overall findings. Put differently, the three variables are provided to prevent the counter argument, that the choice of the dependent variable predetermines the findings.

3.2 OI Practices

In general, open innovation indicators build on insights found in the theoretically-oriented literature. This involves to a large degree the openness of search in innovation (Laursen & Salter 2006). Another approach (Herstad, Bloch, Ebersberger, & van De Velde 2008; Ebersberger, Bloch, Herstad & van De Velde 2011) is based on the insights of Laursen & Salter (2006) that open innovation practices can be distinguished by the breadth and the depth of their activities. This strand elaborates a system of open innovation indicators that includes search, external innovation expenditure, collaboration, and protection. The hierarchical system of indicators that results is also based on the core information derived from the Community Innovation Survey.

However, the analysis in Ebersberger & Herstad (2010) demonstrates that a purely data driven approach can yield interesting insights on which indicators can be developed that capture open innovation practices. The advantages of using factor analysis for deriving indicators are twofold. First, there are less behavioral assumptions required. The data can reveal whether or not breadth and depth are two different dimensions. In addition the data can also reveal whether or not the indicators should be demarcated by the type of activity, such as collaboration or search, or whether they should be distinguished in terms of the actor groups targeted, such as clients or suppliers. A priori, it is not clear if openness relates to the variety of actors targeted for a single activity or whether it relates to the variety of activities targeted towards a single group of actors. Factor analysis of the survey items that reflect these dimensions will shed light on this question. Second, factor analysis will generate orthogonal indicators. These orthogonal indicators can subsequently be utilized as independent variables in a regression analysis while avoiding limitations linked to bivariate correlations. The problem with bivariate correlations is more prevalent in a setting where several open innovation indicators are developed and used simultaneously (Herstad, Bloch, Ebersberger & van De Velde 2008) than in a setting where only one or two open innovation practices are analyzed (Laursen & Salter 2006).

We structure the variables on which our open innovation indicators are based in accordance with the three pillars of open innovation suggested by Gassmann and Enkel (2006). The **inside-out process** encompasses all activities externally exploiting ideas, technologies and products originally developed inside the firm (Teece 1998; Lichtenthaler 2005), where protection of intellectual assets is crucial for the economic viability of this approach. The **outside-in process** relates to all activities that leverages outside innovation, including outside actors, purchasing innovation concepts developed elsewhere or searching for information outside the corporate walls. The **coupled process** is a combination of both the inside-out and the outside-in process and is usually seen as innovation collaboration.

3.2.1 Data Used for the Construction of the OI Indicators

For the construction of the open innovation indicators we draw on the innovation survey that covers details about information sources used during the innovation process, collaboration for innovation and protection mechanisms used in the innovation process. The innovation surveys do not contain information about external commercialization of technologies nor about spinning out of innovation projects. Hence the information about Grassmann & Enkel's (2006) inside-out process is limited. As protection of intellectual property is a precondition for both the inside-out process and the coupled process we include indicators for protection in the analysis.

The survey does contain items that capture the information sources used during the firms' innovation activities. Ten sources are provided where the respondents rank the importance of these sources on a four-level Likert scale ranging from 'not used' to 'high importance' (see Figure 3). The predefined sources can be grouped into internal sources, market sources, institutional sources and other sources. With the exception of the first group all sources are external to the firm and thus can be used in the construction of the open innovation indicators.

Figure 3 Structure of the information sourcing in the Community Innovation Survey

	Information source	Degree of importance *Tick 'not used' if no information was obtained from a source.* High	Medium	Low	Not used
Internal	Within your enterprise or enterprise group	☐	☐	☐	☐
Market sources	Suppliers of equipment, materials, components, or software	☐	☐	☐	☐
	Clients or customers	☐	☐	☐	☐
	Competitors or other enterprises in your sector	☐	☐	☐	☐
	Consultants, commercial labs, or private R&D institutes	☐	☐	☐	☐
Institutional sources	Universities or other higher education institutions	☐	☐	☐	☐
	Government or public research institutes	☐	☐	☐	☐
Other sources	Conferences, trade fairs, exhibitions	☐	☐	☐	☐
	Scientific journals and trade/technical publications	☐	☐	☐	☐
	Professional and industry associations	☐	☐	☐	☐

Source: Eurostat (2004, p. 6)

In terms of its contribution to innovation performance, collaboration is captured as a dimension using the collaboration matrix in the survey. The particular question asks whether innovation projects have been carried out collaboratively with other actors, and if so what type of actor and where the actor is located geographically. The type of actors include (a) other enterprises within your enterprise group, (b) suppliers of equipment, materials, components, or software, (c) clients or customers, (d) competitors or other enterprises in your sector, (e) consultants, commercial labs, or private R&D institutes, (f) universities or other higher education institutions, and (g) government or public research institutes. The geographic location of these actors can either be domestic or (other) Europe countries or United States or all other countries (see Figure 4). To emphasize that innovation collaboration is a mutually interactive effort, the questionnaire explicitly states that "Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. At the same time, this excludes pure contracting out of work with no active co-operation (Eurostat 2004, p. 7).

Figure 4 Structure of the collaboration question in the Community Innovation Survey

Type of co-operation partner	[Your country]	Other Europe*	United States	All other countries
A. Other enterprises within your enterprise group	☐	☐	☐	☐
B. Suppliers of equipment, materials, components, or software	☐	☐	☐	☐
C. Clients or customers	☐	☐	☐	☐
D. Competitors or other enterprises in your sector	☐	☐	☐	☐
E. Consultants, commercial labs, or private R&D institutes	☐	☐	☐	☐
F. Universities or other higher education institutions	☐	☐	☐	☐
G. Government or public research institutes	☐	☐	☐	☐

Source: Eurostat (2004, p. 6)

The firm's protection strategy is captured in the survey by a set of four dichotomous items. In contrast to previous rounds of CIS the data in CIS4 and CIS 2006 do not contain information about so called strategic means of protection such as lead-time advantage, engineering complexity. Instead, it focuses on the legal instruments of protection such as patents, industrial designs, trademarks, and copyrights (see Figure 5).

Figure 5 Structure of the protection question in the Community Innovation Survey

	Yes	No
Apply for a patent	☐	☐
Register an industrial design	☐	☐
Register a trademark	☐	☐
Claim copyright	☐	☐

Source: Eurostat (2004, p. 6)

3.2.2 Indicators for open innovation

From the collaboration information discussed above, we construct a series of dummy variables that captures collaboration for six different types of collaborator, namely: innovation collaboration with customers, innovation collaboration with suppliers, innovation collaboration with competitors, innovation collaboration with consulting firms, innovation collaboration with universities, and innovation collaboration with governmental research organizations.

To distil the open innovation indicators we employ a factor analysis using the information source variable, the collaboration dummies, and the protection dummies. In more detail: the factor analysis includes six dummy variables indicating innovation collaboration with different partner types. The factor analysis includes four dummy variables indicating the use of patent, of industrial designs, of trademarks, and of copyrights. Additionally we include variables that capture whether or not the firm rates as important information obtained from suppliers, from customers, from competitors, from universities, from governmental research organizations, and from conferences and trade fairs.

Figure 6 summarizes the Eigenvalues of the potential factors. As a visual guide one usually observes the elbow of the Eigenvalue scree plot when extracting factors. The graph here clearly shows two elbows: one pointing towards the extraction of only a single factor. The other elbow indicates four factors to be extracted from the analysis. We follow the latter suggestion and extract all factors which are bound slightly below unity.

Figure 6 Scree plot depicting the Eigenvalues of the factors

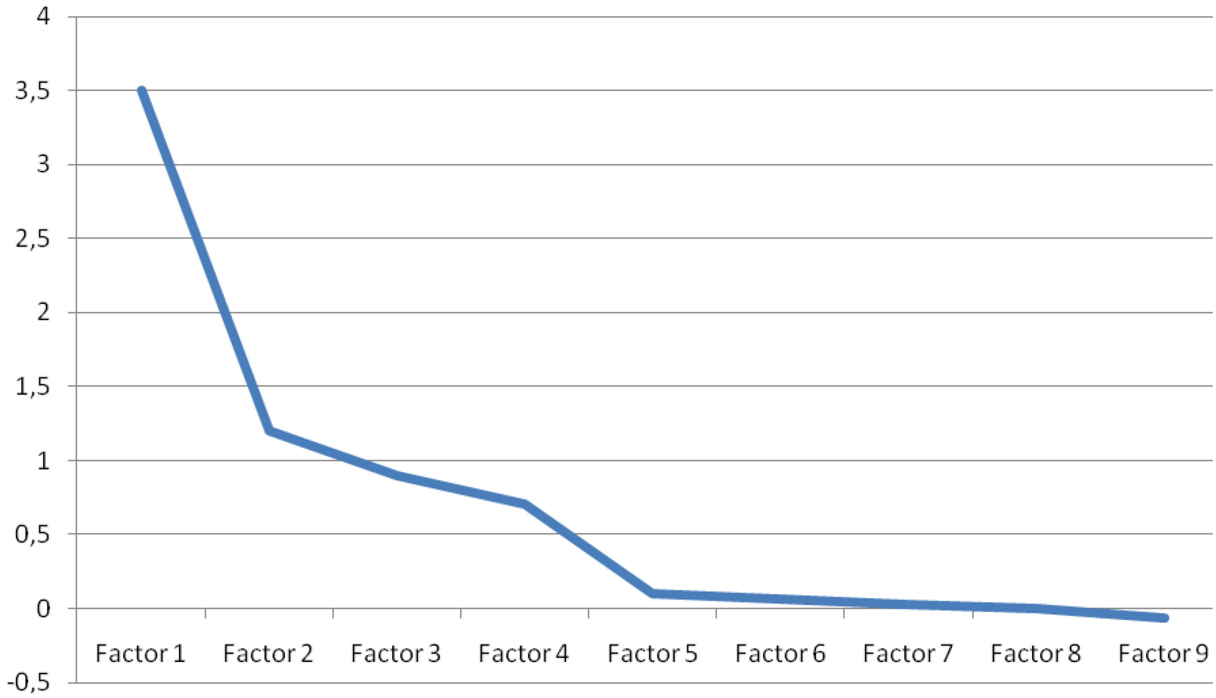


Table 2 shows the varimax rotated factor loading matrix. The extracted factors are used to predict the regression based factor scores which are then used as the open innovation indicators. To support the interpretation of the found factors, Table 2 highlights factor loadings above 0.45. Factor 1 clearly bundles all collaboration activities regardless of the collaboration partners. Factor 2 collapses search activities with academic and science partners such as universities and R&D labs. Innovation search with partners in the industry and with partners in the value chain such as suppliers are bundled by Factor 3. All legal protection activities are finally bundled by Factor 4.

Although we are aware that the inclusion of a substantial number of dichotomous and ordinal scale variables in a factor analysis is far from optimal (e.g. Srholec & Verspagen 2008) we are confident that the findings— and hence the factor scores— are not distorted by our procedure for two reasons. First, in Ebersberger & Herstad (2010), we use a comparable set of collaboration, protection and information search variables for a factor analysis on the Norwegian CIS 4 survey. This survey does not only provide a dummy variable for the innovation collaboration. It also contains the firms' assessment of the importance of the collaboration on a four-level Likert scale. The findings and the bundling of the variables into factors is structurally identical to the one found here. Second, we have conducted a brief analysis on how the variables—that is, the factor scores—depend on the specification of the factor analysis. Using a single national dataset which is available to the authors, we computed the factor scores based on a common factor analysis, based on a factor analysis using polychoric correlations and based on a factor analysis using tetrachoric correlations (e.g. Kolenikov & Angeles 2004; Kolenikov & Angeles 2009). The corresponding factor scores in each case correlate with a correlation coefficient (r>0.5) which is highly significant (p<0.001).[1]

Table 2 Open Innovation Practices: Factors extracted

Variables	Factor1	Factor2	Factor3	Factor4
Collaboration with clients	**0.7470**	0.0457	0.1523	0.0320
Collaboration with suppliers	**0.7014**	0.0163	0.1228	0.0350
Collaboration with competitors	**0.6643**	0.0618	0.0945	0.0358
Collaboration with consultants	**0.6801**	0.2028	-0.0053	0.0655
Collaboration with universities	**0.6198**	0.4110	-0.0587	0.0707
Collaboration with gmtl. R&D labs	**0.5722**	0.3404	-0.0652	0.0450
Information search with suppliers	0.0499	0.0507	0.3428	-0.0763
Information search with clients	0.1296	0.1387	**0.5839**	0.0583
Information search with competitors	0.0987	0.2063	**0.6171**	0.0331
Information search with universities	0.1849	**0.7279**	0.1481	0.0644
Information search with gmtl. R&D labs	0.1478	**0.6943**	0.1526	0.0245
Information search with prof. org.	0.0911	0.2700	0.4327	0.0279
Protection through patents	0.1116	0.1113	0.0143	**0.5366**
Protection thorugh industrial design	0.0580	0.0369	0.0292	**0.5726**
Protection through trademarks	0.0882	0.0622	0.0749	**0.4954**
Protection through copy right	0.0823	0.0474	0.0441	0.2993
Interpretation	**Collabo-ration**	**Science Search**	**Industrial Search**	**Protection**

Note: Table shows the varimax rotated factor loading matrix. For ease of interpretation factor loadings above 0.45 are in bold face.

It has to be noted there that the resulting variables are factor scores. These variables have certain properties, which are important to be borne in mind when discussing the empirical findings. The mean of factor scores is by definition zero. When subsamples of the data show a negative average factor score of, say, collaboration we can immediately see that this subgroup exerts below-average collaboration. The standard deviation of a factor score is about one. Under the assumption of normality, about 68% of the observations will have a factor score between -1 and 1. About 95% of the observations will have a factor score between -2 and 2.

[1] The correlation tables and the descriptives of the factor scores based on polychoric and tetrachoric correlations can be obtained from the authors upon request.

Important Findings

The factor analysis including all innovation collaboration activities, all information search activities and all protection activities shows that the modes of open innovation have to be distinguished by the type of activity rather than by the type of partner.

3.2.3 Collaboration Indicators

Complementary to the indicator obtained from the factor analysis above capturing the diversity innovation collaboration we develop an indicator to capture the type of partner collaborated with and the geography of the collaboration. In particular we develop indicators for vertical collaboration and for science collaboration. Vertical innovation collaboration is the interaction between actors along a value chain, that is, collaboration with suppliers and with clients and customers. Science collaboration entails cooperative interaction with science actors such as universities and government or public research institutes.

The geographical information in the collaboration matrix in the survey (see Figure 4) allows us to reconstruct whether vertical and science collaboration is maintained with national or with international partners. Hence we have four indicators capturing the structure of the collaboration: domestic vertical collaboration, international vertical collaboration, domestic science collaboration and international science collaboration.

For some of the analyses we collapse the two indicators of vertical collaboration in two: i) one indicates no vertical collaboration and ii) the other indicates domestic & international vertical collaboration. In the regression analysis this recoding is beneficial as the coefficients or the marginal effects can be interpreted as the effect relative to domestic vertical collaboration, as the majority of firms only maintaining either domestic or international collaboration maintain domestic collaboration for innovation. A similar scheme aggregates the two indicators of science collaboration.

In addition we construct an indicator for the overall internationalization of the collaboration partner network. It is the fraction of international collaboration partners of all collaboration partners.

3.2.4 Indicator for external innovation expenditure

In addition to the open innovation indicators developed through the factor analysis, we include a measure for the fraction of innovation activities that are conducted outside the focal firm. This indicator is based on the survey's information about innovation expenditure. This information point allows us to distinguish between expenditure spent within the firm and expenditure spent externally (see Figure 7).

Figure 7 Structure of the question about innovation expenditure in the Community Innovation Survey

	Tick 'nil' if your enterprise had no expenditures in 2004	**Nil**
Intramural (in-house) R&D (Include capital expenditures on buildings and equipment specifically for R&D)		☐
Acquisition of R&D (extramural R&D)		☐
Acquisition of machinery, equipment and software (Exclude expenditures on equipment for R&D)		☐
Acquisition of other external knowledge		☐
Total of these four innovation expenditure categories		☐

Source: Eurostat (2004, p. 6)

This indicator for external innovation expenditure activities does the following. It essentially captures the degree to which the corporate decision to make or buy innovations leans towards buying required knowledge, services and machinery for innovation activities. The external innovation expenditure indicator is the share of external expenditure on total innovation expenditure. This indicator is essentially the same as indicators used in Veugelers & Cassiman (1999), although based on a slightly different set of items from the CIS.

3.3 Country Level Indicators

Indicators at the country level capture the specificities for open innovation activities that may arise due to the national contexts and framework conditions. In particular we use a country group indicator and an indicator for the size of the country.

3.3.1 Country Group

Open innovation activities and innovation success might be highly contingent on domestic framework conditions of the country the firm is located. It is therefore important to take into account the level and orientation of economic and scientific development there, as well as to control appropriately for basic country characteristics. Following Reinstaller et al. (2010), we utilize a concept of 'distance to the frontier' to group the countries. Four country groups are desinged according to the degree to which they share the same economic, technological and scientific characteristics of development. This argument is based on the insight that the state of the development of a country affects the process of innovation and growth (Basu & Weil 1998; Los & Timmer 2005). For instance, countries with advanced scientific capabilities, a high level of technological development and a highly efficient economy can be envisaged to be close to the international frontier of development. Countries, however, with a larger distance to the frontier may be expected to be characterized by lower technological and scientific capabilities.

Despite the increasing internationalization witnessed in recent decades, the national innovation system remains an essential determinant of innovation behavior and performance (Carlsson 2006).

The distance to the frontier not only describes the development of the economy and the economic actors but also that of other key actors in the innovation system. As Pavitt (1998) points out, the national innovation system and its performance is socially constructed by the economy's level of development and by the composition of— and by the interaction between— economic, technological, and social activities. In the context of open innovation, key national organizations, such as universities, utilize open innovation practices when they reach out at the national level (e.g. Laursen & Salter 2004).

Reinstaller & Unterlass (2010) use an input-output analysis (Knell 2008) to generate a country classification based on direct and indirect R&D intensity of each country. Here, the direct R&D intensity is captured by the direct R&D investment of the business sector. The indirect R&D intensity measures on the other hand the R&D embodied in capital investment in the national economies; this approximates the level of technology transfer. The absolute size of these indicators and their relative share indicate the level of technical development of a country in terms of its capability to generate new knowledge and technologies. It also captures the country's reliance on foreign technologies. Reinstaller & Unterlass (2010) use hierarchical cluster analysis to derive their country classification based on the indicators discussed here.

This country classification is also used in this analysis for consistency with a previous study on innovation, internationalization and hampering factors (Reinstaller et al. 2010) which contributes to the same overall project as this analysis. The group of Technology Leader Countries (SE, FI, DK, NO, FR, IS, 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). Figure 8 displays how the country groups are distributed across European countries.

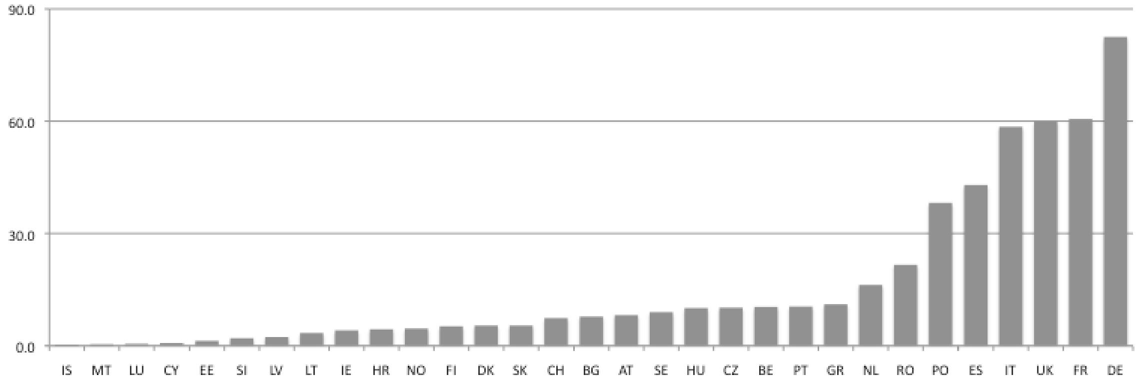
Figure 8 Country groups

Note: Colors indicate the country group Gr.1: Technology Leader Countries (SE, FI, DK, NO, FR, IS*, LU); Gr.2: Technology User Countries (HU, EE, CZ, SK, SI); Gr.3: (IT, ES, PT, GR,CY, MT); Gr.4: Low Income, Low R&D Countries (BG, LT, LV, RO). * not displayed on the map.

3.3.2 Country Size

In addition to national level of development captured by the country group innovation activities, the choice between domestic and international partners in particular may depend on the overall diversity of actors in the country. Country-size is the only way to approximate how diverse the domestic actor base, where we assume that small countries have - by the sheer numbers - a more restricted variety of actors than large countries have.

Figure 9 Size distribution of European countries



Note: Size of European countries measured by million of inhabitants.

The size distribution of European countries (EU27 + NO + IS + CH) yields a mean of 16 million inhabitants. This means that all countries below this threshold would be classified as small countries and all countries above it as large countries. However, using the median as the threshold (8 million inhabitants) would classify Austria, Sweden, Hungary, Czech Republic, Belgium, Portugal and Greece as large economies. This strikes us implausible in the light of the discussion in, for instance, Landesmann (2006). The distribution of the small and large countries in the dataset available is summarized in Figure 10. Note here, that data availability is particularly biased towards small economies. Among the large economies we lack data from the Netherlands, Poland, the UK and Germany.

Figure 10 Small and large countries

Note: Colors indicate the size of a country (small or large); threshold is 16 million inhabitants.

3.4 Sector Level Indicators

Innovation opportunities are contextual. They are dependent on the technological sector, which may be said to offer a limited range the innovation choices. The nature of the innovation opportunities may be higher in one sector than in another. It is therefore conventional to account for sector-context when considering indicators of innovation performance. We introduce conventional sector controls at the level of the company's primary activity in order to adjust for this contextual aspect of innovation.

3.4.1 Technology Intensity of Sector (OECD Classification)

We account for the technology intensity of the company's primary activity by using the sector classification suggested by Hatzichronoglou (1997) and OECD (2001). The NACE classification reported in the survey is the primary information used to construct the sectoral affiliation of the companies. The following five subclassifications and their NACE equivalents are as follows. Table three provides a breakdown of the population according to this classification for our sample.

Low-technology manufacturing

The low-technology manufacturing firms are taken from the following sectors: food and beverages (NACE 15, NACE 16), textiles and clothing (NACE 17, NACE 18, NACE19), wood and furniture (NACE 20, NACE 361), pulp and paper (NACE 21), publishing and printing (NACE 22), and recycling (NACE 37).

Low-medium-technology manufacturing

Low-medium-technology manufacturing companies are from shipbuilding (NACE 351), petroleum refining (NACE 23), other transport equipment (NACE 354, NACE 355), rubber and plastic equipment (NACE 25), non-metallic mineral products (NACE 26), basic metals (NACE 27) other manufacturing (NACE 36 excluding NACE 361) sectors.

High-medium technology manufacturing

High-medium-technology manufacturing are the firms whose activity is in the following sectors: scientific instruments (NACE 33), electrical machinery (NACE 2971, NACE 31, NACE 323), motor vehicles (NACE 34, NACE 352), motor vehicles (NACE 34, NACE 352), chemicals (NACE 24 excluding NACE 244), non-electrical machinery (NACE 29 excluding NACE 2971).

High-technology manufacturing

High-technology manufacturing is comprised of the following sectors: Aerospace (NACE 353), computers (NACE 30), electronics and telecommunication equipment (NACE 321, NACE 322), and biotechnology (NACE 244).

Knowledge intensive services

Knowledge intensive services belonging to the high-technology services: post and telecommunication (NACE 64), finance and insurances (NACE 65, NACE 66,NACE 67), and business activities (NACE 71, NACE 72, NACE 73, NACE 74).

Table 3 Distribution of companies on technology sectors

Technology sectors	Number	Share
High tech manufacturing	5,372	0.041
Med high tech manufacturing	21,183	0.163
Med low tech manufacturing	26,845	0.206
Low tech manufacturing	52,101	0.400
Knowledge intensive serv.	24,773	0.190
Total	130,274	1.000

3.4.2 Other sector level indicators

These indicators are included in the regression models as sectoral controls but are not reported in the regression tables. Detailed regression tables can be obtained from the authors upon request.

Appropriability

Appropriability conditions can be operationalized at the level of the firm by targeting its activities to appropriate rents from innovation via IP protection. This firm-level indicator is already part of the open innovation practices in section 3.2. The sectoral dimension of appropriability relates to how well intellectual property can be used to prevent new knowledge that is generated in a given sector from spilling over to other actors. It is easier to protect intellectual property in certain industries than in others, where IP is less useful in preventing proprietary knowledge from spilling over to competitors.

As in Ebersberger & Herstad (2011), we employ the spillover approach utilized by Belderbos, Carree & Loshkin (2004) as an indirect measure of a given sector's appropriability regime. There, the importance firms in a given sector assign to the information spilling over from competitors is used as a measure of horizontal spillovers. As an indicator for the weakness of a given sector's appropriability regime, we measure the fraction of innovating firms that rate information from competitors as important to their innovation activities.

Opportunity conditions

The opportunity conditions in a sector are characterized by unrealized potential. By implication, firms that are unable to identify and realize such potential are expected to demonstrate lower innovation performance. We cannot measure these real opportunities. Consequently, our approach gauges the existence of opportunities for improved innovation performance by measuring the degree to which other companies in the same sector achieve a higher innovation output with comparable innovation efforts. Opportunity conditions are hence approximated by dividing the turnover generated by new products by the overall expenditure on innovation activities. Thus it can be interpreted as the average amount that a single euro spent on innovation can generate in a given sector.

3.5 Firm Level Indicators

The indicators at the firm level capture the size of the firm, its innovation intensity, its multi-nationality, and its international orientation. These indicators are expected to capture most of the firm level effects on innovation performance and on the decision to employ open innovation practices.

3.5.1 Firm Size (log)

Following the empirical tradition we capture the firm size by the natural logarithm of the number of employees.

3.5.2 Innovation Intensity

Innovation intensity is captured by the fraction of turnover spent on innovation activity or, in other words, the ratio of innovation expenditure to turnover. The innovation expenditure is the sum of the expenditure for intramural R&D; expenditure for the acquisition of extramural R&D; expenditure for the acquisition of machinery, equipment and software; and expenditure for the acquisition of other forms of external knowledge detailed in Figure 7 (above). Note that the external innovation expenditure indicator developed in section 3.2.4 is the fraction of these expenditures that are spent outside the company.

3.5.3 Innovation Policy Indicators

Innovation policy plays a crucial role in shaping the innovation environment and the innovation behavior of firms. Policy measure may help firms to overcome limitations of knowledge development and innovation. Two types of limitation that were introduced above are i) market failure which leads to underinvestment in innovation activities (Arrow 1962b) and ii) suboptimal collaboration and interaction. Some contributors in the current literature illustrate effectiveness of public grant systems (Almus & Czarnitzki 2003; Duguet 2004; Gonzalez et al. 2005; Lööf & Hesmati 2005; Aerts & Czarnitzki 2006; Czarnitzki & Licht 2006; Czarnitzki 2006; Czarnitzki, Ebersberger & Fier 2007; Aerts & Schmidt 2008; Gonzalez & Pazo 2008), while others find insignificant or negative effects (Busom 2000; Wallsten 2000; Lach 2002; Kaiser, 2004). Most of the studies use dummy variables to indicate the firms' receipt of public funding. We follow this tradition and generate dummy variables to indicate that a firm has received public funding for its innovation activities. Yet, we do not lump all sources of funding together. Instead, we differentiate between funding from national (domestic) sources and funding from international (EU) sources.

Overall, 5.1% of the SMEs and 9.3% of the large companies in the dataset reported receiving European funding, whereas the distribution is more balanced at the domestic level. Here, 25.5% of the large and 22.3% of the SMEs reported receive national public funding. More detailed descriptive analysis can be found in Section 10.2.

3.5.4 Multi-nationality

Whether a firm is affiliated with a multinational corporate network may have an impact on its access to resources; this relationship will in turn directly imply the need to interact with external actors. On the other hand, the multi-nationality 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 & Herstad 2011). More detailed descriptive information about the distribution of multi-nationality across sectors, size classes, and country groups can be found in Section 9.4.3.

Foreign ownership

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 in which the headquarters of the group is located. A dichotomous variable indicating affiliation to a corporate group which is not headquartered domestically serves as an indicator for foreign ownership. The data set contains about 11% of foreign owned companies.

Domestic Multinationals

We follow Ebersberger & Herstad (2011) and Ebersberger & Lööf (2005) in order to determine the multi-nationality of a domestically headquartered corporate group and to derive information about innovation collaboration. If a company reports that it maintains innovation collaboration with another international affiliate, it is defined to be part of a domestic multinational network. About 1.5% of the companies in the data set are affiliated with a domestic multinational network.

3.5.5 International Orientation

The effect that the internationalization of the firm has on its innovation activities has been discussed as part of this overall research framework (Reinstaller et al. 2010) and in the literature: incentives to innovate are related to the size of the market on which the firm can commercialize the innovation (Baldwin & Gu, 2004; Harris & Li, 2005; Herstad & Paalshaugen, 2010). The decision to innovate also appears closely linked to the international orientation of the firm. We capture international orientation through a dichotomous variable which takes the value one if the firm reports that its most important markets are international. The most prominent indicator for international orientation—share of exports—cannot be used as export is not consistently surveyed as a firm demographic characteristic in the Community Innovation Surveys available.

3.5.6 Incentives to innovation

Innovation activities tend to be affected by resource constraints. The innovation surveys inquire about the perceived existence of such constraints: these can be included in empirical analysis of innovation behavior and performance (e.g. Lhuillery & Pfister, 2009; Dachs, Ebersberger & Pyka, 2008; Ebersberger, 2004). The survey also includes questions about the reasons for companies not to pursue innovation activities. The importance of these items is ranged according to a five-point Likert Scale. Based on these, a dichotomous variable is constructed to capture low incentives: it takes on the value one if firms report that prior innovation or no demand for innovation is at least somewhat important in hampering innovation. This indicator will be used in the selection equation.

3.5.7 Other firm-level Indicators

Three other firm-level indicators are included in the regressions as controls. These relate to the importance of internal search, whether the firm operates on a synthetic or analytic knowledge base and to what degree the companies follow a product or process oriented innovation strategy.

Knowledge bases

We operationalize the notion of knowledge bases by assuming that the composition of a company's external search space mirrors the composition of the internal knowledge base. When the firm uses specific information sources in its search processes, it does so based on a discrete choice. The choice assumes the existence of internal competencies and knowledge systems conducive to absorption from the specific channel. In the dataset, different channels of external information sources are assessed on a four level scale. Firms that report that information which originates from scientific sources is of higher (average) importance than information from industrial sources are consequently classified as relying on an analytical knowledge base. Inversely, firms that report a higher (average) valuation of non-science knowledge sources (customers, suppliers, competitors) are classified as relying on a synthetic knowledge base. A dummy variable captures the synthetic knowledge base. As would be expected against the background of previous research (see e.g. Laursen & Salter 2004) and the nature of the European economies, firms that purely rely on an analytical knowledge base are comparably rare and account for about 30% of the innovating companies in our sample.

Importance of internal search

Building on the same basic assumption as above, we also use the information provided about search channels in order to operationalize the importance of internal search. This captures the importance of the internal build-up of knowledge in the firm and its reliance on its established expertise. Here we assume the relative importance of the external and the internal search spaces of a company reflects how knowledge is accumulated by the firm. To gauge the importance of internal search, we measure the extent to which firm-specific knowledge that has been accumulated in earlier innovation activities is more important to the firm's current innovation activities than any external information sources. Consequently, if a company attaches a higher importance to internal sources than to all other external sources, we assume a high importance of internal search. As firms (regardless of size) constantly interact with actors outside — particularly in their value chain — and this interaction necessarily involves information interchange, firms are assumedly aware of the external source for information that can be used for innovation activities. If higher relevance is assigned to internal sources than to external sources, this indicates the importance of internal search processes.

We encounter the question of interdependencies between this measure and knowledge base characteristics both substantially and technically. Technically, these interdependencies could arise because both are constructed using the information on search channels. It is not unreasonable to assume that firms that are more based on a synthetic knowledge experience a higher importance of internal search in their knowledge development and innovation efforts, than do firms operating based on analytic knowledge. In a related study we do not find significant dependence of importance of internal search and knowledge base (Aslesen, Ebersberger & Herstad 2011), which is confirmed by the low correlation of -0.049 between the importance of internal search and knowledge base in this study (significant at least at the 1% level).

Product or Product Oriented Strategy

Product and process oriented innovation strategies can have a strong impact on firm choices (e.g. Ebersberger & Lööf 2005). It affects where firms screen for knowledge and ideas, whom they collaborate with, and to what extent they tend to decide to buy rather than to make. The information in the surveys allows us to construct indicators that capture product or process oriented strategies by utilizing information about the effect that the firm's innovation activities generated.

Table 4 Product or Process Oriented Strategies: Factors extracted

Variable	Factor1	Factor2
Increased range of goods and services	0.1648	**0.7332**
Entered new markets or increased market share	0.228	**0.7382**
Improved quality of goods and services	0.3596	**0.6078**
Improved flexibility of production...	**0.6228**	0.2725
Increased capacity of production...	**0.6568**	0.289
Reduced labour costs per unit output	**0.7053**	0.2312
Reduced materials and energy per unit output	**0.7024**	0.1967
Reduced environmental impact	**0.6222**	0.2498
Met regulatory requirements	**0.5586**	0.2746
Interpretation	**Process oriented strategy**	**Product oriented strategy**

Note: Table shows the varimax rotated factor loading matrix. For ease of interpretation factor loadings above 0.45 are in bold face.

A factor analysis that yielded only factors with an eigenvalue larger than unity revealed two distinct factors that can be interpreted as product and process oriented strategies. The regression based factor scores of these variables are used in the analysis (see Table 4).

3.6 Summary of the Indicators in the Analysis

We summarize the set of variables in the analysis and provide an overview of their properties in the following three tables: Table 5, Table 6, and Table 7.

Table 5 Summary of Indicators - Innovation Performance

Variable	Type	Scale
Innovation Activities	Dummy	Dichotomous
Innovation New to the Market	Dummy	Dichotomous
Sales from New products	Log	Metric
Sales Share of New Products	Fraction	Metric

Table 6 Summary of Indicators - Open Innovation Practices and Collaboration

Variable	Type	Scale
Industrial Search	Factor Score	Metric
Science System Search	Factor Score	Metric
Collaboration	Factor Score	Metric
Protection	Factor Score	Metric
External Innovation	Fraction	Metric
Domestic Vertical Collaboration	Dummy	Dichotomous
Domestic Science Collaboration	Dummy	Dichotomous
International Vertical Collaboration	Dummy	Dichotomous
International Science Collaboration	Dummy	Dichotomous
No Vertical Collaboration	Dummy	Dichotomous
Domestic & International Vertical Collaboration	Dummy	Dichotomous
No Science Collaboration	Dummy	Dichotomous
Domestic & International Science Collaboration	Dummy	Dichotomous
Internationality of Collaboration Network	Fraction	Metric

Table 7 Summary of Indicators - Controls

Variable	Type	Scale
Firm Size	Log	Metric
Innovation Intensity	Fraction	Metric
Foreign Ownership	Dummy	Dichotomous
Domestic Multinational	Dummy	Dichotomous
National Public Funding	Dummy	Dichotomous
EU Public Funding	Dummy	Dichotomous
Cumulative Knowledge Base+	Dummy	Dichotomous
Appropriability+	Fraction	Metric
Opportunity Conditions+		Metric
Year	Dummy	Dichotomous
Sectors	17 Dummies	Dichotomous
Country Gruop	4 Dummies	Dichotomous
International Orientation	Dummy	Dichotomous
No Incentive	Dummy	Dichotomous

Note: + Variables in the regression, but not reported in this documentation here. Full regression tables can be obtained from the authors upon request.

3.7 Methodology

This section gives an overview of some of the methodological aspects of the analysis. It discusses the use of sampling weights, it introduces the regression models, and it highlights how we control for selection bias and for potentially interdependent regressions.

3.7.1 Weights

As the available CIS data contains a weight for each observation in order to be able to extrapolate the sample to the whole economy, we used these weights throughout the whole analysis. The weights are not only used in the regression analysis but also in the descriptive analysis and in the factor analyses employed in the variable construction. Please note that the weights are taken from the national datasets. Although we include these weights, the findings are not representative for the whole of Europe as major European countries such as UK, Germany and Poland are not represented in the analyzed data set.

3.7.2 Regression Models

The methodology used for analyzing the effects of open innovation practices and collaboration and for investigating their determinants strongly depends on the scale of the dependent variable. For metric dependent variables which are generated as factor scores in a factor analysis, we use OLS regressions; for metric dependent variables which are fractions we use double constraint Tobit regressions, and for dichotomous dependent variables we use probit regressions.

3.7.3 Selection

In all cases the dependent variables of interest— such as innovation performance, open innovation and collaboration— can only be observed with companies which are innovation active. In accordance with the literature, we use selection models to model the firms' decision to embark on innovation activities. We have to note here that we use the variable of international orientation and low incentive for innovation as instruments to identify the regression in the first—the selection—stage. Comparable specifications have been used in Rammer et al. (2009) or Ebersberger & Herstad (2011). The Mill's ratio computed from the first step regression is included in the second step to correct for the selection bias.

3.7.4 Seemingly Unrelated Regressions

When analyzing the determinants of open innovation practices and when analyzing the determinants of collaboration, we cannot assume that the decision for each of these activities—say, industry search— is independent of the decisions about all the others— say, science search, collaboration, and protection. By using seemingly unrelated regression models in the second stage we capture the correlation of the residuals (Zellner 1962; Zellner and Huang 1962; Zellner 1963). A summary of the properties, the scaling of the variables and the used regression models can be found in Table 8 and Table 9.

Table 8 Innovation Performance as Dependent Variable

Variable	Type	Scale	Regression Model	Stage
Innovation Activities	Dummy	Dichotomous	Probit Regression	First
Innovation New to the Market	Dummy	Dichotomous	Probit Regression	Second
Sales from New products	Log	Metric	OLS Regression	Second
Sales Share of New Products	Fraction	Metric	Tobit Regression	Second

Table 9 Open Innovation Practices and Collaboration as Dependent Variables

Variable	Type	Scale	Regression Model	Stage
Industrial Search	Factor Score	Metric	OLS Regression[1]	Second
Science System Search	Factor Score	Metric	OLS Regression[1]	Second
Collaboration	Factor Score	Metric	OLS Regression[1]	Second
Protection	Factor Score	Metric	OLS Regression[1]	Second
External Innovation	Fraction	Metric	OLS Regression[1+]	Second
Domestic Vertical Collaboration	Dummy	Dichotomous	Probit Regression[2]	Second
Domestic Science Collaboration	Dummy	Dichotomous	Probit Regression[2]	Second
International Vertical Collaboration	Dummy	Dichotomous	Probit Regression[2]	Second
International Science Collaboration	Dummy	Dichotomous	Probit Regression[2]	Second
Internationality of Collaboration Network	Fraction	Metric	Tobit Regression	Second

Note: [1,2] Bundled in the same seemingly unrelated regression set up. [+] As the dependent variable is a fraction a Tobit-Regression would be more appropriate. Yet, as we use a seemingly unrelated regression setup we use an OLS Regression here.

3.7.5 Analysis of Interdependencies

In the second stage, the structure of the seemingly unrelated regressions also facilitates the analysis of complementarity or substitutability of the open innovation practices. Athey and Stern (1998) suggest two approaches to investigate complementarities. The first approach is the production function approach. It is based on the estimation of a production function—in our case an innovation production function—whereby interaction effects have to be included in the set of independent variables. Empirically this is a feasible approach. Yet in the presence of five open innovation practices, one would have ten interaction effects of two practices, ten interaction effects of three practices and five interaction effects of four variables in addition to the five single open innovation practices. This would result in a rather incomprehensible set of parameter estimates.

Hence we prefer the second - the adoption approach. It can be directly linked to the seemingly unrelated regressions of the determinants of open innovation practices above. The adoption approach tests whether there is positive correlation among the adopted practices, conditional on observables. In our case the observables are the independent variables in the regressions determining the open innovation practices (Athey & Stern 1998, Arora & Gambardella 1990). This approach is based on the firm's revealed preference for employing open innovation practices simultaneously. Implicit to this approach is the assumption that if—given the rational behavior of the actors—the simultaneous use is beneficial, the adoption of the open innovation practices will correlate positively.

Positive conditional correlation indicates complementarity of the practices as "complementarity creates a force in favor of positive correlation" (Athey & Stern, 1998, p. 12) between the practices. Similarly, it can be said that negative correlation indicates substitutability. We therefore test whether there is significant correlation of the adoption of open innovation practices conditional on the exogenous determinants of open innovation practices. We test independence using the Breusch-Pagan (1980) test on the residuals of the regression determining the adoption of open innovation practices. It is a Chi2 Lagrange multiplier test analyzing the independence of the regression residuals.

PART II:

The relationship between open innovation and innovation performance

4. Innovation, Performance & Growth

Open innovation practices can be assumed to impact on a) the likelihood that firms develop and introduce innovations on the market, and b) the returns that are generated. In the following, emphasis will be put on mapping innovation performance across European countries, sectors, and firm size-classes. Against this background, we will investigate the extent to which the different dimensions identified have measurable impacts on innovativeness and innovation performance.

As a benchmark for innovation performance, we use the event of the introduction of a new product (a good or a service), and the turnover generated by such new products. Product innovations are chosen because they entail the creative linking of market and technological opportunity into a comprehensive package of attributes (Dougherty, 1992). By contrast, process innovations can be sheltered from the market, thereby reducing the complexities of the innovation process by limiting the diversity of external information which must be accounted for. Product innovations can therefore provide the better benchmark for investigating the link between open innovation practices and innovativeness (Danneels, 2002). Turnover that is generated by new products provides a measure of innovation performance that captures complementary aspects of 'innovativeness'. The first measure—i.e. the introduction of a new product—does not take into account for effects that marketing and other decisions may have: thus it provides the best measure for the technological effectiveness of innovation processes. The second measure—the resulting turnover of new products— provides the better measure for the commercial success of the innovation for the same reason.

We turn now to how different theories of the firm conceptualize i.) the link between open innovation practices and innovation performance at the firm level, and ii.) the relationship between strategies at the firm level and performance at the economy level. This provides the basis to review recent contributions on innovation organization and innovation performance. It will also serve to remind the reader that the different dimensions of open innovation practices will be treated both conceptually and theoretically on a one-by-one basis in subsequent chapters.

4.1 Firms, territorial innovation systems and innovation performance

The debate on 'the nature of the firm' dates back at least to 1937, when Ronald Coase explicitly raised the question of why they exist if markets are assumed to be superior to administrative control in allocating resources. According to the transaction cost school that followed (Williamson, 1975), what the firm does is largely to exercise administrative control over work processes that could have been conducted by somebody else on behalf of the firm. Yet, the cost of administrating processes internally will in many cases be substantially lower than the transaction costs that would be incurred by external sourcing. This leads the firm to choose the internal option to 'make' instead of the external option to 'buy' what it needs. This line of reasoning portrays the formation of firms as relatively 'passive' responses to market failures. In its original form it assumes that technology and knowledge are stable and widely distributed; its contemporary 'open innovation' form assumes that it is readily available in clearly defined markets for IPR, contract R&D or venture capital exit.

By contrast, resource-based theories argue that 'what firms do' (Kogut & Zander, 1996) is to continuously try to create such market failures by developing assets that are not available to anyone else. They do so by seeking out, assimilating, and transforming knowledge from different areas (Kessler, Bierly, & Gopalakrishnan, 2000). The result is its accumulation as knowledge assets that hold varying degrees of firm specificity. When these assets are valuable because they enable commercial activity for which there is market demand and rare because commercial activities cannot easily be conducted by competitors who lack control over or access to similar knowledge assets, they form the basis for competitive advantage. When assets are also difficult to replicate or access without the permission of the firm, then 'isolating mechanism' (Wang, He, & Mahoney, 2009) can be said to protect the assets from imitation and to protect the firm as a whole from competition (DeSarbo, Di Benedetto, & Song, 2007). However, these assets isolating mechanisms are only temporary. The firm must continuously renew them by means of learning and innovation. In this perspective, firms are therefore not the defensive outcome of pre-existing, general market failures, but key drivers of the process of technological change.

The knowledge developed by firms is made available to other firms in different forms: it can be embodied in products, it can be transferred through external commercialization or collaborative relationships, and it can take the form of uncontrolled knowledge spillovers. Firms can thus be said to have a 'dual' role in innovation systems in that they serve both as knowledge developers within and providers to the larger territorial economy in which they are located. The role of firms as developers is exercised by means of internal research and development activities and is linked to search, sourcing, and collaboration networks which may – and often should - extend far beyond the boundaries of the same territorial economy (Bathelt, Malmberg, & Maskell, 2002; E. Giuliani, M. Bell, 2005; Owen-Smith & Powell, 2004). The role of firms as providers, by contrast, arises from public good properties of the underlying knowledge. This entails that some of it will always spill out of the firm and into its surroundings to a smaller or larger degree. When firms combine intramural R&D with networking activities internal and external to the territorial economies in which they are located, they serve as « gatekeepers » which channel information from outside into the system (Graf, 2010). International linkages serve to supply novel information and specialized knowledge that are not found within the boundaries of the firm or its region of location; whereas internal R&D linked to domestic labor markets (Agrawal et al., 2006; Almeida & Kogut, 1999; Dahl & Pedersen, 2004) and open innovation practices serve to absorb, translate, and diffuse this knowledge into the territorial economy (see Graf, 2010; Morrison, 2008 for recent contributions on the role of 'gatekeepers' in territorial innovation systems). The sourcing of technology 'embodied' in components and machinery by one firm in the region may, by means of imitation, not only serve to support the innovation activities of the sourcing firm. It may also sensitize other firms to the availability of the opportunities and thus raise the level of innovative activity in the region as a whole.

In this landscape it is important to distinguish between the private (firm level) and social (economy level) implications of firm level practices, which is absent in the original formulation of the open innovation concept. The social value of knowledge is not captured unless it is diffused to potential user groups, with attention directed towards relevant knowledge that exists externally and towards the internal capacity necessary to absorb it. This raises questions about to the absorptive capacity and integrative capabilities of the firm. It also points to the importance of the innovation system that surrounds the firm. The role of the innovation system is important not only in contributing to the diffusion of information, technology, and knowledge. Its importance is more fundamentally associated with its role in providing the basis for skilled workforce and the internal capacity in firms via broader education policies and general labor market characteristics.

4.2 A Brief Review of Key Concepts and Recent Contributions

At the firm level, it is well established that investments in systematic research and development work is positively associated with innovativeness. Here, the relationship is often found to be curvilinear with decreasing marginal returns to scale, given certain conditions (Cassiman & Veugelers, 2006; Ebersberger & Herstad, 2010; Schmiedeberg, 2008). R&D expenditures are also commonly used as an indicator of the absorptive capacity of firms, i.e. their ability to identify, assimilate, transform and exploit external knowledge resources. Yet, it is also well established that in some sectors (e.g. knowledge intensive business services) and countries (e.g. Norway), large proportions of innovation active firms do not report positive R&D expenditures. Furthermore, the relationship between business sector, R&D expenditures, and economic growth at the aggregate level of the economy is far from a straightforward one, as recognized by the EU. Often cited 'paradoxes' in this respect are the Swedish experience of weak growth combined with strong business investments in R&D, or the contrary situation in neighboring Norway with its weak industrial R&D accompanied by strong growth.

This has led researchers to question the extent to which the commonly applied distinction between 'high-tech' and 'low-tech' industries captures real differences in knowledge intensity. It has also raised the possibility that there might be different 'modes of innovation' for which reported R&D intensity does not adequately capture high knowledge intensity. Furthermore, the relationship between R&D and absorptive capacity has also been questioned on the premise that, while internal R&D may be necessary to successfully relate to certain actor groups (e.g. universities) via specific mechanisms (e.g. contract R&D), other factors may mediate the effect of R&D on absorptive capacity, or substitute for it altogether (Lane & Lubatkin, 1998; Schmidt, 2005; Zahra & George, 2002). These factors may include the knowledge base of the firm and the attention its management directs to individual sections of the external environment (Ocasio, 1997).

A range of general factors are necessary at the firm-level in order to engage in interactive learning processes with external actors, including internal competences, organizational structures, and knowledge management principles. However, the particular factors needed to successfully engage with external industrial actor group are different than those needed when sourcing of technology from a university (Ebersberger & Herstad, 2010). The picture becomes even more complex when we consider the technological context in which a firm is placed. For instance, Sofka & Grimpe (2010) find that the impact of customer and science system search is moderated by the technological class of the firm. This is likely to reflect issues of relative absorptive capacity associated with different modes of innovation. To this comes the more general argument that internal R&D may be associated with rigidities and 'not-invented-here' syndromes, by which external inputs are systematically rejected by the organization (Katz & Allen, 1982; Leonard-Barton, 1992).

Important contributions to the ongoing discussion on the relationship between R&D and innovation performance are the distinctions developed between analytic (science-based), synthetic (engineering-based) and symbolic (design and culture) knowledge bases. These distinctions transcend the traditional high-tech versus low-tech dichotomy by qualitatively considering the composition of knowledge inputs that innovation builds on. The distinctions also take into account the means by which these types of knowledge tend to enter the firm, for example through sourcing of technology 'embodied' in components of machinery or through 'disembodied' knowledge transferred or developed during collaborations. Similarly, a recent contribution based on Danish data identified – inductively – two distinct modes of innovation, which have subsequently been found to be associated with different patterns of external networking and different degrees of innovativeness. The core of the "science-technology-innovation" (STI) mode is R&D departments of firms that are associated with the recruitment of highly skilled individual researchers, search within academic 'epistemic' communities and collaboration with science system actors.

The outcome is explicit knowledge which travels well but requires adaption to the contexts where it is to be applied before it can yield innovation. The strength of the mode lies in its ability to draw on and push disciplinary frontiers, to explore fundamentally new knowledge independent of specific contexts of application, and to provide the basis for radical innovations. This can also be its Achilles heel, as transformation into large-scale industrial applications often requires specialized complementary capabilities developed by other means than STI (Karlsen, Isaksen, & Spilling, 2011). This means that less 'sticky' science-based knowledge is dependent on far more 'sticky' specialized capabilities embedded in firms (DeSarbo et al., 2007) and regions (Asheim & Isaksen, 2002; Isaksen & Karlsen, 2011).

The core of the contrasting "doing-using-interacting" (DUI) mode hinges on the various ways in which the internal learning strategy of the firm is linked to external value chain actors. This model can mobilize and link experience-based knowledge originating in different parts of the organization and value chain. Thus it can help ensure that a stock of knowledge that is context-specific and application-oriented might continue to evolve. If so, it may sustain an ongoing stream of incremental innovations along established technological development paths and can drive the development of highly specialized knowledge assets. By the same token, though, it carries with it the risk of technological lock-in and to diminishing return paths.

Qualitative studies have confirmed that the two 'modes' of innovation practices involve distinct organizational principles and requirements (Isaksen & Karlsen, 2011; Karlsen et al., 2011). This is consistent with findings that it is the co-existence of these two different modes at the firm-level that is most strongly associated with innovation. The findings of a number of studies can be mentioned in this context, including positive impacts from the number of different collaboration partners (Grimpe & Kaiser, 2010) or information (Laursen & Salter, 2006) sources used; and complementarities between different external knowledge sources measured both as their tendency to be used simultaneously (Roper et al., 2008) and as a positive impact from this simultaneous use on innovativeness (Ebersberger & Herstad, 2010). Why this is the case we will get back to in more detail below.

At the level of territorial economies, the relationship between knowledge spillovers and growth is well established (e.g. Griliches, 1979). There is also ample evidence that diffusion and reconfiguration of knowledge through such spillover effects remain heavily constrained by geography (Grünfeld 2003:15, Verspagen and Schoenmakers 2002, Asheim and Gertler 2005). Using US patenting data, Jaffe and Trajtenberg (1996) for instance show that patents are cited more often when the patentee and the citing firm are located in the same state or nation, a finding consistent with European studies e.g. by Maurseth and Verspagen (2002) and Keller (2002) but also quite contrary to the notion of patents as 'commodified' knowledge. This points to the importance of knowledge diffusion mechanisms which operate independently of the collaborative production and innovation networks which are becoming increasingly global; i.e. information diffusion and knowledge mobility through labor markets and personal ties (Agrawal, Cockburn, & McHale, 2006; Cotic-Svetina, Jaklic, & Prodan, 2008; Dahl & Pedersen, 2004) or mediated by linkages between industry and public or private research institutions. Verspagen and Schoenmaker (2002) thus argue that the globalization of innovation, paradoxically, "…implies a strengthening of the notion of regional innovation systems… due to the existence of specific skills and competencies in people who are not perfectly mobile".

There is also growing evidence that the impact of knowledge diffusion is conditioned by the composition of the pre-existing industrial structure: in other words, the extent to the innovation activities conducted by different firms and industries generate knowledge which is different enough to enter into novel combinations (by means of controlled collaboration and external commercialization, or uncontrolled spillovers), while similar enough to existing industrial actors or entrepreneurs to identify the potential for such combinations. The combined result of distance decay and industry composition effects is divergent technological development paths and divergent macro-economic growth rates; implying that diverse factors will enable innovation and drive growth along different paths (Reinstaller & Unterlass, 2010).

The heterogeneity of economy characteristics thus not only determines practices as such, but it also conditions their impact on innovation at the level of the firm and growth at the level of the economy. Naturally, this recognition translates into a challenge for our analysis of open innovation at the European level. In particular it points to the need for classifications which capture essential characteristics of the economies and sectors that are included. For this reason we use average EU country size as the cut-point for distinguishing between large and small economies, as discussed in Chapter 3. This builds on the assumption that larger country size entails larger and more diverse domestic markets as well as broader research system and supplier infrastructures. Moreover, country size impacts the potential for and the impact of open innovation within country boundaries and influences the need for linkages abroad. We also categorize sectors according to the commonly applied OECD taxonomy.

Yet, neither economy size nor sector technology class sufficiently captures the diversity of contextual conditions at play. Reinstaller & Unterlass therefore classify EU national economies according to their technological profile (Reinstaller & Unterlass, 2010). The technological profile is here identified based on the direct R&D intensity of national economies (i.e. R&D conducted within them) and the flow of technology embodied in domestic inputs, as well as their dependence on R&D-based knowledge embodied in inputs sourced from abroad (Hauknes & Knell, 2009; Reinstaller & Unterlass, 2010). This allows for different determinant impacts to be identified across different country groups. Notable findings include that investments in R&D are positively associated with innovation in countries close to the technological frontier (i.e. countries with high direct and indirect R&D intensity), but not so in countries further away from it (i.e. countries with low direct and indirect R&D intensity). A high reliance on internal processes is also important in the former economies, independent of sectors, whereas it is not in the latter. In terms of open innovation, a positive impact is found for deep search strategies that target customers, suppliers, and competitors in economies at a distance from the technological frontier while a positive impact is found for deep science system search for economies at this frontier. Against this background of diversity and complexity, we can now turn to consider innovation performance after we have spelled out the research question analyzed in the following sections.

Research Questions

In the following sections we investigate the joint effect of open innovation practices on the innovation performance of firms. In the following we do not explicitly distinguish between the single open innovation practices but rather analyze their joint effect. Even though this might seem premature it lays the ground for the subsequent discussion. Without finding a joint effect of open innovation practices on the innovation performance of firms it would not make any sense to analyse the individual effects the practices have. These individual effects are the focus of the subsequent chapters. The interested reader can skip Section 4.4 and procede directly to the individual effects of open innovation practices starting from Chapter 5.

4.3 Innovation Performance Descriptives

As discussed in the section 3.1 in more detail innovation performance is measured by three indicators. The first is i.) the firm's ability to commercialize product innovations, which are new to the market. To supplement this, we also measure innovation performance ii.) by the sales (logged) generated with new products, which in contrast to the previous indicator also captures the economic success of the product innovations. The third indicator we use to measure innovation success is iii.) by the share of turnover that is generated by new products: it allows us to capture the relevance of innovation success for the turnover structure.

These indicators of innovation performance can obviously only be observed in innovation active companies. In addition the three indicators of innovative active firms only, a fourth indicator will be primarily used in a preliminary stage to distinguish between the companies that exhibit no innovation activities as against the innovation active companies. This indicator captures innovation activities as discussed in section 3.1. The performance indicators will then be measured only with the latter group of companies. In the following section we characterize the innovation activities and innovation performance broken down on the company size—SME vs. Large Companies—and

Country Groups or Sectors, respectively. The construction of the Country and Sector indicators is documented further in section 3.4.

4.3.1 Innovation activity

Companies that engage in innovation activities are not evenly distributed in Europe. Among the countries included here, the highest concentrations are found in Sweden, Finland, Denmark as well as Estonia and Greece. The concentration of innovation active firms is also higher than average in Norway, Spain, France and the Czech Republic.

Table 10 Innovation active companies as share of all companies

Note: Colors code the share of innovation active companies.

Countries differ as to their overall R&D intensity and the general direction of technical development. Such country-level differences can affect the likelihood that firms there are innovation active or not. Table 11 uses the four groupings distilled from the input-output analysis of Reinstaller & Unterlass (2010). This indicates some differences in the tendency to innovate in these overall country-contexts. Here, it is important to distinguish large and small firms, as larger firms are on average much more likely to be innovation active than smaller firms (nearly twice in terms of the mean of innovation activity).

The concentration of innovation active firms is highest in countries that are characterized by high levels of R&D for both size-groups. National income-levels, however, seem to play a major role, independent of R&D intensity. Table11 thus shows relatively minor differences between countries with high direct and indirect R&D and High income countries, with low direct and indirect R&D. It is also noteworthy that those countries classified as 'Technology User Countries' also show relatively high concentrations of innovation active firms. While small firms in low income, low R&D countries are the least likely to be innovation active.

Table 11 Fraction of innovation active companies (of all companies) by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.779	0.396	0.414
	0.415	*0.489*	*0.492*
Technology User Countries	0.680	0.324	0.347
	0.467	*0.468*	*0.476*
High income, low R&D Countries	0.758	0.378	0.386
	0.429	*0.485*	*0.487*
Low income, low R&D Countries	0.496	0.215	0.230
	0.500	*0.411*	*0.421*
Total	0.710	0.360	0.373
	0.454	*0.480*	*0.484*

Note: Mean of the indicator innovation activity; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

The next set of factors known to affect the propensity of firms to innovate is technology sectors. As shown in Table 12—and introduced in Chapter 3— we again use a recognized classification. And again differences in firm-size are taken into account. Large firms tend to be more innovation active than the smaller firms. But technology sector plays an important role which is in line with expectations. The difference in degree can be best seen among the smaller firms, where they are largest.

Table 12 Fraction of innovation active companies (of all companies) by company size and sector

Technology Sectors	Firm Size Large Comp.	SME	Total
High tech mfg	0.799	0.546	0.561
	0.401	*0.498*	*0.496*
Med high tech mfg	0.800	0.476	0.498
	0.400	*0.499*	*0.500*
Med low tech mfg	0.751	0.357	0.368
	0.433	*0.479*	*0.482*
Low tech mfg	0.612	0.303	0.313
	0.487	*0.460*	*0.464*
Knowledge intensive serv.	0.700	0.384	0.396
	0.458	*0.486*	*0.489*
Total	0.710	0.361	0.374
	0.454	*0.480*	*0.484*

Note: Mean of the indicator for innovation activity; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

4.3.2 Innovation performance

Innovation activity is one thing. The more important question for open innovation is whether the firm introduces product innovations that are new to market. We first present this measure of innovation performance in terms of the country groups introduced above. We again find major differences between small and large firms, but smaller values than in Table 12. On average, it is firms in Technology User countries that are most likely to introduce an innovative product, followed by those in countries with high R&D intensities. Table 13 indicates that the relative role of high income countries does not play a role here, as it did above. The concentration of small innovative firms is in fact higher in low income rather than high income but low R&D country contexts.

Table 13 Descriptives of the introduction of product innovations new to the market by company size and country group (innovation active companies only)

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.603	0.443	0.457
	0.489	*0.497*	*0.498*
Technology User Countries	0.552	0.455	0.467
	0.497	*0.498*	*0.499*
High income, low R&D Countries	0.511	0.293	0.303
	0.500	*0.455*	*0.460*
Low income, low R&D Countries	0.448	0.407	0.411
	0.497	*0.491*	*0.492*
Total	0.544	0.358	0.371
	0.498	*0.479*	*0.483*

Note: Mean of the indicator for product innovation new to the market; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Technology sectors are an important determinant of the propensity of firms to bring new products onto the market. The pattern in Table 14 is broadly similar to that found in Table 11 although the overall averages for larger companies are smaller. The level among knowledge intensive service sector firms ranks as high (third) as in the case of innovation active firms. In terms of innovation products, there is a clearer effect of sectors involving more R&D intensive technologies for both size-groups.

Table 14 Descriptives of the introduction of product innovations new to the market by company size and sector (innovation active companies only)

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.647	0.557	0.565
	0.478	0.497	0.496
Med high tech mfg	0.579	0.456	0.469
	0.494	0.498	0.499
Med low tech mfg	0.516	0.305	0.318
	0.500	0.461	0.466
Low tech manuf	0.506	0.288	0.301
	0.500	0.453	0.459
Knowledge intensive serv.	0.556	0.419	0.428
	0.497	0.493	0.495
Total	0.545	0.360	0.373
	0.498	0.480	0.484

Note: Mean of the indicator for product innovation new to the market; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

The level of a company's sales that stem from innovative products is a further, and in some ways stronger, test of firm innovativeness. Here the country context again plays a pronounced role. Large firms in countries characterized by high R&D intensities report the largest sales from innovative products (in logs). A less expected result is that firms in low income, low R&D countries post the next largest level of innovation related sales. Table *15* shows that this is the case both for large and small firms. Companies in countries characterized as technology users have higher values than those found in the high-income, low R&D category.

Table 15 Descriptives of the sales of new products (in logs) by company size and country group (innovation active companies only)

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	10.653	6.919	7.236
	7.934	*6.790*	*6.973*
Technology User Countries	8.200	5.510	5.855
	7.763	*6.278*	*6.549*
High income, low R&D Countries	7.810	3.737	3.923
	8.265	*5.998*	*6.179*
Low income, low R&D Countries	8.430	6.107	6.374
	7.503	*6.101*	*6.321*
Total	8.912	4.938	5.217
	8.075	*6.419*	*6.627*

Note: Mean of sales of new products (log); standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

The level of innovative sales is closely linked to technology sectors. Large firms in particular show a pattern that is familiar from above. Table *16* confirms that in particular large innovative active firms in R&D intensive sectors that have highest sales from innovative products, followed again by firms in the knowledge intensive sectors. A similar pattern is found among small firms. However, differences in this population between highest and lowest sales attributable to innovative products is much starker.

Table 16 Descriptives of the sales of new products (in logs) by company size and sector (innovation active companies only)

	Firm Size		
Technology Sectors	Large Comp.	SME	Total
High tech mfg	10.820	7.553	7.837
	8.037	6.695	6.884
Med high tech mfg	9.441	6.309	6.653
	8.091	6.765	6.991
Med low tech mfg	8.421	4.293	4.533
	8.067	6.228	6.422
Low tech manuf	8.409	3.995	4.255
	7.922	6.047	6.260
Knowledge intensive serv.	9.017	5.672	5.896
	8.170	6.507	6.684
Total	8.939	4.962	5.242
	8.075	6.429	6.637

Note: Mean of sales of new products (log); standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

The above measure based on the volume of innovation sales accentuates the innovation performance of larger firms, as their sales volumes tend to be larger than smaller firms. In such a comparison, a small firm whose products are mainly new to the market may still be overshadowed by a large firm with relatively small emphasis on innovative products just because of volume. The final innovation performance metric is based on sales from innovative products as a ratio of a company's total sales. The ratio of innovative sales deflates the effect of sales volume in question of innovation performance.

Table *17* confirms this rebalancing with respect to the small and large firms in the four country groupings. It is remarkably small innovative firms in countries characterized by Low income, low R&D countries that report the highest proportion of sales being derived by innovative products. This is followed by firms in both size-classes in technology user countries. Large firms do better according to this innovation performance metric in high income countries characterized by low R&D intensities, while smaller firms do slightly better than large in national contexts with high R&D intensity.

Table 17 Descriptives of the sales share of new products by company size and country group (innovation active companies only)

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.085	0.090	0.090
	0.151	*0.182*	*0.180*
Technology User Countries	0.105	0.104	0.104
	0.192	*0.198*	*0.197*
High income, low R&D Countries	0.095	0.075	0.076
	0.195	*0.185*	*0.185*
Low income, low R&D Countries	0.119	0.153	0.149
	0.221	*0.259*	*0.255*
Total	0.096	0.087	0.087
	0.184	*0.191*	*0.191*

Note: Mean of the sales share of new products; standard deviationsare in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

In terms of technology sectors, the greater strength of small firms as measured by the innovation sales ratio is isolated to the knowledge intensive services sector. Table *18* shows that innovative large firms report higher levels of innovation sales than do small firms in all other technology sectors. The sector with highest levels of innovation performance in terms of levels of sales of innovative products is the high-tech sector, while the lowest is the low-tech sector. This is very much in line with expectations.

Table 18 Descriptives of the sales share of new products by company size and sector (innovation active companies only)

	Firm Size		
Technology Sectors	Large Comp.	SME	Total
High tech mfg	0.158	0.153	0.153
	0.226	*0.239*	*0.238*
Med high tech mfg	0.108	0.101	0.102
	0.188	*0.190*	*0.190*
Med low tech mfg	0.090	0.069	0.070
	0.183	*0.170*	*0.171*
Low tech mfg	0.084	0.066	0.067
	0.175	*0.169*	*0.169*
Knowledge intensive services	0.086	0.116	0.114
	0.174	*0.226*	*0.223*
Total	0.096	0.087	0.087
	0.184	*0.191*	*0.191*

Note: Mean of the sales share of new products; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

4.4 Effects of OI Practices on Innovation Performance

The first analytic question we turn to is whether or not open innovation practices affect the innovation performance of companies. In light of the preceding chapters which introduced what open innovation practices are, how we operationalize open innovation and how it is measured, we want to emphasize the relevance of this endeavor. This is to strengthen the argument that it will be worthwhile to disentangle open innovation into distinct practices and to investigate the effects. In contrast to Herstad, Bloch, Ebersberger & van De Velde (2008) we do not report the effects of an aggregate open innovation indicator here. Rather, we report the joint effect of the single indicators, which will be developed and analyzed below. In particular the indicators capture search activities (see section 5 below), collaboration activities (see section 6 below), protection strategies (see section 7 below) and, external innovation expenditure (see section 8 below).

Here we summarize whether open innovation as a whole has an effect on innovation performance; that is whether search activities, collaboration activities, protection and external innovation expenditure jointly affect innovation performance. Table *19* displays the F-test statistics of the regressions on innovation performance to indicate the joint significance of open innovation practices for all companies and in different contexts. Contexts are captured by subsamples of firms thought to approximate different environments, different regimes or different opportunities. These contexts are given by the size of the country, by the technological development of the country, by the sector of major activities and by the size of the firm.

Table 19 Joint effects of open innovation practices (search, collaboration, protection and external innovation expenditure) on innovation performance.
F-statistic of the regressions on innovation performance for all innovation active firms and for subsamples of innovation active firms.

F-Statistic	**Products new to the Market**	**Sales from new Products**	**Sales share of new Products**
All firms	1063.22***	260.92***	157.49***
In different subsamples			
Small Countries	437.87***	111.01***	67.27***
Large Countries	634.86***	157.46***	98.75***
Technology Leader Countries	257.91***	71.37***	30.89***
Technology User Countries	336.97***	97.45***	54.09***
High income, low R&D Countries	567.41***	135.65***	98.98***
Low income, low R&D Countries	148.72***	40.38***	17.38***
High Tech Manufacturing	72.59***	21.12***	9.75***
Med High Tech Manufacturing	200.20***	53.33***	29.52***
Med Low Tech Manufacturing	333.94***	79.10***	50.61***
Low Tech Manufacturing	257.58***	56.68***	36.23***
Know. Intensive Services	270.98***	73.08***	42.33***
> 250 Employees	507.95***	94.47***	29.50***
101-259 Employees	270.61***	60.99***	35.00***
51-100 Employees	343.04***	76.49***	49.34***
21-50 Employees	300.76***	67.64***	53.65***
< 21 Employees	267.88***	62.16***	46.04***

Note: F-tests on joint significance of open innovation practices are reported. *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: Products new to the market; Sales from new products (log); Sales share of new products.

Table 19 vividly illustrates the relevance of open innovation practices for the innovation performance of firms. For all firms, in all contexts and for all measures of innovation performance we find that open innovation activities jointly determine innovation performance in a significant way. Without being able to really identify it from Table 19 let us somewhat prematurely indicate that the effect of open innovation practices is not only significant in most cases it is positively so.

Important Findings

.: Open innovation practices jointly affect innovation performance significantly.

.: The effect is independent of the measure used to capture innovation performance.

.: This finding is independent of the country, sector and firm size contexts.

5. Search and Screening

5.1 Introduction

External knowledge components which are novel to the firm are by definition not known in advance but have to be identified through processes of search and experimental recombination (Ebersberger & Herstad, 2010). This makes the act of innovating fundamentally uncertain (Fleming, 2001) and introduces elements of serendipity to it, because one cannot define a universe of ideas and information in advance from which to select. Organizations are left to rely on those information flows which they are exposed to by strategic choice, routine, and accident. This exposure defines their search spaces (Katila & Ahuja, 2002). As a distinct open innovation activity, firms systematically explore new opportunities, for example, through active use of publicly available data in patent registers or academic publications or market research. Systematic search efforts in these generic information sources may reveal solutions to specific problems or may uncover relevant patterns of consumer preference.

5.2 Review of Literature

The impact of innovation search on subsequent technological evolution can be seen in terms of looking beyond organizational (Rosenkopf & Nerkar, 2001) and sector boundaries (Katila, 2002), as well as into other target domains outside the searching firm's realm of experience (Hargadon & Sutton, 1997; Majchrzak, Cooper, & Neece, 2004). Search spaces are created partly through 'strong tie' linkages (Hansen, 1999), but should extend beyond these to ensure exposure to novelty (Grabher, 1993; Granovetter, 1973). They may include the active use of information sources such as publications or databases. They may furthermore be built on information spillovers that emanate from personal ties (Agrawal et al., 2006; Dahl & Pedersen, 2004), from within business communities (Maskell, Bathelt, & Malmberg, 2006) or from within the geographical neighborhood of the firm (Almeida & Kogut, 1999). This means that the industrial and technological context that a firm finds itself in— i.e. its economy of location— will tend to influence its search patterns.

Searching the demand side of the market may provide the firm with vital information about preferences and future trends (von Hippel, 1988, 2005), while searching among competitors can provide information about technological opportunities not perceived by the focal firm (Lukas & Ferrell, 2000). Suppliers are similarly recognized not only to be important sources of complementary capabilities and technology 'embodied' in machinery and components (Hauknes & Knell, 2009; Pavitt, 1984), but may also provide indirect contact points to competitors, research communities and the market. Using information from product development and consultancy firms may provide the firm with insights into technological opportunities that exist outside the firm's own value chain or sector boundaries (Hargadon & Sutton, 1997; Sutton & Hargadon, 1996; Tether & Tajar, 2008). Patents and publications that are generated by the research system may provide vital information about not only cutting-edge technologies but also about what paths are not worth pursuing (Asheim & Gertler, 2005).

Thus, different information sources may be seen to serve complementary functions in the innovation process. This suggests that firms may rely too much on information from one actor group (e.g. clients) and that it may be beneficial to search complementary information elsewhere – for instance in the science system (Laursen & Salter, 2004) or among consultancy firms (Tether & Tajar, 2008). The diversity of information sources a firm relies upon may thus serve as an indicator of overall openness towards external information (Fey & Birkinshaw, 2005): and, indeed, breadth of search has been found to be conducive to innovation (Laursen & Salter, 2006). Reliance on a diversity of information sources may also indicate a process by which a firm simultaneously integrates a range of complementary information sources that are external to it in order to innovate: this suggests an indicator of the intensity of search.

It is helpful to draw a distinction between the diversity of information sources that a firm relies on during the innovation process and the intensity with which it uses them. However, this distinction does capture all dimensions of the search process. It does not sufficiently capture the direction of search (Sofka & Grimpe, 2010). This is important since where an innovative firm searches for new knowledge will build on its internal R&D processes and on the fact that different external information sources may require different forms of absorptive capacity. We therefore distinguish between search processes that target industrial sources (customers, suppliers, competitors) from search that targets science system sources. Furthermore, we consider complementarities between the different forms of search. This allows us to account for the possibility that the use of one form of search may positively (complementarities) or negatively (substitution) condition the use of the other. Along the same lines, it also allows us to account for the possibility that the impact from the various forms of search is affected by the R&D intensity of the firm either in a positive (absorptive capacity) or a negative (not-invented here) way.

Research Question

Below we investigate the effect of search activities on the innovation performance of firms. Since search as an open innovation practice comprises industrial search and science search we investigate the effects of both dimensions. The overall question here is whether search activities increase the innovation performance of firms.

5.3 Descriptives

The indicators capturing innovation search are discussed in more detail in section 3.2. There, the methodological approach and the details about the construction of the indicators can be found. In short, the indicators for innovation search distinguish between two generic types of partners used for search. Innovation search with industrial partners mainly focuses on the partners in the value chain as sources of information. Suppliers and customers are the most prominent sources of inspiration for innovation. Also information sought with competitors falls into this category. In general, industry search encompasses all search activities with other industrial partners whether vertical or horizontal in relation to the firm in question. Science search on the other hand captures all search activities for information with partners in the science system such as research organizations, laboratories or universities.

The following section provides an overview of the industrial search and science search. We first report the average level of searching activity broken down by country group, sector, and firm size.

5.3.1 Industrial Search

The average level of systematically exploring new opportunities in industry search spaces is highest among central eastern countries (as well as Luxembourg), moderate in the Nordic countries (and Portugal), and, otherwise, lowest among the other southern European countries.

Figure 11 Geographical distribution of OI practices – industry search

Note: Colors code the average industry search per country. High indicates the quarter of countries with the highest industry search. Low indicates the quarter of countries with the lowest industry search.

Table 20 Descriptives of the industry search of innovation active firms by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.111	-0.005	0.006
	0.732	*0.738*	*0.738*
Technology User Countries	0.370	0.247	0.263
	0.730	*0.769*	*0.765*
High income, low R&D Countries	0.045	-0.087	-0.081
	0.754	*0.757*	*0.757*
Low income, low R&D Countries	0.319	0.193	0.207
	0.779	*0.787*	*0.787*
Total	0.166	-0.015	-0.003
	0.758	*0.766*	*0.767*

Note: Mean of the industry search indicator; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The industry search indicator is a factor score. A positive/negative mean in a subsample indicates an average industry search above/below the European mean.

As expected, the incidence of industry search is greatest for innovative firms in countries characterized as technology users. Also innovative firms in low income countries characterized by low direct & indirect R&D engage disproportionately in this search strategy. It is not important in other country contexts, especially among smaller firms. In general, larger innovation active firms tend to perform industry search to a greater degree than smaller firms.

Table 21 Descriptives of the industry search of innovation active firms by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.196	0.131	0.136
	0.707	*0.738*	*0.735*
Med high tech mfg	0.154	0.031	0.044
	0.754	*0.765*	*0.765*
Med low tech mfg	0.108	-0.071	-0.061
	0.740	*0.760*	*0.760*
Low tech mfg	0.192	-0.009	0.003
	0.749	*0.767*	*0.768*
Knowledge intensive srv	0.207	-0.012	0.003
	0.798	*0.772*	*0.775*
Total	0.168	-0.013	0.000
	0.758	*0.766*	*0.767*

Note: Mean of the indicator industry search; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The industry search indicator is a factor score. A positive/negative mean in a subsample indicates an average industry search above/below the European mean.

Smaller firms only really engage less in industry search. The lowest level of industry search is found with medium low tech manufacturing, while the highest level is found with the firms from high technology manufacturing. In low technology manufacturing and in knowledge intensive services we find about European average industry search, while the differences within the sector, that is, the differences between large companies and SMEs is most pronounced in these two sectors.

5.3.2 Science Search

The profile for science search is more mixed than industry search. In geographical terms the average is highest among Nordic countries (as well as Romania and Portugal), followed by a mixed bag of southern, northern, and eastern countries.

Figure 12 Geographical distribution of OI practices – science search

Note: Colors code the average science search per country. High indicates the quarter of countries with the highest science search. Low indicates the quarter of countries with the lowest science search.

Table 22 shows that systematically exploring the science system for new opportunities is highly size dependent, with large companies exhibiting a level of science search which is clearly above the European average, and SMEs exhibiting a below average science system search. In contrast to the industry search we do not find striking differences between the country groups.

Table 22 Descriptives of the science search of innovation active firms by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.412	-0.026	0.014
	1.076	*0.818*	*0.855*
Technology User Countries	0.320	-0.048	-0.001
	0.998	*0.825*	*0.858*
High income, low R&D Countries	0.516	-0.037	-0.012
	1.060	*0.775*	*0.799*
Low income, low R&D Countries	0.190	0.031	0.049
	0.931	*0.864*	*0.874*
Total	0.408	-0.032	-0.001
	1.042	*0.796*	*0.823*

Note: Mean of the science search indcator; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The science system search indicator is a factor score. A positive/negative mean in a subsample indicates an average science system search above/below the European mean.

Table 23 Descriptives of the science search of innovation active firms by company size and sector

	Firm Size		
Technology Sectors	Large Comp.	SME	Total
High tech mfg	0.628	0.138	0.180
	1.086	*0.919*	*0.944*
Med high tech mfg	0.559	0.021	0.080
	1.037	*0.819*	*0.862*
Med low tech mfg	0.460	-0.088	-0.057
	1.030	*0.739*	*0.769*
Low tech mfg	0.277	-0.101	-0.079
	1.013	*0.724*	*0.749*
Knowledge intensive srvs	0.284	0.081	0.095
	1.045	*0.909*	*0.920*
Total	0.409	-0.031	0.000
	1.041	*0.797*	*0.824*

Note: Mean of the indicator for science search; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The science system search indicator is a factor score. A positive/negative mean in a subsample indicates an average science system search above/below the European mean.

Science search is related to innovation intensity of the sector, both in manufacturing and in knowledge intensive services. In high technology and medium high technology manufacturing sectors the average intensity of science search is above the European average and so it is in knowledge intensive services. In low technology manufacturing and in medium low technology manufacturing it is below the European average.

5.4 Effects of Search on Innovation Performance

5.4.1 Effects of Industrial Search

Table 24 below shows the EU-level marginal effects of industrial search (i.e. search targeting customers, competitors and suppliers) on innovation, under different contextual conditions. Industrial search has clear-cut positive and strong impacts. Overall, we see that a one unit (= one standard deviation) increase in industrial source search is associated with a 9 % increase in the likelihood of new product introduction. The marginal effects of industrial source search are lowest in low income, low-R&D economies. This can be interpreted either as a result of industrial search being excessively oriented towards domestic industrial environments with weak technological capabilities and a weak demand base, or systematic problems related to assimilation, transformation and exploitation of external information found in these countries. Consistent with Unterlass & Reinstaller (2010) we also see that the association between industrial search and innovation is distinctively weaker among firms in high-tech manufacturing, and distinctively stronger in knowledge intensive services. This could be attributed to not-invented-here syndromes at play in R&D intensive industries. On the other hand, it may also indicate that firms in high-tech industries experience stronger supply side limitations to their search strategies, than do firms in less R&D-intensive industries.

How to read the results tables

Let us at this stage of the discussion pause to describe how to read the tables which we will use in the following to report most of the regression findings. Please note that the table differs markedly from a standard regression table. The table format here condenses the results of 42 single regressions.

Take Table 24 for instance. In it, each column reports the regression result for a different dependent variable. The first column reports the results for the regressions where products new to the market are used as a dependent variable. Although the regressions—as described in more detail in the Appendix—use a broad range of independent and control variables, Table 24 reports the results for one single independent variable, the industrial search only. The table does not only report the results for the whole data set of all firms, which is 0.088 in Table 24. To investigate different contexts and different national, sectoral or firm size conditions we break down the whole sample in subsamples and run each analysis for the subsamples. The results of these are reported in the lower part of 24. In the regressions the product new to the market (dummy) variable the industrial search has an effect of 0.074 when in the small countries. It has an effect of 0.084 in the large countries. Please refer to the Appendix for the definition of the variables and for the definition of the subsamples. The full set of regression results can be supplied on request to the authors.

Numerically the table reports the marginal effects ($\partial y/\partial x$) of the independent variable (x) on the dependent variable (y) to facilitate comparison across different subsamples even when non-linearity of the regression models such as probit models does not allow for the comparison of the regression coefficients (β). Observe that in Table 24 the effect of industrial search is lower in the high technology manufacturing sectors (0.065) than for instance in the knowledge intensive service sectors (0.102).

Table 24 How openness towards industrial information sources affects innovation performance. Marginal effects of industrial search based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Products new to the Market**	**Sales from new Products**	**Sales share of new Products**
Independent Variable		**Industrial Search**	
Regression on all firms	0.088***	0.943***	0.079***
Subsample regressions			
Small Countries	0.074***	0.892***	0.062***
Large Countries	0.084***	0.848***	0.073***
Technology Leader Countries	0.092***	0.924***	0.028
Technology User Countries	0.088***	0.948***	0.046***
High income, low R&D Countries.	0.092***	1.052***	0.116***
Low income, low R&D Countries.	0.051***	0.330*	0.018
High Tech Manufacturing	0.065*	0.413	-0.001
Med High Tech Manufacturing	0.080***	0.832***	0.046***
Med Low Tech Manufacturing	0.089***	1.045***	0.104***
Low Tech Manufacturing	0.082***	0.932***	0.089***
Know. Intensive Services	0.102***	1.064***	0.088***
Large Companies	0.085***	1.168***	0.041***
SMEs	0.086***	0.937***	0.082***

Note:	*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables:	Products new to the market; Sales from new products (log); Sales share of new products.
Indep. variables:	Industry Search

5.4.2 Effects of Science System Search

Table 25 below shows the EU-level marginal effects of science system search (i.e. search targeting universities, research institutes and public/private R&D laboratories) on innovation, under different contextual conditions. The overall picture is again one of strong, positive impacts, in all sectors and economies except low income & low R&D countries. This can again be interpreted as reflecting structural weaknesses of firms in these economies to systematically explore the science system for new opportunities: in this case, such a weakness may stem for example from workforce education levels or little intramural R&D activity. Another possible interpretation is that this result is that science system search is excessively oriented towards relatively weak domestic science system actors. We also note that the marginal effects of science system search are distinctively higher in high-tech manufacturing industries and knowledge intensive services, than in other industries; and stronger in large countries than in small. The latter may reflect stronger and more diverse science bases in large countries.

Table 25 How openness towards science system information sources affects innovation performance. Marginal effect of science search based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Products new to the Market**	**Sales from new Products**	**Sales Share of new Products**
Independent Variable		**Science Search**	
Regression on all firms	0.049***	0.651***	0.042***
Subsample regression			
Small Countries	0.037***	0.506***	0.025*
Large Countries	0.050***	0.660***	0.043***
Technology Leader Countries	0.058***	0.847***	0.037***
Technology User Countries	0.053***	0.704***	0.025**
High income, low R&D Countries	0.048***	0.639***	0.047***
Low income, low R&D Countries	-0.001	0.024	-0.014
High Tech Manufacturing	0.077***	1.253***	0.052**
Med High Tech Manufacturing	0.036**	0.463**	0.023*
Med Low Tech Manufacturing	0.056***	0.620***	0.033*
Low Tech Manufacturing	0.024*	0.366**	0.035*
Know. Intensive Services	0.078***	1.076***	0.070***
Large Companies	0.054***	0.819***	0.028***
SMEs	0.049***	0.639***	0.044***

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: Products new to the market; Sales from new products (log); Sales share of new products.
Indep. variables: Science system search

Important Findings

- .: The incidence of industry search is greatest for innovative firms in countries characterized as technology users, but also relatively high in low income countries characterized by low direct & indirect R&D.
- .: The relative income of the economy seems to be important to science search as does firm size and R&D intensity. It is highest in manufacturing and in knowledge intensive services.
- .: Firm size plays an important role in Search. Innovation active large firms report science search across the board. The proportion is most notably in high tech sectors and in high income economies and lowest in low income countries.
- .: Smaller firms only really engage in industry search in the medium and high tech manufacturing. They also engage in science search in knowledge intensive services
- .: The effect of industry search and of science search on innovation performance is similar for both large and small firms (in terms of new products)
- .: The marginal effects of industrial source search are substantial, but clearly lowest in low income, low-R&D economies.
- .: The marginal effects of science system search are distinctively higher in high-tech manufacturing industries and knowledge intensive services, than in other industries; and stronger in large countries than in small

6. Collaboration

6.1 Introduction

Engaging with researchers at a university in joint project is qualitatively different from reading scientific publications or tapping into the informal academic information. It requires the innovating firm to allocate dedicated personnel to project work with a clearly defined objective, and it entails that the firm's own knowledge – which is potentially proprietary – may be shared with the collaboration partner (Tether, 2002). The upside is that the innovating firm gains richer access to the knowledge of the collaboration partner. This illustrates the fundamental difference between innovation search and innovation collaboration. Due to the tacit and organizationally 'sticky' (Asheim & Isaksen, 2002; von Hippel, 1994) nature of knowledge, and the complexity and uncertainty involved in much industrial development work, solving the search problem may open up issues of resource mobilization, knowledge transfer and interactive new knowledge development. This may necessitate stronger, more direct collaborative ties.

6.2 Review of Literature

Different modes of innovation collaborations are covered in the diverse literature (see Tether, 2002). Industrial firms may collaborate with universities or research institutes (Bailetti & Callahan, 1992; Balconi & Laboranti, 2006; Bekkers & Freitas, 2008; Conway, 1995; Lhuillery & Pfister, 2009), 'extend their enterprises'(Dyer, 2000) to include collaborative relationships with suppliers and customers (Helper et al., 2000; Lettl et al., 2006); form alliances or joint ventures with other industrial firms holding complementary knowledge and engage in consortia within which competitors may participate (Caloghirou et al., 2003; Chiesa & Manzini, 1998; Hagedoorn, 1993).

Different partnerships imply different contributions and different levels of engagement on the part of the partners. Different forms of collaboration may serve different functions at different stages in the innovation process (Kessler et al., 2000; Roper et al., 2008). Collaboration with lead customers may provide complementary technical knowledge that can help reduce market uncertainty and help the innovating firm to find the right balance between performance & price (Shaw, 1994). As noted, there is the danger that collaboration through the same channels may result in a form of myopia which can blind the firm to other possibilities from other channels (Sofka & Grimpe, 2010). Collaborations with even the most competent customer might not be sufficient to an innovation project. The solution needed to develop a new product or product platform may for instance require that the innovating firm interact with science system actors in order to conduct fundamental research and with suppliers in order to develop purpose-made components and machinery.

There is therefore a danger that excessive reliance on existing market partnerships may actually preclude radical innovation (Danneels, 2003).There is a similar danger of a collaboration strategy that solely relies on universities and research institutes. While these collaborations may give the firm access to tailor-made, cutting edge technologies, they may also require the firm to collaborate with other actors in order to implement the technology (Berg-Jensen, Johnson, Lorenz, & Lundvall, 2007; Isaksen & Karlsen, 2009). As a result, collaborative linkages to different external knowledge sources are found to co-exist (see in particular Roper et al., 2008:966-967), and this co-existence has been found to impact innovation positively (Grimpe & Kaiser, 2010).

Collaborative linkages emerge from the identification (e.g. by means of prior search). Over time, these may lead to stable relationships with collaboration partners with whom codes for communicating complex knowledge have been developed and in whom trust is high: ultimately, there is the risk of 'lock-in' to a collaboration mode identified above. These collaborative relationships may be contractually regulated (Adams, 2002). In principle, the composition of the project group may be continuously adjusted to suit evolving project needs. This suggests that collaborative linkages may be established and operated across relatively large geographical distances. The impact of collaboration on innovation performance is thus not only a question of diversity of collaboration partners used. It also has a geographic dimension. As is particularly the concern for small economies, collaboration networks may form a way to source knowledge important from outside the firm's own geographical neighborhood. However, there may be transaction costs which limit their efficiency. Once established, innovation collaborations require substantial management attention (Ocasio, 1997), they require allocation of personnel, and they involve exposure of own knowledge. Several studies have therefore found that the impact of collaboration on new product development is mediated by the geography of the collaborative network, with a particularly strong impact of international collaboration (Cotic-Svetina et al., 2008; Ebersberger & Bloch, 2008). Similarly, international collaboration provides a potentially strong channel for transfer of 'disembodied' knowledge and technology, complementary to transfers of technology embodied in components & machinery (Knell & Srholec, 2008).

Research Question

In the following sections we analyse the effect of innovation collaboration on the innovation performance of firms. Since we can distinguish different types of collaboration such as vertical or science collaboration, and since we can differentiate between domestic and international collaboration we can include both the geography and the type of the network in the analysis.

6.3 Descriptives

In international comparison, innovation collaboration is particularly prevalent among smaller economies, including the Baltic and Nordic states, as well as Slovenia and Slovakia in the East. Collaboration is also relatively widespread in France.

Figure 13 Geographical distribution of OI practices – collaboration for innovation

Note: Colors code the average collaboration for innovation per country. High indicates the quarter of countries with the highest collaboration. Low indicates the quarter of countries with the lowest collaboration.

Table 26 Descriptives of the innovation collaboration of innovation active firms by company size and country groups

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.909	0.226	0.289
	1.395	*1.061*	*1.113*
Technology User Countries	0.883	0.274	0.353
	1.360	*1.098*	*1.154*
High income, low R&D Countries	0.254	-0.193	-0.173
	1.122	*0.629*	*0.667*
Low income, low R&D Countries	0.376	0.060	0.096
	1.297	*1.040*	*1.078*
Total	0.577	-0.045	-0.001
	1.308	*0.843*	*0.897*

Note: Mean of the collaboration indicator; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: This collaboration indicator is a factor score. A positive/negative mean in a subsample indicates an average collaboration above/below the European mean.

In Table 26 we observe that two types of country contexts promote innovation collaboration to a much higher degree than others: that is in countries characterized as technology users and in countries characterized by high levels of R&D, which are technology leading countries. In these countries even SMEs show innovation collaboration above the European average. In high income but low R&D countries SMEs collaborate below the European average. Table 27 illustrates that collaboration is strongly sector-specific, with higher intensity found in more innovation intensive sectors.

Table 27 Descriptives of the innovation collaboration of innovation active firms by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.954	0.114	0.186
	1.385	*0.972*	*1.040*
Med high tech mfg	0.688	-0.003	0.073
	1.357	*0.907*	*0.991*
Med low tech mfg	0.621	-0.101	-0.059
	1.341	*0.771*	*0.832*
Low tech mfg	0.364	-0.143	-0.114
	1.223	*0.716*	*0.763*
Knowledge intensive srvs	0.572	0.130	0.160
	1.257	*1.000*	*1.026*
Total	0.574	-0.043	-0.000
	1.308	*0.844*	*0.899*

Note: Mean of the indicator for innovation collaboration; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: This collaboration indicator is a factor score. A positive/negative mean in a subsample indicates an average collaboration above/below the European mean.

6.4 Effects of Collaboration on Innovation Performance

In the following we investigate first how the degree of collaboration is associated with innovation performance, given different contextual conditions. We then consider explicitly whether the degree of internationalization of the collaboration network has such performance impacts; and if such are associated with different forms and geographies of collaboration. Lastly, we consider interaction effects involving collaboration, search, and R&D intensity.

6.4.1 Openness towards interactive, collaborative learning

Table 28 below describes how the use of collaboration partners in innovation processes is associated with new product introduction and innovation performance, within different country contexts. The effect of collaboration on innovation performance is unambiguously positive for all country groupings. It is however weakest for the low income, low R&D countries, suggesting a relative lack of potential collaboration partners in these country contexts and/or a lower level of absorptive capacity on the part of innovating firms here.

Collaboration is as demonstrated above most widespread in high tech sectors, where it is ubiquitous. At the same time, the relative impact of collaboration is weakest in high tech manufacturing: the fact that an innovation active firm collaborates increases the probability that it launches an innovative product by about five percent. The effect on innovation performance is highest in knowledge intensive service sectors. The fact that collaboration contributes so strongly to innovation performance across technology sectors is more important that these relative differences. It is furthermore noteworthy that the positive effect of collaboration on innovation performance is stronger for small firms than for large firms, where it is more widespread.

Table 28 How the openness towards interactive and collaborative innovation affects the innovation performance of firms.

Marginal effects of collaboration diversity based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Products new to the Market**	**Sales from new Products**	**Sales Share of new Products**
Independent Variable		**Collaboration**	
Regression on all firms	0.079***	1.077***	0.062***
Regression on subsamples			
Small Countries	0.063***	0.899***	0.051***
Large Countries	0.092***	1.271***	0.070***
Technology Leader Countries	0.088***	1.199***	0.046***
Technology User Countries	0.072***	1.032***	0.059***
High Income, low R&D Countries	0.089***	1.157***	0.071***
Low Income, low R&D Countries	0.049***	0.465***	0.039*
High Tech Manufacturing	0.053***	0.479*	0.027
Med High Tech Manufacturing	0.077***	0.970***	0.036***
Med Low Tech Manufacturing	0.081***	1.264***	0.083***
Low Tech Manufacturing	0.063***	0.852***	0.054***
Know. Intensive Services	0.093***	1.246***	0.081***
Large Companies	0.061***	0.902***	0.029***
SMEs	0.082***	1.103***	0.070***

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: Products new to the Market; Sales from new products (log); Sales share of new products.
Indep. variables: Collaboration for innovation

6.4.2 Dimensions & Geography of Collaboration

The fact that economic globalization is associated with territorial specialization in innovation patterns entails both strengths and limitations. Regional or national innovation systems can become a constraint if they impose limitations on access to technological inputs or market demand. While this risk decreases with the domestic innovation system's size and overall level of development, the innovation performance of domestic companies may benefit additionally from access to external sources of complementary knowledge, capabilities and markets. We therefore expect the degree to which the innovation active firm collaborates internationally to have a positive effect on innovation performance, especially for firms in small country contexts.

Table 29 confirms that the degree of international collaboration does have a distinct, positive impact in small countries but not for innovation active firms in large countries. The table also reveals that the degree of international collaboration has a particularly distinct impact on innovation success in high income, low R&D economies, as well as in technology user countries. This is consistent with the notion that such economies are heavily dependent on access to technology and knowledge which extend beyond R&D investments internal to these economies and it illustrates the importance of international collaboration as a technology transfer channel that serves this purpose.

Firms collaborate with different types of external entities for a variety of reasons. Thus, the effect that geographic proximity plays may be contingent on the form of collaboration in question. For instance, the effect of distance might affect collaboration within the value chain (i.e. customers & suppliers) differently to collaboration with universities and other science system actors. Collaboration in the value chain is expected to be more directly related to problem-solving while those with science system actors may be more exploratory in nature. Thus, the impact of science system collaboration may be more sensitive to distance decay effects, than are collaboration within the value chain. On the other hand, collaboration involving customer and suppliers can be very context-dependent and 'sticky' and thus depend on geographical proximity. Collaboration with the science system may be less affected by distance in cases where the partners acknowledge the same scientific norms which exist globally.

Table 29 How the internationalization of the collaboration network affects innovation performance. Marginal effects of network internationalization based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable:	Products new to the Market	Sales from new Products	Sales Share of new Products
Independent Variable:	**Internationalization of the Collaboration Network**		
Regressions on all firms	0.066**	1.231***	0.097***
Regressins on subsamples			
Small Countries	0.079**	1.379***	0.109***
Large Countries	0.025	0.601	0.035
Technology Leader Countries	0.061	1.064*	0.072*
Technology User Countries	0.070*	1.116**	0.082***
High Income, low R&D Countries	0.098*	1.391**	0.088*
Low Income, low R&D Countries	0.040	1.228*	0.132*
High Tech Manufacturing	0.098	1.621*	0.107*
Med High Tech Manufacturing	0.003	0.083	0.014
Med Low Tech Manufacturing	0.065	1.177	0.061
Low Tech Manufacturing	0.041	0.810	0.055
Know. Intensive Services	0.106	1.983**	0.190***
Large Companies	0.080***	1.884***	0.098***
SMEs	0.061*	1.079**	0.095***

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: Products new to the market; Sales from new products (log); Sales share of new products.
Indep. variables: Collaboration for innovation

To investigate this more closely, we compare the innovation performance of firms that report only having domestic collaboration against two other types of firms: (i.) firms that report not having any collaboration and (ii.) firms that report having both domestic and international collaboration. Table 30 focuses on collaboration within the value-chain (vertical collaboration) given different country contexts. It shows that firms that only engage in vertical collaboration domestically are in general not significantly more successful in terms of launching an innovative product than firms that do not collaborate at all: the coefficient (-0.031) is negative but small and the result is not statistically significant for the population as a whole. However, having an international collaboration partner in addition to domestic ones is associated with strong positive effects in innovation performance across the board.

There are some nuances of this picture to take stock of. First, large enterprises are able to derive positive effects from only having domestic collaboration within the value-chain while small firms are not. This suggests that national innovation systems are more conducive to supporting innovation in the large enterprise than in small enterprises. This holds across all three performance measures. Second, the impact of the combination of domestic and international collaboration is strongest in the high technology manufacturing sector group. This confirms that the knowledge involved is particularly complex in high tech manufacturing, and that this sector is dependent on knowledge inputs that originate outside the science system (Laursen & Salter 2004). Third, the combination of domestic and international collaboration does not affect the likelihood of new product development in technology leader countries, while it does for innovation active firms in technology user countries and less so for those in low R&D intensive country contexts.

On the other hand, the combination of domestic and international vertical collaboration does augment the innovative sales of firms in technology leader countries quite dramatically. In technology leader countries, the combination of domestic and international collaboration in the value-chain affects sales of innovative new products to a higher degree than it does in low R&D countries, which are assumedly further from the technological frontier. This means that firms in countries which are at the frontier are less dependent on collaborative knowledge development involving industrial actor outside these countries, whereas firms in countries most distant from the frontier appear to experience absorptive capacity problems when collaborating abroad.

Table 30 How vertical collaboration for innovation affects innovation performance.

Marginal effects of no vertical collaboration and domestic and international vertical collaboration on innovation performance based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	Products new to the Market		Sales from new Products		Sales Share of new Products	
Independent. Variable	Vertical Collaboration					
	No Collaboration	Dom.& Interna-tional	No Collabora-tion	Dom.& Interna-tional	No Collabora-tion	Dom.& Interna-tional
Regressions on all firms	-0.031	0.106***	-0.552*	1.355***	-0.029	0.071***
Regressions on subsamples						
Small Countries	-0.029	0.114*	-0.437	1.381**	-0.020	0.075***
Large Countries	-0.028	0.082*	-0.447	1.217**	-0.018	0.053*
Technology Leader Countries	-0.031	-0.031	-0.131	1.382***	0.018	0.064**
Technology User Countries	-0.043	0.144***	-0.617	1.842***	-0.023	0.100***
High Inc., low R&D Countries	-0.04	0.090**	-0.750*	1.283**	-0.046	0.074*
Low Inc., low R&D Countries	0.078	0.081*	0.939	1.006**	0.063	0.067
High Tech Manufacturing	0.041	0.177***	-0.134	2.027***	0.022	0.067*
Med High Tech Manufacturing	-0.069*	0.041	-0.867	0.420	-0.044	0.011
Med Low Tech Manufacturing	0.046	0.131***	0.569	1.550***	0.060	0.076*
Low Tech Manufacturing	-0.065	0.092**	-1.169**	1.135**	-0.092*	0.044
Know. Intensive Services	-0.042	0.122***	-0.754	1.814***	-0.043	0.130***
Large Companies	-0.056**	0.095***	-1.096***	1.260***	-0.048**	0.024*
SMEs	-0.026	0.104***	-0.458	1.315***	-0.026	0.080***

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
+ Contexts indicate subsamples.

Dep. variables: Products new to the Market; Sales from new products (log); Sales share of new products.

Indep. variables: No vertical collaboration for innovation, both domestic & international vertical collaboration for innovation. Domestic vertical collaboration for innovation is the reference category.

Reference: The independent variables are constructed such that domestic collaboration can be interpreted as the reference to which the marginal effects are measured.

The comparable results are presented in Table 31 for science system collaboration. It shows that the effects of science system collaboration are distinct from those seen within the value-chain. There is first of all a strong positive impact from domestic science collaboration in relation to not collaborating at all with the domestic science system (i.e. the negative signs). This is in contrast to the impact observed for vertical collaboration. Also in contrast, is that the addition of an international partner in the science system does not augment the innovative performance of firms in general. A notable exception appears to be small countries where the contribution of adding an international collaborator in the science system can be seen to particularly influence innovation sales (as indicated, these results are weakly significant).

This finding is consistent with the notion that whereas collaborations within the value-chain may involve knowledge that often is tacit and context-specific, the knowledge generated by the science system is less sensitive to search constraints and distance decay effects. The lack of result here may support the idea that domestic science system partners serve as ‘gatekeepers’ towards international scientific communities (Graf, 2010). If domestic science system actors are able to gather science-based knowledge on an international scale, interpret and adapt such knowledge to domestic circumstances, and make it available to domestic industry, it would explain the lack of impact from direct collaborative linkages to foreign actors. As this effect assumes a certain degree of diversity in the domestic science base, it also explains the positive impact from direct linkages to scientific communities abroad found in small countries. Last, it assumes that science systems are relatively mature, and that there is a requisite level off absorptive capacity in the industrial actors. This helps to explain the lack of impact from science system collaboration in countries farthest from the technological frontier.

Table 31 How science collaboration for innovation affects innovation performance.

Marginal effects of no science collaboration and domestic and international science collaboration on innovation performance based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Products new to the Market**		**Sales from new Products**		**Sales Share of new Products**	
Independent Variable			**Science Collaboration**			
	No Collaboration	**Dom. & International**	**No Collaboration**	**Dom. & International**	**No Collaboration**	**Dom. & International**
All firms	-0.098***	0.031	-1.185***	0.495	-0.053***	0.02
Regressions on subsamples						
Small Countries	-0.070***	0.040 [12%]	-0.731***	0.727*	-0.022	0.048 [6%]
Large Countries	-0.147***	0.014	-2.041***	0.270	-0.105***	-0.008
Technology Leader Countries	-0.093***	0.004	-1.140***	0.436	-0.047**	0.027
Technology User Countries	-0.119***	0.072	-1.796***	0.702	-0.082***	0.037
High Inc., low R&D Countries	-0.107***	0.066	-1.549***	0.835	-0.091***	0.026
Low Inc., low R&D Countries	-0.065	0.015	-0.461	0.410	-0.011	0.002
High Tech Manufacturing	-0.127***	-0.025	-1.806***	-0.309	-0.085**	-0.031
Med High Tech Manufacturing	-0.092***	-0.056	-1.372***	-0.859	-0.065***	-0.075
Med Low Tech Manufacturing	-0.124***	0.081	-1.416***	1.182	-0.056	0.037
Low Tech Manufacturing	-0.034	0.082	-0.327	1.109	-0.005	0.034
Know. Intensive Services	-0.123***	0.037	-1.249***	0.599	-0.046	0.054
Large Companies	-0.106***	0.036	-1.534***	0.640	-0.045***	0.008
SMEs	-0.096***	0.019	-1.130***	0.272	-0.053***	0.022

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.

Dep. variables: Products new to the Market; Sales from new Products (log); Sales Share of new Products.

Indep. variables: No science collaboration for innovation, both domestic & international science collaboration for innovation. Domestic vertical collaboration for innovation is the reference category.

Reference: The independent variables are constructed such that domestic collaboration can be interpreted as the reference to which the marginal effects are measured.

Important Findings

.: The diversity of collaboration by and large increases innovation success significantly.

.: The relative impact of collaboration on innovation performance is robust and positive across sectors and country contexts

.: The effect of collaboration is in relative terms weakest in high tech manufacturing, where it is most widespread, and strongest among knowledge intensive service firms.

.: Small firms derive a larger effect from collaboration than larger firms, where it is more common.

.: The degree of international collaboration does have a distinct, positive impact in small countries but not for innovation active firms in large countries. The effect is markedly lower for SMEs than for large companies.

.: In sum, international vertical collaboration has a positive effects on innovation success.

.: In sum, science collaboration exerts a strong positive effect on innovation performance relative to no science collaboration. However, international science collaboration does not yield greater effects relative to national science collaboration alone.

.: Only in small countries is the effect of international science collaboration on innovation performance observably greater than that of national science collaboration alone.

7. Protection

7.1 Introduction

Protection strategies, especially those involving patents, are recognized in general to play a positive—if sector specific— role in the pursuit of innovation performance. The patent-system can affect how new knowledge is generated and accumulated in the economy in a number of ways. The prospect of patent protection can promote new R&D; the existence of a patent can provide the basis for further utilization as well as the basis to coordinate the use of new knowledge (especially through licenses); and the patent system can limit the underutilization of inventions, for example if it leads to a license by an organization better positioned to work the invention (David, 1993).Open Innovation posits in this context that a shift in innovation modes is increasingly being accompanied by the emergence of 'markets for patents' that are mediated by auctions or other third party intermediaries (Chesbrough 2006, 139).This section looks at the relationship between protection and innovation performance in light of the way it plays in the OI practices of different firms.

7.2 Review of Literature[1]

There is a large and longstanding literature on the role of patent protection in terms of innovation performance. A suitable starting point is that, “Patents are designed to create a market for knowledge by assigning propriety property rights to innovators which enable them to overcome the problem of non-excludability while, at the same time, encouraging the maximum diffusion of knowledge by making it public.” (Geroski, 1995: 97). Patenting can help induce innovation if the firm expects to be able to capitalize on its innovation investments under its protection. In addition to this “invention motivation”, the patent system may also play a range of supplementary roles in promoting innovation, including a) promoting disclosure and thus wider use of inventions, b) facilitating further development and commercialization of inventions and c) ensuring an “orderly development of broad prospects” by coordinating research activities among different actors (see the review in Mazzoleni & Nelson, 1998).

The ‘market for knowledge’ to which patents contribute is recognized to be imperfect. Its limitations tend to stem from the fact that ‘knowledge’ is an epistemologically complicated subject. As such, it is very different from that of other more generic economic commodities that can be traded on markets.2 A key consideration here is that the propensity to patent is strongly related to industry. Empirical (survey-based) studies consistently indicate that the prospect of patent protection plays only a subsidiary role in research and development decisions in most industries, but that it plays a much stronger one in specific industries, especially pharmaceuticals, scientific instruments and chemicals.3 On average, firms tend to find that the patent-system is imperfect in

[1] This section is based on Iversen (2010).

[2]See Arrow’s (1962) influential welfare-analysis spells out some of the ‘peculiar attributes’ of information/knowledge not only in terms of its supply but also in terms of its demand.

[3] Scherer (1983), Mansfield (1986), the Yale survey (Levin et al. 1987) the Carnegie Mellon study (Cohen, Nelson, and Walsh 1996).

appropriating profits (e.g. Mansfield et al., 1981; Levin et al, 1987). In turn, only a minority of innovations are patented (e.g. Arundel & Kabla, 1998).We also find that the relationship between patents and R&D is unclear, especially in industries where innovation builds on prior innovation (Merges and Nelson, 1992; Green & Scotchmer, 1995).

If the corporate target is to generate value, open innovation explicitly broadens the traditional view where knowledge, ideas and technologies are only exploited through new product or service development within the firm (March 1991; Cooper & Kleinschmidt 1995). Open innovation explicitly extends this view by emphasizing paths of value creation outside the firm boundaries. This includes external technology exploitation (Teece 1998; Lichtenthaler 2005) and corporate venturing. Protection of knowledge assets ensures that external pathways of value creation are economically beneficial for the knowledge generating firm. Although being important in the discussion of open innovation strategies, this motive is still a minor one for patenting (Blind et al 2006).

The market for patents idea in the OI literature thus derives from the view reflected in Geroski (1995), that the patent system was 'designed' to generate a 'market for knowledge'. And indeed, history is littered with attempts to manage licensing regimes based on the patent system, such as the centrally-managed and ultimately unsuccessful licensing-regime found in the UK during the 1930s (see Plant, 1934). Current studies indicate that patents that are exclusively licensed out by applicants make up about 6.4 percent of the patents in Europe (Gambardella 2005; 40: Gambardella et al 2007; Guiri et al 2007: 1118). This type of licensing, which may be facilitated by third party intermediaries with little involvement of the developer, varies considerably by applicant type and by technological field: the incidence is lowest for firms, especially larger firms, and highest for research institutions. A slightly larger proportion of European patents (7%) are both used by the applicant and licensed out, for example through cross-licensing arrangements. A further 17 percent of European patents are not used by the applicant (including blocking strategies) nor are they licensed out.

7.2.1 Patenting and research collaboration

In terms of the role of patenting plays in collaborative innovation, collaborative agreements are generally expected to be more beneficial in cases where it is difficult to appropriate emerging knowledge.[1] In the context of competing firms, collaboration provides a mode to internalize the externalities (appropriate) that emerge under these circumstances and to share research results among consortium partners. For these firms, the underlying goal of maintaining competitive advantage is offset by the need to coordinate information flows during collaborative technological innovation.

The literature shows that firms that rate 'strategic IP protection' (patent, design, and trademark) highly are more likely to engage in internal R&D activities while those that rely on other modes of protection—such as lead-time and technological complexity— also engage in all R&D activities

[1] See Spence, 1984 for a seminal paper in this tradition. For a review of the overlapping issues, consult Caloghirou et al. (2003). or the review sections of Negassi (2004); Czarnitzki, D. et al. (2006); as well as Grimpe & Kaiser (2010)

(Cassiman & Veugelers, 2002; 2006; Schmeideberg, 2008). This is consistent with the industrial organization premise, that spillovers increase incentives to cooperate. Knowledge spillovers increase the incentives to cooperate especially if cooperation allows knowledge transfers to take place among the collaborating partners more securely. Here, patenting plays a role. In addition to increasing the patenting activity of the individual participant firms, collaboration may also lead to co-patenting. CIS based studies have looked at different dimensions of collaboration address the relationship between patenting and collaboration in different ways. Areas of analysis include:

i) The determinants of R&D co-operation and its impact on innovative performance (Cassiman & Veugelers, 2002; 2006; Negassi, 2004; Faria & Schmidt (2004); López (2008))
ii) Complementarities of innovation activities in terms of innovative output, (Schmiedeberg, 2008; Grimpe and Kaiser, 2010)
iii) As well as more heterogeneous studies that for example focus on differences in collaboration strategies (Belderbos et al 2004) or the relationship between R&D collaboration, subsidies and patenting activity (Czarnitzki et al., 2007).

7.2.2 R&D alliances involving different types of collaborators

In order to highlight the partitioning of knowledge externalities between rival firms, the traditional focus has involved collaborations between competitors (e.g. Branstetter & Sakakibara, 2002) or between firms and universities (e.g Mowery, 1983).[1] However, Tether (2002) shows that there are differences between the way service and manufacturing firms interact with specialist knowledge providers. Belderbos et al (2004) emphasize the importance of differentiating three types of partner (horizontal, vertical, and university–firm cooperation) to study cooperation strategies (using two waves of Dutch CIS). Relying on one wave of the CIS in the UK, Janne & Frenz (2006) take this distinction further to show that patenting accompanies collaboration while Iversen (2011) uses two waves of CIS data (for Norway) that shows that patenting also tends to take place in front of as well as simultaneously with research collaborations.

Research Question

Below we investigate how protection affects innovation performance. Note that the protection indicator here is a factor score which does not only capture patenting activities but also the use of other legal measures to protect intellectual property.

7.3 Descriptives

The propensity to seek patent protection reflects national market situations and may also be said to have a cultural component. As such, firms in different European countries differ in terms of the likelihood that they apply for patent protection. The following figure illustrates such country-

1 However, Kleinknecht and Van Reijnen, 1992 also consider the type of partner (supplier, customer, public labs, etc.) or of the type of agreement (joint venture, research partnerships, license contracts, equity holding).

differences. The countries for which data is available are ranked in four quartiles to distinguish whether the tendency to seek patent protection in a given country on average is high (top 25 percent), medium-high, medium-low or low. In the absence of the patenting powerhouses of Europe (such as Germany and the UK), the Nordic countries—as well as Portugal and Romania—emerge as the countries with the highest average propensity to seek patent protection in this context. Italy, Slovakia, Estonia, and Latvia fall into the lowest segment, other things being equal.

Figure 14 Geographical distribution of OI practices –protection

Note: Colors code the average patent protection per country. High indicates the quarter of countries with the highest patent protection. Low indicates the quarter of countries with the lowest patent protection.

In terms of the more specific factors that affect the propensity to patent within these national economies, firm-size and the level of direct or indirect R&D contribute most. The probability that a large firm reports seeking patent protection is, as expected, much greater than that of a SME in the whole area. This pertains especially to large firms with high levels of direct or indirect R&D. But even large, high income large firms with low levels of R&D also report using patent protection to a greater degree than with R&D intensive SMEs. Firms that are technology users report the lowest average tendency to seek patent protection.

Table 32 Descriptives of the protection strategies by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.845	0.215	0.272
	1.033	*0.867*	*0.902*
Technology User Countries	0.005	-0.153	-0.133
	0.761	*0.569*	*0.600*
High income, low R&D Countries	0.249	-0.060	-0.046
	0.882	*0.667*	*0.682*
Low income, low R&D Countries	0.131	-0.156	-0.123
	0.896	*0.616*	*0.660*
Total	0.333	-0.025	-0.000
	0.953	*0.707*	*0.732*

Note: Mean of indicator for the innovation protection strategy indicator; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The protection indicator is a factor score. A positive/negative mean in a subsample indicates an average protection above/below the European mean.

Large firms patent on average in all technology sectors. The more R&D intensive manufacturing sectors report higher than average propensities to seek IPR protection across firm-size. Low tech small firms, on average, exhibit the lowest propensity to patent while discrepancies between small and large firms are pronounced in knowledge intensive service sector firms as well as in the less R&D intensive sectors.

Table 33 Descriptives of the protection strategy by company size and sector

	Firm Size		
Technology Sectors	Large Comp.	SME	Total
High tech mfg	0.469	0.107	0.138
	0.997	*0.825*	*0.847*
Med high tech mfg	0.493	0.099	0.142
	1.022	*0.814*	*0.848*
Med low tech mfg	0.353	-0.043	-0.020
	1.007	*0.725*	*0.749*
Low tech mfg	0.293	-0.076	-0.055
	0.931	*0.633*	*0.659*
Knowledge intensive srvs	0.141	-0.044	-0.032
	0.785	*0.668*	*0.678*
Total	0.337	-0.025	0.000
	0.957	*0.706*	*0.733*

Note: Mean of the indicator for the innovation protection strategy; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

Interpretation: The protection indicator is a factor score. A positive/negative mean in a subsample indicates an average protection above/below the European mean.

7.4 Effects of Protection Strategies on Innovation Performance

The use of intellectual property has a generally positive impact on the likelihood that an innovative firm launches a product that is new to market. A strategy that is based on IPR protection is expected to assist the firm to make the move from its novel innovation output (patenting entails technological novelty) to launching a novel product. This is the case because the novel components of the new product can be protected against imitation if covered by patents. This affords the firm the possibility to address the appropriability problem and to secure returns from a product launch. This strategy may allow the firm to roll out the new product more confidently and more profitably on the market. Attempts to extract monopoly profits from the novel product (based on patent protection) may however dampen sales and ultimately undermine the success of the new product. So a balance between a defensive protection strategy and an offensive one needs to be struck.

If successful in finding a balanced a protection strategy, the firm may see greater shares of its sales coming from the new product. The results show that patent protection strategies augment the performance of innovative firms in terms of raising the probability of the launch of a novel product, of an increase in sales from new products, and an increase in the share of sales that it derives from new products. The contribution of patent protection is unequivocally positive across different types of countries and different industries.

In terms of the contribution to the probability of launching a new product, the effect of IPR protection is higher in small than in large countries, and higher in technology user than in technology leader countries: it is even important for low R&D countries, whether high or low income. In terms of firm-size, the marginal contribution of patent protection is larger for small than large firms. The role played by different country context and firm-size indicates that IPR protection may either be used for innovative firms to help firms in these country contexts to enter larger markets. This defensive strategy does not tend to suggest an open innovation strategy per se. However, the patent protection avenue may relate to a heightened tendency to engage in research collaborations if combined with other open innovation practices.

Table 34 How protection strategies affect innovation performance.

Marginal effects of protection strategies based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Products new to the Market**	**Sales from new Products**	**Sales Share of new Products**
Independent Variable	**Protection strategy**		
Regression on all firms	0.125***	1.584***	0.098***
Regressions on subsamples			
Small Countries	0.148***	1.716***	0.090***
Large Countries	0.114***	1.536***	0.099***
Technology Leader Countries	0.106***	1.390***	0.061***
Technology User Countries	0.186***	2.154***	0.108***
High income, low R&D Countries	0.122***	1.606***	0.114***
Low Income, low R&D Countries	0.122***	1.000***	0.044**
High Tech Manufacturing	0.095***	1.260***	0.069***
Med High Tech Manufacturing	0.119***	1.554***	0.069***
Med Low Tech Manufacturing	0.148***	1.850***	0.122***
Low Tech Manufacturing	0.111***	1.471***	0.102***
Know. Intensive Services	0.125***	1.517***	0.109***
Large Companies	0.105***	1.389***	0.040***
SMEs	0.127***	1.600***	0.106***

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. Variables: Products new to the market; Sales from new products (log); Sales share of new products.
Indep. Variables: Protection strategies

Another aspect of the picture is that the marginal contribution of IPR protection is lower for high R&D intensity manufacturers than in other sectors. This combines with the fact that the effect is lower for large firms (contra small firms), lower for large countries (contra small countries), and lower for technology leader countries (contra technology user countries). This is noteworthy in as far as these dimensions (high tech, large firms, large countries) tend to be linked to high patent propensity. This result suggests that, in relative terms, other factors explain a larger proportion of innovation performance in the firms in these contexts than patent protection. However, the fact that patent protection does not contribute more strongly to innovation performance for these firms is interesting. However, it is not sufficient to make wider claims on the open innovation practices of such firms.

Important Findings

.: Protection strategies correlate with firm- size. Large firms tend to utilize protection strategies irrespective of sectors whereas IPR use among smaller firms is clustered in R&D intensive sectors.

.: IPR use is most widespread in countries characterized by high levels of R&D use and least widespread in countries characterized as technology users.

.: The contribution of patent protection to innovation performance is unequivocally positive across different types of countries and different industries.

.: The effect is strong for all measures of innovation performance, including sales of innovative products and the share of those sales on total sales. This suggests that the cost of these strategies do not reduce the dissemination of innovative products

.: However, the marginal effect of patent protection on innovation performance is larger for small than large firms and lower for high R&D intensity manufacturers than in other sectors

.: The effect of patent protection on innovation performance is also lower for large countries (contra small countries), and lower for technology leader countries (contra technology user countries).

8. External Innovation Expenditure

As we already have argued, reading scientific publications or tapping into the informal information 'buzz' surrounding a university is different from joint project work involving researchers at this university. The latter requires allocation of dedicated personnel to project work with a clearly defined objective, and entail that own knowledge - potentially proprietary - knowledge is shared with the collaboration partner (Tether, 2002). As an alternative or supplement to internal development or collaboration, firms may choose to acquire technology 'embodied' in components, machinery or patents; or even in small firms. Such external innovation expenditure refers to the acquisition of solutions on a market basis (Fey & Birkinshaw, 2005; Granstrand, Bohlin, Oscarsson, & Sjöberg, 1992). Building on the same example as used before, it is evident that paying external actors to solve a problem for you (sourcing), is different form joint project work involving own and external actor personnel (collaboration), which in turn is different from the activity of scanning external environments to identify actors who may have a solution to the problem (search).

8.1 Introduction

Input-output analysis has revealed that large international flows of technology occur as 'embodied' in various products which are used as inputs to innovation (Hauknes & Knell, 2009). As the country groups used in our analysis to define the context of open innovation have been developed based partly on the inflow of product embodied knowledge, and because such flows follow as a result of innovation rather than serve as a determinant of it, the following analysis focuses on the specific aspect of R&D sourcing.

Contract R&D can be defined as work of an innovative character undertaken by an external actor on behalf of the firm, under predefined and contractually determined conditions (Howells, 1999). Contract R&D is different from search in that it entails the actual transfer of technology; but different from collaboration in that this transfer do not extend into the tacit, experience-based and contextual knowledge of the contract partner, nor does it include knowledge externalities resulting from the development work conducted (Fey & Birkinshaw, 2005). Building on the example from above, it is evident that using information available in academic publications to find solutions to a problem (search) is different from establishing a project group involving both university researchers and own staff (collaboration), for the purpose of solving the problem jointly; which in turn is different from hiring university researchers to solve the problem on behalf of the firm (sourcing).

8.2 Review of Literature

There has been a substantial growth in the amount of contracted out research in recent decades (Howells, 1999; Whittington, 1990); followed by a strong research interest in its determinants and impacts (Cassiman & Veugelers, 2006; Mudambi & Tallman, 2010; Teece, 1988; Weigelt, 2009). On the one hand, contracting out development work may be an important mechanism for gaining access to cutting-edge technologies, specialized capabilities and learning opportunities (Weigelt,

2009) in a manner which is more flexible and less demanding on organizational resources than collaboration. Compared to intramural R&D, contracting allow for less fixed costs related to maintain internal R&D capacity (Love & Roper, 2002), less danger of internal rigidities (Leonard-Barton, 1992) and not-invented-here syndromes (Katz & Allen, 1982) institutionalizing, and ease of access to a much broader range of competencies than what can be maintained internally.

On the other hand, external innovation expenditure assumes that problems can be clearly defined and development work modularized at the initialization phase; problems solved in isolation from the knowledge core of the contracting firm during the project phase, and the results easily integrated back into the contracting firm at the finalization stage. It comes with potential coordination and communication challenges (Novak & Eppinger, 2001; Teece, 1988), and related confidentiality problems and IPR issues (Grimpe & Kaiser, 2010) all require attention and sensitivity. The ability of firms to deploy resources through organizational capabilities may be more important than the access to resources per se (see e.g. DeSarbo et al., 2007; Weigelt, 2009:611), and this integrative capacity is contingent on cumulative learning within the boundaries of the firm. Consequently, and contrary to what is assumed in the original open innovation approach of Chesbrough, external innovation expenditure may provide broader access to external technology, at the expense of the development of internal capacity necessary to exploit these. Empirical work is inconclusive with respect to the relative weight of these pains and gains, which can partly be contributed to different measurement techniques and control variables used. For instance, Kaser & Gimpe (2010) find an inverted U-shape relationship between external innovation expenditure per employee and innovation performance. Another recent study include purchases of components, machinery and equipment in their measure; and find a clear-cut positive impact. (Frenz & Ietto-Gillies, 2009) Yet another recent study finds a positive impact from external innovation expenditure when the dependent variable is patenting, but this disappears when the dependent variable is innovation performance (Schmiedeberg, 2008).

Research Question

The following sections are devoted to the analysis of the performance effects of external innovation expenditure. External innovation expenditure as conceptualized here is the fraction of innovation expenditure spent outside the corporate walls. The estimates of the effects assume the variation of the external innovation expenditure with the overall sum of innovation expenditure being constant. A variation of the external innovation expenditure hence always goes on the expense of internal innovation expenditure.

8.3 Descriptives

Table 35 Descriptives of external innovation expenditure by company size and country group

Country group	Firm Size Large Comp.	SME	Total
Technology Leader Countries	0.294	0.320	0.318
	0.414	*0.443*	*0.441*
Technology User Countries	0.157	0.210	0.203
	0.311	*0.379*	*0.372*
High income, low R&D Countries	0.183	0.200	0.199
	0.322	*0.374*	*0.371*
Low income, low R&D Countries	0.265	0.377	0.364
	0.425	*0.477*	*0.473*
Total	0.223	0.244	0.243
	0.369	*0.406*	*0.403*

Note: Mean of the indicator for external innovation expenditure; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Table 36 Descriptives of external innovation expenditure by company size and sector

Technology Sectors	Firm Size **Large Comp.**	**SME**	**Total**
High tech mfg	0.195	0.211	0.210
	0.345	*0.365*	*0.363*
Med high tech mfg	0.191	0.209	0.207
	0.331	*0.369*	*0.365*
Med low tech mfg	0.207	0.232	0.231
	0.354	*0.403*	*0.401*
Low tech manuf	0.231	0.264	0.262
	0.386	*0.424*	*0.422*
Knowledge intensive serv.	0.281	0.260	0.261
	0.406	*0.410*	*0.409*
Total	0.224	0.244	0.243
	0.369	*0.405*	*0.403*

Note: Mean of the indicator for external innovation expenditure; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

8.4 Effects of external innovation expenditure on Innovation Performance

Table37 below shows the marginal effects of the degree of external innovation expenditure on our three innovation measures. We see first and foremost that for all EU firms combined, the degree of external innovation expenditure has a negative impact on innovation and innovativeness. When comparing country sizes, we see that the negative impact is not present in small countries. For the sales share of new products we even find a positive effect in small countries. This suggests either that external sourcing, collectively, contribute to the innovation system dynamics of these economies; or that external innovation expenditure targeting actors abroad is an important source of R&D services complementary to those which can be sourced domestically. This line of reasoning is supported by the strong negative impact found for firms in technology leader countries, compared to the strong positive impact found only for firms in countries far from the technological frontier.

Table 37 How external innovation expenditure affects innovation performance.

Marginal effects of external innovation expenditure based on regressing innovation performance for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	Products new to the Market	Sales from new Products	Sales Share of new Products
Independent Variable	**External innovation sourcing**		
Regression on all firms	-0.028*	-0.365**	-0.002
Regression on subsamples			
Small Countries	0.027	0.299	0.044**
Large Countries	-0.084***	-1.025***	-0.076***
Technology Leader Countries	-0.074*	-0.853*	-0.037
Technology User Countries	0.014	-0.059	0.007
High Income, low R&D Countries	-0.049**	-0.556**	-0.035
Low Income, low R&D Countries	0.110***	2.153***	0.315***
High Tech Manufacturing	-0.157**	-1.951***	-0.077
Med High Tech Manufacturing	-0.054*	-0.735*	-0.029
Med Low Tech Manufacturing	-0.027	-0.437	-0.012
Low Tech Manufacturing	0.016	0.148	0.042
Know. Intensive Services	-0.091**	-0.821*	-0.030
Large Companies	-0.067***	-0.719**	-0.022
SMEs	-0.027*	-0.333*	0.000

Note: *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
+Contexts indicate subsamples.
Dep. variables: Products new to the market; Sales from new products (log); Sales share of new products.
Indep. variables: External innovation

With respect to sector differences, we see that the negative impact from external innovation expenditure is most distinctively present in knowledge intensive services, and high technology manufacturing sectors. On the other hand, negative impacts are not found for firms in the two low-tech manufacturing groups. This suggests that the hollowing-out effect of external innovation expenditure is reinforced by the overall complexity and knowledge intensity of activities. The hollowing out through external innovation expenditure is most prevalent in sectors where competitiveness rests on the intensive exploitation of knowledge and information.

Important Findings

.: In sum, external innovation expenditure undermines innovation success as it exerts a negative impact across the board.

.: this effect is not present in small countries. External innovation expenditure either does not affect innovation success or it even supports it.

.: the innovation activities of firms in countries furthest away from the technological and economic frontier benefit from external innovation expenditure.

.: the negative effect of external innovation expenditure is most clear among large firms and in high tech manufacturing, with strongly negative effects on the probability of to bring innovative products to market and to report sales from innovative products

PART III:

Determinants of OI Practices

9. Firm level Determinants of OI Practices

Open innovation practices are influenced by numerous structural properties of the firm, its context of location (i.e. country group, see Reinstaller & Unterlass, 2010), the sector in which it operates (i.e. from high-tech to low-tech), the technological regime conditions it experiences (Malerba & Orsenigo, 1993; Marsili & Verspagen, 2002) and the policy incentives it is exposed to (Herstad, Bloch, Ebersberger, & van De Velde, 2010) at the regional, domestic and EU levels respectively.

In this section of the report, we start our investigation into these determinants by considering those which are directly associated with firm characteristics. In particular we investigate the effect of firm size, of innovation intensity, of foreign ownership, and of domestic multi-nationality on the firms' implementation of open innovation practices.

Research Questions

In the sections below we analyze the effect of firm level characteristics on the adoption of open innovation activities. In particular we are interested in the effects of firm size in section 9.1, the effects of the firms' innovation intensity in section 9.2, and the effects of foreign ownership and of domestic multi-nationality in sections 9.3 and 9.4 respectively.

9.1 Determinants of OI Practices: Firm Size

9.1.1 Review of Literature

Previous studies have found that size influence the propensity of the firm to engage in innovation collaboration (Czarnitzki et al., 2007; Tether, 2002) and perform broad search (Laursen & Salter, 2004; Morrison, 2008; Simmie, 2003). Increasing firm size is associated with an increasing number and diversity of 'receptors' towards the external environment. With firm size the diversity of those internal competences increases which can be allocated to collaborative knowledge development. In addition, increasing size may be positively related to financial strength and administrative capabilities, which can impact on the willingness of the firm to engage in such collaboration. Last but not least, size in itself entail that the firm attract more attention from its surrounding environment, domestically and abroad. This mode of preferential attachment holds for partners from industrial as well as science system and policy communities. The sector of large firms of a given country may have exerted a strong influence on the national innovation system of the country by creating a dynamic of co-evolution between this sector and the system as a whole. This process creates a dense linkage between a country's subpopulation of large firms and its innovation system (Benito, Larimo, Narula, & Pedersen, 2002; Narula, 1996, 2002). This leads us to expect that firm size has a positive impact on open innovation practices. On the other hand, increasing size comes with more distinctively routinized behavior (Cyert & March, 1963), and may also be associated with management attention allocation challenges (Ocasio, 1997). If this is combined with maturity and a legacy for orientation towards internal R&D, size may also be associated with rigidities (Leonard-Barton, 1992) and not-invented-here syndromes (Katz & Allen,

1982) which could decrease the propensity of the firm to perform broad search and engage in collaboration.

9.1.2 Descriptives

Table 38 and Table 39 give an overview over the average firm size measured by the natural logarithm of the number of employees broken down on country group and technology sector. We observe that the on the average firm size is largest in technology using countries and in low income and low R&D countries, which is due to larger SMEs on the average.

Table 38 Descriptives of the firm size by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	6.380	3.214	3.357
	0.776	*0.764*	*1.008*
Technology User Countries	6.299	3.402	3.591
	0.709	*0.846*	*1.102*
High income, low R&D Countries	6.308	3.144	3.217
	0.758	*0.706*	*0.853*
Low income, low R&D Countries	6.264	3.378	3.532
	0.642	*0.824*	*1.041*
Total	6.322	3.215	3.329
	0.739	*0.756*	*0.956*

Note: Mean of the firm size (log of employees); standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

We also observe that the average firm size is largest in medium technology manufacturing sectors. This again is caused by SMEs in this sector being larger on the average than in other manufacturing or service sectors. Although comprising of large companies being—on the average—the largest in the sample the knowledge intensive service sectors exhibit the smallest firm size over all. This again is attributable to the rather small SMEs in these sectors.

Table 39 Descriptives of firm size by company size and sector

	Firm Size		
Technology Sectors	Large Comp.	SME	Total
High tech mfg	6.348	3.301	3.488
	0.752	*0.814*	*1.091*
Med high tech mfg	6.362	3.354	3.559
	0.736	*0.821*	*1.114*
Med low tech mfg	6.260	3.221	3.307
	0.699	*0.735*	*0.891*
Low tech manuf	6.195	3.216	3.305
	0.611	*0.750*	*0.902*
Knowledge intensive serv.	6.514	3.110	3.238
	0.890	*0.728*	*0.980*
Total	6.321	3.215	3.330
	0.738	*0.757*	*0.957*

Note: Mean of the indicator for firm size (log of employees); standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

9.1.3 Effects of Firm Size on OI Practices

Table 40 below shows the impact of firm size on the functional dimensions of open innovation, and how increasing size has an unambiguous impact on all open innovation practices except external innovation expenditure. Overall, the impact of size is particularly strong for industry search. In low income countries we find that firm size strongly influences science search. This indicates that in economies, further away from the technological frontier, larger companies have a stronger propensity to connect to the science system than smaller companies. This is an even more pronounced finding as overall size does not affect science search in the large companies. Yet it does so among the SMEs. The larger the SME the more likely it is to extend its search space into the science system.

Overall we do not find a significant effect of firm size on external innovation expenditure. We find that for certain subsamples firm size exerts a positive effect on external innovation expenditure and for some it creates a negative effect. With respect to external innovation expenditure, positive impacts are detected in small countries, suggesting again that there is a distinct small economy dimension to this form of R&D. Contrary to previous studies, we do not find any indications that small firms are more inclined to engage in external innovation expenditure.

Table 40 How firm size determines open innovation practices.

Marginal effects of firm size on innovation practices based on regressing open innovation practices for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	Collaboration	Industry Search	Science Search	Protection Strategy	External innovation
Independent Variable			**Firm Size**		
Regression on all firms	0.050***	0.114***	0.056***	0.045***	0.003
Regressions on subsamples					
Small Countries	0.115***	0.151***	0.036***	0.038***	0.018***
Large Countries	0.071***	0.107***	0.036***	0.082***	0.000
Technology Leader Countries	0.104***	0.138***	0.030***	0.124***	0.014*
Technology User Countries	0.128***	0.122***	0.006	0.046***	-0.018*
High income, low R&D Countries	0.068***	0.120***	0.037***	0.059***	0.005
Low income, low R&D Countries	0.064***	0.101***	0.076***	0.058***	-0.018*
High Tech Manufacturing	0.094***	0.140***	0.002	0.083***	-0.008
Med High Tech Manufacturing	0.089***	0.172***	0.022**	0.097***	0.011*
Med Low Tech Manufacturing	0.101***	0.152***	0.039***	0.081***	0.004
Low Tech Manufacturing	0.078***	0.117***	0.061***	0.058***	0.012*
Know. Intensive Services	0.053***	0.052***	0.018**	0.031***	-0.001
Large Companies	0.170***	0.154***	-0.005	0.141***	0.039***
SMEs	0.050***	0.114***	0.056***	0.045***	0.003

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.

Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy; external innovation expenditure.

Indep. variable: Firm size (log of employees).

We now turn to consider how firm size affects the geography of open innovation, here measured as collaboration. Table 41 below shows how size is associated with domestic or international collaboration, within the value chain or with the science system respectively. Overall, firm size has—as expected—a positive impact on domestic collaboration, which is more distinct than the impact found in international collaboration. When we disentangle this, we see that the impact on domestic collaboration is particularly strong for firms in large economies, where it increases the propensity to engage in all forms of collaboration but vertical abroad.

Table 41 How firm size determines collaboration for innovation.

Marginal effects of firm size on innovation collaboration based on regressing innovation collaboration for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	International		National	
	Science	Vertical	Science	Vertical
Independent Variable	Firm size			
Regression on all firms	0.019***	0.017	0.061*	0.092***
Regression on subsamples				
Small Countries	0.024*	-0.015	0.091	0.076*
Large Countries	0.015**	0.016	0.067*	0.120***
Technology Leader Countries	0.059**	0.071	0.016	0.121**
Technology User Countries	0.008	-0.035	-0.026	0.075*
High income, low R&D Countries	0.012	0.003	0.046	0.147***
Low income, low R&D Countries	0.008	0.081	-0.013	0.083*
High Tech Manufacturing	0.014	0.015	-0.010	0.032
Med High Tech Manufacturing	0.036**	0.036	-0.065	0.147***
Med Low Tech Manufacturing	0.034**	0.052	0.218**	0.090
Low Tech Manufacturing	0.024**	0.055	0.052	0.059
Know. Intensive Services	-0.009	0.006	0.045	0.074***
Large Companies	0.036***	0.010	0.008	0.037*
SMEs	0.008	0.000	0.052	0.063*

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.

+ Contexts indicate subsamples.

Dep. variables: International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.

Indep. variable: Firm size (log of employees).

In technology leader countries we find that firm size affects only the propensity of firms to collaborate with value chain partners domestically, and science system actors abroad. In all other country groups, the only effect detected is with respect to value chain collaboration at home. We also see that this effect is most pronounced within the group of large companies, compared to SMEs. These findings are consistent with the notion that the large-firm sector in any given economy exerts–directly by means of influencing demand and indirectly by means of knowledge spillover effects–a strong influence on the evolution of the industry side of the innovation system as a whole.

Important Findings

.: Firm size increases the implementation of open innovation practices

.: This size effect is also prevalent among SMEs. The larger the firm, the more intensively open innovation practices are used.

.: Only external innovation expenditure or external innovation expenditure is an exception to this finding. In small countries we find that larger companies have more external innovation expenditure than smaller companies do. We do not find this in larger economies.

.: Overall we find two modes of collaboration being particularly affected by firm size. International science collaboration and domestic collaboration with value chain partners.

.: Everything else equal international collaboration within the value chain and national science collaboration is driven by factors other than the firm size.

9.2 Determinants of OI Practices: Innovation Intensity

9.2.1 Review of Literature

The relationship between investments in R&D and various forms of open innovation practices is debated in the literature, but no clear consensus on the issue has emerged. Following Rosenberg (1990) we can argue that the ability to identify relevant external information and transform it into new products is contingent on prior related knowledge, built by means of R&D. Consequently, investments in R&D should be positively associated with both search and collaboration. Findings consistent with this line of reasoning are obtained for instance by Grimpe & Sofka (2009) or Tether (2002). Similarly, studies have also found internal and external innovation expenditure to co-exist (Arora & Gambardella, 1990, 1994), and external innovation expenditure to stimulate rather than crowd out internal expenditures (Veugelers, 1997).

On the other hand, studies have also suggested that a strong emphasis on internal R&D may crowd out external information by means of the not-invented-here (NIH) syndrome (Katz & Allen, 1982), and result in the evolution of internal knowledge systems which are less able to absorb effectively (Bosch, Volberda, & Boer, 1999) from other, non-science information sources (Lane & Lubatkin, 1998; Leonard-Barton, 1992). This in turn should not only be reflected in a reduced impact of a given search diversity on innovation performance, but also in a negative association between internal R&D and the diversity of search or collaboration maintained. It has been argued that investments in intramural R&D come with increased attention towards protection of IPR, which in turn may reduce the willingness of the firm to engage in collaborative interaction which involves broad sharing of knowledge (Love & Roper, 2002). This means that even though internal R&D may stimulate external sourcing; it may at the same time crowd out collaboration. Non significant effects of innovation intensity on innovation collaboration as found in Czarnitzki et al (2007), Dachs et al. (2008) or Miotti & Sachwald (2003) would support this line of reasoning.

9.2.2 Descriptives

In Table 42 we summarize the average innovation intensity of the innovation active companies broken down by size and country group. Overall we observe that the innovation intensity—measured by the share of turnover spent on innovation activities—is markedly higher among innovation active SMEs than among innovation active large companies. Between the countries we do not observe differences which draw our attention. This is particularly interesting as the country groups have been constructed also including information about innovation expenditure (Reinstaller & Unterlass 2010).

Table 42 Descriptives of the innovation intensity by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.049	0.067	0.065
	0.142	*0.155*	*0.154*
Technology User Countries	0.039	0.071	0.066
	0.089	*0.148*	*0.142*
High income, low R&D Countries	0.039	0.067	0.066
	0.105	*0.139*	*0.138*
Low income, low R&D Countries	0.041	0.073	0.069
	0.109	*0.161*	*0.156*
Total	0.042	0.068	0.066
	0.116	*0.146*	*0.144*

Note: Mean of the innovation intensity; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Table 43 summarizes the innovation intensity broken down on the technology intensity of the sector and the size of the firms. In contrast to the breakdown on country groups the differences in innovation intensity between the sectors is obvious, yet not fully expected in its structure. Among the manufacturing sectors we note that large companies as well as SMEs in high technology manufacturing sector exert the highest innovation intensity. What is as striking as the findings in the breakdown on country groups is that the other manufacturing sectors do not differ in their innovation intensity.

These findings suggest that the construction of the sector groups (Hatzichronoglou 1997; OECD 2001) and the construction of the country groups (Reinstaller & Unterlass 2010) does not fully capture the innovation intensity. It also integrates other characteristics which might be orthogonal to the innovation intensity. For the multivariate analysis this reduces the potential collinearity problem which would arise had the grouping been built solemnly on the innovation intensity.

Table 43 Descriptives of the innovation intensity by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.063	0.086	0.084
	0.090	*0.135*	*0.132*
Med high tech mfg	0.037	0.053	0.051
	0.068	*0.116*	*0.112*
Med low tech mfg	0.031	0.056	0.054
	0.081	*0.113*	*0.112*
Low tech manuf	0.029	0.057	0.055
	0.092	*0.123*	*0.121*
Knowledge intensive serv.	0.072	0.107	0.104
	0.197	*0.212*	*0.211*
Total	0.042	0.068	0.066
	0.116	*0.146*	*0.144*

Note: Mean of the indicator for innovation intensity; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

9.2.3 Effects of Innovation Intensity on OI Practices

In Table 44 we report how innovation intensity determines open innovation practices. For all firms one can observe that with exception of external innovation expenditure all open innovation activities are positively affected by the firms' innovation intensity. The more intensive companies engage in innovation activities the more intensively they engage in open innovation activities. What seems obvious on the level of all companies does not hold for a number of subsets of firms. First, in small countries more intensive innovation activities imply an increase in collaboration and protection. Yet, search activities are unaffected by the firms' innovation intensity. Second, among large companies innovation intensity does not affect collaboration positively. It increases industry search and protection but decreases science search.

The last column in Table 44 reports the effect of innovation intensity on external innovation expenditure. We observe a strong negative effect. The more companies spend on internal creation of knowledge the lower the need, the incentives and the willingness to engage in external knowledge sourcing through external innovation expenditure.

Table 44 How innovation intensity determines open innovation practices.

Marginal effects of innovation intensity on innovation practices based on regressing open innovation practices for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	**Collaboration**	**Industry Search**	**Science Search**	**Protection Strategy**	**External innovation**
Independent Variable			**Innovation Intensity**		
Regression on all firms	0.346***	0.188***	0.080***	0.158***	-0.517***
Regressions on subsamples					
Small Countries	0.194***	0.022	-0.003	0.080**	-0.637***
Large Countries	0.452***	0.269***	0.082**	0.232***	-0.451***
Technology Leader Countries	0.581***	0.251***	0.021	0.609***	-0.632***
Technology User Countries	0.576***	0.203***	-0.063	-0.032	-0.396***
High income, low R&D Countries	0.218***	0.178***	0.147***	0.066*	-0.439***
Low income, low R&D Countries	0.237**	0.099	-0.041	0.005	-0.835***
High Tech Manufacturing	0.750***	0.051	0.089	-0.01	-0.486***
Med High Tech Manufacturing	0.341***	0.174**	0.039	0.082	-0.484***
Med Low Tech Manufacturing	-0.058	0.031	0.120*	0.109	-0.676***
Low Tech Manufacturing	-0.011	-0.055	0.094*	-0.032	-0.722***
Know. Intensive Services	0.516***	0.241***	0.037	0.372***	-0.357***
Large Companies	0.164	0.223**	-0.153*	0.399***	-0.305***
SMEs	0.360***	0.195***	0.092***	0.144***	-0.527***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy; external innovation expenditure .
Indep. variable: Innovation intensity.

Table 45 introduces the results of the determinant regressions compiled to report the effects of innovation intensity on the collaboration for innovation. Overall we find that only international collaboration is significantly affected by innovation intensity. National collaboration regardless of the collaboration partner is not affected by the firm’s innovation intensity. In the large countries we find that international collaboration is spurred by more intensive innovation activities. In small countries only international science collaboration is affected by innovation intensity. The effect in both cases is of the same magnitude. National vertical collaboration in large countries is strongly driven by innovation intensity, in small countries this is not the case.

Table 45 How innovation intensity determines collaboration for innovation.
Marginal effects of innovation intensity on innovation collaboration based on regressing collaboration for all innovation active firms and for subsamples of innovation active firms.

Dependent Variable	International		National	
	Science	**Vertical**	**Science**	**Vertical**
Independent Variable	**Innovation Intensity**			
Regressions on all firms	0.055***	0.164***	0.012	0.061
Regressions on subsamples				
Small Countries	0.053**	0.101	-0.057	-0.072
Large Countries	0.047***	0.196***	0.034	0.208***
Technology Leader Countries	0.054**	0.123	0.022	0.072
Technology User Countries	0.049**	0.132	-0.161	0.005
High income, low R&D Countries	0.045***	0.178***	0.116	0.063
Low income, low R&D Countries	0.004	0.046	0.042	0.104
High Tech Manufacturing	0.060	0.227	-0.257	-0.146
Med High Tech Manufacturing	0.110***	0.272	0.167	0.127
Med Low Tech Manufacturing	0.017	-0.006	0.011	0.047
Low Tech Manufacturing	0.050**	0.349**	-0.033	-0.026
Know. Intensive Services	0.048**	0.076	0.018	0.062
Large Companies	0.131***	0.104	0.196*	0.075
SMEs	0.046***	0.167***	0.000	0.066

Note:	Marginal effects; *** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables:	International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.
Indep. Variable:	Innovation intensity.

Important Findings

.: The intensity of the use of open innovation practices is strongly affected by the firms' innovation intensity.

.: In small economies search is unaffected by the firms' innovation intensity. Yet, international linkages through international science collaboration are positively affected by innovation intensity.

.: In large companies collaboration is unaffected by innovation intensity but industry search increases and science search decreases with innovation intensity. As science collaboration increases with innovation intensity (both nationally and internationally) this suggests that with increasing innovation intensity large companies substitute science search and science collaboration.

.: Overall firms with more intensive innovation activities maintain a more open industrial and science search space. Additionally they are more open towards a diverse set of collaboration partners.

.: The overall openness of intensively innovating firms is largely driven by a more international set of collaboration partners. This is not at the expense of their national embeddedness.

9.3 Determinants of OI Practices: Foreign Ownership

9.3.1 Review of Literature

Affiliation to a parent enterprise group entails that the focal firm is part of a larger administrative system which channels financial resources, technology and information, assigns mandates (Cantwell & Mudambi, 2005) and requires management attention (Ocasio, 1997). The multinational enterprise (MNE) group is in a unique position because it coordinates production and innovation activities which cut across different territorial contexts, and establish corporate information and knowledge diffusion networks into which the individual subsidiary may tap (Björkman, Barner-Rasmussen, & Li, 2004; Dachs, Ebersberger, & Lööf, 2008; Forsgren, 1996; Foss & Pedersen, 2002; Frenz & Ietto-Gillies, 2007). Similarly, its presence in different territorial contexts may be motivated by information and knowledge access concerns (Asheim, Ebersberger, & Herstad, 2011; Cantwell & Mudambi, 2005). All this may not only affect the open innovation practices of affiliated nodes, but also generate positive or negative external effects in MNE host and home economies (see e.g. Görg & Greenway, 2004; Meyer & Sinani, 2009; Unctad, 2005).

MNE affiliation may consequently increase the geographical scope of innovation collaboration by means of identifying place-specific opportunities and partners with whom tight interaction is required (Lowe & Wrigley, 2010; Maskell, Pedersen, Petersen, & Dick-Nielsen, 2007). This is achieved by providing international platforms for collaboration in the form of subsidiaries abroad (Asheim et al., 2011) and by representing an administrative support structure with bargaining power in support of these external linkages. This of course applies particularly when affiliated nodes have mandate as active knowledge creators (Cantwell & Mudambi, 2005), or when the nature of the activity of the MNE suggests a particularly strong need to adapt to or learn from local contexts (Currah & Wrigley, 2004; Lowe & Wrigley, 2010). Consequently, MNE affiliation may also influence the collaboration breadth of affiliated nodes within their contexts of location (Asheim, Ebersberger & Herstad 2011).

Yet, the impact is not necessarily positive. Within advanced economies, incoming FDI primarily takes the form of acquisitions. This may force actor attention (Ocasio, 1997) towards the corporate network at the expense of attention towards external collaborative knowledge development (Asheim & Herstad, 2005; Blanc & Sierra, 1999; Phelps & Fuller, 2000). Initial post-acquisition tensions may be strong; and attention may subsequently be directed towards internal politics and bargaining between elite actors in different parts of the MNE (Currah & Wrigley, 2004). This may in turn shift the focus of search and collaboration patterns inwards, towards the MNE network (Blanc & Sierra, 1999; Forsgren, 1996). Concern has therefore been raised in relation to whether MNE presence is associated with ‘branch plant’ syndromes at the level of host economies (Hoare, 1978; Phelps & Fuller, 2000; Stewart, 1976); i.e. loss of industrial dynamics stemming from the decoupling of MNE subsidiaries from surrounding economic activity.

MNEs are heterogeneous, and the actual outcome of these tensions is contingent on various structural and actor-specific properties. These include MNE internationalization strategies and the necessity of combining internal and external linkages which is given by the nature of its area of activity (Currah & Wrigley, 2004; Lowe & Wrigley, 2010). Recent studies have in particular pointed to possible ‘headquarter proximity’ effects being at play within the internal MNE network (Ebersberger & Herstad, 2011). This points to the importance of distinguishing between the multi-nationality of the parent group and its foreign or domestic control (Bellak, 2004). Consequently, below we investigate first the impact of affiliation to a corporate group headquartered outside the economy of focal firm location. In the next section we consider the impact of affiliation to a multinational group headquartered within the same European economy.

9.3.2 Descriptives

Foreign ownership is most pronounced among large firms in technology user countries, and least pronounced among small firms in high and low income countries with low R&D intensities. This reflects how acquisitions dominate as mode of entry, and that such often are motivated by access to specialized in-house competences of acquired firms.

Table 46 Descriptives of foreign ownership by company size and country group

Country group	Firm Size Large Comp.	SME	Total
Technology Leader Countries	0.285	0.086	0.103
	0.452	*0.280*	*0.304*
Technology User Countries	0.460	0.140	0.181
	0.498	*0.347*	*0.385*
High income, low R&D Countries	0.319	0.045	0.058
	0.466	*0.208*	*0.234*
Low income, low R&D Countries	0.275	0.079	0.102
	0.447	*0.270*	*0.303*
Total	0.333	0.069	0.087
	0.471	*0.253*	*0.282*

Note: Mean of the indicator for foreign ownership; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Against this background it is not surprising to find foreign ownership to be most pronounced among large enterprises in high-tech manufacturing, and least among small firms in low-tech manufacturing. On average, foreign ownership rates are higher among high and medium high-tech manufacturing firms, again suggesting that access to advanced production facilities and specialized knowledge is an important driver of FDI into European economies.

Table 47 Descriptives of foreign ownership by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.444	0.103	0.133
	0.497	*0.304*	*0.340*
Med high tech mfg	0.450	0.101	0.139
	0.498	*0.301*	*0.346*
Med low tech mfg	0.350	0.053	0.071
	0.477	*0.225*	*0.256*
Low tech mfg	0.246	0.037	0.049
	0.431	*0.188*	*0.216*
Knowledge intensive srvs.	0.257	0.112	0.122
	0.437	*0.316*	*0.328*
Total	0.334	0.071	0.089
	0.472	*0.256*	*0.285*

Note: Mean of the indicator for foreign ownership; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

9.3.3 Effects of Foreign Ownership on OI Practices

We first consider how foreign ownership—that is the affiliation to a corporate group headquartered abroad (i.e. a foreign MNE)—affects various functional aspects of open innovation at the focal affiliate firm level, within various contexts. From Table 48 below, we see that foreign ownership increases collaboration breadth and the orientation external innovation expenditure. The unambiguous impact of foreign ownership on the degree of external innovation expenditure suggests that foreign owners are more inclined to source external knowledge and that they are simultaneously less willing to build and maintain intramural R&D capacity in their subsidiary firms. The long-term impact of a strong degree of external innovation expenditure and a neglect of internal R&D can be hollowing-out of internal competences (Fey & Birkinshaw, 2005; Weigelt, 2009). In addition, we see that the impact on subsidiary use of IPR protection mechanisms is negative – and most distinctively so in technology user countries and medium high technology manufacturing. By contrast, it is foreign owned firms that have stronger protection activities in technology leader countries. No significance is found in high-technology manufacturing sectors. Taken together, this reflects differences in the mandates assigned and the degree to which the parent group is willing to allow their subsidiaries control over intellectual property. In large countries, foreign ownership has a negative impact on industry search; and in technology leader countries it contributes to broadening both industry and science system search.

Table 48 How foreign ownership determines open innovation practices.

Marginal effects of foreign ownership on open innovation practices based on regressing open innovation practices for all firms and for subsamples of firms.

Dependent Variable	Collabora-tion	Industry Search	Science Search	Protection Strategy	External innovation
Independent Variable			**Foreign Ownership**		
Regressions on all firms	0.148***	-0.013	-0.005	-0.028*	0.046***
Regressions on subsamples					
Small Countries	0.190***	0.031	-0.034*	-0.055***	0.055***
Large Countries	0.102***	-0.046**	0.024	0.001	0.043***
Technology Leader Countries	0.142***	0.055*	0.098***	0.151***	0.063***
Technology User Countries	0.101**	0.02	-0.040*	-0.114***	0.043***
High income, low R&D Countries	0.122***	-0.062***	-0.030	-0.097***	0.040***
Low income, low R&D Countries	0.318***	-0.034	-0.083**	-0.012	0.053**
High Tech Manufacturing	0.093	-0.068	-0.067	0.056	0.069***
Med High Tech Manufacturing	0.140***	-0.089***	-0.060**	-0.158***	0.034**
Med Low Tech Manufacturing	0.163***	0.027	-0.025	-0.068*	0.019
Low Tech Manufacturing	0.149***	-0.008	-0.039	0.054*	0.013
Know. Intensive Services	0.119***	0.004	0.110***	-0.002	0.096***
Large Companies	0.168***	-0.056**	-0.044**	-0.037	0.039***
SMEs	0.132***	-0.005	0.012	-0.033*	0.055***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.

Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy; external innovation expenditure.

Indep. variables: Foreign ownership.

Foreign ownership has a distinct impact on the geography of collaboration patterns maintained. From 49 below we see that while the impact on international science system and vertical collaboration is positive, the impact on national collaboration propensities is distinctively negative. This is consistent with the notion that foreign ownership increases the international orientation of affiliated firms, at the expense of orientation towards host economy collaborative linkages. This may in turn cause ‘branch plant syndromes’ at the level of the host economy (Fuller & Phelps, 2004; Hoare, 1978; Phelps & Fuller, 2000; Stewart, 1976). Yet, although this holds for both small and large countries, notable differences exist between the different country groups. In technological leader countries, no significant impact on national collaboration can be detected. This is again consistent with the notion that subsidiaries in such contexts are assigned mandates more conducive to innovation collaboration, both domestically and abroad.

Table 49 How foreign ownership determines collaboration for innovation.

Marginal effects of foreign ownership on innovation collaboration based on regressing innovation collaboration for all firms and for subsamples of firms.

Dependent Variable	**International**		**National**	
	Science	**Vertical**	**Science**	**Vertical**
Independent Variable	**Foreign Ownership**			
Regression on all firms	0.039***	0.090***	-0.044*	-0.069***
Regressions on subsamples				
Small Countries	0.041***	0.100***	-0.03	-0.098***
Large Countries	0.034***	0.069***	-0.071**	-0.050*
Technology Leader Countries	0.093***	0.134***	-0.061	-0.023
Technology User Countries	0.014*	0.073**	-0.042	-0.142***
High income, low R&D Countries	0.013	0.062*	-0.090**	-0.009
Low income, low R&D Countries	0.033	0.042	0.056	-0.129*
High Tech Manufacturing	0.016	0.127*	-0.018	-0.108*
Med High Tech Manufacturing	0.026*	0.065*	-0.063	-0.056
Med Low Tech Manufacturing	0.023*	0.054	-0.071*	-0.085*
Low Tech Manufacturing	0.049**	0.138***	-0.026	-0.095*
Know. Intensive Services	0.059**	0.115***	-0.038	-0.069
Large Companies	0.059***	0.139***	-0.044	-0.043*
SMEs	0.036***	0.071***	-0.043	-0.077***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
$^{+}$ Contexts indicate subsamples.

Dep. variables: International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.

Indep. variables: Affiliation with a foreign owned group.

We also note that among firms in high technology manufacturing sectors only weak positive (international science system) and negative (domestic vertical) impacts of foreign ownership. By contrast, strong positive impacts on international collaboration are found for knowledge intensive services and low-tech manufacturing. Combined, these findings illustrate how national and international collaboration patterns of firms in high technology manufacturing sectors are more independent of foreign ownership than the patterns of firms in other sector groups. This presumably reflects overall a stronger orientation towards collaboration both domestically and abroad which is related to the complexity of involved knowledge and the velocity of the technological context faced by such firms, combined with differences in mandates assigned and resilience towards attention demanded by headquarters. In technologically leading countries we do not find a significantly lower domestic collaboration, which is consistent with the findings in Dachs, Ebersberger & Lööf (2008) and with Ebersberger & Herstad (2011) where no significant difference in the domestic collaboration is found while analyzing the Nordic countries which fall into the group of technologically leading countries.

Foreign ownership has a substantial impact on the open innovation practices of their affiliated firms – they are systematically more open towards a broader range of collaboration partners than are firms under domestic ownership. But this broadening is oriented outwards, towards international partners - and appears to occur at the expense of the domestic collaborative linkages and intramural R&D efforts of firms. Our findings therefore allow us to conclude that the danger for 'branch plant syndromes' at the level of territorial economies stemming from foreign ownership is empirically supported, and requires policy awareness. Similarly, the negative impact of such owners on focal firm use of IPR measures, and the positive impact on focal firms' external orientation of R&D, taken together suggest a risk of hollowing out at the individual firm level (see e.g. Grimpe & Kaiser, 2010; Novak & Eppinger, 2001; Weigelt, 2009) which is specific to foreign ownership.

Important Findings

.: Foreign owned firms are more open than domestically owned firms.

.: Openness of foreign owned firms it typically oriented towards international partners.

.: This international openness comes at the expense of domestic embeddedness.

9.4 Determinants of OI Practices: Domestic Multinational

9.4.1 Introduction

As indicated above, the limited number of studies which acknowledge this distinction suggest that the impacts and characteristics which often are claimed to be associated with foreign ownership are actually related to the multi-nationality of the parent corporate group (Bellak, 2004), or to the geographical scope of its network (Goerzen & Beamish, 2003). This applies for example with respect to the use of the corporate network for innovation search purposes (Dachs et al., 2008), and to innovation performance (Frenz & Ietto-Gillies, 2007). Consequently, the impact from foreign (inward FDI) and domestic (outward FDI) multi-nationality must be distinguished from each other.

Recent empirical work has taken this line further by arguing that there may be headquarter proximity effects at play within the corporate network. Having corporate headquarters nearby helps determine level of a subsidiary's responsibilities and the degree to which it is exposed to the information and knowledge spillovers that arise within the multinational corporation (see Ebersberger & Herstad, 2011 for a discussion and empirical analysis). It is for instance commonly argued that MNEs prefer to conduct their most basic research and development activities close to HQ. Headquarter proximity effects may also mediate the tensions between internal (to the corporate network) and external (to collaboration partners) characteristic of multinational enterprises (Blanc & Sierra, 1999). If so, this would directly link the open innovation practices and geographies of affiliated nodes of the firm to their organizational and social distance (Boschma,

2005) towards the HQ. If such effects are at play, they may translate into headquarter location effects on territorial economies.

9.4.2 Review of Literature

Affiliation with a domestic multinational corporate group is similar to affiliation with a foreign corporate group in one important respect – it implies that the group network is multinational, and thus present in more diverse business contexts than uninational group networks. This increases the information content of the network (Ebersberger & Herstad, 2011), and provide subsidiaries in one country with platforms for partner identification, collaboration and external innovation expenditure in other contexts (Asheim et al., 2011).

On the other hand, domestic multi-nationality is different from foreign ownership in several important respects. First, because this co-location with headquarters means that the subsidiary is part of a labor market which overlaps with that of the HQ. This entails richer personal networks in the HQ-subsidiary relationship, and enables more frequent exchanges of personnel. While richer networks entail richer from HQ to the subsidiary, the mobility of personnel entail more intense transfer of knowledge (see e.g. Agrawal, Cockburn, & McHale, 2006; Björkman et al., 2004; Ebersberger & Herstad, 2011; Hansen, 2002). Second, because HQ and other strategic functions tend to serve as information and knowledge gravitation nodes in the corporate network. This increases the likelihood that valuable information and knowledge may spill over onto collocated subsidiaries by means of the mechanisms mentioned above. Last, because outward expansion by means of FDI entails that the corporate network which comes to be established reflect contextual rationalities and institutional conditions prevalent at home – around the home subsidiary-HQ nexus (Geppert, Williams, & Matten, 2003; Pauly & Reich, 1997) – in contrast to what is the case when a foreign group enters and incorporate the host country firm into a network with predefined characteristics developed in potentially quite different institutional contexts. Against this background it is not surprising to find that affiliation with a multinational corporate group headquartered within the same economy as the focal firm trigger more geographically dispersed collaboration patterns than do foreign ownership; and functionally broader collaboration networks within any given world region than do affiliation with a corporate group headquarter within the same region (Asheim et al., 2011). It is neither surprising to find that domestic multinational affiliation comes with a far higher likelihood that corporate group network search (i.e. internal proximity (cf. Blanc & Sierra, 1999)) is combined with local collaborative linkages (i.e. external proximity) (Ebersberger & Herstad, 2011).

9.4.3 Descriptives

Table 50 presents the share of enterprises that are affiliated with a domestic multinational firm according to country groups. On average, only 2 % of the total sample is affiliated with a domestic multinational firm. The share is most pronounced among large enterprises within high direct and indirect R&D intensity countries, and least pronounced within country contexts characterized by low direct and indirect R&D intensities. The ability of national economies to grow domestic multinationals therefore appears to be interwoven with their technological profile.

Table 50 Descriptives of domestic multi-nationality by company size and country group.

Country group	Firm Size Large Comp.	SME	Total
Technology Leader Countries	0.210	0.040	0.054
	0.407	0.195	0.226
Technology User Countries	0.047	0.015	0.020
	0.213	0.123	0.138
High income, low R&D Countries	0.037	0.004	0.005
	0.190	0.059	0.071
Low income, low R&D Countries	0.021	0.010	0.011
	0.143	0.099	0.105
Total	0.096	0.015	0.021
	0.295	0.122	0.143

Note: Mean of the multi-nationality ; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Consistent with this, we find domestic multi-nationality to be most pronounced among large firms in high-tech manufacturing (Table 52), and least pronounced among SMEs in low-tech manufacturing.

Table 51 Descriptives of domestic multi-nationality by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.152	0.028	0.039
	0.359	*0.165*	*0.193*
Med high tech mfg	0.115	0.019	0.030
	0.319	*0.137*	*0.169*
Med low tech mfg	0.091	0.010	0.015
	0.288	*0.100*	*0.121*
Low tech manuf	0.071	0.009	0.013
	0.256	*0.097*	*0.113*
Knowledge intensive serv.	0.096	0.025	0.030
	0.294	*0.156*	*0.169*
Total	0.096	0.015	0.021
	0.295	*0.123*	*0.143*

Note: Mean of the indicator for domestic multi-nationality ; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

9.4.4 Effects of Domestic Multi-nationality on OI Practices

Affiliation with a domestically based multinational corporate group (DOM)—ie. a multinational company that is headquartered in the same economy as the focal firm— is seen to affect different dimensions of open innovation practices. In the sample as a whole we find DOM affiliation to have a strong, significant impact on all forms of open innovation practices, except science system search and external innovation expenditure. By contrast, the impact for foreign ownership on external innovation expenditure is significantly positive whereas no impact is found on the industry search which is impacted positively by DOM affiliation. The affiliates of DOMs are also more active users of IPR protection mechanisms, in contrast to the affiliates of foreign enterprises which use such mechanism to a significantly lower degree than reference companies. The findings are consistent when the sample is split into small and large countries, suggesting that they are robust.

Table 52 How affiliation with a domestic multinational group affects open innovation practices.

Marginal effects of domestic multi-nationality on innovation practices based on regressing open innovation practices for all firms and for subsamples of firms.

Dependent Variable	Collaboration	Industry Search	Science Search	Protection Strategy	External innovation
Independent Variable	**Domestic Multi-nationality**				
Regression on all firms	1.381***	0.163***	0.039	0.283***	0.008
Regression on subsamples					
Small Countries	1.485***	0.080*	-0.019	0.175***	-0.004
Large Countries	1.157***	0.165***	0.037	0.442***	-0.027
Technology Leader Countries	1.273***	0.199***	0.082*	0.383***	0.009
Technology User Countries	1.347***	0.031	-0.003	0.210***	0.042
High income, low R&D Countries	1.410***	0.157**	0.060	0.007	-0.026
Low income, low R&D Countries	1.380***	0.166*	-0.082	0.279***	0.004
High Tech Manufacturing	1.361***	0.362***	0.013	0.297**	0.059
Med High Tech Manufacturing	1.390***	0.237***	-0.121*	0.263***	0.084**
Med Low Tech Manufacturing	1.365***	0.123	0.016	0.271***	0.05
Low Tech Manufacturing	1.581***	0.116*	0.120*	0.184***	-0.033
Know. Intensive Services	1.158***	0.044	0.123**	0.306***	-0.086**
Large Companies	1.233***	0.179***	-0.032	0.125**	0.048**
SMEs	1.331***	0.098**	0.102**	0.257***	-0.009

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy; external innovation expenditure .
Indep. variables: Domestic multi-nationality .

When we consider the impact of DOM affiliation in different sector and country contexts, the overall picture remains the same. In particular, we note the strong and consistent impact on collaboration breadth across all country and sector groups. Significant negative impacts are detected only on science system search among firms in MHT manufacturing, and on external innovation expenditure among firms in knowledge intensive services. The latter suggest that co-location between subsidiaries and HQ is associated with a particularly strong focus on internal R&D in the latter.

The theoretical arguments presented above suggest that the impact of domestic multi-nationality will be particularly distinct with respect to the geographical configuration of open innovation practices, and the relative weight put on domestic versus foreign innovation collaboration. Below we see that DOM affiliation is associated with higher vertical and science system collaboration propensities – both domestically and abroad. This is in relatively stark contrast to the impact from foreign ownership, which was also significant but negative for national collaboration. When splitting into country size groups, we see that only the impact on national science system collaboration in large economies disappears.

Table 53 How affiliation with a domestic multinational group determines innovation collaboration. Marginal effects of domestic multi-nationality on innovation collaboration based on regressing innovation collaboration for all firms and for subsamples of firms.

Dependent Variable	**International**		**National**	
	Science	**Vertical**	**Science**	**Vertical**
Independent Variable	**Domestic Multi-nationality**			
Regression on all firms	0.096***	0.318***	0.076*	0.095***
Regression on subsamples				
Small Countries	0.085***	0.262***	0.142**	0.065*
Large Countries	0.086***	0.287***	-0.076	0.114***
Technology Leader Countries	0.120***	0.289***	0.064	0.123***
Technology User Countries	0.025	0.256***	0.159*	-0.031
High income, low R&D Countries	0.091**	0.411***	0.030	0.118**
Low income, low R&D Countries	0.070*	0.024	0.029	0.030
High Tech Manufacturing	0.026	0.271***	0.272***	0.045
Med High Tech Manufacturing	0.098***	0.317***	0.152**	0.141***
Med Low Tech Manufacturing	0.073*	0.236**	0.000	0.087
Low Tech Manufacturing	0.071**	0.341***	0.093	0.099*
Know. Intensive Services	0.128**	0.356***	0.011	0.070
Large Companies	0.154***	0.325***	0.137***	0.092***
SMEs	0.078***	0.296***	0.052	0.094**

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.
Indep. variables: Affiliation with a domestic multinational group.

In essence, we have found that the impact of DOM affiliation on international collaboration to be strong and positive in the sample as a whole – and in a variety of specific sectoral and country settings. The impact of DOM affiliation on collaboration with customers or suppliers abroad is positive in all sectors, and all but low income, low R&D countries. And we find no negative impacts on national collaboration from DOM affiliation which would be similar to the negative impacts found for foreign ownership, in any sectoral or country contexts. This means that domestic multinational groups are much more likely to serve as gatekeepers to their host economies – by which the link external collaboration networks at home to external collaboration networks abroad (Giuliani & Bell, 2005; Graf, 2010; Morrison, 2008) – than are the affiliates of foreign corporate groups.

This means that domestic multinational enterprises, although comparatively rare and often neglected by research preoccupied with foreign firms, are at the heart of the complex interplay between internal system dynamics and external linkages by which regions and nations continuously define and redefine their roles in the international landscape of knowledge and technology. One learns more from going abroad, than from having strangers visit (Ebersberger & Herstad, 2011; van Pottelsberghe de la Potterie & Lichtenberg, 2001).

Important Findings

.: Only 2 % of the total sample report being domestic multinationals. They tend to be large enterprises within high direct and indirect R&D intensity countries, particularly within higher tech sectors

.: Affiliation with a domestically based multinational corporate group (DOM) has a strong, significant impact on all open innovation practices, except science system search and external innovation expenditure.

.: The effect is particularly strong and consistent on collaboration across all country, size and sector groups

.: Affiliation with a domestically based multinational corporate group increases the probability that firms use IPR protection across the board. This effect is most noteworthy in the case of large countries as well as in countries characterized by low income, low R&D intensities

.: SMEs derive a stronger positive effect than larger firms from being affiliated with a domestically based multinational corporate group in terms of three open innovation practices: collaboration, protection strategies, and on science search

.: DOM affiliation is associated with higher vertical and science system collaboration propensities both domestically and abroad

.: The impact of DOM affiliation on collaboration with customers or suppliers abroad is positive in all sectors, and all but low income, low R&D countries.

10. Policy Determinants of OI Practices: Public Funding

Governmental intervention in economic activities can be justified on the basis of a market failure argument. Basically this rationale also applies to governmental intervention in corporate innovation activities. Hauknes & Nordgren (1999) argue that governmental intervention in innovation-related activities is justified by the market failure argument and by the need to meet governmental and public needs in the field of health, the environment and defense. However, as governmental intervention in these fields can also be justified by the market failure argument (e.g. Frisch, Wein and Ewers 2001), the overall and basic line of reasoning for governmental intervention is market failure.

10.1 Review of Literature

Generally the notion of market failure refers to a situation where the market's innate coordination mechanism fails to allocate goods and resources efficiently. In this context efficiency refers to the concept of Pareto-efficiency. Pareto efficiency is achieved though a perfectly competitive market. It thus requires quite a number of conditions to be met: (1) Perfect competition. Perfect competition excludes market power of any of the players involved in market transactions. As a result each actor in a market transaction has to take the price of a certain good or resource as given when optimizing his or her outcome. (2) No externalities. Economic interaction only affects the actors involved in the market transaction. No third party is affected outside the market interaction. (3) Property rights. Property rights are strictly defined and unambiguously allocated. (4) Exclusivity. Property rights make sure that actors who are not entitled to use a commodity can be excluded from doing so. (5) Transferability of property rights. Property rights need to be tradable. (6) Perfect rationality of the actors, no asymmetric distribution of information across actors.

Knowledge, with its public good characteristics, spills over from its creator and other actors who are only limited by their own capabilities in utilizing the knowledge in question (Cohen & Levinthal 1989; 1990). This results in an appropriability problem for the creator of the knowledge. Innovating companies cannot fully appropriate the returns of their innovation and will hence under-invest in knowledge and knowledge-creating processes (Nelson 1959, Arrow 1962). From an incentive point of view, firms will seek complete protection of their created knowledge. This will also lead to a suboptimal situation as resources will be wasted in duplication of research.

Collaboration for innovation and research joint ventures are a means for companies to manage the non-rivalrous nature of knowledge and the associated appropriability problems. As the companies' perceived disadvantages of collaborative innovation activities may outweigh the expected private return on collaboration, a suboptimal level of collaboration and knowledge sharing may result. Fruitful collaboration for innovation requires a firm to possess a distinct set of capabilities. The success of cooperative innovation activities may fall short of what it could be, if these capabilities are not present. These considerations justify governmental intervention to increase the capabilities to collaborate for innovation and to raise the incentives to do so. For instance Georghiou et al.

(2003) mention the policy of the Finnish National Technology Agency (Tekes) (at that time) that large companies will more likely receive funding if they collaborate with SMEs.

The effects of underinvestment are even more prevalent, as knowledge acquisition and knowledge creation is subject to large sunk costs which create a strong barrier to entry. An additional and related argument in favor of governmental intervention is that the financial market may fail to provide appropriate financing for innovative activities (Hyytinen & Toivanen, 2005). As market failure resulting in the under-provision of R&D and innovation activities provides the rationale for governmental intervention the aim is to raise innovation activities to a socially optimal level by the use of adequate policy instruments. There are principally two instruments that are commonly employed: tax incentives or grant where both measures induce change rather than command it, hence they are market-compatible.

Tax incentives

Tax incentives are designed to reduce the cost of R&D and innovation activity and therefore encourage companies to invest more in innovation-related activities. They may be designed to allow an immediate write-off of R&D-related expenses, to give R&D tax credits or to allow an accelerated depreciation of R&D-related investment. Tax incentives do not discriminate between R&D projects – they are available for any R&D activity. Hall and van Reenen (2000) find in their analysis of the effects of R&D tax credits that on the average a dollar in tax credits triggers additional private expenditure by another dollar. As the available data does not allow us to identify tax incentives on the firm level, we will only concentrate on the second basic instrument, grants.

Grants

Grants are usually set up based on matching grants, by which public funding has to be matched by private innovation expenditure at a certain percentage. Matching grants are selective in as much as funding is not provided for all projects but only to a selected number of projects. Grants allow the government to influence the investment behavior of companies in a more targeted way. It can therefore be an efficient instrument to implement specific objectives or target specific technological fields or distinct sectors. However, the selective nature of the subsidy has to be accounted for in the empirical analysis (David et al., 2000; Klette et al., 2000)

The focal point in analyzing the effects of grants is their efficacy. Since the aim of governmental intervention is to increase private innovation spending, it is necessary to investigate whether the public money really gets spent on additional R&D activities: in other words, the question is, whether or not public funding crowds out private investment at the firm level. With some exceptions (Wallsten, 2000; Lach, 2002), most of the more recent analysis rejects full crowding out effects at the level of the subsidized firms (Almus & Czarnitzki 2003; Duguet 2004; Gonzalez et al. 2005; Lööf & Hesmati 2005; Aerts & Czarnitzki 2006; Czarnitzki & Licht 2006; Czarnitzki 2006; Aerts & Schmidt 2008; Gonzalez & Pazo 2008). Since so called input additionality is found, we can conclude that public funding for innovation triggers private invest investments and can be regarded a means to reduce underinvestment in innovation.

More recently the literature has progressed beyond the basic analysis of crowding out and input additionality, moving towards an investigation of output and behavioral additionality. The underlying question here is whether or not public funding triggers positive effects in terms of innovation output and whether or not public funding changes the innovation behavior of firms. For instance, Branstetter and Sakakibara (2002), Czarnitzki and Hussinger (2004), Czarnitzki and Licht (2006) and Hussinger (2008) analyze the effects of subsidies on patenting and new product sales. Czarnitzki et al. (2007) investigate the heterogeneous treatments effects of R&D subsidies and R&D collaborations on innovation input and on innovation output. Positive behavioral additionality effects have been found in Clarysse, Wright, & Mustar (2009). The analysis of the effects national and EU funding has on the intensity of open innovation practices is clearly an analysis of the behavioral effects of public funding.

Research Question

Below we analyze how public funding affects the adoption of open innovation practices. As discussed above, the adoption effects of open innovation practices can be interpreted as behavioral additionality effects of public funding.

Before we proceed in this direction we have to highlight the fact that we may not be able to indentify causality from the cross sectional data set we employ here. Although we investigate the effects of funding employing an econometric technique to capture the selection, which is clearly present in the funding decisions we may not have sufficient information about the firms open innovation behavior prior to the funding decision: this would be necessary to unequivocally identify a causal effect. However, our analysis of funding schemes clearly shows that funding aspires to induce behavioral effects. Hence we assume that if we find indication of differences in innovation behavior, it is likely to be triggered by the funding scheme rather than being an inherent characteristic of the funded firm prior to the funding decision.

10.2 Descriptives

In Table 55 and Table 56 we summarize the distribution of national public funding on the size, on the country groups and the technology sectors, respectively.

Table 54 Descriptives of national public funding by company size and country group

Country group	Firm Size Large Comp.	SME	Total
Technology Leader Countries	0.165	0.149	0.150
	0.371	*0.356*	*0.357*
Technology User Countries	0.257	0.161	0.173
	0.437	*0.367*	*0.378*
High income, low R&D Countries	0.385	0.288	0.292
	0.487	*0.453*	*0.455*
Low income, low R&D Countries	0.094	0.062	0.066
	0.291	*0.241*	*0.248*
Total	0.255	0.223	0.225
	0.436	*0.416*	*0.418*

Note: Mean of the indicator for national public funding; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

In the dataset innovation active SMEs have a slightly lower likelihood of 22.3% of receiving national public funding than large companies have (25.5%). We find striking differences in the innovation active firms' propensity to receive public funding for innovation across country groups. In high income countries with a low R&D intensity we find more than 29% of the companies to receive national governmental subsidies for innovation. Only about 7% of firm from low income and low R&D countries receive national public funding. Technology using countries and technology leading countries do not differ markedly in their overall likelihood of public funding. However, where large companies are concerned, in technology using countries companies have a 10 percentage points higher likelihood to receive public funding than in technology leading countries.

Table 55 Descriptives of national public funding by company size and sector

	Firm Size		
Technology Sectors	**Large Comp.**	**SME**	**Total**
High tech mfg	0.381	0.300	0.307
	0.486	*0.458*	*0.461*
Med high tech mfg	0.331	0.258	0.266
	0.471	*0.438*	*0.442*
Med low tech mfg	0.290	0.238	0.241
	0.454	*0.426*	*0.427*
Low tech mfg	0.207	0.223	0.222
	0.405	*0.416*	*0.415*
Knowledge intensive srvs	0.160	0.165	0.164
	0.366	*0.371*	*0.370*
Total	0.256	0.223	0.225
	0.436	*0.416*	*0.418*

Note: Mean of the indicator for national public funding; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

Table 56 shows the fraction of companies receiving public funding from national sources broken down on the technology sectors. Among the manufacturing sectors the fraction of funded companies increases with technology intensity of the sectors from about 22% in the low technology sectors to more than 30% in the high technology manufacturing sector. Knowledge intensive services appear to have the smallest fraction of companies which receive public funding. The fraction of funded companies in the knowledge intensive services is about half that of the high technology manufacturing and markedly lower than the one in the low technology manufacturing.

This distribution and in particular the low share of firms with funding in the service sector might reveal two characteristics of the national funding systems. In terms of public intervention though, grants priority is put on high technology manufacturing sectors. Services tend to be covered less by sectoral or technology specific funding schemes. It should again be noted that the above findings base on innovation active companies only. The different likelihood to commit to innovation activities does not affect the findings above.

Table 56 Descriptives of public funding (EU) by company size and country group

	Firm Size		
Country group	**Large Comp.**	**SME**	**Total**
Technology Leader Countries	0.081	0.034	0.038
	0.273	*0.182*	*0.192*
Technology User Countries	0.081	0.072	0.073
	0.274	*0.259*	*0.261*
High income, low R&D Countries	0.113	0.053	0.056
	0.317	*0.224*	*0.230*
Low income, low R&D Countries	0.089	0.066	0.069
	0.285	*0.249*	*0.253*
Total	0.093	0.051	0.054
	0.291	*0.220*	*0.226*

Note: Mean of the indicator for EU public funding; standard deviations are in italics. Country groups refer to the classification in Reinstaller & Unterlass (2010); companies are SMEs if employees < 250; they are large companies otherwise.

Table 57 and Table 58 report the distribution of innovation active companies receiving public funding from the EU by size, country group and technology sector. For all innovation active firms we observe that the fraction of large companies receiving EU public funding is about twice as large as the fraction of SMEs. This pattern can be found in the technology leading countries and the high income, low R&D countries. It cannot be found in the technology using countries or the low income low R&D countries. The simple descriptive also illustrate that the companies' likelihood to receive public funding in the technology leading countries is lowest. It is highest in technology user countries such as Hungary, Estonia, Slovakia, the Czech Republic, and Slovenia.

Table 57 Descriptives of public funding (EU) by company size and sector

Technology Sectors	Firm Size Large Comp.	SME	Total
High tech mfg	0.172	0.061	0.070
	0.377	*0.239*	*0.256*
Med high tech mfg	0.078	0.038	0.042
	0.269	*0.190*	*0.201*
Med low tech mfg	0.104	0.049	0.052
	0.306	*0.216*	*0.222*
Low tech manuf	0.076	0.054	0.055
	0.265	*0.226*	*0.228*
Knowledge intensive serv.	0.106	0.056	0.059
	0.308	*0.230*	*0.237*
Total	0.093	0.051	0.054
	0.291	*0.219*	*0.225*

Note: Mean of the indicator for EU public funding; standard deviations are in italics. Technology sectors refer to the classification in Hatzichronoglou (1997) and OECD (2001); companies are SMEs if employees < 250; they are large companies otherwise.

When we investigate the descriptives in Table 58, we find the highest likelihood of receiving public funding from EU sources can be found in the high technology manufacturing sectors. Across the other sectors there is rather low variation. This does not point to a particular pattern of funding.

10.3 Effects of Public Funding on OI Practices

Let us now turn to the analysis of the effects public funding has on the use of open innovation practices. In Table 59 and Table 60 we report the effects of national public funding on the use of open innovation practices and on domestic and international collaboration patterns. Table 61 and Table 62 report the effects of the funding received from EU sources respectively. It has to be emphasized here that the dataset does not contain information about the size of the funding. It merely indicates whether or not funding has been received. Our results only indicate the effects of receiving public funding versus not receiving public funding.

The effects of national public funding on the use and on the intensity of the use of open innovation practices is positive across the board with exception to industry search. National public funding increases the intensity of search within the sciences system, it increases the collaboration and it increases the firms' use of protection mechanisms. However it does not contribute to extending the firms' search space to other industrial partners. Yet, the analysis of subsamples shows a more varied picture. In large countries we find a strong positive effect of national public funding on industry search, yet in small countries we find no significant effect at all.

In technology leading countries national public funding do indeed strengthen and intensify industry search, whereas in high income but low R&D countries national funding does not have a significant effect on industry search. In technology user countries and in low R&D countries with low income we find a strong negative effect of national public funding on industry search. The analysis of the sectoral subsamples reveals that in all sectors except for one, national funding does not affect industry search significantly. Only in low technology manufacturing national public funding reduces industry search, yet it increases science search.

In short, the effect of national public funding on industry search seems to depend on the size and the overall technological level of the economy. In a small or technologically less developed economic environment national public funding does not induce companies to extend their search space into the industrial system.

In slight contrast to the above, national public funding does support the firms' intensification of their sciences search. This holds for all country groups and for all technology sectors. Interestingly we find an inverse u-shape pattern across size. We find the strongest effects of national public funding on the largest and the smallest companies. The lowest effects are found for larger SMEs.

The diversity of collaboration is particularly strengthened through national public funding in small countries, in technology using countries in low R&D and low income countries, in knowledge intensive sectors and among the larger companies. The collaboration patterns induced by national public funding are vertical linkages domestically (see Table 60), yet in some of the sectoral subsamples the effect is positive but not significant. Across sectors, across countries and across size classes, we find the consistent picture that national public funding does not induce international collaboration of either type nor does it induce science collaboration. Only in medium low technology manufacturing national public funding supports collaborative interaction with the national science system.

Table 58 How the receipt of national public funding for innovation determines open innovation practices.

Marginal effects of national public funding on innovation practices based on regressing open innovation practices for all firms and for subsamples of firms.

Dependent Variables	**Industry Search**	**Science Search**	**Collaboration**	**Protection Strategy**
Independent Variables		**National Public Funding**		
Regression on all firms	-0.009	0.604***	0.450***	0.821***
Regression on subsamples				
Small Countries	-0.096	1.179***	0.921***	0.711***
Large Countries	0.376***	0.409***	0.155	0.511***
Technology Leader Countries	0.378**	0.520**	0.556*	-0.021
Technology User Countries	-0.728***	2.298***	1.753***	1.228***
High income, low R&D Countries	-0.048	0.603***	-0.154	0.873***
Low income, low R&D Countries	-0.968***	2.313***	0.566*	0.751***
High Tech Manufacturing	-0.100	0.505	-0.464	0.660
Med High Tech Manufacturing	0.028	0.422*	-0.228	1.306***
Med Low Tech Manufacturing	-0.170	0.622***	0.112	0.180
Low Tech Manufacturing	-0.483***	0.263*	0.089	0.247*
Know. Intensive Services	0.149	0.899***	1.127***	0.454***
> 250 Employees	-0.017	0.726***	0.942***	0.837***
101-259 Employees	0.212	0.168	0.443*	0.429**
51-100 Employees	0.161	0.230	0.315	0.487***
21-50 Employees	-0.018	0.290*	-0.098	0.398***
< 21 Employees	0.061	0.497***	0.148	0.479***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy.
Indep. variables: National public funding for innovation.

Table 59 How the receipt of national public funding determines collaboration for innovation.

Marginal effects of national public funding on innovation collaboration based on regressing innovation collaboration for all firms and for subsamples of firms.

Dependent Variable	**International**		**National**	
	Science	**Vertical**	**Science**	**Vertical**
Independent Variable	**National Public Funding**			
Regression on all firms	0.006	-0.051	0.130*	0.189***
Regression on subsamples				
Small Countries	0.026	-0.116	0.154	0.185***
Large Countries	0.003	-0.028	0.147*	0.231***
Technology Leader Countries	0.148	0.141	0.042	0.278***
Technology User Countries	-0.015	-0.177	-0.025	0.153*
High income, low R&D Countries	-0.003	-0.090*	0.056	0.253***
Low income, low R&D Countries	0.045	0.16	-0.123	0.237***
High Tech Manufacturing	-0.027	-0.13	0.13	0.098
Med High Tech Manufacturing	0.004	-0.069	-0.044	0.181***
Med Low Tech Manufacturing	0.007	-0.019	0.202*	0.067
Low Tech Manufacturing	0.045	-0.017	0.064	0.178**
Know. Intensive Services	-0.055**	0.039	0.259	0.279***
Large Companies	0.033	-0.03	0.016	0.071*
SMEs	-0.004	-0.075	0.129	0.171***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.

Dep. variables: International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.

Indep. variables: National public funding for innovation.

Having observed little or no negative effect of national public funding on industry search, we see from Table 61 that EU funding has a strong and rather unequivocal effect on industry search. This negative effect is found for all subsamples where it is only the magnitude of the effect—and therefore the significance—that varies. The difference between small and large economies, which is striking in the analysis of national public funding, does not carry over to EU funding. The size of the negative effect is comparable for large and small countries.

Table 60 How public funding through the EU determines open innovation practices.
Marginal effects of EU funding on innovation practices based on regressing open innovation practices for all firms and for subsamples of firms.

Dependent Variable	Industry Search	Science Search	Collaboration	Protection Strategy
Independent Variable	**Public Funding (EU)**			
Regression on all firms	-0.698***	1.716***	1.414***	0.901***
Regression on subsamples				
Small Countries	-0.730***	1.401***	-0.054	0.754***
Large Countries	-0.724***	1.778***	2.134***	0.725***
Technology Leader Countries	-0.291**	1.387***	0.759***	0.845***
Technology User Countries	-0.777***	1.971***	1.739***	0.560**
High income, low R&D Countries	-0.831***	1.388***	1.909***	0.337***
Low income, low R&D Countries	-0.827***	2.349***	0.278	0.944***
High Tech Manufacturing	-0.343	0.587	0.982**	0.440
Med High Tech Manufacturing	-0.539***	0.522*	0.173	0.965***
Med Low Tech Manufacturing	-0.774***	1.726***	1.769***	0.456*
Low Tech Manufacturing	-0.550**	0.774***	0.478*	0.634***
Know. Intensive Services	-0.638***	1.548***	1.378***	0.680***
> 250 Employees	-0.293**	1.055***	0.719***	0.739***
101-259 Employees	-0.101	1.316***	0.910***	0.366
51-100 Employees	-0.754***	1.631***	1.458***	0.442*
21-50 Employees	-0.588***	1.930***	1.836***	0.433*
< 21 Employees	-0.861***	1.948***	1.116***	0.141

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
Dep. variables: OI indicators for collaboration; industry search; science search; innovation protection strategy.
Indep. variables: EU public funding for innovation.

The effect of EU funding on the intensification of science search is strong and significant for almost all subsamples. With respect to the technology intensity of the sector, the regressions produce the insight that in high technology sectors public funding from EU sources does not have a significant effect on differentiating the levels of science search. Yet it does so for collaboration. The positive effect of public EU funding only accrues in large countries. In small countries EU funding does not affect the diversity of collaboration partners.

Table 61 How public funding through the EU determines innovation collaboration.

Marginal effects of public funding (EU) on innovation collaboration based on regressing innovation collaboration for all firms and for subsamples of firms.

Dependent Variable	International		National	
	Science	Vertical	Science	Vertical
Independent Varialb	**Public Funding (EU)**			
Regression on all firms	0.203***	0.120**	0.068	0.197***
Regression on subsamples				
Small Countries	0.126**	-0.008	0.029	0.117**
Large Countries	0.274***	0.140**	0.171*	0.255***
Technology Leader Countries	0.631***	0.243	-0.032	0.218***
Technology User Countries	0.050	-0.081	-0.104	0.172***
High income, low R&D Countries	0.166***	0.145**	0.052	0.280***
Low income, low R&D Countries	0.105	0.135	-0.134	0.224***
High Tech Manufacturing	0.251**	0.063	0.063	0.249***
Med High Tech Manufacturing	0.215**	0.180*	-0.095	0.222***
Med Low Tech Manufacturing	0.159**	0.131	0.251*	0.119
Low Tech Manufacturing	0.148*	0.118	-0.006	0.078
Know. Intensive Services	0.073	0.153	0.077	0.293***
Large Companies	0.209***	0.062	-0.077	0.081*
SMEs	0.171**	0.101	0.075	0.181***

Note: Marginal effects;
*** (**, *) indicate 0.1% (1%, 5%) level of significance. The detailed result tables of the estimations can be obtained from the authors upon request.
$^{+}$ Contexts indicate subsamples.

Dep. variables: International science collaboration; International vertical collaboration; National science collaboration; National vertical collaboration.

Indep. variables: EU public funding for innovation.

In Table 62 we identify two major impacts of public EU funding on the collaboration pattern. First, we find that EU funding, as with national public funding, increases the firm's likelihood of vertical national collaboration. The second pattern we observe is that EU public funding induces international science collaboration, which is particularly strong in large countries, in technology leading countries in high income and low R&D countries and in all manufacturing sectors.

The effect of EU public funding on international science collaboration is stronger in large countries than in small countries. This indicates that, given a more diverse scientific domestic environment, the leverage of EU funding is larger in these countries to establish international scientific linkages. In small countries with a less diverse science system international linkages may be induced by a lack of appropriate science partners. Hence, the leverage of EU funding is lower there.

The overall pattern which we observe both with national and EU funding is that it discourages industry search but that it encourages vertical collaboration within the domestic value chain. Funding supports the establishment of formal linkages in substitution to informal, one-way linkages. Yet it has to be considered that the cost of search and collaboration is by no means comparable. Also both forms of external linkages build on different preconditions within the corporate organization and both yield different ideas. Also they tend to be integrated in different phases of the innovation process.

Important Findings

.: More than 29% of innovation active companies receive national governmental innovation funding in high income countries with low R&D intensity while the comparable figure is less than 7% in low income and low R&D countries.

.: National funding systems tend to be directed more towards manufacturing sectors and particularly on high technology manufacturing sectors. Service sectors are less covered. This pattern is less observable for EU public funding

.: The proportion of large innovation active firms that receive EU public funding is about twice as large as that of innovation active SMEs

.: National and EU public funding exerts in sum a positive impact on firms search in the science system, on their innovation collaboration and on their protection strategy.

.: Industry search is affected slightly negatively by national funding but strongly so by EU funding.

.: National and EU funding discourages informal industry search but formal collaboration within the domestic value chain. Funding induces a substitution of informal external linkages with formal and possibly more sustainable linkages.

11. OI Practices: Dependence of OI Practices

11.1 Introduction

A firm's decision to engage in open innovation practices is certainly contingent on the larger industrial context and conditions which the firm is a part of (Cassiman & Veuglers, 2006). It depends on the linkages and interfaces the firm already has established, institutionalized and become used to. And it also hinges on the internal competence base of the firm and its routines (Bosch, Volberda, & Boer, 1999). The decision to engage in the open innovation practices introduced above is not only contingent on external factors and on the internal structure of the firm; the intensity of each open innovation practice also depends on the level of all other open innovation practices (Schmiedeberg 2008; Ebersberger & Herstad 2010) arguably because they are complementary to each other.

This section investigates the complementarity of open innovation activities. Here we elaborate on potential interactions that might lead to complementary or substitutive relationships emerging between them. The following discussion however does not explore the whole set of possible interactions but rather highlights what we regard as the backbone of the discussion. Additional arguments can admittedly be developed along the lines laid out below.

11.2 Review of Literature

It is not the external linkage and the open innovation practice per se which exerts an impact on innovation activities of the firm. Rather is it the organizational response to inputs and processes associated with different external linkages that lead to an impact on innovation activities and on their performance (Zahra & George, 2002). A linkage, an external interface or an open innovation practice cannot be understood independently. It is rather the full range of interfaces, internal resource bases, and routines that together determine the organizational response.

The relationship between internal knowledge and external information is dynamic. Following Rosenberg (1990), the firm's internal knowledge organization systems are fundamental to its ability to identify external information and knowledge that it can use and to its ability to utilize it to make new products. The measurement most often used to approximate internal knowledge creation at the firm level is internal R&D expenditure. In industries that are strongly dependent on basic research and on scientific knowledge, the importance of R&D as the basis for the firm's absorptive capacity is certainly relevant. (Arora & Gambardella, 1990, 1994; Cassiman & Veugelers, 2006; Cohen & Levinthal, 1989; Rosenberg, 1990). However, a strong and almost exclusive focus on internal R&D may crowd out external information by means of the so called not-invented-here (NIH) syndrome (Katz & Allen, 1982). In this setting, external knowledge systems become less absorptive of new ideas, knowledge and technologies if they originate from outside the corporate, sectoral or scientific borders (Bosch, Volberda, & Boer, 1999; Lane & Lubatkin, 1998; Leonard-Barton, 1992). This may lead to substitution rather than to complementarity (Schmidt, 2005). Empirical evidence of this syndrome is rare, but indications are found in Laursen & Salter (2006).

Interactive and collaborative relationships often require relation specific, irreversible investments. The marginal cost of maintaining collaborative relationships is rather low compared to the cost of establishing a new collaborative configuration (Narula, 2002). Hence rationally acting companies proceed selectively when establishing innovation collaborations. In addition, the patterns of collaboration tend to be less active due to the costs (see above) than those external interfaces that do not require mutual consent and interaction. For example search processes introduced above. This means that the impact of collaboration on new product development can be assumed to be sensitive to the emphasis put on identifying the 'right' collaboration partners, and on continuously evaluating existing linkages based on external information. In other words, it depends on the ongoing search processes of the firm. There is thus good reason to expect that collaboration activities are not independent of search activities, regardless of whether industrial or science systems are searched.

Innovation collaborations raise issues of absorptive capacity and resource commitment which are distinct from those of search. On the one hand, we can expect that the ability of firms to allocate sufficient personnel and attention to collaborative work is contingent on their overall willingness to invest in research and development (Cohen & Levinthal, 1989). It is also contingent on the internal availability of competencies to mirror those of their collaboration partners (Nooteboom et al., 2007). Complementarities between R&D and collaboration are to be expected (Schmiedeberg, 2008). On the other hand, placing too strong an emphasis on internal research and development may trigger the above mentioned NIH syndrome, thus resulting in substitution. A strong orientation towards systematic learning by means of large investments in R&D may facilitate collaboration with science system actors; but it may also result in knowledge systems that are less capable of managing diverse, distributed and interactive innovation activities involving numerous external actors. Thus, there may be conflicting goals and tensions involved in organizing for intramural R&D and collaboration (Schmidt, 2005). A strong external orientation in R&D leads to weaker creation and use of internal capabilities, which may in turn reduce the absorptive capacity required for successful collaborative innovation activities. By the same token, investments in contract R&D may back up collaborative relationships.

The advantageous properties of external innovation expenditure—such as flexibility and ease of access— may raise the likelihood of innovation for organizations surrounded by a ready supply of external information and potential contracting partners. It may also facilitate innovation in those organizations which avoid the hollowing-out effect of external innovation expenditure by substituting R&D-based learning with other forms of knowledge generation and accumulation. However, the relationship between internal R&D and sourcing has been focused on, to the extent that complementarities involving external innovation expenditure have been explored. Empirical studies find internal and external sourcing to co-exist (Arora & Gambardella, 1990, 1994;); external sourcing to stimulate internal expenditures (Veugelers, 1997) and the make and buy decision to have a stronger impact on innovation than the decisions to either make or buy (Cassiman & Veugelers, 2006). This is consistent with complementarity. However, others report results consistent with substitution effects leading either to the NIH syndrome or hollowing out (Basant & Fikkert, 1996; Schmiedeberg, 2008). Thus, existing empirical research is narrow in its focus, and mixed in its findings (Schmiedeberg, 2008).

Research Question

In the following analysis we investigate whether or not the adoption of open innovation practices are mutually dependent. We test for independence. If we can reject independence we find mutual dependence. This will however not be sufficient to determine the direction of the dependence, if any. More detailed analysis would have to be carried out to establish mutual complementarity or mutual substitutability of the practices.

11.3 Analysis of Complementarity and Substitutability: Adoption Approach

In section 3.7 we noted that Athey and Stern (1998) introduce two approaches to investigate mutual dependency between the management practices: the production function approach and the adoption approach. Here we use the adoption approach which we link directly to the analysis of the determinants of open innovation practices in section 9. The adoption approach tests whether there is correlation among the adopted practices, conditional on the independent variables determining the open innovation practices (Athey & Stern 1998, Arora & Gambardella 1990). As discussed above, this approach is based on the revealed preference of companies to adopt open innovation practices simultaneously. Implicit to this approach is the assumption that if the simultaneous use is beneficial to the rational actor, it will adopt the practices simultaneously. Hence the conditional correlation indicates complementarity of the practices because “complementarity creates a force in favor of positive correlation” (Athey & Stern, 1998, p. 12) between the practices. For practices that are substitutes the opposite holds true.

Table 63 then goes ahead to test whether there is significant correlation between the adoption of the different open innovation practices conditional on the exogenous determinants of open innovation practices. We find that independence can be rejected. This holds for the whole sample and for all subsamples analyzed and documented in Table 63. This means that the firms’ decision about whether to use open innovation practice—and to what degree— is contingent on the use and the intensity of the other practices. This finding is consistent with the identification of complementarity or substitutability of certain open innovation practices in the literature (Ebersberger & Herstad, 2010; Schmiedeberg, 2008; Cassiman & Veuglers, 2006, Kaiser & Grimpe 2010).

Table 62 Testing independence of OI practices after regression

Context	LM test
All firms	2386.76***
In different subsamples	
Small Countries	739.73***
Large Countries	1373.50***
Technology Leader Countries	258.08***
Technology User Countries	139.55***
High income, low R&D Countries	1906.82***
Low income, low R&D Countries	538.40***
High Tech Manufacturing	32.26***
Med High Tech Manufacturing	493.14***
Med Low Tech Manufacturing	637.85***
Low Tech Manufacturing	1339.30***
Know. Intensive Services	320.14***
SME	2204.10***
Large Comp.	342.98***

Note: Test for independence of the regressions determining the open innovation practices. *** (**, *) indicate 0.1% (1%, 5%) level of significance.

Important Findings

.: The use of one open innovation practice depends on the use of other open innovation practices.

.: Given the assumption of rational actors, we can infer that the mutual dependence observed is an indication of substitutability or complementarity of the open innovation practices.

.: The research setup does not allow us to distinguish mutual substitutability from mutual complementarity.

PART IV: Conclusions

12. Policy assessment

The findings above provide a unique empirical basis for the further development of innovation policy measures. In earlier contributions linking innovation policy to open innovation (e.g. Herstad et al. 2010; De Jong, Vanhaverbeke, Chesbrough 2008), the premise that open innovation practices have a positive effect have been either simply assumed (De Jong et al, 2008); supported by anecdotal evidence (Chesbrough, 2008) or – at best –supported by empirical data from a limited range of countries (Herstad et al 2010, 2008). By contrast, our evidence that open innovation practices matter is based on a sample of more than 130,000 European firms. The discussion which now follows is based on previous work by some of the authors (e.g. Herstad et al 2008, Herstad et al. 2010), and on the material presented in Annex 14. It focuses on immediate policy implications of the empirical findings we have presented. For a more elaborate discussion of the national and EU level policies on which policy recommendations are made, we refer to the annex.

12.1 Classification of Policy Instruments

In a previous EU-funded project on open innovation (Herstad et al, 2008), three different categories of policy instruments were identified (Herstad et al., 2010). These categories are based on the target and main purpose of the intervention involved. The first two reflect the market-failure (i.) and the system-failure (ii.) arguments traditionally applied; while a third dimension linked to the system failure argument, focuses on the functional and geographical dimension of linkages nurtured (iii).

Set 1 of Innovation Policy Instruments

The first set of instruments is grouped around the argument that the embedding of firms within territorial systems is crucial for the ability of these systems (regional, national) to harness spillovers from global linkages and intramural R&D. Central to this is the fostering of intramural research and development. The rationale for intervention is the familiar market failure argument (Arrow 1962b) that actual investment in new knowledge creation will tend to fall short of the socially-desirable level due to spillover-effects (or in other words, that potential developers of new knowledge will not invest due to his inability to fully appropriate profits from his investment). In the context of globalization, attempts to harness knowledge spillovers leads to the creation of corporate R&D strongholds in the economy which serve as gatekeepers of information and knowledge from outside.

Set 2 of Innovation Policy Instruments

The second set of instruments focuses on the interactive dimension of innovation activities. They involve the complementarities between activities that take place within the firm and its networking activities. A main focus of these instruments is innovation collaboration, as it functions not only as a means of joint generation of knowledge but also as a channel for intentional and unintentional knowledge diffusion. The rationale for policy intervention here is the system failure argument (e.g. Klein Woolthuis et al 2005). System failure might limit choices of potential innovation partners. Absent suitable partners, innovative processes may be constrained into becoming overly closed, locked-in with existing partners and/or paired off with unsuitable partners. Economies run the risk that individual firm-level choices will not lead to the socially desirable level of experimentation with new linkages and combinations of knowledge, across sectoral and value-chain boundaries. This legitimizes public intervention.

Set 3 of Innovation Policy Instruments

Considerable uncertainty surrounds what linkages might lead to the best outcomes as well as at which geographical level they would best be pursued. However, it is possible to strike a balance between broad and narrow interaction patterns, between national and international partners' structures, between intra-sectoral and inter-sectoral networks of external linkages. This is important not only at the firm level but also at the level of economies. This is because these linkages define the exposure of the territorial innovation system to novel technologies and knowledge from outside (international linkages) and condition the ability of the system to effectively redeploy and create novelty from specialized industrial and academic capabilities already present within.

12.2 Search

The open innovation practice of screening information and ideas from industry and science system were found in our analysis to be conducive to innovation. The importance that both firm size and R&D intensity exerts on search supports the position that the successful implementation of external search strategies requires strong internal competences. Thus, our findings on the impact of search point directly back to the first set of innovation policy instruments (introduced in section 0): policy measures that help firms generate the internal competences needed to undertake broad external search are important (Zahra and George, 2002; Asheim, Ebersberger & Herstad, 2011). We emphasize that we find no indication that a focus on this intramural R&D leads to not-invented-here syndromes.

Industry search

- .: The incidence of industry search is greatest in countries characterized as technology users, but also high in low income countries characterized by low direct & indirect R&D.
- .: Industry search has an unambiguously positive impact on innovation, except within high-tech manufacturing where its contribution is less clear
- .: Industry search increases with firm size and R&D intensity
- .: Foreign ownership (inward FDI) has no overall impact on industry search
- .: Domestic multi-nationality (outward FDI) has a positive overall impact on industry search
- .: National funding increases industry search in technology leader countries, but reduces search in other country groups
- .: EU level public funding decreases industry search

Science search

- .: Science search has an unambiguously positive impact on innovation, except in low income, low R&D countries.
- .: The marginal effects of science system search are distinctively higher in high-tech manufacturing industries and knowledge intensive services than in other industries; and stronger in large countries than in small
- .: Science search increases with firm size, while the impact of R&D intensity is weak.
- .: Foreign ownership (inward FDI) has no overall impact on science search, but does have a positive impact among technology leader countries
- .: Domestic multi-nationality (outward FDI) has no overall impact on science search but does have a positive impact for firms in technology leader countries
- .: Both EU and national funding increases science search.

In all European countries covered by our data, there are a large number of programmes that provide support to firms' knowledge development and accumulation. Tools that aim at supporting R&D activities can be distinguished into direct measures like R&D grants and loans and indirect measures, for example tax incentives and guarantees. Direct support measures can be further differentiated into horizontal measures that are not bound to a specific field of research, such as the "Research vouchers for SMEs" (Denmark), "SkatteFunn" (Norway) or "SME innovative" (Germany)) schemes, and measures that are closely connected to research activities targeted at specific (key/enabling) technologies, such as "Advanced Metals Technology" (Finland) or "Innovation programmes" (Netherlands). Indirect measures like R&D tax credits or tax incentives belong for the most part to the group of horizontal tools, as they tend to be non-discriminatory across sectors of activity. While most of the R&D promoting tools are designed to increase already existing R&D activities of firms, only a small minority of tools aim to stimulate R&D activities of firms that did not perform any intramural R&D in the past.

It is well established that search patterns should extend beyond existing value chain and collaborative linkages; and that efforts to broaden search interfaces are contingent on the informal networks into which a firm already is linked. The assimilation and adaptation of new knowledge may be hampered by employees sticking to obsolete mental models, by applying old and outdated theories applied and by maintaining a lack of mental and cognitive flexibility (Baker & Sikula 2002; Sikula 2002). Both factors can be addressed by policy instruments that promote the employment of highly educated personnel, and by policy measures that facilitate the mobility of researchers between the science system and industry. Annex 14 provides details on such initiatives at the individual country level. Such mobility flows generate informal networks which are known to function as information diffusion channels long after the mobility event itself (Ebersberger, Herstad & Lehtoranta 2011; Huber et al. 2010). Other important measures would be the construction of regional information ecologies, notably through cluster and centre initiatives in which a diverse range of actors are involved (Asheim et al, 2007), where local informal information flows are allowed to feed on the international networks maintained by individual actors. This seems even more appropriate as labor mobility—which in this line of reasoning is a major driver for knowledge diffusion—is recognized to be geographically rather sticky.

As patents are used by the business as well as the science sector, they support both the industrial and the science mode of search. One often overlooked and underdeveloped function of the patent system is that it can promote the dissemination of technology by disclosing details of the patented invention. In this context, the implementation of a common EU-wide patent by 2014 as planned by the EU 2020 strategy (European Commission, 2010, 546: 23) may improve search conditions if the advent Community Patent stimulates new knowledge spill-overs. Evidence shows that the passive role of the patent-system in disseminating technological knowledge is currently very limited. Internationally, policymakers are now investigating ways to improve the application of disused IPR among new user groups. Given the importance of search and the richness of patent-information, this area should be further pursued in Europe. A complementary way to promote patent-based linkages is through third-party mediated markets for IPR. The advent of ‘markets for patents’, based on auctions and other third-party mediated deals, have been much touted in the US, especially by Chesborough (2006). Some approaches already found at the national level to link IPR holders with potential users include in Wallonia (“ACQUITECH”), Denmark (patent exchange) or Germany (“Patent Information Centres and Thematic Information Centres”). Apart from this, the EU also runs the instrument of "Enterprise Europe Network (EEN)" which offers support in identifying (international) partners by providing access to business database that allows for target- and knowledge-oriented matching of collaboration partners.

At the EU level, the most important instrument for promoting industrial and science search activities today is the Framework (FP) and Competitiveness and Innovation (CIP) programmes. The Framework Programme is composed of four pillars: the "Cooperation" programme, the "Ideas" programme, the "people programme" and the "Capacities" programme). The "Cooperation" activity is the largest one in terms of monetary resources (approx. 32 million Euros) and aims directly at establishing stronger ties between different actors within the European innovation system to support and strengthen research in ten policy-defined themes. Moreover, the "Capacities" programme addresses search activities through its target to optimise the use and development of research infrastructures and to strengthen the ability of SMEs to benefit from research (EU 2006, L412: 3). The second main European policy instrument which addresses search activities in the industrial and science system is "The Competitiveness and Innovation Programme (CIP)". It integrates several existing, sometimes quite specific programmes supporting competitiveness and innovation into a common framework to close the gap between research and innovation by promoting all forms of commercialisation, particularly in terms of the needs and participation of SMEs (EU 2006, L310). As the European Union has no taxing authority, indirect measures like R&D tax credits or tax incentives remain reserved for the Member State level.

The majority of existing policy measures at the European level that address the search activities of firms still focuses on the "supply-side" or "science-based" dimension of innovation, and are biased in favour of research excellence more than innovation relevance. They tend to focus on knowledge transfer and collaboration between the business and science sector. These instruments are strongly in line with the prevailing nature of policy instruments at the country level which also emphasize rather narrowly defined linkages between the science and industry sector and thus science search. Support initiatives that are explicitly targeted at search activities along the industrial value chain (suppliers, customers) or at specific constellations of value chain partners are rare at the European level today. One exception is the "EUREKA" initiative founded in 1985 (EC 1985) which seeks in part to complement the mission- and excellence oriented characteristic of the programmes mentioned above by supporting the market-oriented development and application of innovative products, processes and services along the economic value chain.

EUREKA does not provide direct funding. Rather it supports partnering and access to foreign markets, and project partners have to apply for national or other funding separately. Moreover, even the EUREKA measure puts strong emphasis on industry and science cooperation and thus on science search activities. Another more recent measure to address the demand-side of innovation was launched by the "Lead Market Initiative" (European Commission, 2007, 860). Under the label of "complementary instruments", it pursues the objective to "accelerate and improve the interactive flow of information between suppliers and users, thus contributing to improve market transparency" (European Commission, 2007, 860: 8). In addition to the supply of thematically targeted support laid out by the Structural Funds of the CIP-Programme, the lead market initiative attempts to coordinate the use of networking projects and industry platforms for "mutual learning and knowledge-sharing" to "speed up the flow of ideas and knowledge" between knowledge-based clusters across Europe (European Commission, 2007, 860: 9).

Key policy issues and trends – search

Raising industrial R&D intensity and supporting firm growth is conducive to broader screening of information from the science and business environments. Foreign ownership (inward FDI) has no notable direct impacts on search, whereas affiliation with a domestically-based multinational corporate group impacts industrial search positively. Consequently, foreign ownership neither increases nor decreases the use of affiliated firms of external information. This is an important observation if European countries attempt to attract foreign investment under the assumption that it will bring a broader use of external knowledge from abroad. Our findings do suggest that affiliation with a multinational corporate group has such broadening effects. This however is related to the outreach of the affiliate's own or its parent group abroad (outward FDI) rather than foreign ownership. Consequently, from the perspective of innovation system construction, inward FDI is no substitute for domestic competent capital.

Our analysis only captures the added effect of various policy initiatives on innovation performance indirectly. It does so based sole on information on funding in general. In this sense, our findings reveal that the direct impact of **national funding schemes** is largely one of broadening both industry and science system search. When we split the sample, we see that the positive impact on science search remains while negative effects on industry search are found in the case of certain country groups. This clearly warrants policy attention. EU funding does not appear to compensate for this reallocation of attention. On the contrary: the impact of **EU funding** is most distinctively seen in the form of a reorientation of search away from customers and suppliers (industry search), towards research institutes and universities (science search). This means what while EU funding, serve to strengthen university-industry linkages in accordance with defined objectives, it weakens the perceptiveness of firms towards information from industrial sources – presumably those outside project consortia. This effect is most distinct for small (<21 employees) firms. It is problematic for several reasons. The most general concern here is that the ability of the firm to identify market opportunity is directly related to the effort put into innovation and the likelihood that this effort might translate into innovation success.

There is therefore reason to welcome elements of the Innovation Union initiative, including the discussion of how to create a more innovation friendly market within the union, how to address the growing concern about how to mobilise SMEs and support non-technological innovation, and how to emphasize the stronger, more explicit emphasis on innovation, value creation and employment growth. There are also grounds to **emphasize more strongly the exploration of the industrial competence base of the Union.**

As part of the Flagship Initiative called "Innovation Union", a "European Design Innovation Initiative (EDII)" to be launched in 2011 that is meant to bring together actors from various backgrounds including the business sector, higher education, designers and national as well as regional agencies promoting design and innovation (European Commission, 2010, 546; DG Enterprise and Industry, 2011). Industrial design can be important for the user-centred aspect of open innovation in as much as it links creativity and innovation. Industrial design helps shape creative new ideas into usable and practical forms that can contribute to increased competitiveness (think of the iPhone effect). Hence, design is a paramount example for industry search as it involves a multi-disciplinary approach that is centred on user´s needs and requirements. This process typically brings together different perspectives and areas of expertise, both from technological and non-technological backgrounds. It can also complement R&D activities and can be important for mature sectors and firms with low R&D investments (European Commission, 2009, SEC 501). While the topic of design has been addressed in various European policy initiatives in the past, it has not been an explicit part of the Commissions innovation strategy before the EU 2020 Strategy.

The European Union is striving to generate a fully functioning European Research Area by 2014. The overall target is to remove obstacles to mobility and international collaboration. A major focus is to create incentives for international mobility of researchers. An effort to establish internationally compatible career structures is one initiative whose aim is to reduce uncertainty around educational and vocational qualifications. Cross-border public research organizations (PROs) and funding agencies will support and offer academic and research opportunities which do not have geographical limitations. This approach is certainly backed up by the empirical findings as by and large multi-national environments are found conducive to search activities (see 9.3.3 and 9.4.4) and consistent with Huber et al. (2010) where research infrastructure and the research environment are driving factors for international researcher mobility. However, the fact that researchers are tied to geographical space by their social networks, by their family networks and by cultural and language preferences through life satisfaction of family members (Huber et al. 2010) means that efforts will only be successful in the long term and only in the case the family needs of researchers is appropriately taken care of. Consequently, information diffusion networks that follow on from the mobility of individuals will remain most intensive within regions. Additional mechanisms such as 'loose' industry collaboration projects and virtual centers with strong industry participation are important for the amplification of industry information and for sharing networks at the level of the union.

Relatedly, it is increasingly argued that cross-sectoral technology flows are becoming ever more important in innovation. For instance, the Commission argues that "firms in traditional sectors are far more likely to find innovative growth by forming new linkages and applying new technology to their existing products and services. This can be facilitated by opening the clusters to cooperation with and learning from other clusters in the same or other sectors" (European Commission, 2010, 546: 22). Thus, policy approaches are being developed to promote the potential for greater cross-fertilization between sectors, including traditional manufacturing sectors and SMEs (European Commission, 2010, 614). This suggests that broad industrial search is becoming more central to industrial dynamics as a whole. Hence, business networks, centers and other schemes that seek to mobilize industry on a broad basis for the purpose of creating new information sharing networks are increasingly important as innovation policy supplements to traditional supply-side policies. In this environment, it becomes even more critical to balance between the attention paid to the science system and attention paid to seeking out new opportunities on the industrial side.

12.3 Collaboration

As in the analysis of search, the analysis of collaboration shows that the implementation of external collaborative strategies has a positive impact on innovation – and that this implementation is determined by internal competences. This is again supported by the positive impacts of firm size and R&D intensity. Consequently, our empirical evidence again contradict the notion that a strong emphasis on the build-up of internal capacity results in 'closed' innovation processes, as suggested by Chesbrough (2003). This means that policies that strengthen the internal competence bases of firms more broadly, and that increase R&D activity in particular, are also policies which strengthen the ability of firms to engage in innovation collaboration.

Our analysis indicates that collaboration patterns can be described in terms of their diversity and that the ability of firms to maintain diverse collaborative linkages is conducive to innovation. In exploring the geographical dimension of collaboration, our analysis distinguishes between vertical (customers & suppliers) and science system (universities and research institute) linkages domestically and abroad. We find that it is generally international vertical collaboration that has the most distinctly positive impact on innovation at the level of the firm. We show that national public funding schemes is linked to domestic collaboration in the value-chain. However, we find only weak if any positive impacts from national vertical collaborative linkages that have been emphasized by Porter's cluster concept (Porter, 1998) and by early contributions in innovation studies (Lundvall, 1992). By the same token, we find that national science system collaboration does have a positive impact and that this impact is relatively stable across different firm and contextual conditions. But the international science system collaboration nurtured by different EU level policy initiatives and funding appears not to have any notable impact on any of our performance variables – except in small countries. Notwithstanding, national and EU public funding both increase the overall collaboration breadth of innovation active firms. This raises the question of the extent to which the predominant impact of existing EU funding schemes is to incorporate science system actors into collaboration networks already (largely) determined by firm characteristics and by prior search activities. This begs the question of what the 'real' behavioral additionality of EU funding is, especially in light of the negative impact that this funding has on industrial search (see above).

Collaboration diversity

.: Collaboration patterns are most diverse in the most advanced European economies and in medium high-tech and high-tech manufacturing

.: The diversity of collaboration by and large increases innovation success significantly.

.: Overall, the diversity of collaboration increases with size, R&D intensity, and the multi-nationality of the parent group (foreign owner or domestic multinational)

:. The impact of national funding on collaboration breadth is highly contingent on country size and type as well as on firm size and sector group. Overall, the impact is positive.

.: EU funding has an unambiguously positive impact on collaboration

Vertical collaboration

.: It is predominantly international vertical collaboration that has a positive effect on innovation

.: Firm size primarily affects the likelihood of national vertical collaboration

.: The likelihood of international vertical collaboration increases with increasing R&D intensity and multi-nationality of the parent group. The impact is more consistent for domestic multi-nationality (outward FDI) than for foreign ownership (inward FDI).

.: National public funding only increases the likelihood of national vertical collaboration.

.: EU funding has an overall weak, positive impact which is highly sensitive to firm and country contextual conditions.

Science system collaboration

- .: National science collaboration exerts a positive effect on the innovation success relative to no science collaboration.
- .: Only in small countries do we clearly observe that international science collaboration is superior to national science collaboration, which in turn is superior to no science collaboration at all.
- .: The likelihood of science system collaboration (any geography) increases with firm size. R&D intensity increases the likelihood of international science system collaboration.
- .: Foreign ownership has a positive impact on international science system collaboration in technology leader and user countries. In large countries, it has a negative impact on national science system collaboration
- .: Domestic multi-nationality has an overall positive impact on science system collaboration conditional on country and firm characteristics.
- .: National funding has a positive impact on national science system collaboration
- .: EU funding has a positive impact on international science system collaboration

Internationalization of the collaboration network

- .: The internationalization of the collaboration network has an overall positive impact on innovation. Yet, this impact is primarily present in small countries; and in high-tech manufacturing or knowledge intensive services.

As demonstrated in Annex 14, most national policy instruments that aim to promote collaboration place strong emphasis on linkages between industry or business actors and basic or applied research organizations. The policy measures that explicitly aim at the downstream aspect of lead market construction or lead user involvement are scarce. Some examples are found in the Nordic countries. There is a Danish program ("Programme for User-driven innovation") that aims at building on the input of customers and citizens to make Danish companies and public institutions more innovative; there are two Norwegian 'Research and Development Contract' schemes that explicitly target advanced public procurement projects or industrial customers, not least international lead customers; there is a Finish programme ("Strategic Centres for Science, Technology and Innovation (SHOK)") in which companies and research units work in close cooperation, carrying out research that has been jointly defined in the strategic research agenda of individual centres in which stakeholders, including those that utilize the research results, participate into the decision making related to future R&D agendas.

At the EU level, the Lead Market Initiative launched in 2007 builds on the recognition that European demand side limitations constitute large barriers to the ability of member countries to transform a strong research base into innovation, value creation and employment (cf. the Aho group report, 2006). Policy measures that explicitly try to strengthen broader linkages between multiple socio-economic actors remain scarce. This impression is supported by our finding that EU funding – somewhat paradoxically – does not contribute in relative terms to international vertical linkages. More work is needed if the Union is to exploit the innovation potential inherent in its diverse industrial competences. In general, the EU follows the main tendency of the innovation policies of Member States to focus primarily on cooperation structure between actors within own territorial boundaries. To date, there are no special funds directly dedicated to the formation and intensification of international innovation or knowledge sourcing activities – by firms within the EU, targeting actors and communities outside it (Reinstaller et al., 2010). This problem is also addressed by the EU 2020 strategy. Based on the objectives raised by the "Small Business Act (SBA)" (European Commission, 2008, 394), the Commission plans to present a strategy within the frame of EU 2020 to strengthen the support of SMEs regarding their internationalization efforts (European Commission, 2010, 614). (see also below: "Enterprise Europe Network (EEN)" or the "China SME IPR Helpdesk").

The EU 2020 strategy raises other potential ways to enhance third-party collaboration beyond the boundaries of the EU. One area that is mentioned involves public procurement. This can act as a vehicle by implementing joint procurement between different entities. This is proposed by the Flagship Initiative Innovation Union (European Commission, 2010, 546), an improvement of the conditions for attracting leading academics and researchers to Europe or the facilitation of science and technology cooperation with countries outside Europe by offering "equivalent protection of IPRs, open access to interoperable standards, non-discriminatory public procurements, and removing other non-physical barriers to trade" (European Commission, 2010, 2020). However, these supports to internationalisation activities of the business or science sector outside the EU are still mainly built around more indirect instruments designed to improve general infrastructure. Dedicated policy instruments which directly target internationalisation strategies beyond the boundaries of the EU are, however, not raised in terms of a corresponding guideline by the EU 2020 strategy.

Key policy issues and notable trends – collaboration.

Our analysis of collaboration clearly shows the relevance of considering the balance between broad and narrow interaction patterns, between national and international partners structures, between intra-sectoral and inter-sectoral networks of external linkages. Overall, our evidence suggests adjusting the balance of EU programs and funding so that it to a much larger degree supports the formation of international industry-industry linkages, within the EU to capitalize on the diverse industrial capabilities already present – and outside to broaden the ability of member countries to tap into industrial capabilities not found within the EU. Preferably, such initiatives should be linked to efforts to increase EU-level industrial search and information diffusion in general and to the construction of a more innovation-friendly market at the EU level in particular. This would serve as complementary to the industry-science linkages nurtured by member country policies.

The EU 2020 strategy itself is characterized by a stronger emphasis on supporting heterogeneous linkages between different actor groups to promote knowledge transfer and diffusion. This is for instance reflected by the measure of the "European Institute of Innovation and Technology (EIT)" (European Commission, 2010, 546) financing support structures for knowledge transfer and networking by funding virtual "Knowledge and Innovation Communities (KICs)" and supporting business-academia collaborations through the creation of "Knowledge Alliances". Moreover, the new approach of "European Innovation Partnerships (EIP)" will focus not only on technological aspects, but also on societal effects and implications for the entire innovation chain, value chain and markets. European Innovation Partnerships aim at tackling societal challenges that are of high relevance for Europe in general and justify government intervention. By bringing together all key stakeholders relevant for a specific innovation area, European Innovation Partnerships should be “platforms for open innovation and citizen engagement” (European Commission, 2010, 546).

In 2011, the European Commission presented a **Green Paper** which proposes major changes to EU research and innovation funding to make participation easier, increase scientific and economic impact and provide better value for money. The paper raises numerous issues which are perceived as important to the development of a **Common Strategic Framework** for research and innovation; it apparently marks yet another shift towards a more balanced view of supply and demand side factors. And it signals a much stronger focus on broad industry mobilization extending into non-technological innovation and SMEs, which reflect the issues of EU funding impact on industry search and international vertical collaboration which we have pointed to above.

12.4 Protection

Although it is difficult to empirically establish cause and effect relationships, our analysis show that the issue of IPR protection is closely linked to innovation performance, based on the introduction of new products. IPR protection in broad terms may serve as an enabler of collaboration at the individual firm level, because it reduces the risk of imitation inherent in collaborative work. At the system level, the codification of inventions into patents serves to create a search space that is visible to other firms. Furthermore, patents can provide the basis for technology transfer through licensing agreements on an ad hoc basis, but potentially as the basis for the possible future emergence of organized markets for IPR.

Protection

- .: Large firms tend to utilize protection strategies irrespective of sector, whereas IPR use among smaller firms is clustered in R&D intensive sectors.
- .: IPR use is most widespread in countries characterized by high levels of R&D use and least widespread in countries characterized as technology users.
- .: The association between IPR protection and innovation performance is unequivocally positive across different types of countries and different industries.
- .: The marginal effect of IPR protection is strong for all measures of innovation performance, including sales of innovative products and the share of those sales on total sales. This suggests that the cost of these strategies do not reduce the dissemination of innovative products
- .: The marginal effect of IPR protection on innovation performance is larger for small than large firms and lower for high R&D intensity manufacturers than in other sectors
- .: The effect of IPR protection on innovation performance is also lower for large countries (contra small countries), and lower for technology leader countries (contra technology user countries).

Annex 14 considers a range of countries with policies that address the use of property rights in general and patents in particular. There are basically two types of policy measures. The first one intends to increase the use of IPR and is usually deployed by countries whose IPR activities are below the average level of the EU and thus obviously face innovation system failures regarding IPR. (see for instance policy measures in Poland, Spain, and Italy). The second group of IPR related policy measures focuses on the information and sourcing function of patents and IPR by promoting cross-licensing and providing informational platforms for IPR exchange (see the examples of Wallonia and Denmark, above). There are also policy initiatives that target specific sectors, such as “The Biotechnology Exploitation Platform Challenge” in United Kingdom, which encourages syndicates of bioscience research organizations and technology transfer units to work together and build portfolios of intellectual property. This illustrates emerging attempts to use IPR protection to promote collaboration and collective competitiveness.

A major initiative at the European level is the intended introduction of an EU patent by 2014. The EU Patent or Community Patent will replace the more costly and timely practice by which the European Patent Office (EPO) allows national patent applications to be extended into the jurisdictions of other (EPC) Member States. The Commission sees this as a major step towards ensuring the protection of intellectual property and enabling a more effective and efficient protection, diffusion, and exploitation of knowledge within the EU innovation system (European Commission, 2010, 546). Other policies proposed at the European level also aim towards improving the efficiency of the patent system in Europe. Access to patent information has for example been greatly increased during recent years. The "Espacenet" initiative of the European Patent Office (EPO) now offers free access to more than 70 million patent documents worldwide, containing information about inventions and technical developments from 1836 to today. A set of 20 national patent offices has joined forces to provide IPR support services to SMEs (see the

"IPeuropAware" programme and its "Innovaccess" initiative). In addition, the "IPR Helpdesk" is an e-module based training for IPR issues and management in the context of EU funding programmes (e.g. FP7, CIP), while the "China IPR - Helpdesk" specifically focuses on training on IPR issues related to China. There are also a range of efforts to take stock of problems (see for example the "IPR Enforcement Report").

In terms of a more direct role that IPR protection plays in a framework of Open Innovation, there are efforts to support sourcing and licensing of new technologies (see "Enterprise Europe Network (EEN)"). There is also a specific policy concern that is current in Europe involves technological standardization. Echoing reform activities elsewhere (see the US FTC document, 2011), European policymakers are exploring policy measures to better align the legitimate concerns of the owners of patented technologies with the overall aim of elaborating successful standards (see section 6.2.3). These policy concerns are evident in Council Conclusions on standardisation and innovation (2008) and the Communication on 'Towards an increased contribution from standardisation to innovation in Europe' COM(2008) 133 final. There are also more sector-specific policy initiatives under review, especially in the area of ICT where difficulties have been most evident. (A Commission White Paper on “Modernising ICT Standardisation in the EU: the Way Forward” (COM(2009) 324 final)). These concerns involve rectifying a range of limitations that are associated with the licensing arrangements (fair, reasonable and non-discriminatory (FRAND)) currently used in the standardization environment. Within the bounds currently set (e.g. competition law and IPR law), the European efforts are addressing ways to make the IPR policies of standards development organizations more transparent, balanced and more sensitive to the different business models of stakeholders. A concern is to promote the timely and accurate level of disclosures by IPR holders of rights which might be ‘essential’ to the elaboration of a given standard. Under consideration are ways to lower collective royalty rates and to reduce overall uncertainty during the development of standards.

12.5 External innovation expenditure

External innovation expenditure is different from search in that it, by definition, entails that the knowledge development is conducted by an outside actor. Our findings align well with other empirical studies which point to problems in coordination and integration, increased costs of innovation and long-term hollowing out of firm competences following in the wake of this activity. At best, our findings give some legitimacy to the argument that external innovation expenditure may compensate for certain other supply side and internal competence weaknesses. This is because the negative impact is not present in small economies where we even detect a positive impact on innovation sales. This is because the negative impact is most distinct for large enterprises (with strong internal competences) and not least because we detect an unambiguous positive impact in those countries which are the farthest away from the technological frontier.

External innovation expenditure

- .: Firms in high-tech manufacturing source a lower proportion of total R&D externally, than do firms in other industry groups.
- .: The overall impact of external innovation expenditure on innovation is negative.
- .: In low-income, low-R&D intensity countries, the impact of external innovation expenditure is positive.
- .: In small countries, external innovation expenditure does not affect innovation success in any way
- .: Firm size increases the the degree of external innovation expenditure of firms, in small countries and technology leader countries.
- .: R&D intensity decreases the degree of external innovation expenditure of the firm; in all size, sector and country groups.
- .: Foreign ownership unambiguously increases the degree of external innovation expenditure
- .: Domestic multi-nationality has no overall impact on external innovation expenditure, but increases such for large companies, firms in medium high tech manufacturing and knowledge intensive services.

The question of policies and funding impact on external innovation expenditure is largely a question of behavioral impacts from other funding schemes. In this respect, issues such as the ability of programs to achieve 'real' collaboration and thus interactive learning e.g. in the relationship between industrial and science system actors, as opposite to establishing relationships which de facto are contractual sourcing of R&D services, are critical – pointing in particular to the importance of collaboration incentive design and implementation. As disentangling this issue requires detailed analysis at the level of individual programs, we have not estimated direct public funding effects on external innovation expenditure. However, we note that policies that increase overall R&D effort of the firm will, by means of the negative correlation with its R&D intensity, serve to reduce its external innovation expenditure. This is likely to be an effect of fixed internal capacity effects reducing the rationale for engaging in external innovation expenditure. This can in turn be combined with increased absorptive capacity strength and scope shifts external relationships away from contract R&D and towards 'real' collaboration. Logically, it follows that all policy measures which aim at strengthening and diversifying the internal competence of the firm serve to reduce its dependence and use of external innovation expenditure. Such measures are found across the board, from tax incentives for intramural R&D to education policy and mobility schemes. It also follows that ill-designed collaboration programs, or programs aimed directly to stimulate external innovation expenditure, may serve to weaken the internal knowledge base of firms. This not only reduces the likelihood of innovation but may increases the dependence of the firm on contract R&D in the next round.

Yet, as we have looked only at the relative size of external innovation expenditure, we have not considered how impacts may be contingent on the content of outsourced development and how this relates to the core competence base of the firm. Nor have we considered complementarities between external innovation expenditure and the firm's other innovation activities, notably internal

R&D, search and collaboration, in a production function setting (see Herstad & Ebersberger, 2010; Kaiser & Grimpe, 2010, Schmiedeberg, 2008, Cassiman & Veugeleres, 2006). Thus, our findings do not in any way rule out the possibility that selective R&D contracting, for example targeting modular technologies or development work well outside the core competencies of the firm, may impact innovation positively. Again, these are questions of qualitative content that are difficult to judge based on innovation survey data alone.

Tools that seek to increase the use of R&D contracting exist at the national level. The most widespread types of policy measures in this field aim either at the provision of technological and strategic services around innovation projects. They entail measures that support firms in getting external expertise in forms of technical and financial feasibility studies or the development of the firms' innovative capabilities and innovation management strategies. These include, "Advanced Technology Group - GTS" (Denmark), "National Competition for Creation of New Technology-Based Firms" (France), "Funding for purchase of innovation services" (Finland), "Stimulating Business Innovation" (Ireland), “Syntens” in the Netherlands, “Business Link” in the United Kingdom, and "Innovation Cheque” in Switzerland.

At the European level, such policy measures explicitly dedicated to support external or contract R&D of firms (e.g. innovation vouchers) do not exist to date. In 2009 the “Support for Innovation” Unit of the European Commission's DG Enterprise and Industry conducted a survey of innovation voucher schemes across Europe to provide a snapshot of the current design and implementation of such schemes by identifying commonalities and distinctive features (European Commission, 2009c). The aim was to assess the potential for establishing collaboration between regional or national innovation voucher schemes in order to open them up to further European cooperation. Our findings on EU funding impact on search and collaboration do raise questions about the extent to which for example framework programme projects entail shifting R&D activities away from industrial firms, towards universities and research institutes.

The EU 2020 strategy plans to grant open access to publicly funded research and smart research information services. The Commission aims to enable easy and – whenever possible – free access to international research results is a measure to make it easier for businesses to draw upon and make use of and better exploit existing knowledge. This can widen and broaden the firm´s ability for knowledge sourcing and enable them to incorporate international research results into their own knowledge development activities (European Commission, 2010, 546).

Key policy issues and notable trends – external innovation expenditure

Sourcing R&D from external actors rather than conducting this R&D internally is beneficial primarily for firms in countries and sectors which are far away from the technological frontier. At the technological frontier, in high-tech manufacturing and technology leader countries, firms conduct a larger proportion of their R&D internally and the impact of external innovation expenditure is distinctively negative. This is in itself sufficient reason to warn against policy measures and funding programs which –intentionally, but often unintentionally, stimulate firms to contract R&D services which should have been conducted internally.

A main recommendation is therefore that policy makers at both national and EU level design their incentives for collaboration in ways that differentiate between the different spatial dimensions and different functional dimensions. An important aim here should be that the linkages result in interactive learning rather than in passive contractual sourcing that entail little if any learning in the focal firm and only limited knowledge transfer for the actors involved. Furthermore, we again note that firm size and R&D intensity serve to shift behaviour in the directions which are most conducive to innovation – away from contract R&D, towards external search and collaboration. Consequently, we have another set of findings which substantiate the argument that the 'traditional' research and innovation policy objectives of increased industry R&D are highly relevant – if not even more relevant – in the era of open innovation.

13. Concluding policy discussion

The networks maintained by individual firms located within a national or regional economy represent the micro-foundations for learning and knowledge embedding at the larger system level. Knowledge development and accumulation at the firm-level enrich the wider economy by laying the basis for labour market mobility and personal network formation and by promoting collaborative ties. Territorial (national, regional) economies therefore represent potential melting pots for on-going experimental diffusion, recombination and transformation of specialized industrial and scientific knowledge. These aspects of open innovation practices have been discussed above in light of the results of the rich and diverse body of empirical and policy information collected in this report. In this final section, we suggest some issues that we think policymakers could focus on.

Firms & economies in the era of global open innovation

The open innovation practices of firms enable them to build on ideas, knowledge and technologies developed by other industrial actors and academic institutions. This is done through activities by which firms inevitably signal, transfer or by other means expose their own knowledge to the surrounding economic environment. The dynamics of territorial innovation systems are thus substantially driven by the open innovation strategies of firms and by the knowledge spillovers that diffuse through labor markets and through personal networks. In order to sustain growth in an increasingly competitive international landscape, these dynamics are more and more dependent on the introduction of novelties from outside – through linkages to other economies, especially those with different patterns of industrial and scientific specialization. Knowledge spillovers are however strongly prone to distance decay-effects; in other words, their effect tends to dissipate the further away the source is. In this light, the existing international collaboration networks of domestic firms are seen as particularly important to the introduction of novelty into territorial systems.

The impact of open innovation practices

The empirical analysis in the preceding chapters showed that open innovation has a positive and robust impact which is largely independent of the measure used to capture it. We found no evidence of the contradictory relationship between internal R&D and open innovation that is suggested in much of the recent open innovation literature. On the contrary, we found that strong internal corporate knowledge bases[1] drive complementary processes of external search and collaboration. In this respect, our findings stand in sharp contrast to the original formulation of the 'open innovation' concept by Chesbrough, which focused heavily on the virtues of external technology sourcing. Such arms-length sourcing – in the form of R&D services and knowledge embodied in machinery and equipment – is shown to at most have a positive impact on innovation performance in those countries that are farthest away from the technological frontier. But in advanced countries— and in demanding sector groups— our analysis shows that external technology sourcing may actually undermine innovation and competitiveness, in accordance with the logic of hollowing out of competences.

[1] i.e. as measured directly R&D intensity and indirectly by size and sector classes.

The geography of open innovation practices

We also found that the degree— and the nature—of corporate internationalisation matter. Here, we emphasized the distinct impact that one type of linkage in particular has for innovation performance; this is the set of linkages that a given firm has with industrial partners in other countries. It is possible to build up this type of international industrial network within the EU in such a way as to capitalize on the diverse industrial competences and capabilities that are already present in its member and associated states. As the policy review indicated, there is scope for EU level innovation policies to look into further ways to exploit the innovation potential that exists at the interface between these diverse industrial competences. By the same token, it is to be recognized that the potential positive effects of industrial linkages that extend to third countries may be even stronger. Efforts to further link Europe to innovation networks that extend into emerging economies such as India and China may therefore be worth exploring further from this point of view.

The report supports the view that affiliation with a multinational corporate group affects firm behaviour. The indication here is that it does so in a different way than that which is widely assumed in strategies to attract inbound FDI that have been implemented by many if not most European countries. Affiliation with a multinational parent group as such links the individual subsidiary to collaboration networks abroad. But whereas foreign ownership is associated with symptoms of hollowing out of their European subsidiaries, the affiliation with a *domestic* multinational does not show such symptoms. For the European Union as a whole, there is clearly little reason for concern about the impact of foreign ownership based in other European countries. To the contrary, in fact. But there are concerns about possible threats of hollowing out and of branch-plant syndromes that might stem from FDI inflow into the EU from non-EU countries. These concerns find some support in our results. The analysis also suggests that there are opportunities in non-EU countries that might be realized in conjunction with outward FDI. This has apparent implications for the policy emphasis currently placed on attracting external FDI. In terms of innovation performance, the case can be made that such an emphasis might be considered against whether—and to what degree—supplementary, long-term policies should be implemented to strengthen the ability of European economies to branch into countries such as China, India, and the US by means of outward FDI. That said, such initiatives would assumedly fall partly within the realm of innovation policy as traditionally defined and partly within the realms of industrial and financial market policies more broadly.

The complementarity between policy tools

The results of the report fit well with the policy assessment framework that was selected and introduced in earlier in the report. Based on Herstad et al (2010), the first set of instruments (Set 1) was grouped around the argument that the embedding of firms within territorial systems is crucial for the ability of these systems (regional, national) to harness spillovers from global linkages and intramural R&D. The second set of instruments (Set 2) focused on the interactive dimension of innovation activities that involve the complementarities between activities that take place within the firm and its networking activities. The third set of instrument (Set 3) involved geographical level linkages. These help define the exposure of the territorial innovation system to novel technologies and knowledge from outside (international linkages) and condition the ability of the system to effectively redeploy and create novelty from specialized industrial and academic capabilities already present within.

First and foremost, the analysis indicated that Set 1 instruments remain critical even in the era of open innovation. By focusing on the build-up of competences and R&D activity *within* corporate enterprises, they contribute to the embedding of firms and increase the flow of spill-overs stemming from them. They also strengthen the ability of individual firms to successfully engage in external search and collaboration. Lastly, they compensate for the individual firm incentive to 'free-ride' on knowledge externalities produced by other firms— an approach which is described as a best corporate practice in much of the management literature on open innovation. Set 1 instruments are therefore important not only for the ability of individual firms to participate in the game of open innovation; but also to ensure that the game itself is sustainable and results in long-term socially desirable outcomes at the aggregate level of economies.

These instruments may take on many forms, which range from traditional direct (cash funding) or indirect (tax incentives) support for corporate R&D, and well into market initiatives of both carrot (lead markets) and stick (regulation) types. A common element of these Set 1 instruments is that they help raise the long-term R&D capacity of firms and thus to strengthen their own build-up and utilization of specialized knowledge. This makes these policy tools distinct from initiatives that seek to raise industry *funding* of R&D that is conducted elsewhere e.g. by universities and research institutes. The EU's current emphasis on complementing supply-side policies with demand-side lead-market initiatives appears apt in light of the dynamics of industrial innovation that are observed. For example, the provision of incentives for industrial firms to build new knowledge and products upon the strong science base already present is congruent with concerns raised in the analysis above (for a detailed review of set 1 tools at the national and EU level, we refer to Annex 14).

Set 2 and set 3 policies were argued to be important supplements to Set 1 instruments. This is because they reinforce processes of diffusion and experimentation within the territorial economy while contributing to building linkages outside it**.** Because our empirical analysis directly captured how public funding at national and EU levels affect open innovation practices, it may be used to indicate whether the different types (EU and national) tend to have different impacts on the innovative firm. Both forms of funding tend to increase collaboration diversity, for example in terms of the balance between broad and narrow linkages. Yet, there are apparent differences that may raise concerns. For example, the empirical analysis suggests that EU funding tends to affect collaboration diversity largely by adding science system partners to industrial collaboration networks that have already been developed. If this is the case, the impact of EU funding schemes on the formation of new industrial collaboration networks may be limited.

The analysis further indicates that EU funding has a distinctly negative impact on industrial search. This suggests that either EU programs tend to draw the attention of funded firms away from information and knowledge that may be available in the industrial domain, or that they tend to favour science-oriented firms. This negative effect on industrial search becomes more pronounced given that EU funding also appears to have little if any impact on the likelihood that a firm will engage in international collaboration with customers or suppliers, an activity that does impact innovation and opens up the host economy to inputs from outside (OECD, 2011). These results serve to question the role that such funding schemes have on the exploration of technological linkages across European firms. On the other hand, EU funding is observed to increase international science system collaboration. A question that emerges in this context is whether this apparently positive effect comes at the expense of industrial linkages. This may imply that there is an overemphasis on industry-science linkages. Further analysis of the policy balance between industry-industry and industry-science linkages is however called for before a firm conclusion can be reached.

National funding schemes, by contrast, have a distinct bias in favour of innovation collaboration between domestic users, producers, and suppliers. Their impact on innovation is however ambiguous. The impact of national funding on domestic science system collaboration is also ambiguous, despite the fact that its impact on innovation is generally unambiguous and positive. This means that neither form of public funding has a clear-cut impact on open innovation behaviour associated with innovation at the firm level, or on the behaviour which most easily translates into technology transfers from abroad**.** This indicates the need for careful consideration of what should be the main behavioural focus of national versus EU level policies; including the complementary relationship between the two with respect to the geography and functional dimensions of search and collaboration.

Conclusions

The European Union is made up of countries with a diversity of industrial competences and capabilities. Its underlying heterogeneity helps make the EU a potentially unique arena for open innovation processes. This study has indicated some areas of innovation policies at the level of member states and of the Union where adjustments may help to realize this potential. On this basis, some of the implied implications have been briefly discussed in this chapter. It argued that future innovation policies may be thought of in terms of three “Set” instruments.

In terms of Set 1 instruments, the embedding of firms within territorial systems was again seen as crucial for the ability of these systems (regional, national) to harness spillovers from global linkages and intramural R&D. In light of our results, we highlighted that innovation policies designed to promote open innovation would be those that are effective in mobilizing industry more broadly– including SMEs and non-technological innovators – into stronger *intramural* R&D and knowledge development efforts.

In terms of Set 2 instruments, the interactive dimension of innovation activities was again seen to involve the complementarities between activities that take place within the firm and its networking activities. In light of our results, we highlighted that open innovation policies might better be directed to encourage socially beneficial effects of intra-industry linkages that could capitalize on interactions between diverse knowledge bases. The empirical work indicated a possible effect that these activities may be crowded out or otherwise undermined by the current policy emphasis on science-industry linkages. If this is the case, there may be a case to relax requirements of science system involvement in industrial RD&I programs and to make a clear distinction between such programs and other funding schemes.

In terms of Set 3 instruments, geographical level linkages were noted to help define the exposure of the territorial innovation system to novel technologies and knowledge from outside (international linkages) and condition the ability of the system to effectively redeploy and create novelty from specialized industrial and academic capabilities already present within. In light of our results, we highlighted the danger that linkages between EU countries may draw attention away from the evolving landscape of technology and talent outside Europe. Thus, we highlighted that open innovation policies might better focus on the establishment and maintenance of innovation network linkages, not only towards traditional scientific strongholds such as the US but also towards new and potentially dominant global players such as China. Successful policies here can be instrumental in building on the EU's position as a gravitational hub for industrial knowledge flows in the global economy.

PART V: Appendix

14. Appendix: Overview on innovation policy measures addressing open innovation at the national and European level

14.1 Policy Assessment Framework

Within the concept of open innovation, firms basically fulfil two roles. Firstly, firms serve as knowledge developers and providers to the larger territorial economy in which they are located. This role is exercised by means of their own internal R&D activities linked to search, sourcing and collaboration networks which may – and often should - extend far beyond the boundaries of their territorial economy (Bathelt, Malmberg, and Maskell, 2002; Giuliani and Bell, 2005; Owen-Smith and Powell, 2004). Secondly, externalities from private sector R&D is a key determinant for new firm formation and for structural change (Acs, Braunerhjelm, Audretsch, and Carlsson, 2009; O'Sullivan, 2000). Such externalities contribute to the economy's common stock of (technological) knowledge which in turn builds the basis for open innovation strategies of established enterprises. The social value of knowledge is not captured unless it is diffused to potential user groups, with perceptiveness towards the existence of relevant knowledge externally and the internal capacity necessary to absorb it. The second function of firms to ensure that the economy uses, and thus capitalizes on, those knowledge assets which are already present within its realm. This is the role emphasized in the original formulation of the open innovation concept (Chesbrough, 2006a; Chesbrough, 2006b). Yet, it cannot be understood independently of the first role, as it assumes the existence of firms which actively develop new knowledge and make this available intentionally (through collaboration and external technology commercialization) and unintentionally (through spillovers). Simply speaking: not everybody can replace own R&D with the patented outcomes of other firms' R&D nor reduce own knowledge spillover production by tapping into the spillovers produced by everybody else. Firms' individually rational behaviour in the fashion of Chesbrough's recommendations will inevitably lead to socially inefficient results which – using the traditionally accepted line of argument about the market failure (Klein Woolthuis, Lankhuizen, and Gilsing, 2005; Blankart 2008).

Due to this dual role of firms, a European innovation policy in an era of open innovation does not necessarily equal policies promoting open innovation practices on the level of sectors or member state economies. This is also clear from the previous work on open innovation which has struggled with translating the concept into policy advice (OECD, 2008; Herstad et al., 2008) without normatively promoting the activity of open innovation for its own sake, and which does not entail replicating the highly idiosyncratic labour markets and financial systems found in the U.S. (e.g. Jong et al., 2008). Secondly, it holds the option open for the fact that public policy may be biased against or in favour of various forms of open innovation which may or may not be conducive to innovation at the firm level and long-term growth at the economy level.

This discussion points to the need of innovation policy to balance different categories of tools by considering their complementary effects on the desired outcome; not open innovation per se, but sustainable, territorially embedded industrial knowledge development and innovation processes.

Put simply, the challenge for policy is to support the domestic embedding of internationally linked industries, which develop specialized knowledge through these linkages that spills over into their surroundings and by the way of diffusion is recombined and transformed.

In order to take this aspect into consideration, the following overview on existing policy measures addressing open innovation at the national and the European level as well as the discussion about future perspectives laid out by the new Europe 2020 strategy will be based on the policy assessment framework suggested by Herstad et al. (2008), and later published in Herstad et al. (2010). According to this, European innovation policy must take as its point of departure on the specific open innovation profiles and policy traditions in its different member states. After accounting for differences caused by the sectoral composition of industries, and different levels of overall economy development, policy must carefully balance between

a) Providing incentives for **domestic industry knowledge development and accumulation**, for the purpose of building absorptive capacity and ensuring a potential for spillovers
   Securing **well-functioning networks within territorial economies** to allow accumulated knowledge to diffuse and recombine, potentially facilitating external technology commercialization...
   ...either through **narrow linkages between industry and specific actor groups** (such as customers or universities) or through **broader collaborative networks** which include various actors and actor groups
b) Promoting the **formation of international linkages** for knowledge sourcing and information exposure

When adapted to the European level, c) translates into a need for linkages outside Europe and b) into the need for strong internal linkages and coordination mechanisms which enable the diversity of knowledge available within the Union to be exploited by its member firms and harnessed for growth by its member economies.

Excessive emphasis on a) may lead to the problems of ‘closure’ described by Chesbrough, by which individual firms become pockets of knowledge unable to contribute to and capitalize on opportunities available externally. This in turn means that available knowledge is not exploited fully by the surrounding economy. Excessive emphasis on d) may cause the problems of territorial innovation system ‘hollowing out’ pointed to by the OECD (2008), in that strong incentives to engage in R&D and innovation activities abroad reduce the production of knowledge spillovers at home. Thus, d) must be balanced by a), as the latter provide the necessary anchoring points to the home economy and contribute to building home absorptive capacity. Lastly, excessive emphasis on b) may over time lead to reduced dynamics because of the lack of knowledge externalities from a) intramural industry R&D, and technological ‘lock-in’ due to a lack of c) international networks (Narula, 2002). Yet, this is less a danger within the European Union than within individual member states. This means that the balancing between involving b) and d) will have to play out differently at the level of the Union as a whole, than within its individual member states.

Considering then c), the balance between narrow and broad linkages. Recent empirical work suggests that innovation is...

- ...stronger associated with the ability to use different information sources (Laursen and Salter, 2006), than with the intense use of specific such sources (e.g. customers or the science system).

- ...stronger associated with the ability to integrate different forms of knowledge (Berg-Jensen et al., 2007) than the use of either science-based knowledge or tacit experience-based knowledge.

- ...stronger associated with the ability to link up with different collaboration partners, than the ability to interact intimately with specific partner groups.

Particularly, the latter points to the complementary functions served by different information sources, actor groups and forms of knowledge in the innovation process, and how open innovation cannot be understood only within the context of specific forms of interaction, involving specific actor groups.

Of course, these policy dimensions are not mutually exclusive at all, but rather closely interconnected and need to be balanced both on the national and the European policy level. The question of policy thus becomes a question of establishing complementarities between the set of tools and initiatives, and between the different objectives of different tools and initiatives (see Herstad et al., 2008; Herstad et al., 2010, for more elaborate discussions). For instance, there are various means available to increase industry intramural knowledge development activities, among which direct (subsidies) or indirect (tax grants) fiscal support are but two rather narrow although highly relevant examples. In Norway, tax grants targeting primarily SMEs have been shown to have a very positive impact on firm investments in and strategic awareness of knowledge development (Cappelen et al., 2008). Other, more indirect ways include industry PhD schemes and - importantly – the establishment of incentives at the demand side in the form of regulations (i.e. environmental), public procurements or committed 'lead market' initiatives.

The overall aim of this policy analysis is to provide an inventory of existing innovation policy instruments in the light of open innovation both on the level of national European countries and on the European level. It will be shown to what extent existing innovation policy funding measures address and cover the four main dimensions laid out be policy assessment framework, and how these dimensions are balanced on national and EU level. However, it is not the purpose of this policy analysis to derive concrete policy implications or recommendations on which instruments should be strengthened to achieve certain effects or outcomes. Instead, policy recommendations and implications will be directly derived from the findings of the comprehensive empirical analysis which builds the core of this report (see chapter 11). The open innovation policy instruments presented in this part will then serve to substantiate the policy recommendations and to provide some examples of how policy instruments in certain countries or EU-programmes are already addressing these identified effects.

14.2 Overview on (open) innovation policies in some selected European economies

In this section, we provide a short overview on existing policy measures in 15 European Countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Poland, Spain, Sweden, United Kingdom, and Switzerland). The selection of countries for the policy analysis is based on the existence of relatively elaborate open innovation related policy measures and is therefore not congruent with the selection of countries in the empirical analysis. The policy analysis is drawing on a different set of data and as such is not bound by the same data restriction as the empirical analysis above. In order to obtain a broad overview over different types of national policy initiatives, it seemed necessary to also include those important European countries that have not been part of the empirical analysis - due to unavailability of statistical data. The following policy analysis is based on Trend Chart reports and other policy documents in these countries which were reviewed according to the analytical framework outlined above. However, the present analysis does not claim to provide an exhausting coverage of overall innovation policy or specific innovation policy measures in these countries. Instead, it serves the purpose to draw a general overview of the balance and potential complementarities between different existing policy measures in the light of open innovation.

14.2.1 Industry intramural R&D, knowledge accumulation and absorptive capacity

The policy measures assigned to this category focus on the increase of both the firm internal stock of knowledge through in-house R&D activities, the engagement of highly qualified or academic personnel or other forms of knowledge, and the increase of the commonly shared knowledge within the economy through the stimulation of spillovers and the absorptive capacity of firms. In their seminal contributions, Cohen and Levinthal (1989, 1990) described the "absorptive capacity" of firms as the "ability to recognize the value of new, external information, assimilate it and apply it to commercial ends". The absorptive capacity of a firm can be distinguished by two interdependent dimensions: a) the capability to search and acquire new, external information about technological trends, and b) the capability to adapt internal processes and resource configurations in such a way that their competitive potential is fully exploited (Zahra and George, 2002; Cassiman and Veugelers, 2006; Arbussa and Coenders, 2007). The basic assumption is that those firms which manage external knowledge flows more efficiently, stimulate innovative outcomes and thus obtain superior competitive advantage (Escribano et al., 2009).

Originally, internal R&D has been treated as a primary determinant of a firm's absorptive capacity, which means that absorptive capacity is argued to be a cumulative result of internal R&D activities suggesting that internal R&D capacity and practices of external knowledge sourcing are complementary to each other (Ebersberger and Herstad, 2010; Schmiedeberg, 2008) rather than substitutes (Chesbrough, 2003). Following this line of argumentation, this would imply that firms with low or without any internal R&D activities have a lower absorptive capacity and thus are not as well equipped to benefit from external knowledge sourcing as firms with internal R&D capacities. However, recent contributions have pointed out that factors such as employee vocational and tacit competencies, internal routines, motivation and intra-organizational communication also exert a strong influence on the ability of organizations to assimilate, transform and exploit external ideas and knowledge (Zahra and George, 2002). Against this background, the absorptive capacity of firms rather seems to be a multidimensional construct which encompasses both, technological capacities as well as non-technological firm-internal and external resources (Schmidt, 2005; Spithoven et al., 2010; Murovec and Prodan, 2009).

Both conceptualizations of absorptive capacity converge in recognizing how this capacity is defined by cumulative, internal processes which build up specialized knowledge, the diversity of which directly impact the scope of absorptive capacity and thus dynamic organizational capabilities (Bosch et al., 1999). They are therefore consistent with the so-called resource-based view of the firm, and numerous recent contributions pointing about the role of such cumulative, specialized and multifaceted knowledge development to explain the competitiveness of firms and innovation systems (Jensen et al., 2007; Asheim and Gertler, 2005). Hence, policy measures belonging to this category aim at improving the internal resource (i.e. knowledge) base of firms to either stimulate their capacity to develop new knowledge by themselves, and to adopt external knowledge available by others.

In all analyzed countries there are a large number of programmes that provide support to knowledge development und accumulation. Because of this, the following paragraph tries to group them along their main characteristics and to give some examples of corresponding measures within the countries.

Tools that aim at supporting R&D activities can be distinguished into direct measures like R&D grants and loans and indirect measures, for example tax incentives and guarantees. Direct support measures can be further differentiated into horizontal measures that are not bound to a specific field of research (e.g. "Research vouchers for SMEs" (Denmark), "SkatteFunn" (Norway) or "SME innovative" (Germany)) and measures that are closely connected to research activities targeted at specific (key) technologies (e.g. "Advanced Metals Technology" (Finland), "Innovation programmes" (Netherlands), "Innovation in food" (Sweden), "Call of the National Agency for Research for thematic projects in Sustainable Energy and Environment" (France), or the "Austrian Security Research Programme - KIRAS"). Indirect measures like R&D tax credits or tax incentives also mostly belong to the group of horizontal tools, as they tend to be non-discriminatory across sectors of activity. While most of the R&D promoting tools are designed to increase already existing R&D activities of firms, only a small minority of tools aims at stimulating R&D activities of firms that did not perform any intramural R&D in the past. For instance, the scheme of "Innovation Vouchers" in Austria serves the purpose to turn non-innovators into innovators. Following the example of the "WBSO Act" in the Netherlands, the overall aim is to broaden the base of businesses that undertake R&D by promoting newcomers to R&D. Besides these financial based programmes, the Wallonian measure of "Technological Innovation Manager" aims to encourage

SMEs to undertake R&D and technological development projects by facilitating the recruitment of a specialised innovation manager who works inside the firms and supports them in taking strategic decisions with respect to the launch of a new product, process or service notably by reducing the margin of error and risk. In contrast, many of the R&D support measures across the countries are directly targeted towards the group of start-ups or fast growing firms ("gazelles") that are located in key technology sectors. Examples are "i2 - Business Angel Network" (Austria), "Gazelle growth programme" (Denmark), "Funding scheme for young innovative companies" and "Vigo Accelerator Programme" (Finland), "Aide aux Projets des Jeunes Entreprises Innovantes, JEI" (France), "High Technology Poles" (Italy), and "CTI - start up" (Switzerland).

Beyond the set of measures that are directly aimed at an increase of firms' R&D activities, there is also a broad variety of policy tools focusing on generation of a R&D-friendly framework for firms. Thereby, the most widespread types of policy measures are those aiming either at the provision of (technological, strategic) services around innovation projects or the facilitation of the recruitment of highly qualified, academic personnel respectively training of employees involved in. The first group of tools particularly entails measures that support firms in getting external expertise in forms of technical and financial feasibility studies or the development of the firms' innovative capabilities and innovation management strategies. Examples are "Start-up Funding Initiative" (Austria), "Advanced Technology Group - GTS" (Denmark), "National Competition for Creation of New Technology-Based Firms" (France), "Funding for purchase of innovation services" (Finland), "Stimulating Business Innovation" (Ireland), “Syntens” in the Netherlands, “Business Link” in the United Kingdom, and "Innovation Cheque” in Switzerland. With the latter, SMEs can apply for an innovation cheque of a maximum of €5000, which they can use to buy services at public research facilities. This amount corresponds to up to 12 days of work. In particular it is possible to use the innovation cheque for idea studies, preparatory operations for an R&D project, analysis of the technology transfer potential and analysis of the technical innovation potential in the dimensions process, product, service and technology.

The second group of measures can be characterised by its efforts to place more academically educated in businesses, particularly those with little or no such personnel. "Increasing the number of highly educated in enterprises" is for example one of four target areas of the Danish "Innovation Action Plan" which is reflected by the policy measures of "Knowledge Pilots" and "Industrial PhD Initiative" in Denmark. While the first one provides subsidies to SMEs to hire academic personnel, the second one focuses more stronger on cooperation between firms and universities with a PhD student spending half of his or her time working at the university and half at the firm. The objective is both to increase the number of researchers in the business sector and to educate more business-oriented researchers. Similar programmes can also be found in other countries: "FIRST - enterprise" (Wallonia), "wl1-3d Torres Quevedo" (Spain), or the "CIFRE- Convention" and "CNRS PhD Grants for Engineers" (France). Besides these measure that directly aim at an increase of the academic personnel in the private sector, there are several other policy instruments that aim more broader at enhancing the training and education programmes to build competences vital for business innovation (e.g."Competence Development Programme" in Norway, "Competence Development in Industry" in Sweden, " Training of Research Personal for selected R&D projects -

FPI" in Spain, "Stimulating Business Innovation" in Italy, "CTI Start-up" in Switzerland, and "Learndirect" in the United Kingdom).

These existing policy measures to boost and support intramural R&D and innovation activities of firm in general and in particular vary also in their emphasis on collaboration between different actors within the national innovation system. This point clearly overlaps with the fourth (d) dimension of open innovation discussed above. While a lower emphasis on collaboration underlines the role of internal knowledge and intramural capabilities of knowledge creation and accumulation, measures with a stronger collaborative aspect stronger rely on the aspect of functional diversification across the national innovation system assuming that specific problems can be solved more effectively and efficiently by specialised actors. Collaborative R&D support measures can among other for example be found in Flanders ("The Flemish Cooperative Innovation Networks - VIS), in Denmark ("Knowledge voucher (small scale innovation projects"; "High-tech Networks"), in Germany ("Central Innovation Programme SME"), in the United Kingdom ("Small Business Research Initiative - SBRI"), or in Switzerland ("Discovery Projects"). However, clearly collaborative R&D projects will on the one side also strengthen the internal knowledge accumulation of the participants (Fey and Birkinshaw, 2005). On the other side, such measures also run the risk that what is intended to promote collaborative ventures may end up inducing arms-length contract R&D. Such may indeed solve specific problems effectively and efficiently, but have a very limited impact on knowledge development capabilities on the industry side of the collaboration (Fey and Birkinshaw, 2005), leaving little impact on absorptive capacity and potentially increasing the dependence on sourcing through hollowing out (Novak and Eppinger, 2001).

According to mainstream innovation research, many of the existing financial and non-financial measures to support business R&D activities explicitly (e.g. through the connection with certain key technology areas) or implicitly ("High-tech start-ups") refer to the technological dimension of innovation. However, there is an increasing awareness that innovation encompasses more than only technical innovations like new physical products or technical processes. Hence, an increasing number of countries has adopted such a wider understanding of innovation as for instance laid out in the current edition of the OSLO-Manual (2005) and provide financial funding also in the fields of organisational innovation like new forms of work (e.g. "The Finnish Workplace Development Programme Tykes" in Finland), new channels of distribution (e.g. "Innovation center for eBusiness - IBIZ" in Denmark), creativity as a general enabler of innovativeness (e.g. "INNOFINLAND" and "Innovations in social and healthcare services" in Finland, and service innovation (e.g. "wl2-2a Subprogramme of industrial applied research" in Spain, "SkatteFUNN" and "Incubator grant" in Norway). Among these, especially the field of innovation in (product) design has been gaining importance as it is increasingly seen as an important innovation tool that can benefit business and contribute to increase the competitiveness of trade and industry. This is reflected in certain policy programmes that are directly targeted at promoting the role of design innovations. For instance, the Norwegian "Ice Breaking Measure for Design" pursues the goal to contribute to the increased use of design as a competitive force in Norwegian business life. The grant may be used for industrial or product design, packaging design or development of visual profile or identity of the firm. Likewise, Denmark promotes the greater use of external design services and design-based approaches in firms' innovation activities. "Design Denmark" is a policy initiative by the Danish Government both to strengthen the design industry and to promote the use of design or the incorporation of many of the ideas used in traditional design based sectors across a wide range of industries. In Poland, a survey conducted by the Institute of Industrial Design in 2007 on behalf of the Ministry of Economy showed that only one-tenth of companies develop exclusively new design, while the vast majority introduce and modify already existing ones. Hence, innovation policy in Poland also aims at stimulating design activities of firms ("Investments related to R&D activities within enterprises").

14.2.2 Securing well-functioning national networks

From the perspective of economic growth and knowledge diffusion, the main rationale for supporting the emergence, expansion and intensification of national and regional linkages and networks of socio-economic actors is the recognition that the diffusion of knowledge developed by R&D activities of enterprises may recombine with knowledge developed elsewhere in the economic system, thereby forming the basis for ongoing endogenous process of renewal and growth. Hence, the main purpose of nurturing such linkages and networks is not only to provide innovation support to specific industrial firms, but also to strengthen the evolutionary dynamics of the economic system as a whole by compensating for those system failures which might mediate between knowledge components developed and their potential social returns if recombined (Herstad et al., 2010). Moreover, from the innovation systems approach, bringing together the relevant actors within the system, promoting their interaction and stimulating the knowledge diffusion from public research into the private sector may also serve the purpose to reduce bottlenecks within the innovation process and counteract system failures such as the lack of risk capital, lack of opportunities to commercialise new findings and ideas, barriers of the foundation of new firms (e.g. spin-offs from universities) or the insufficient use of intellectual property rights (IPR).

The characterization by which these national linkages can be described is reflected by c). On the one hand, there is the option to stimulate the formation of centres of excellence which are typically more well-defined in terms of objectives and participants, essentially creating a platform of knowledge diffusion and exchange within specific (technology) areas of research. On the other hand, networks are usually characterised by a broader range of different, often more loosely coupled actors from various fields. Hence, networks are rather designed as horizontal connections of actors not bound to a specific field of technology and whose aims and objectives are often defined to until through the interaction of their members, while centres of excellence in most cases are oriented towards a certain previously defined technological ”mission”. Hence, c) can be considered as a subcategory of b) and should thus be integrated in the overview on policy measures of building national linkages of innovation actors.

Against the backdrop discussed above it is not surprising to find that beside the stimulation of business R&D activities this field accounts for the largest part of national innovation policy measures. All of the analysed countries have recognised the value of creating and fostering forums, platforms, and networks for knowledge diffusion and bringing together the relevant actors in the innovation process. To start with the innovation policy measures that are aimed at broader networks of multiple socio-economic actors, Table 64 presents a small compilation across some European countries.

Table 63 Selected innovation policy measures on the national level that aim at the emergence, intensification and promotion of network relationships between multiple actors in the innovation system

(Source: TrendChart Country Reports 2009; own compilation)

Belgium	”Competitive poles” – one of five priorities of the Marshall Plan for Wallonia. Representing the main policy focus in Wallonia since 2005 regarding its budget allocated, the measure of targets a broader range of participants and seeks to attract a critical mass of scientific and industrial expertise in leading sectors of activity.
Denmark	“Danish National Advanced Technology Foundation” - supports strategic initiatives in form of advanced technological project or platforms of innovation and research. Areas of focus are nanotechnology, biotechnology, and information and communication technology. The foundation takes a particular effort in supporting the innovation of SMEs. "Knowledge voucher” - consists of a 50% funding of development projects applied for by SMEs who wish to use the funding for knowledge acquisition from a public research organization or a member of the Advanced Technology Group (GTS). It is an objective to expand the utilization of collaboration with knowledge organizations to a wider group of the Danish SMEs and to raise the attention of SMEs of the opportunities within utilization of the knowledge of public research and technology institutions. “Centres of Excellence” - initiative of the Danish National Research Foundation to support Danish basic research regardless of subject area. The activities of the Foundation are regulated by law, and the purpose of the Foundation is to support the development of unique Danish research. It is the position of the board that the best Danish basic research environments should have a possibility for extra support when and if expertise, creativity and the right constellation of people is present in combination.
France	“Federative Research Institutes” – supports research in the field of life sciences requires bigger and multidisciplinary teams. The programme aims to federate research units coming from different institutional partners to gather their means on a common scientific strategy by way of contract. The measure wants to enforce the visibility of research activity and encourage searchers' training. The programme also aims to create relationships with the environing network and to commit to the development of social economic partnership. “Technological Development Networks” - gathers regional public and private actors with the objective of supporting innovation, technology transfer and technological development in SMEs. The RDT is in charge of making easier the access to suitable skills in order to carry out innovative projects. The RDT offers a set of services to assist companies in implementing their projects.
Germany	“Top Cluster Competition” - provides funding for clusters, which means a group of organizations (firms, research organizations, government authorities, NGOs) that aim at

	jointly developing and introducing innovations in a certain field of technology or sector within a region. Cluster activities may involve skill development, long-term oriented research strategies, close-to-market technology development, facilitating new business ventures and international cooperation. "Networks of Competence" - initiative of the Federal Ministry of Economics and Technology (BMWi) which tries to connect the best-performing innovation clusters in Germany. Currently the Initiative includes 110 networks that are differentiated in 9 thematic groups. Those groups are again spread in 8 defined regions within Germany. The concept of the Initiative is to be the "League of the best innovation networks" in Germany. Membership to the initiative is a quality label only for the best networks. "IGF - Promotion of Joint Industrial Research (incl. ZUTECH)" - offers direct grants for R&D projects which are carried out by sectoral research institutions or - on behalf of these institutions - by consortia of companies and/or research organizations. The programme is solely accessible to 106 sectoral research institutions that are members of the Association of Industrial Research Organizations (AiF). These institutions have been founded by SMEs from certain sectors in order to carry out R&D that is in the joint interest of the membership firms. The ZUTECH programme is a special part of the IGF scheme and aims at developing new solutions for structural renewal of the SME sector of the German economy on the base of high-grade technologies.
Italy	"The industrial innovation projects (IIPs)" - aim at coordinating the activities of large-scale public and private enterprises, industrial and technological districts and the world of research and innovation. The programme's objective is to encourage the creation of partnerships between universities, research centres, private enterprises and financial capital, of national and international scope, in order to implement medium/long-term industrial initiatives able to make industry more competitive.
Netherlands	"Syntens" – this "innovation network for entrepreneurs" (of 15 centres /ca. 270 advisors), has the objective to increase innovativeness of SMEs by providing support and advice to SMEs on technology and innovation. In practice, the advisors help SMEs with drawing up an Innovation Action Plan. Within this framework, tailor-made technological and non-technological innovation oriented knowledge is made accessible and applicable for firms.
Norway	"Programme for Regional R&D and Innovation VRI" - promotes knowledge development, innovation and value creation through regional cooperation and increased R&D efforts. VRI consists of regional programmes which involve several types of actors. Cooperation within a regional VRI programme should be dynamic, and it is expected that the cooperation between the actors become increasingly binding. The most central actors in VRI will include the so-called 'regional partnerships' (led by county council districts), R&D institutions which seek to strengthen their regional development role as well as firms and networks of firms with potential for increased value creation through closer cooperation with R&D environments. "Business gardens" – pursues the idea that firms will collectively establish a professional and social environment that stimulate cooperation, exchange of knowledge, and mutual skills upgrading. The industrial garden environment is to stimulate the starting up of development activities, either within the single firm or in cooperation between firms.
Sweden	"Cluster Programme" - initiative that seeks to strengthen regional concentrations of

	enterprises and public as well as non-public organizations, both competitive and cooperative (i.e. clusters). Some of the advantages with regional geographical concentrations are easy access to specialized labour, products, information and technology. The cluster initiatives work as joint ventures between industry and public sector, and set off from current clusters. The overall goals are to increase economic growth and strengthen regional and national competitiveness. “The Key Actor's Programme” - develops competence, methods, processes and structures to enhance the professionalism of key actors in the Swedish innovation system. It will focus on increasing the amount and efficiency of cooperation between research performers, industry and other actors in the surrounding society, as well as activation of knowledge (i.e. knowledge transfer and commercialization of research results).
United Kingdom	"Innovation Platforms” - bring together government, research funders, and other stakeholders focused on a societal challenge to facilitate the dialogue amongst parties and foster innovation. Their aim is to engage with businesses and the research community by aligning innovation policy and government procurement to deliver quality public services and provide solutions for the market place. The measure focuses on the integration of a range of technologies and better coordination of policy and procurement resulting in a more efficient provision of public services and enhanced ability of UK businesses to provide innovative products and services.

As can be seen from these few examples, most of the network policies within the countries aim at bringing together key actors on the national or regional level, particularly from the triangle of private business, basic and applied research, and government respectively the public sector to stimulate knowledge spill-overs and thus the performance of the innovation system.

Nevertheless, in some countries there are additional network related policies which widen up the scope of actors in the innovation system. For instance, the Wallonian instrument “Diffusion of science and technologies” wants to create a more favourable climate for innovation amongst the economic actor but also the wider public. Moreover, it aims at an increase of the young people’s awareness for scientific and technological issues and to attract them to choose scientific studies and careers. This idea, that the development of science cannot be seen independently of societal development is also reflected in the programme of “Science et Cité” in Switzerland. Because scientific results, for example in the fields of bio-technology and stem-cells, very often cause public worries, the measure promotes the dialog between science and society in order to address public worries about new developments. Thus the social climate for innovation should be improved. Additional programmes that pursue similar goals can also be identified in the United Kingdom (“Sciencewise”, “Make Your Mark”, “National Endowment for Science, Technology and Arts (NESTA)”).

Another interesting approach of network oriented policy measure is furthermore represented by the United Kingdom’s “Foresight Programme” which wants to develop foresight networks by linking business, the science base and government to identify opportunities in markets and technologies over the medium and longer term. Thereby, this policy measure goes beyond the mere improve of today’s existing network relations as it addresses the general adaptability and meta-routines of the innovation system itself.

In addition to the previously described instruments fostering broader of multiple socio-economic actors and stakeholders across the whole innovation system, there are several policy tools to be identified in each country that focus more narrowly on the linkage of actors within national or regional innovation systems. Some examples of such policy tools are summarized by Table 65:

Table 64 Selected innovation policy measures on the national level that support linkages between specific groups of actors in the innovation system

(Source : TrendChart Country Reports 2009; own compilation)

Denmark	"Regional innovation agents" - two of the five Danish regions in cooperation with other parts of the innovation support system have established an experimental project where "innovation agents" offer innovation checks to SMEs of the corresponding region. The purpose of the programme is to strengthen innovation in SMEs, to create links between enterprises with little or no contact to research organizations and institutionalized knowledge, and to establish an access point for SMEs to the knowledge based system. "High-tech Networks - establishment of high-tech networks in bio-, nano- and information technology with lasting and binding partnerships between private companies and knowledge institutions to create stable collaboration patterns between companies and knowledge institutions. The networks should make possible that companies and knowledge institutions can meet, develop and disseminate research based knowledge to solve high-tech problems. The Ministry co-finances the establishment and operation costs of the network.
Finland	"Centre of Expertise Programme (OSKE)" - to enhance regional competitiveness and to increase the number of high-tech products, companies and jobs. To achieve this goal, the programme is used to implement projects reflecting the needs of industry, to encourage industry, research and training sectors to co-operate, to ensure rapid transfer of the latest knowledge and know-how to companies and to exploit local creativity and innovation. "Centres of Excellence (CoE)" - to increase funding of academic research units that are at, or very close to, the international cutting edge of research in their particular fields. The aim of the Programmes is to raise the quality of Finnish research by facilitating the development of high-level research environments and supporting researcher training.
France	"Carnot award" - part of the global "Pact for research" programme passed at the end of 2005. The philosophy of this measure is to develop partnership research between public research entities and socio-economic actors (mainly companies). The idea is to award a limited number of public research entities (laboratories, research units) or private research organization with general interest goals, for their implication with the socio-economic partners (enterprises). The Carnot award is obtained for a four years renewable period by public research laboratories called "Carnot Institutes". "Financial support to foster R&D partnerships between key accounts and SMEs" - a grant provided by OSEO, the French agency for SMEs. The main goal of this support measure is to foster the links between innovative SMEs and large entities. More specifically, the measure aims at facilitating the SMEs' access to large companies' sales and contracts.

Germany	"Innovation Alliances" - a new instrument of public support to industrial innovation that provide funding for strategic cooperation between industry and public research in key technology areas that demand a large amount of resources and a long time horizon, but promise considerable innovation and economic impacts.
Netherlands	"Casimir" - main objective is to increase public-private mobility of researchers and to enhance exchanges of researchers between companies and knowledge institutes and vice versa. Such mobility of researchers can help to reduce the gap between knowledge production and knowledge application. Mobility is also perceived as a means to improve the attractiveness of the job of researcher. "Regional Attention and Action for Knowledge Innovation (RAAK)" - aims to improve knowledge exchange between SME's and Universities of Applied sciences. Subsidies can be awarded to regional innovation programmes that are aimed at the exchange of knowledge, and are executed by a consortium of one or more education institutes and one or more businesses.
Ireland	"Innovation Partnership Initiative" - its purpose is to support the undertaking of collaborative applied research with direct industrial and commercial application, between industry and third level colleges. The Innovation Partnership scheme is open to academic staff of higher education institutions in collaboration with an Irish-based company, including commercial state bodies or a consortium of both.
Norway	"Centres for Research-based Innovation (CRIs)" - main objective is to enhance the capability of the business sector to innovate by focusing on long-term research based on forging close alliances between research-intensive enterprises and prominent research groups. The CRI scheme encourages enterprises to innovate by placing stronger emphasis on long-term research and by making it attractive for enterprises, to facilitate active alliances between innovative enterprises and prominent research groups, to promote the development of industrially oriented research groups that are on the cutting edge of international research and are part of strong international networks, to stimulate researchers training in fields of importance to the business community, and encourage the transfer of research-based knowledge and technology.
Poland	"Support to applied research projects undertaken by science institutions" - provides co-financing for development research projects for specific sectoral and society needs. Such development projects are understood as projects, the aim of which is to carry out research assignment, which will constitute the basis for practical applications. This measure also co-finances the costs related national and international IP protection of research results generated by research institutions as a result of their activities. "Transfer of knowledge" - to increase the knowledge transfer and strengthen science-industry co-operation with the view of bolstering the regional development. It supports several types of projects, including in-service training and trainings for entrepreneurs in research institutions and vice versa, temporary employment of high-level experts in SMEs, promotion of academic entrepreneurship as well as preparation of updates of Regional Innovation Strategies.
Spain	"Subprogramme of fundamental research oriented to knowledge transmission to enterprises" - supports basic R&D projects focused on the transfer of technology knowledge from all types of public or private research organizations (universities, public research organizations, technology centres etc…) to enterprises. The projects are

	oriented to collaboration between research groups that can transmit knowledge which has significant degree of excellence could generate a competitive advantage for enterprises. "Torres Quevedo" - aims to facilitate the incorporation of academic, scientific or technologist personal into the private sector to carry out R&D projects or to make previous technical feasibility studies. It is mainly directed towards SMEs, which might not possess the knowledge, skills or means to acquire, develop or implement a new technology. Furthermore, it fosters the interaction between the public and the private sector and actively contributes to an efficient knowledge transfer.
Sweden	"VINN Excellence Centre" - provides a new generation of Competence Centres (Centres of excellence in Research and Innovation) which are supposed to build bridges between science and industry in Sweden by creating excellent academic research environments in which industrial companies participate actively and persistently in order to derive long-term benefits. "Berzelii Centres" - to develop strong R&I environments as a critical factor in the effort to promote growth. The initiative is a joint collaboration between the Swedish Research Council and VINNOVA. The Berzelii Centres should focus on excellent basic research and must also have a clear ambition in the long term to collaborate actively with stakeholders from the private and public sectors.
Switzerland	"Knowledge and Technology Transfer (KTT)" - this measure is supposed to trigger knowledge and technology transfer (KTT) in Switzerland between public science institutions and private firms in order to foster innovation and new market products. There have been built five consortiums consisting of KTT service centres. Theses service centres aim at reinforcing demand of companies for university knowledge and research results, enabling companies to better identify existing knowledge and future requirements, reinforcing companies, above all SMEs, in their contact with universities, improving ability of universities to transfer their knowledge to companies, improving joint development of problem resolutions between universities and business.
United Kingdom	"Innovation Voucher" - designed to encourage SMEs to engage with the knowledge base of higher and further education institutions in order to promote knowledge generation and transfer to benefit SMEs from gaining external knowledge and collaborations. "Collaborative Research and Development (CRD)" - designed to meet some of the costs and risks associated with research and technology development, by facilitating collaboration between different businesses and the Science, Engineering & Technology base across the CRD provides funding for collaborative R&D projects between businesses, universities and other potential collaborators. Collaborative Research & Development projects must involve two or more collaborators, at least one of which is from industry. "Cooperative Awards in Science and Engineering (CASE)" - to provide funds for the training of postgraduate PhD students in projects of joint interest to industry and higher education institutions. Likewise, "Industrial CASE" is a variation of CASE where studentships are allocated direct to an industrial partner with the company devising its own projects. "LINK" - supports collaborative R&D projects between business and the research base.

	It encourages innovative research well ahead of the market but with good potential for commercial exploitation and offers opportunities for business and academia to develop partnerships. Ideally, these partnerships are continued after the project has finished. The scheme covers a wide range of technology, product and sector areas through a number of programmes.

As can be seen from this small compilation of national policy instruments aiming at linkages between specific actor groups, most of them put a strong emphasis on linkages between industry or business actors and organizations belonging to the sector of basic or applied research. Thus, user-driven innovation is most commonly interpreted as industry-driven innovation. But with regards to open innovation, user-driven innovation in terms of consumer- or end-user-driven innovation is of particular importance and represents one of the core elements of open innovation. But policy measures which are explicitly aimed at this aspect are very scarce. One example can be found in Denmark. The "Programme for User-driven innovation" aims at building on knowledge of customers and citizens to make Danish companies and public institutions more innovative. By strengthening the diffusion of methods for user-driven innovation, the programme aims to contribute to increased growth in the participating companies and increased user contentedness. Finally, the programme should increase the qualifications of employees to take part in the innovation processes in the participating companies and public institutions. Another measure which at least rudimentarily accounts for this kind of user-driven innovation is the Finish programme called "Strategic Centres for Science, Technology and Innovation (SHOK)" in which companies and research units work in close cooperation, carrying out research that has been jointly defined in the strategic research agenda of each Centre. Each Centre is coordinated by a non-profit limited company, jointly owned by the shareholders (including companies, research organizations, funding agencies and different interest groups). The Centres represent market-driven and user-driven innovation policy approach by allowing industry and other interest groups like actors that utilize the research results, to participate into the decision making related to future R&D agendas.

Besides these above described tools to promote networks and linkages to enhance knowledge diffusion between more or less open groups of actors, there are several policy instruments which in addition are characterised by a slightly different connation. They are targeted towards specific functions of innovation system that obviously are likely to be subject to innovation system failures and can be described by the following dimensions: networks of financiers and capital donators, networks who are primarily aimed at an increased use of intellectual property rights (IPR) and the improve of the firms' awareness and management of IPR, as well as networks that focus on the purpose of commercialisation of research findings and inventions for instance by promoting spin-offs from public research organisations or the valorisation of existing results from the research sector.

Procurement of seed-, venture- and risk capital

Regarding the policy measures that aim at innovation financing, it has to be stressed that they should not be confused with tools that directly provide financial subsidies for R&D or innovation activities of firms like grants and loans. Instead, these instruments seek to establish national or regional networks of private financiers and private funds to facilitate risk capital procurement for firms and companies. Especially in those stages of the innovation process that are close to market introduction of a ground shaking new product or process, firms often have difficulties to gain capital funds, because on the one hand public funding is usually restrained to pre-competitive basic and applied research and, on the other hand, the innovation project is not mature enough to attract risk capital from private investors. This stage is often described by literature as ”the valley of death” (Mills and Livingston, 2005). Due to this scarcity of seed and venture capital may European countries decided to stimulate the establishment of new private venture capital funds that would address the financing needs of new companies and especially growth oriented SMEs which are, on the one hand, often characterised by visionary thinking and growth potential on innovative market niches, but on the other hand are marked by short business history and high business risks.

Activities of private equity markets provide incentives (equity-based open innovation) as well as constraints (long-term cumulative, collective knowledge development) on incumbents, and impose their own set of constraints on portfolio companies. Seed and venture capitalists do not commit to financing the ongoing accumulation of organizational knowledge. Instead, they finance stand-alone, discrete modular technology development projects for a limited period of time in terms of the predetermined lifespan of the fund, not to the commitment required by involved technologies (Herstad, 2008).

One of the most widespread policy measures in this field are ”seed-capital”, ”venture funds” or networks of so-called ”Business Angels”. All these measures have in common that they represent a joint initiative between national or regional governments and private investors and financiers to provide companies, in particular SMEs and promising start-ups in the area of high-technology access to private risk capital. Thus the government acts as a catalyst and/or co-founder with private sector funders to meet the seed capital and venture capital needs of new enterprises and SMEs. Table 66 gives some examples of these policy tools in the examined countries.

Table 65 Selected innovation policy measures on the national level that promote procurement of seed-, venture- and risk capital

(Source: TrendChart Country Reports 2009; own compilation)

Austria	”i2 Business Angel Network” - supporting young, growth oriented firms by providing them access to private risk capital and management expertise. „Förderung von Gründung und Aufbau junger innovativer technologieorientierter Unternehmen (JITU)“ - promotes young, innovative and technology intensive firms by cushioning risks involved in getting started. It provides non-pecuniar support, but also at filling the finance gap of venture capital.
Ireland	”Business Angels Database” - representing the central business angel network in Ireland which established a database of more than 70 business angels with more than 12 million Euro to invest in SMEs seeking for equity. Until now, the business angel network has developed into a joint initiative between Enterprise Ireland, InterTrade Ireland and the Irish Business and Innovation Centres (BICs).
France	”Seed-capital funds” - the seed capital funds are driven by private companies (mostly

	private venture capital funds), but research organisations and higher education institutions are encouraged to take part in them, so as to permit proximity between investors, business and academic worlds.
Italy	”Risk capital fund for SMEs” -fund for risk capital for the SMEs located in the South of Italy. This is one of the measures included in the e-government 2012 Plan.
Netherlands	”TechnoPartner Seed Facility” – aims to improve the risk-return ratio for investors and to increase the chance for ""Technostarters"" to get financing. The objective of the TechnoPartner Seed facility is to encourage and mobilise the bottom end of the Dutch risk-capital market in such a way that technostarters are able to meet their capital requirements.
Norway	“The Seed Capital Scheme” - includes several seed capital funds established on the basis of both private and public capital, and are organized as independent companies. Through these funds, non-listed SMEs get access to equity capital in early and/or capital intensive phases. The companies are furthermore to benefit from the competence and networks of the funds' administrators and board members. “State Investment Fund” – find long-term financial support for innovative start-ups with international growth ambitions. This new measure is meant to increased the survival rate of this type of firms.
Poland	"NewConnect” - provide young and at the same time small and middle size Polish companies access to alternative financing, aside from business angels, seed capital as well as venture capital funds.

In some countries, these measures are supplemented by fiscal incentives (e.g. "Mutual Funds for Innovation” in France, ”Technology Credit” in Poland) or tax exemption (”Tax exemption on capital gains from start-ups” in Italy) for private investors and commercial banks involved in such funds. In France, the ”Mutual Funds for Innovation” is also an instrument of risk mutualisation complemented by a fiscal incentive given to individual investors involved in such funds to attract funds to finance new entrepreneurial initiatives. Another very interesting, rather holistic approach can be found in Spain. The ”INNOCASH” scheme promotes the recovery of R&D results developed in Research and Technology through studies and reports done by approved consultants to facilitate understanding and demonstrate the benefits it has for investors, betting on investment in Science and Technology and thus to increase the firms’ opportunities to gain risk capital.

Use and management of intellectual property

Rational firms which intentionally invest in R&D-activities to develop new technologies and products expect that these developments provide them competitive advantage and additional profit. Firms would not be willing to invest in any R&D and to bear the enormous cost of these activities, if they do not feel certain to actually benefit from their R&D. If knowledge were a completely public and non-excludable good, other enterprises would be able to “free ride” on the developments of their competitors and profit from them without any own R&D costs. If innovative firms should have the chance to realize a reasonable rate of return on their innovations, a mechanism is needed which allows the firms for securing their competitive advantage and additional profit, at least for a certain period of time.

This mechanism is provided by the principle of intellectual property rights, especially the patent law. Protection by patent leads to a monopolistic competition of innovating enterprises. The innovator holds the monopoly for its specific product (and its profit) and competes with other monopolists and their products. Competition is thereby not characterized by the pricing pressure on one and the same product (perfect competition) but is based upon the market implementation of new products that appear substitutable from the customers' perspective.

However, as discussed above, beside their protective function, patents also have an information function (Arnold, 1997; Burr et al., 2007). The patent certificate compulsorily contains a detailed description of the invention. This accelerates the knowledge diffusion and counteracts the principle of exclusivity. Thus, patent protection is imperfect as it cannot prevent the incorporated knowledge from its diffusion into the economy's stock of knowledge (Dreher, 1997), and only preserves the commercial benefit for the innovator to covering its cost of R&D and to skim off profit.

The knowledge which is inherently immanent in each new product or new manufacturing process is contained in the patent and published through the patent specification which can be freely assessed by others. Thereby, two types of knowledge can be distinguished: product specific knowledge and general knowledge (Romer, 1990). The product specific knowledge is mainly developed through R&D activities and closely tied to a single product and is thereby to somewhat extent protected by the patent application. Unlike, the general knowledge included in each product can be seen as an unintended, non-excludable by-product of manufacturing processes ("learning-by doing") and spills over into the economy's common stock of knowledge.

Thus, also governments and public funding institutions have a strong interest in fostering the use and rate of applied intellectual property to increase the economies' shared stock of knowledge and thus to raise the social returns from R&D subsidies.

There are several policy measures in the considered countries dealing with the use of property rights in general and patents in particular. However, there are basically two types of policy measures. The first one intends to increase the use of IPR and is usually deployed by countries whose IPR activities are below the average level of the EU and thus obviously face innovation system failures regarding IPR. For instance, Poland deploys two policy measures ("Creator of innovativeness" and "Management of intellectual property rights") which seek to increase the qualifications of academic staff in the area of intellectual property rights as well as to improve the functioning of the innovation market and promotion of innovative solutions through the intensification and encouragement of intellectual property rights application. The measure will cover the costs of application and protection of IPR and contribute to the goal of raising the awareness about the importance of IPR issues among the group of entrepreneurs. Spain also provides "Financing support for fostering to apply for international patents" to enhance the international competitiveness of its enterprises and to overcome language barriers and geographic distance to the European Patent Office. The measure is also based on funding a percentage of the expenses for patent appliances. Similarly, Italy aims at the re-qualification of national patents. The policy measure "Strengthening patents and intellectual property" seeks to reinforce the Italian Patents and Trademarks Office (IPTO) through the addition of technical examiners, the provision automatic translation services of national patens from Italian to English, and an increased security of information flows between IPTO and the European Patent Office.

The second group of IPR related policy measures in this field focuses on the intensification of the information and sourcing function of patents and IPR by promoting cross-licensing and providing informational platforms for IPR exchange. “ACQUITECH” in Wallonia for instance wants to support the external acquisition of patents, licenses and know-how through reimbursable advances. Denmark has also recently piloted a patent exchange, where patents can be listed for purchase or licensing. The exchange initially only includes Danish patents, but with the clear intention eventually to allow international patents as well. Likewise, “Patent Information Centres and Thematic Information Centres” in Germany provide access to scientific and technological information that is contained within patents, registered designs and trade marks for firms and private inventors while the thematic information centres aim at improving the access to various databases relevant for innovation activities by firms and research organizations. Last but not least, United Kingdom has established “The Biotechnology Exploitation Platform Challenge (BEP Challenge)” which encourages syndicates of bioscience research organizations and technology transfer units to work together and build portfolios of intellectual property. It is supposed that this will help academic bioscience departments to audit their existing intellectual property and identify commercial opportunities.

Commercialization

Following the early definition by Schumpeter (2006), innovation consists of two major aspects: the first one is novelty, which means that there is a new product or type of process which deviates from previously existing ones by a certain degree of novelty. The second one refers to the successful market introduction of this novelty which means that a novelty becomes an innovation not until it has been successfully implemented and commercialized in the market and thus contributes to the competitive success of the innovating firm. In general, commercialization may be defined as the process of transferring and transforming theoretical knowledge (Chiesa and Piccaluga, 1998) such as existing in an academic research institution, into some kind of commercial activity. An important aspect of the commercialization process is that it will often undergo a change from a mainly technology-driven process to a process which is mainly market-driven. This shift towards increased emphasis on market opportunities will gradually emerge, making apparent how these may be exploited by developing products or services in order to meet anticipated needs in the market (Spilling and Godø, 2008).

While the funding of business R&D activities triggers the input dimension of innovation (i.e. financial help to invent new problem solutions), commercialization represents an output dimension of innovation. From the perspective of policy making, the commercialized product or process innovations contributes to the legitimacy and evaluation of success of the corresponding policy measures, particularly in the national context where innovation funding is usually based on tax money. Last but not least, a higher number of commercialized product and process innovation obviously increases the economy’s national competitiveness and economic growth. Thus, innovation policy has a strong interest to promote the commercialization of findings and inventions resulting from public and business R&D. The following Table 67 shows some examples of existing national innovation policy measures to enhance commercialization efforts.

Table 66 Selected innovation policy instruments on the national level that supports commercialization of findings from private and public research

(Source: TrendChart Country Reports 2009; own compilation)

Austria	„Förderung von Gründung und Aufbau junger innovativer technologieorientierte Unternehmen (JITU)“ - promotes innovative and R&D intensive start-ups with R&D expenditures accounting for at least 15% of its total expenditures through cushioning typical risks involved in getting started and supports the creation of new and original ideas and not just a further development of an already existing product or process. The measure also aims at filling the finance gap which stems from an insufficiently working venture capital market.
Belgium	„TETRA Fund“ – aims at the valorisation of scientific achievements of Flemish Higher Education institutes (HEI) (i.e. universities and organizations of applied science). Valorisation is facilitated by technology transfer processes between HEIs and companies or NGOs. The final goal is to increase the innovative capacities of companies and NGOs as well as to increase the knowledge base of HEIs to improve education, research and social services. “STIMULE” - fosters SMEs to exploit research results within 24 months after the end of a research project supported through a reimbursable advance. “FIRST Enterprise spin-out” - created in 2005 with the aim to foster the creation of spin-offs through the financing of an entrepreneurial-minded person within a company, which will exploit a technology available within a company but which is outside its core-business, in a new company. This concerns innovative products, processes or services.
Finland	“Funding scheme for young innovative companies” – In February 2008, Tekes introduced a new funding instrument for young, innovative growth oriented companies. Its goal is to improve the opportunities for the most promising young companies to develop their businesses in a comprehensive way and to accelerate their growth and internationalization activities. “Venture Cup Finland” - a three-stage business plan competition for aspiring growth companies, primarily designed for researchers, teachers and students. During the three stages of the competition, participating teams go through a process of education, coaching and screening, developing their business ideas into complete business plans with a clear focus. Venture Cup is organized by universities, polytechnics, business incubators and technology centres.
France	“Entrepreneurship Houses (Maisons de l Entrepreneuriat) - Entrepreneurship Houses (Maisons de l Entrepreneuriat) are established within Universities and Higher Education Institutions (HEI). Their mission is to open up universities to the business world, strengthen the links between universities and enterprises, raise students’ awareness to entrepreneurship, identify and exchange good practices promoting entrepreneurship culture within universities. “Regional incubators structures” – a measure to support cooperation between public

	research bodies and enterprises to valorise public research through the creation of technology based firms (start-ups shall either be spin-offs of public research labs or use public research innovations/technologies).
Germany	“EXIST - Start-ups from Science” - support programme of the Federal Ministry of Economics and Technology (BMWi) aimed at improving the entrepreneurial environment at universities and research institutes and at increasing the number of technology and knowledge based company formations. The objectives are to establish a lasting “culture of entrepreneurship” at universities and research establishments, to support consistent transfer of scientific knowledge into commercial output, to promote the potential of “business ideas and entrepreneurial personalities at universities and research establishment in a targeted manner, and – as a result - to increase the number and the chances of success of innovative business start-ups
Ireland	"Business Incubation Centre programme” – conceptualized to foster entrepreneurship and new company activity on campus, to commercialize research carried out in third level institutions for the benefit of local enterprise, and to support balanced regional development by creating new companies. “The Commercialisation Fund” - designed to assist the exploitation of inventions and innovations produced by academic research. It includes patenting, prototype development and commercialization.
Netherlands	"Valorisation Grants” - inspired by the American Small Business Innovation Research (SBIR) programme, the measure aims to promote commercialization of knowledge within public scientific research institutes. Researchers at public research institutes can apply for a Valorisation Grant to create a spin-off. The grant can be used for product-market analysis, for development of a prototype, for development of personal skills, for protection of intellectual property, etc. “TechnoPartner Knowledge Exploitation funding programme - (SKE)” - encourages entrepreneurial knowledge organizations and private parties to help to set up knowledge-intensive and innovative companies ("technostarters"). To goal is to eliminate a number of thresholds that make it difficult for technostarters to start. In order to minimise risks and increase the chances of success, TechnoPartner provides support with regard to screening and scouting, patent applications and offers access to equipment and networks of specialists. And TechnoPartner wants to help parties that wish to provide technostarters with soft loans.
Norway	"FORNY - Commercialisation of R&D results” - increase economic growth based on commercialising research-based business ideas with big marked potentials. The programme finances the stimulation of ideas in R&D groups and the evaluation and realisation of such ideas at commercialisation units. Its target group is comprised of employees and students at scientific facilities who have good, but latent ideas for projects. Students as well as researchers should be encouraged to focus more on the potential commercialisation of their research results and to flesh out sound business ideas.
Poland	"Creator of innovativeness” - the programme firstly includes the creation and development of existing entities operating within the structures of academic institutions to improve science-industry co-operation through support to initiatives undertaken by students and academic staff with focus on innovation and promotion of entrepreneurship. Secondly, qualifications of academic staff in the area of

	commercialization of R&D results should be increased. Thirdly, innovative projects prepared by the science sector should be stronger popularized among entrepreneurs information sources. Fifthly, the commercialization of R&D results should be promoted through support to spin-offs.
Spain	"CEIPAR Programme" - devoted to the creation of innovative technology-based companies located in scientific and technological parks. The main objectives are to enhance and to consolidate the entrepreneurial base in innovation firms, to enhance the participation of Technological Parks as an instrument to foster the creation of innovative technology-based companies, and to encourage the creation and development of incubator units in Scientific and Technological Parks.
Sweden	"VINN NU" - competition for new companies that base their operations on R&D results. The aim of VINN NU is to make it easier for new R&D-based companies to prepare and clarify commercially-interesting development projects at an early stage as well as to identify and establish customer relations so that they can progress, find subsequent funding and, in the long term, become successful Swedish companies.
Switzerland	"Venturelab - Fast Track for Start ups" - carried out in co-operation with the federal institutes of technology, universities and universities of applied sciences. Venturelab provides customized education tools to promote innovative young entrepreneurs and to inspire students for entrepreneurship. For existing start-ups, venturelab offers 5 day intensive courses and advisory services. Finally, Venturelab offers 20 entrepreneurs each year to participate in a workshop in Boston that offers opportunities for networking beside of providing education. The initiative focuses on the best projects, accompanies them with professional consulting. "KTI-CTI-Invest" - aims to close the financing gap in the initial phase of getting a new company off the ground. CTI Invest is a private, independent association of investors and offers start-ups a platform on which to present their business ideas to a broad audience of business angels as well as both national and international venture capital firms. It stages regular events at which young entrepreneurs can present their firms to potential investors (so-called match-making events). It also organizes networking events, whose emphasis is on the transfer of knowledge and information.
United Kingdom	"Knowledge Transfer Partnership" - programme coordinated by the DTI and sponsored by several other agencies, in order to tap knowledge and expertise in public and private research organizations and apply them to business to develop new products, services and processes. "Public Sector Research Exploitation Fund – PSRE" - set up to support commercialisation of intellectual property from research carried out in the public sector, including public sector research establishments, Research Council institutes and the NHS. It should help bridge the 'development gap' between research funding running out and the stage at which the private sector might be interested in investing. "Faraday Partnerships" – aim at linking firms, scientists and engineers in universities, research organizations, and capital providers on collaborative, technology specific research projects and commercialization processes.

To summarize, existing policy measures which aim at the successful commercialization of existing or newly developed findings within the innovation system mostly address the prevailing culture of entrepreneurship. This means that the majority of instruments seeks to promote entrepreneurial thinking of both the scientific community as well as the private sector. More specifically, the policy tools tend to strengthen commercialization in terms of supporting promising, fast-growing start-ups ("Gazelles") or spin-offs from public or private research organizations. Some instruments also link their commercialization stimulus with supporting the mobility of researchers and engineers and thus establishing closer linkages between the two worlds of science and private sector. Due to the complexity of the innovation processes and the fact that commercialization can hardly be separated from the innovation process as such, these policy instruments show of course considerable overlapping with other dimensions of innovation policy like intellectual property rights, collaborative R&D funding or the provision of technical or management services.

14.2.3 Promoting the formation of international linkages within and beyond the EU

Recent research findings suggest that international linkages formed by firms may be equally important to the internal dynamics of territorial innovation systems as the internal system linkages themselves (Herstad et al., 2010). As pointed out by Narula (2002), the relative ease of identification, establishment and maintenance of domestic linkages compared to international ones may cause a situation of lock-in and, from the perspective of the national innovation system, suboptimal exposure to diversity. To avoid such lock-in effects, public policy should be sensitive to the need for international linkages independently from whether they might be more difficult to identify, risky to establish, and costly to maintain compared to national linkages. Types of measure and instruments to promote the formation of international linkages vary from business support services to the assistance of firms in entering new markets abroad, identifying international partners or participating in EU and other international programs. The following Table 68 contains some examples of such policy measures.

Table 67 Selected innovation policy measures on the national level to support the formation of international linkages

(Source: TrendChart Country Reports 2009; own compilation)

Austria	"CIRCE Cooperation in Innovation and Research with Central and Eastern Europe (CIR-CEE)" – aims at the organisation and expansion of transnational innovation networks - especially with SME - between Austria and countries of Eastern, Central and South-eastern Europe for the implementation of innovations and strengthening technology transfer. The cooperations aim at the creation of bilateral and trilateral networks, where the accent is put especially on the establishment and extension of R&D synergies as well as technology transfer, benchmarking and quality management. "Transdisciplinary Research Social Sciences, Cultural Studies, and Humanities (TRAFO) - to encourage problem orientated, transdisciplinary research in the social sciences, cultural studies, and humanities, to stimulate innovative, especially participatory methodological approaches and research processes, to promote national and international project cooperation and networking, especially between researchers and stakeholders, to particularly promote women scientists, and promote young scientists.

Belgium	”Horizon Europe” – is a subsidy offered by the Walloon Region to support the preparation and submission of proposals of international R&D projects of enterprises and research centres in the framework of the EU R&D framework programs and the European Program EUREKA. The measure is open to SMEs with an establishment in the Walloon region, collective research centres certified by the Walloon region, research centres of universities, and other third level education institutes. It aims at supporting the preparation, registration and negotiation of R&D or innovation projects in the framework of international partnerships, mainly in the context of FP7 projects and new European programmes such as Joint Technology Initiatives (JTIs), ERA-NETS, Eurostars and EUREKA. ”Research in Brussels” - incorporated in 2008 into the newly launched 'Brains (Back) to Brussels' initiative. The program aims at bringing back Belgian high-level researchers that pursued their research work abroad. This should be instrumental in improving the quality of research carried out in Brussels universities, eventually increasing their reputation in order to get access more easily to European funding.
Denmark	“25 % Tax Scheme: Taxation of the Salaries of Well-paid Foreigners and Foreign Researchers” – introduced for researchers and key employees who take up residence in Denmark for a limited period of time. It supports well-paid employees and researchers recruited abroad with taxation at the rate of 25% of the remuneration with no deductions compared to the normal income tax. The reduced taxation is however limited to a maximum of 36 months. "Pre-project grant for the 7th EU framework programme” – to increase the number of applying and participating Danish SMEs in the EU FP7. Beneficiaries of this measure are SMEs according to the definition of the European Commission, i.e. they have less than 250 employees, a turnover of maximum €50m and they should not have received funding for other EU FP7 projects under this measure. It is also possible to apply for funding by industrial associations. “Increased Danish participation in international research and innovation programmes” – supports increased participation of Danish enterprises and technological service institutes in international research and innovation programmes. In this strategy, the DCTI will among other things present the options of expanding the pre-project scheme to include other European and international research and innovation programmes. In addition, the DCTI will present other models for how to improve support for Danish enterprises’ (particularly small and medium-sized) and technological service institutes’ participation in international research and development programmes and international organizations.
Finland	“TRIO Programme” – aims at enhancing the competitiveness of firms by promoting the internationalization and improving the business environment of enterprises so that they would be able to continue economically viable activities in Finland. The TRIO programme focuses particularly on technology industries and on system integrators and component manufacturers within them. The measure wants to help firms to cope with the challenges they are facing with respect to growth, internationalization and networking by backing up development projects and by providing funding. “Finland Distinguished Professor Programme (FiDiPro)” – enables Finnish universities and research institutes to hire international scientists who normally work abroad. These experts will then conduct research together with Finnish research groups for 2-5 years.

	The experts to be recruited shall have recognized scientific merits and strong experience in researcher training. “Funding scheme for young innovative companies” – introduced as a funding instrument for young, innovative growth oriented companies. The aim is to provide for these companies an opportunity to develop their businesses in a comprehensive way, as well as grow and internationalize their activities faster than in general.
France	“Support for international mobility (cultural areas)” – allows the attribution of a financial support for PhD students who need to travel abroad in the framework of their researches excluding travels to assist to workshops or seminars. The programme only supports travel and accommodation expenses for short term mobility (three to 12 weeks). “Post- PhD initiative programme” – provides financial assistance for researchers who have spent a few years abroad after their PhD, with the view of facilitating their professional insertion in the national research, development and innovation system. The aid is dedicated to the procedure of search of laboratories or other host structure for the continuation of their activities.
Germany	“High-Tech-Strategy” – pursues among others the objective to strengthen international cooperation and active participation of funding recipients in the European Research and Innovation Policy. “Top Cluster Competition” – provides funding for clusters, which means a group of organizations (firms, research organizations, government authorities, NGOs) that aim at jointly developing and introducing innovations in a certain field of technology or sector within a region. Cluster activities may involve skill development, long-term oriented research strategies, close-to-market technology development, facilitating new business ventures and international cooperation.

Basically, the support of international linkages can be clearly seen as the most neglected dimension of innovation policy (Cotic-Svetina et al., 2008) which results in a lack of direct focus on external linkages outside the domestic innovation system. In many cases countries consider themselves satisfied with establishing closer ties with selected neighbours (Herstad et al., 2010). For instance, Denmark and Norway are mainly involved in collaborations with their Nordic partners (Sweden, Finland, and Iceland), Flanders collaborates with the Netherlands, and Austria tries to establish linkages with the emerging economies of its neighbouring countries of Central and Eastern Europe.

With a clear exception in R&D collaboration, many of these instruments and initiatives, however, share the common characteristic of top-down, community-oriented processes instead of promoting industry-driven, bottom-up processes (Herstad et al., 2010). Subsequently, firm or industry level linkages which would be faster conducive to knowledge transfer and innovation are only indirectly supported.

Regarding the international orientation of R&D funding policies, one can distinguish between international projects like EU funded programs in the FP7 and national projects allowing for or even require for participation of international partners. However, as recent empirical research has shown (Herstad et al., 2010) both come with the disadvantage of large consortia and difficulties for individual firms to pursue their interests. As Herstad et al. (2010) further point out that according to Norway business associations large consortia imply less control over intellectual property because they are not bound to corresponding IPR measures. Additionally, the well-known perception of bureaucratic hurdles to access international funding build another barrier to the formation of international linkages, in particular for SMEs. In most cases, opportunities for international participation in nationally funded projects are scarce or rare in practice. In Austria, international participation is possible and can in some cases even be funded. Similarly, Denmark recently has increased its efforts to promote participation and funding of international partners and the Norwegian scheme of "SkatteFUNN" which provides firms with larger tax incentives if they collaborate with foreign research partners.

14.3 Summary

The previous paragraphs provided an overview on some existing innovation policy measures on the national level of selected European Countries along the four dimensions of open innovation. A full review of further policy measures across all European countries was not feasible here, but may be found in the corresponding country reports of TrendChart[1].

Firstly, the selected policy measures can be distinguished into mission- and diffusion-oriented measures. In its original understanding, mission-oriented policy instruments is targeted at questions and problems of national sovereignty (Ergas, 1987) like the technological fields of aerospace, material science, atomic technology as well as agriculture, mining, health research, infrastructure, and information and communication technology. Today, mission-oriented technology and innovation policies are defined as these instruments that explicitly address the big unsolved challenges of modern societies (e.g. climate change, aging society, shortage of resources) (Gassler et al., 2006). Against this background, the innovation policy of France, Finland or the United Kingdom can be named as examples of rather mission-oriented policy tools. In contrast, diffusion-oriented innovation policies are rather focused to support the knowledge diffusion and breakthrough of promising technologies. To fulfil this purpose they also seek to include as much as possible different actors in research and development and the use of these new technologies, particularly SMEs. Regarding their thematic focus, diffusion-oriented innovation policies can include both, key technology areas as well as unspecified funding programs. Examples for a diffusion-oriented policy characteristic are Sweden, Denmark Germany or Switzerland.

Secondly, the policy instruments differ in their focus on either the science or the business sector. On the one hand, in neoclassical economics a strong focus on the science sector is justified by its understanding of knowledge as a non-rival (but not completely excludable), public good (Romer, 1990). The funding of R&D in the science sector thus serves one of the most basic functions of the innovations system: the development and accumulation of new knowledge to diffuse and spill-over into the private sector. On the other hand, innovation policy might also predominantly focus on the commercial and economic success of R&D in terms of the successful market implementation of new products and processes. This might encompass instruments to support knowledge transfers

[1] http://proinno.intrasoft.be/index.cfm?fuseaction=page.display&topicID=263&parentID=52

from science into the business sector and to promote all types of collaboration between science and industry. Regarding the considered countries, it is not possible to identify distinct types which more or less focus only on one aspect. In the context of the well-known interrelationships between science and business sectors this would be really surprising. Nevertheless, there are some tendencies to be identified. Countries like Switzerland, the United Kingdom, and Sweden are slightly more oriented towards the science sector, while countries like Finland, France or Germany put a slightly stronger focus on R&D in the business sector.

Thirdly, policy instruments can be distinguished whether they prioritise excellence or coherence within the innovation system. Policy tools targeted towards excellence more often stimulate the emergence of high-reputed research organizations, clusters of excellence. By preserving and supporting existing strengths these policies want to develop and extent the leading role of a nation in a certain field of technology ("spearheads" respectively "lighthouses"). In contrast, coherence-oriented policy instruments want to support the coherent development of regions. Subsequently, their primer goal is to firstly support disadvantaged regions or groups of actors. Recently, By coining the concept of "smart specialisation" Soete et al. (2009) has added a middle category between these both priorities which aims at supporting the specific strengths of different regions simultaneously. An excellence focus can be found for example in the United Kingdom, Switzerland, and Sweden while countries like Belgium, Denmark and Germany show higher priorities for coherence. However, within all countries new policy instruments show the tendency to put more emphasis on excellence.

Continuously adapting its content to changing and highly dynamic challenges and frame conditions, the main objective of existing national innovation policy is to stimulate domestic knowledge generation in order to enhance performance and competitiveness of the national economy. However, regarding the frame conditions of the increasing complexity and distributed modes of knowledge development and innovation, such policy measures can no longer be solely constraint to the internal landscape of national or regional innovation systems, nor can it be restricted solely to specific constellations of actors like industry-business linkages (Herstad et al., 2010). As a result, there is need for the development of new, multifaced innovation policy logics (Cooke, 2005; Cook, 2006). Against the backdrop of open innovation, it has thus been pointed out that innovation policy has to balance well between the four dimensions of supporting domestic industry knowledge development and accumulation, securing well-functioning networks within territorial economies, establishing narrow linkages between industry and specific actor groups, and fosters the formation of international linkages.

The short review of existing innovation policies across some selected European Countries has shown that national policies and tools focusing on linkages within territorial economies are well developed among most European member states. Although they vary in the extent to which they focus primarily on narrow industry-science linkages, or the formation of broader consortia involving users, producers and e.g. research institutes, the prevailing instruments are mainly built around the well-known set of instruments like R&D subsidies, tax incentives, building stocks of seed- or venture capital as well as commercialization efforts in terms of support of young promising start-ups or spin-offs from science. As international interfacing is presumably the least developed dimension of national innovation policies, the apparent "inwardness" of existing innovation policy measures both in terms of direct R&D funding and linkage-building seems to represent a main weakness. One gets the impression that innovation policy tries to cope with the challenges of the globalized economy by backing on their national strengths and isolating them from external access in order to secure their competitiveness and prevent losses of spill-over and the hollowing-out of their national innovations systems. From the perspective of open innovation, this means that innovation policy is still dominated by "outside-in" thinking. Hence, open innovation is interpreted like a "one-way-road" which allows foreign knowledge (e.g. in terms of the engagement of foreign researchers) to enter the domestic innovation system but with simultaneously minimizing knowledge flows from inside-out.

Thus, there seems to be the need for national innovation policy to prepare itself not only for the challenges of globalization but also to its opportunities (Herstad et al., 2010; Huang and Soete, 2008). It has been argued before that the purpose of international linkages is to feed domestic knowledge development processes, to stimulate further spillover effects, and thereby expose national innovation systems to the variety beyond what they can generate endogenously. Nevertheless, to avoid unintended effects of knowledge drain or hollowing-out mechanisms, the establishment of such international linkages should to be backed up by a strengthening the development and accumulation of specialized, synthetic knowledge by and between corporate firms (Herstad et al., 2010).

Moreover, the overview on existing national innovation policies has also revealed a second weakness regarding the balance between broader, network-oriented instruments of building linkages, and the focus on narrow, specific relationships between certain groups of actors. In other words, diversity as a source of innovation is considered differently by existing policy instruments (Lundvall, 2009). With regard to innovation theory, this might be reflected by the two prevailing rationales of the nature of innovation processes. Policy measures that aim at making society in general more science-based are often characterized by providing incentives to enhance the absorptive capacity of non-scientists and supporting scientists with adequate resources and autonomy, to enable them to carry out the research they see themselves as pertinent. This is the essence of what we call the "linear innovation model" thinking about the relationship between science and productive activities in society, be it in business or in public service provision (Ørstavik, 2008). Although "everybody knows that the linear model of innovation is dead" (Rosenberg, 1994), it still shapes national innovation policy due to its very simplicity (Arundel, 2007), and is represented in innovation policy which puts a large emphasis on the stimulation of knowledge flows from science into business. But with the upcoming of a systemic understanding of innovation processes, innovation has more and more be considered to result from broad social interaction of multiple actors and stakeholder. Consequently, innovation is not just the result of scientific work in a laboratory-like environment. Instead, it is understood as complex and variable. Thus, the systemic model of innovation stresses the role of networking collaborative systems of innovation with knowledge bases distributed all over the innovation system (Freeman and Soete, 2009). Firms increasingly rely on sourcing information from and collaborating with diverse external sources to develop and expand their internal stock of knowledge. User-driven innovation is, for example, not a phenomenon encompassed by the user-producer relationship. But it will force the producer more frequently to interact with a broad range of other actors to source knowledge and to develop solutions that meet the requirements of his users. Even science-driven firms are similarly dependent on a wide range of external, non-science knowledge and information sources (Herstad et al., 2010). This indicates that it is especially in the intersections between scientific advances, market preferences and specialized cumulative knowledge development what accounts for the competitiveness and performance of national innovation systems. Regarding the prevailing characteristics of the considered countries, it seems like this innovation systems thinking is strongest reflected in the "Nordic design" (Denmark, Norway, Finland) of innovation policy which emphasis the role of collaboration and interaction between a broad, open and network-oriented set of multiple socio-economic actors (Ørstavik, 2008). In the context of open innovation, our call is for industry to form heterogeneous, international interfaces and make use of them to feed domestic, specialized knowledge development. As Herstad et al. (2010) points out, in the course of Barcelona and Lisbon processes national innovation policy often seems to have shifted distinctively in the opposite direction. Policy makers appear primarily occupied with the question of how to force stronger, more intensive linkages between industry and academic research. In some cases, this culminates in the circumstance that an increased industry sourcing from the science system is considered as an end in itself.

14.4 Towards an European Innovation Union - policy measures to address open innovation practices at the European level

How then, does EU level innovation policy fit into this picture? Despite the circumstance, that European Community institutions have early included innovation policies in their documents which have gradually been developed and led to First Action Plan for Innovation in Europe, research, education and innovation policy in Europe was predominantly left to the authority of individual Member States (Soete and Arundel, 1993). As the previous chapters have shown, this limited union involvement beyond framework programme support for cross-border initiatives has led to a great deal of heterogeneity of national policy measures as a result. Since the mid-1980s, innovation policy within the European Union has thus become a multi-level policy area regarding contents, budgets and institutions (Grande, 2000; Borras, 2003).

In the last decade, and accelerated in the recent years, European research and innovation policy has undergone considerable developments. Most importantly, these developments are targeted towards more concerted action across research and innovation in Europe. To set the overall frame for its current efforts to integrate the fragmented landscape of national policy measures and to foster innovation and economic renewal in the coming years, the European Union has formulated an economic and societal vision for Europe, the Europe 2020 strategy (European Commission 2010, 2020)[1]. As far as research and innovation are concerned, one key pillar to achieve this is the "Innovation Union" (European Commission 2010, 546)[2], which essentially is a very comprehensive attempt to bring current developments together, make research and innovation an essential part of EU policy. The "Innovation Union" initiative represents the current end of a line of developments

[1] For documentation on the EU 2020 strategy see http://ec.europa.eu/eu2020/index_en.htm.

[2] http://ec.europa.eu/research/innovation-union/index_en.cfm

having started with the Lisbon Agenda in 2000. It mirrors the growing significance of innovation and innovation policy at the EU level and is a flagship initiative of the Lisbon Agenda's successor for the coming decade, the Europe 2020 strategy (European Commission, 2010, 546).

The EU 2020 Strategy has been formulated and agreed upon while Europe is still facing the effects of a severe economic crisis. It represents a vision of transformation, with innovation and knowledge as core elements. The new strategy strongly relies on the concept of knowledge triangle, whereby the policy areas of research, innovation and education are integrated and their strong interdependence is acknowledged (Soriano and Mulatero, 2010).

The overall EU 2020 Strategy is broken down into seven thematically distinct flagship initiatives:

- **Innovation Union**[1]
- Youth on the move
- A digital agenda for Europe
- Resource efficient Europe
- **An industrial policy for the globalization era**[2]
- An agenda for new skills and jobs
- European platform against poverty

While innovation as a systemic and multidimensional phenomenon can be related - directly or indirectly - to all seven flagship initiatives, in the more specific context of open innovation two of these flagship initiatives, namely "Innovation Union" and "Industrial policy for the globalization era" seem particularly relevant. These two initiatives thus stand in the main focus of the following discussion.

The first InnoGRIPS study on "Barriers to internationalisation and growth of EU's innovative companies" (Reinstaller et al., 2010) already provides an extensive and excellent overview on policy instruments targeted towards general barriers to innovation and internationalisation. We will thus refer to their study and shed some light specifically on the aspect of open innovation. As an analytical framework, we will redraw on the policy assessment framework suggested by Herstad et al. (2010) as outlined previously.

14.4.1 Incentives for domestic industry knowledge development and accumulation

The most important instruments for funding or co-funding innovation activities and building increasing potentials for spillovers in the Member States are the Framework Programme (FP), the Competitive and Innovation Programme (CIP), the Structural Funds/ESF, the European Regional

[1] http://ec.europa.eu/research/innovation-union/index_en.cfm

[2] http://ec.europa.eu/enterprise/policies/industrial-competitiveness/industrial-policy/index_en.htm

Development Fund (ERDF) as regional policy instrument, the new instrument of the Commission in cooperation with the European Investment Bank (EIB) to finance risky research projects, and the Enterprise Europe Network which provides assistance to SMEs not only in terms of finance, but also internationalization. The framework programmes'[1] objective is to strengthen "...the scientific and technological bases of Community industry, thereby ensuring a high level of competitiveness at international level" (EU 2006, L412: 1). To meet this objective, the Framework Programme is composed of four pillars: the "Cooperation" programme, the "Ideas" programme, the "people programme" and the "Capacities" programme). Thereby, the "Cooperation" activity is the largest one in terms of monetary resources (approx. 32 million Euros) and aims directly at establishing stronger ties between different actors within the European innovation system to support and strengthen highest quality research in ten policy-defined themes. Cohesion in terms of closing technology gaps (e.g. in certain regions or in SMEs) is not the prime objective of the Framework Programme (Reinstaller et al., 2010). Nevertheless, the "Capacities programme" (EU 2006, L412) constitutes an exception as it supports the improvement of research infrastructure and research projects for the benefit of SMEs as well as the unlock of the research potential of European "Regions of Knowledge" respectively the enlarged European Union ("Convergence of Regions")[2]. Due to these objectives, this policy instrument is mostly focused on technology and knowledge diffusion and transfer between different regions of Europe.

The second main European policy instrument for the funding of knowledge generation "The Competitiveness and Innovation Programme (CIP)"[3] integrates several existing, sometimes quite specific programmes supporting competitiveness and innovation into a common framework (EU 2006a, L310). Firstly, the "Entrepreneurship and Innovation Programme (EIP)" pursues to establish frame conditions that are beneficial to collaboration between SMES, to promote an innovation friendly culture of entrepreneurship, and to set up firm- and innovation-related economic and administrative reforms. Additionally, the "The Information Communication Technologies Policy Support Programme (ICT-PSP)" aims at creating a common European information space by stimulating the diffusion and absorption of innovative ICT based services and the exploitation of digital content across Europe by citizens, governments and businesses, in particular SMEs. As a third sub-programme of CIP, the "Intelligent Energy Europe Programme (IEE)" contributes to the sustainable development in the field of energy (e.g. renewable energy). As it can be seen from its main objectives the CIP instrument is targeted towards the diffusion and adoption of new technologies in the mentioned fields. In doing so, it supplements the Framework Programme which is more focused on basic research.

Moreover, "Eureka"[4] and "COST"[5] are initiatives which involve a larger group of states in- and outside the EU. Both activities complement the Framework Programme with regard to the support of different actor groups along the economic value chain. Eureka stresses the application aspect by supporting the development of innovative products, processes or services, while COST is the

[1] http://cordis.europa.eu/fp7/home_en.html

[2] http://cordis.europa.eu/fp7/capacities/home_en.html

[3] http://ec.europa.eu/cip/

[4] http://www.eurekanetwork.org/

[5] http://www.cost.esf.org/

counterpart for the pre-competitive stage by supporting basic research projects. Both instruments do not provide direct funding. Eureka provides its supports partnering and access to foreign markets, while the project partners have to apply for national or other funding separately. Projects can be proposed bottom-up by researchers and the programme is thematically open. Projects are often small-scale in terms of the number of involved partners and duration. COST works quite similar. Since 2005, the instrument of "EUROSTARS"[1] is a part of Eureka. It is a variable-geometry initiative by 32 states following Article 185 Treaty of the Functioning of the European Union (TFEU) with aims at improving the R&D performance of SMEs through the support of intramural research. Further pillars of Eureka are cluster and umbrella initiatives that seek to foster collaboration.

Regarding the human resource dimension, the new European funding organization for “frontier” research of scientists, the "European Research Council (ERC)"[2] has been established in 2007. Its main aim is to stimulate scientific excellence by supporting and encouraging the very best scientists, scholars and engineers from different countries to be adventurous and take risks in their research. By its “bottom-up” nature, the ERC allows researchers to identify new opportunities and directions in any field of research, rather than being led by priorities set “top-down” by politicians. ERC grants are awarded through open competition to projects headed by starting and established researchers, irrespective of their origins, who are working or moving to work in Europe - the sole criterion for selection is scientific excellence. The aim here is to recognize the best ideas, and retain and confer status and visibility to the best brains all across Europe, while also attracting talent from abroad.

With regard to the Europe 2020 strategy communication, funding of R&D and knowledge development is explicitly addressed by the fourth guideline which points out the need for "optimising support for R&D and innovation, strengthening the knowledge triangle and unleashing the potential of the digital economy” (European Commission, 2010, 193). Thereby, the EU continues the integral role of R&D and innovation support in European innovation policy by calling the Member States to set their R&D and innovation policies within the EU context. The EU´s aim is to create procurement markets across the EU with a yearly budget of at least 10 billion Euros could significantly accelerate and foster the development of innovative products and services, thus contributing to knowledge development and increasing the potential for spillovers in strategically chosen areas. By directing public procurement activities towards designated innovation areas (as already proposed by the Commission for eco innovation) systematic knowledge accumulation for specific future markets should be enhanced (European Commission, 2010, 546).

At a first glance, by explicitly underlining its mission orientation in terms of societal challenges and megatrends such as renewable energy, resource efficiency, climate change, social cohesion, ageing, health, and security, fostering excellence and specialisation, R&D and innovation funding in the EU 2020 still follows a "top down" mission-oriented approach. It also seems that there prevails a science-push perspective which is reflected in the notion that governance of research institutions should be improved to make national research systems more effective. To this end university-based research should be modernised, infrastructures developed, attractive careers and

[1] http://www.eurostars-eureka.eu/

[2] http://erc.europa.eu/

mobility of researchers promoted (European Commission, 2010, 193). However, this impression has to be qualified, as the guideline explicitly advocates for a broad understanding of innovation by including also non-technological forms of innovation which are not necessarily bound to science and R&D activities. In addition to R&D-based modes of innovation, the systemic understanding of innovation further enhances the concept of open innovation, by explicitly stressing the role of multiple, and diverse sources of knowledge. Hence, the EU 2020 strategy adopts the broad understanding of innovation proposed by the OECD and its OSLO Manual (2005). The EU 2020 strategy puts strong emphasis on a broad concept of innovation that explicitly includes service innovation, design, organisational change, marketing innovation, business model innovation and social innovation. It also points towards the need for intensification of collaboration involving different user and consumer groups “as important constituencies of open innovation” (European Commission, 2010, 546).

This explicit display of the increased importance of non-technological based forms of innovation is for instance reflected in the promotion of design and the launch of the "European Design Innovation Initiative (EDII)"[1]. Design is of key importance for the user-centred aspect of open innovation. Design can be viewed as a linking element between creativity and innovation. Through design, creative new ideas are being shaped into a usable and practical form, which then is becoming an innovation and can contribute to increased competitiveness. Design is a multi-disciplinary approach that is centred on user´s needs and requirements and typically brings together different perspectives and areas of expertise, both from technological and non-technological backgrounds. It can also complement R&D activities and can be important for mature sectors and firms with low R&D investments (European Commission, 2009, SEC 501). While the topic of design has been addressed in various European policy initiatives in the past, it has not been an explicit part of the Commissions innovation strategy prior to the EU 2020 Strategy. Within the Flagship Initiative Innovation Union a European Design Innovation Initiative will be launched in 2011, bringing together actors from diverse backgrounds such as the business sector, higher education, designers and national as well as regional agencies promoting design and innovation (European Commission, 2010, 546; DG Enterprise and Industry, 2011).

14.4.2 Securing well-functioning networks within the European Union

As stated before, most innovation promotion policies by member states are targeted at linkages between domestic actors within the national innovation system. Due to its main functions, innovation policy on the European level is in most cases strongly affected by the idea to promote any kinds of collaboration between its Member States and the different actors within. The EU Framework Programme has thus by far been the most important instrument of the EU research policy during the last decades to stimulate the formation of mutual linkages across European member states. It represents an umbrella for the supporting actions, and its major means is to fund transnational collaboration projects within thematic programmes. Until today, the major benefit of the Framework Programme is to enable transnational collaboration of firms and institutes in

[1] http://ec.europa.eu/enterprise/policies/innovation/policy/design-creativity/edii_en.htm

Europe to do application and solution oriented research. This is linked to EU goals through thematic priorities that are derived from those goals. Thus, while the thematic programmes are a compromise between EU suggestions and Member State priorities, the basic principle is contributing to EU goals. However, due to their restrictions regarding financial and human capital, SMEs frequently are rather hesitant to participate in innovation collaboration outside the national innovation system. If any, only highly R&D-intensive SMEs with a strong export orientation might have good reasons to engage in cross-border collaboration. Unfortunately, most initiatives within the Framework Programme are not explicitly targeted at involving SMEs, except the "Capacities Programme"[1] which aims at closing knowledge gaps at the level of SMEs. Besides the Framework Programme, the "Entrepreneurship and Innovation Programme (EIP)"[2] also wants to stimulate collaboration participation of SMES through business and innovation services all around the EU by providing enterprises with a range of quality and free-of-charge services. Moreover, it aims at supporting transnational networking of different actors in the innovation process and innovative companies, including benchmarking initiatives and the exchange of best practice. Last but not least, the "European Regional Development Fund (ERDF)"[3] seeks to stimulate regional cohesion within the EU by financing innovation projects in less developed regions (EU 2006b, L210).

Apart from this, the EU also runs the previously mentioned instruments of "Enterprise Europe Network (EEN)" and "EUROSTARS" to support international cooperation specifically targeted towards high-tech SMEs. The EEN offers support in finding international partners for collaboration by providing access to business database that allows for target-oriented matching of partners. Additionally, the EEN also offers assistance with regard to technology transfer, access to finance, research funding as well as to issues of IPR. The EUROSTARS programme as a part of the Eureka network joins 32 countries and is designed to support market-driven innovation projects of SMEs. Thereby, it requires two participants from two different European countries with a R&D performing SME being the main participant.

However, as it becomes apparent from this short overview, policy measures on the EU level prior to the EU 2020 Strategy have been mainly targeted towards rather narrow linkages between business and science sector. In contrast, implemented measures that explicitly trigger broader linkages between multiple socio-economic actors (e.g. user-or consumer-driven innovation, social innovation) or dialogue-oriented interactions to strengthen community- or identity-building among different actors, and thus to create an innovation-friendly climate are still scarce. One measure that has been recently taken to strengthen the market- or demand side of innovation is the “Lead Market Initiative” who aims at accelerating and improving the interactive flow of information between suppliers and users (European Commission, 2007, 860). Beside the supply of thematically targeted supports as for instance performance by the CIP-Programme, the lead market initiative wants to coordinate the use of networking projects and platforms for "mutual learning and knowledge-sharing" to "speed up the flow of ideas and knowledge" between knowledge-based clusters across Europe (European Commission, 2007, 860: 9).

[1] http://cordis.europa.eu/fp7/capacities/home_en.html

[2] http://ec.europa.eu/cip/eip/index_en.htm

[3] http://ec.europa.eu/regional_policy/funds/feder/index_en.htm

To promote the intensification of transnational collaboration networks within the EU, the provision of functioning infrastructure, legal frameworks, and opportunities for financing such projects seems to be of equal importance as direct funding of collaborative projects (Reinstaller et al., 2010). As mentioned above, the "Competitiveness and Innovation Programme (CIP)" also entails sub-initiatives which try to accelerate the development of a common European ICT infrastructure to support the exploitation of digital content across Europe by citizens, governments and businesses, in particular SMEs.

In order to facilitate knowledge diffusion within Europe, the European Union proposes to set a deadline of end 2014 for achieving a well functioning “European Research Area (ERA)”[1]. In 2012, the Commission will propose a European Research Area framework and supporting measures to remove obstacles to mobility and cross-border cooperation, aiming for them to be in force by end 2014 (European Commission, 2010, 546). This goal should be achieved by incentives for increasing (international) mobility of researchers, internationally comparable career structures, cross-border operation of research performing organizations as well as funding agencies ensuring the mutual coherence of funding rules and procedures. Through "ERA-Nets" a self-defined group of national (and regional) programme managers and owners with variable country representation are co-funded by the Commission in order to establish learning and coordination among them. This coordination and cooperation can take very different forms. It reaches from simple learning and exchange of good practice to funding joint calls and even the establishment of more durable joint structures, with few ERA-Nets even establishing truly joint programme structures through so-called “Art. 169 initiatives”.[2] Hence, the ERA-Net scheme and the ERA-Net plus scheme both have already been successfully evaluated in mobilizing national and regional programmes to an entirely new level of joint action (Daimer et al., 2011; Lock et al., 2009).

Compared to the past, the EU 2020 strategy is characterised by a stronger emphasis on supporting heterogeneous linkage formations between different actor groups (e.g. industry, suppliers, customers, universities, research institutions, public sector, professionals, etc.) to promote knowledge transfer and diffusion. The "European Institute of Innovation and Technology (EIT)"[3] goal is to address shortcomings in knowledge transfer between and to bring together diverse actor groups from business, research and academia to collaborate on joint projects. It is the first European initiative to integrate fully the three sides of the "Knowledge Triangle" (European Commission, 2010, 546). The EIT finances support structures for knowledge transfer and networking by funding virtual “Knowledge and Innovation Communities (KICs)”, being organized as public-private partnerships. The Commission will also support business-academia collaborations through the creation of "Knowledge Alliances" between education and business to develop new curricula addressing innovation skills gaps. Hence, the EIT´s multidisciplinary approach is directly addressing the need for the creation and development of heterogeneous linkages by bringing together actors from different disciplinary and institutional backgrounds. A strong EIT Governing Board shall ensure implementation of major strategic goals. There is an incremental approach for

[1] This term was firstly coined by the European Comission in 2000: „Towards a European Research Area“ (European Commission, 2000, 6)

[2] now Art. 185

[3] http://eit.europa.eu/

setting up the KICs, with the first three now being in place. The planned introduction of the "EIT Degree" should further foster the institutionalization of this interdisciplinary approach and its wider adoption. Yet, it is too early to evaluate the impact assessment of the EIT.

Furthermore, network-building between different actors of the European Innovation Union is also being promoted through the launch of the "European Technology Platforms (ETP)"[1], which have been introduced in 2002. They intend to pave the way for a stronger European industrial and innovation policy as a means to realize the ambitious goals of the Lisbon agenda. ETPs should bring together different stakeholders like regulatory bodies, industry, public authorities, research institutes and the academic community as well as the financial world and civil society in areas of major industrial relevance for Europe. Their major role is seen in enhancing science-industry collaboration and in developing long-term R&D strategies which address major technological challenges. The initiatives for ETP should follow a bottom-up approach, with the stages of setting up and developing the strategic research agenda (SRA) being financed either by EC funds, industry or membership fees. For the implementation activities of the SRAs, the ETPs are expected to raise private and public funding, meaning with respect to the latter that they are expected to influence public programming, in particular the priorities of the Framework Programme. The new approach of "European Innovation Partnerships (EIP)" goes even further, as they will focus not only on technological aspects, but also on societal effects and implications for the entire innovation chain, value chain and markets. This more holistic approach is challenge-driven and reaches out to all relevant actor groups involved in and affected by a specific innovation initiative (examples: smart cities, active and healthy ageing, water efficiency, etc.). European Innovation Partnerships aim at tackling societal challenges that are of high relevance for Europe in general and justify government intervention. By bringing together all key stakeholders relevant for a specific innovation area, European Innovation Partnerships should be "platforms for open innovation and citizen engagement" (European Commission, 2010, 546). One main reason for establishing European Innovation Partnerships are efficiency gains by creating a critical mass and pooling scarce resources. This necessarily involves intense national and international collaboration between different actor groups.

Another instrument to promote network linkages between a broad set of actors is related to the issue of social innovation. Social innovation points at complex shifts in behaviour that are necessary in society in order to develop the capacity to effectively deal with fundamental challenges such as climate change or demographic developments. Social innovation involves many different actor groups and reaches far out beyond the linking of just specific sectors. Citizen-centred approaches to service delivery, social entrepreneurship as well as the involvement of the public sector in innovation processes are some of the ways in which linkage formation between heterogeneous actor groups in society can be facilitated. Within the frame of the EU 2020 Strategy, the Commission is planning to support the development of social innovation through more targeted efforts by the European Social Fund (ESF) as well as through the launch of a European Social Innovation Pilot, a "virtual hub" providing expertise and networking opportunities for social entrepreneurs and public sector actors (European Commission, 2010, 546).

[1] http://cordis.europa.eu/technology-platforms/

Besides these instruments, the EU 2020 strategy also proposes to grant open access to publicly funded research and smart research information services to enhance. The Commission´s aim to enable easy and – whenever possible – free access to international research results is a measure to make it easier for businesses to draw upon and make use of and better exploit existing knowledge. This can widen and broaden firm´s ability for knowledge sourcing and enable them to incorporate international research results into their own knowledge development activities (European Commission, 2010, 546). With regard to establishing new cross-sectoral networks within the EU, new strategic initiatives are on the way. Based on previous findings about the significant potential of culture and creative industries as drivers for innovations in other sectors, effective collaboration between creative industries and other private and public sectors should be fostered by the launch of a "European Creative Industries Alliance" (European Commission, 2010, 614). Regarding the policy programmes that are directly targeted at promoting the role of design in Norway or Denmark, this is an example, how pilot programmes existing on the level of Member States gradually diffuse on the European level.

Following the overall aim of the Commission to strengthen industrial sectors (both high-tech and also mature/traditional sectors) the development of new business concepts and related manufacturing technologies focused on the development of sustainable, user-driven design-based products will be supported. Furthermore, policy approaches are about to be developed to foster the potential for greater cross-fertilization between sectors, including traditional manufacturing sectors and SMEs (European Commission, 2010, 614).

With regard to regional cohesion within the EU, the envisioned establishment of a “smart specialization platform” by 2012 should further strengthen the re-allocation of Structural Funds towards supporting innovation, and more specifically smart specialization through the emergence of world class clusters. Different regions can develop excellence in different areas, depending on their specific advantages and local strengths. Besides regional specialization, trans-regional and trans-national cooperation is being encouraged as well. This should ensure the information flow between leading innovation regions across Europe and also the pooling of resources and expertise - wherever meaningful (e.g. shared research infrastructure). Collaboration between leading innovation regions is thus also strongly related to the previous point of promoting international linkages for knowledge sourcing (European Commission, 2010, 546). It is the explicit aim of the Commission to orient structural policies towards the strategic goals of the EU 2020 strategy by creating a single innovation market to improve the use of existing Structural Funds for R&D projects. Thus the aim of Structural Funds therefore is not only to redistribute financial resources but also to strengthen the factors determining regional development. The challenge of research, innovation and technology policy in the Cohesion and Structural Funds is to assist adapting local policies and institutions to enhance and realign of functioning national and regional innovation systems, for example through the promotion of collaboration and technology transfer.

Financing

Regarding the issue of venture capital financing on the European level has been already recognized by the European Commission as one innovation bottleneck (European Commission, 2009a; European Commission, 2008, 394). As Reinstaller et al. (2010) point out venture capital fund activity relies on a considerable amount of specialized know-how which requires years to form. As shown before, there is a large number of public funds on the level of Member States to provide equity capital at the early (seed-capital) and later stages (venture capital) of new ventures. Likewise to the policy instruments and initiatives on the Member State level, the support of corresponding networks, bridging mechanisms, corporate investors as well as entrepreneurial culture on the European level can accelerate this process. Thus, several initiatives have been already started to overcome this bottleneck and to create a "Pan-European Venture Capital Market"[1] by supporting the provision of risk capital for firms in early growth stages. It covers three types of financing: informal investment by business angels, venture capital, and stock markets specialized in SMEs and high growth companies. For this purpose, the "European Investment Fund (EIF)" follows a fund-of-funds strategy and aims at pairing money from the public and private sector. Regarding SMEs, the "Competitiveness and Innovation Programme (CIP)" of the EU also provides equity finance to fast growing SMEs (gazelles) and start-ups using the EIF as a vehicle. The EIF also provides guarantees for SME financing. Many of these policies are, however, linked with financing institutions on the national level. Another policy instrument is the "Enterprise European Network (EEN)"[2] whose objective is to help and assist SMEs to access new European markets, to source or licence new technologies, and to access EU finance and funding more easily. To fulfil this mission, the EEN consists of more than 580 member organisations across the EU and beyond. They include chambers of commerce and industry, technology centres, universities and development agencies. A similar gateway function is also provided by the initiative "SME techweb"[3] which tries to help SMEs in participating in research framework programmes, thus enabling and fostering stronger collaboration and network building.

The EU 2020 Strategy is planning to put in place financial instruments by 2014 to “attract a major increase in private finance and close the market gaps in investing in research and innovation” (European Commission, 2010, 546). These include investment in knowledge transfer and start ups, venture capital for fast growing firms expanding on EU and global markets, risk sharing finance for investments in R&D and innovation projects, and loans for innovative fast growing SMEs (gazelles). Furthermore, by 2012 Venture Capital funds established by any member state should be able to operate and invest freely across Europe. Cross-border activities should explicitly be made easier by implementing new legislation, if necessary.

Use and management of intellectual property

Until today, despite the existence of the European Patent Office (EPO) which allows for bundling patent application in Member State economies, the grant and enforcement of intellectual property rights is still organized on the level of Member States and their national patent offices. From the perspective of a European Innovation System, the current IPR system has several characteristics that are unfavourable for promoting the diffusion of technology and knowledge. With regard to the innovation activities of firms there is strong evidence by now that the lack of a single European Patent affects firms’ incentives to innovate and raises financial barriers to innovation (Reinstaller et

[1] http://ec.europa.eu/enterprise/policies/finance/risk-capital/index_en.htm

[2] http://www.enterprise-europe-network.ec.europa.eu/index_en.htm

[3] http://ec.europa.eu/research/sme-techweb/index_en.cfm

al., 2010). Hence, a missing European patent or more generally speaking, a European system of intellectual property rights, might aggravate the situation in two ways. Firstly, due to the enormous costs and bureaucratic hurdles firms (particular SMEs) might refrain from patenting if not necessary. Secondly, this induces delayed knowledge diffusion and spillovers, because the amount of new technological knowledge available is reduced. The European Commission has been fully aware of this problem with the European IPR system for years (European Commission, 2007, 165; Reinstaller et al., 2010). Policies proposed on the European level thus aim at the implementation of a single community patent and improved IPR enforcement. The results of the "IPR Enforcement Report" provide information on risks and challenges when dealing with certain third countries outside the EU, particular for SMEs. The above mentioned "Enterprise Europe Network (EEN)" also holds an IPR-related aspect by supporting sourcing and licensing of new technologies. Likewise, the "IPeuropAware"[1] programme and its "Innovaccess"[2] initiative are composed of 20 national patent offices providing IPR support services to SMEs. In addition, the "IPR Helpdesk"[3] is an e-module based training for IPR issues and management in the context of EU funding programmes (e.g. FP7, CIP), while the "China IPR - Helpdesk"[4] specifically focuses on training on IPR issues related to China. Moreover, to support knowledge diffusion by exploiting the information function of patents, the "Espacenet"[5] initiative of the European Patent Office (EPO) offers free access to more than 70 million patent documents worldwide, containing information about inventions and technical developments from 1836 to today. As can be seen from these examples, policy instruments on the European level are hitherto predominantly aiming at the improvement of the identification of priority countries, the provision of technical assistance and advice to firms, and the increase of the patent holders' awareness of trade barriers regulation mechanisms (Reinstaller et al., 2010).

Given that the costs for patent protection in the EU (27) are currently 15 times higher than in the US, the lack of a single, simple and affordable EU Patent is a major barrier for effective knowledge protection and with this also knowledge accumulation and diffusion on the long term. The EU´s commitment to finally implement the EU Patent by 2014 is a major step towards ensuring the protection of intellectual property and enabling a more effective and efficient protection, diffusion, and exploitation of knowledge within the EU innovation system (European Commission, 2010, 546). Corresponding to this, the Commission plans to implement market places (similar to trading platforms) to enable financial investments in intangible assets, and other ideas for breathing new life into neglected intellectual property, such as patent pools and innovation brokering (European Commission, 2010, 546). This should better enable the use and flow of existing knowledge, and the mutual exchange of intellectual property between different states (international linkage of knowledge sourcing hereby refers however only to the transfer between different Member States).

[1] http://www.ipeuropaware.eu/

[2] http://www.innovaccess.eu/

[3] www.ipr-helpdesk.org

[4] http://www.china-iprhelpdesk.eu/

[5] http://www.epo.org/searching/free/espacenet.html

14.4.3 Promoting the formation of international linkages for knowledge sourcing and information exposure

As mentioned above, particularly SMEs are in generally quite reluctant in taking part in international innovation collaboration. This accounts for transnational linkages within the EU as well as for international collaborations outside the EU. Only in case they have strong interests or export activities in foreign markets of the U.S. or Japan, SMEs might show a higher willingness to establish international linkages outside the EU. Recently, two broad surveys of individual scientists and of universities and research organisations (Edler, 2007) have clearly demonstrated the importance of the EU Framework Programme not only as funding tool, but as catalyst for international collaboration. For example, those research organisations that are actively engaged in EU funding are at the same time more international in their activities in terms of cooperation, internal support structures etc. EU participation and international activities are mutually re-enforcing (Ebersberger and Edler, 2007); this is true also for the individual level. However, that study also found a big gap in the European funding (which is not sufficiently closed through national sources), i.e. the lack of opportunities to collaborate with extra-European players and the need to be fitting into the thematic working programmes (Ebersberger and Edler, 2007).

International knowledge sourcing is becoming increasingly important for innovation, but establishing international collaborations and business contacts is especially difficult for SMEs. The main strategy for increasing sustainable growth and competitiveness of European SMEs is outlined in the "Small Business Act (SBA)[1] (European Commission, 2008, 394). In general, it aims at creating a more favourable environment for SMEs including the encouragement and support of SMEs to benefit from growing markets outside the EU (European Commission, 2008, 394). In summary, by coining the "Think Small First" principle, the SBA entails a set of guidelines of how to design national policy that meets the specific requirements and needs of SMEs. Among other things, these guidelines also suggest relevant aspects for SMES internationalisation. However, the governance of the SBA remains weak as Member States are only "invited" to follow the proposed guidelines (Reinstaller et al., 2010). Building on measures presented in the “Small Business Act” the Commission plans to present a strategy within the frame of EU 2020 to strengthen the support of SMEs regarding their internationalization efforts (European Commission, 2010, 614). As some Member States and business organisations already provide this kind of support, the Commission wants to promote synergies between the efforts of the EU, Member States and these organisations.

Public procurement can also function as an enabling mechanism for building international linkages by implementing joint procurements between different entities as proposed by the Flagship Initiative Innovation Union. Incentives for cross-border joint procurements could establish new international collaboration linkages and contribute to better knowledge sourcing (European Commission, 2010, 546).

[1] http://ec.europa.eu/enterprise/policies/sme/small-business-act/

Besides further improving the conditions for attracting leading academics and researchers to Europe, science and technology cooperation with countries outside Europe should also be further facilitated in the future by favourable framework conditions, offering "equivalent protection of IPRs, open access to interoperable standards, non-discriminatory public procurements, and removing other non-physical barriers to trade" (European Commission, 2010, 2020). This will include among others facilitating standardization, protection of intellectual property rights, access to procurement, and exploration of the potential scope for "umbrella" agreements between the EU and Member States with countries outside Europe (European Commission, 2010, 546). However, these supports to internationalization activities of the business or science sector outside the EU are still mainly build around indirect instruments of improving the general infrastructure. There are no special funds specifically dedicated to the formation and intensification of international innovation or knowledge sourcing activities outside the EU to date. Support of internationalisation outside the EU takes place only indirectly. Specific policy instruments which directly aim at internationalisation strategies beyond the boundaries of the EU are also not raised by the EU 2020 strategy in terms of a corresponding guideline. Hence, international interfacing with third-party countries is the least developed dimension of future European innovation policy within the EU 2020 strategy.

14.5 Summary

As shown by the policy analysis, there is a broad scope of policy instruments among Member states which differ in their design, mission and direction of impact. In the light of the strategic goal of achieving an "Innovation Union" in Europe, it seems essential to better harmonize these existing policy schemes on the national level and also to clarify the complementarities between national and EU level innovation policy measures. Joint efforts between Member States would provide the opportunity for higher efficiency and impact. Moreover, even on the EU level, existing funding schemes have often evolved historically in their respective fields without necessarily being aligned to a superior mission which is now available in the form of the EU 2020 strategy. In this context, a better interlinking between different EU level funding schemes is vital to clarify objectives, reduce complexity and increase leverage by pooling resources. Synergies of national policy initiatives with the programmes of other Member States or those of the EU still remain underexploited. An integration and harmonisation should be fostered for example by a "Common Strategic Framework" – as proposed by the EC´s recent Green Paper (COM 2011:48) - which would bundle all relevant EU research and innovation funding activities that are currently represented for instance by FP7, CIP, and other EU innovation initiatives such as the EIT. In the light of open innovation, a functionally integrated and harmonised set of policy instruments assures that all actors interested or in need for innovation support will find a specific scheme that addresses their requirements. It might also prevent a bias to narrow or specific sets of funding instruments (e.g. promoting only industry-science linkages) as well as the simultaneous existence of contradicting policy instruments at different administrative levels. Moreover, it would enable the development of a simpler and more efficient structure and a streamlined set of funding instruments covering the full innovation cycle and value chain in a seamless manner and particularly make it easier for SME´s to participate. A "single entry point" for innovation support could thus enhance collaboration and stimulate a broader participation of different actors (particulary SME´s) in joint initiatives. On a practical level, this could be realised through the implementation of integrated policy information platforms that would provide information on all different policy support schemes. Such a "single entry point" that firms could use to identify suitable innovation support schemes could significantly lower the barrier for their participation.

EU 2020 Strategy as a big step forward towards a system of open innovation within the European Union...

This overview of the current EU 2020 Strategy documents reveals that within the context of fostering knowledge and innovation in Europe, **many elements** of open innovation are being explicitly addressed. In the communication on the Flagship initiative Innovation Union the European Commission expresses its commitment to remove the remaining barriers for entrepreneurs to "bring ideas to the market". Several policy initiatives and measures can be identified that directly target each of the four dimensions previously presented in the policy assessment framework. The 7th Framework Programme has already mapped out and supported several open innovation related aspects such as collaborative research (national and international), Joint Technological Initiatives that bring together heterogeneous actors groups around a certain technological development, exchange and international mobility of researchers (e.g. Marie Curie projects), industry-research partnerships, or the establishment of the European Research Council. Besides these, the European Commission aims for better access to finance (particularly for SMEs), affordable IPRs, smarter and more ambitious regulation and targets, and a faster setting of interoperable standards, all of which contribute to open innovation.

Despite the fact that the "European Innovation Union" subscribes to a mission-orientation by addressing major societal challenges such as climate change, energy and resource scarcity, health, and demographic change, there is considerable change in European innovation policy within the EU 2020 strategy from a rather narrow, science-push understanding of innovation to a broader systemic nature of innovation that considers technological as well as non-technological dimensions of innovation, recognizes their interplay and thereby also leaves enough room for bottom-up initiatives. Although such a systemic approach and the idea of the "knowledge triangle" (i.e. the integration of the areas of research, education and innovation) have already been addressed in the Lisbon Strategy in 2000, the integration of different knowledge related policy areas has remained a challenge in the past decade (Soriano and Mulatero, 2010). The new EU 2020 Strategy is now moving towards a much stronger integration of these different domains: "(…) the new agenda has kept the most positive features of the Lisbon strategy, the accent on the three pods of the knowledge system. But it also progressed with respect to the former provisions, thanks to the greater prominence attached to the linkages between the three dimensions of knowledge policy" (Soriano and Mulatero, 2010: 299). This is also reflected in the range of long-term initiatives that have been developed within the EU 2020 strategy, most notably within the process of establishing a "European Research Area (ERA)" by embedding traditional instruments (Framework Programme, EUREKA and COST) and developing new instruments. These new instruments deviate from the classical cooperation funding by addressing either excellence (ERC, EIT) or coordination issues (ETP, ERA-Net). This stronger integration between the different knowledge domains relates to open innovation by contributing both to increased knowledge exploration as well as knowledge exploitation (Lichtenthaler, 2011). Furthermore, a better integration between different knowledge domains enables complementarities and the occurrence of potentially important positive externalities. Integrating knowledge and capabilities from various domains is one of the features of open innovation related collaboration strategies (Herstad et al., 2010).

...yet, there are still major challenges

To start with, open innovation has – up to now – mainly been discussed in the context of manufacturing firms. Only recently open innovation is being increasingly recognized in the context of service firms (Chesbrough, 2011), which broadens the current discussion and expands it to open innovation in service firms. However, markets remain still fragmented, and the potential of lead user initiatives and demand oriented innovation policy is not yet completely harnessed and adopted to the opening up of the innovation process. Patenting is key to open innovation, as it serve to protect proprietary knowledge during collaboration, to signal the existence of a specific technology or competence (through the public nature of patent databases), and to commodify at least some core aspects of a technology. Perhaps somewhat surprisingly, it has also been shown that the propensity to quote patents fall with geographical distance to the actor which originally registered the patent, suggesting that patents are a particularly important mechanism for knowledge diffusion when operating in tandem with other, informal mechanisms at play within territorial economies (Maurseth and Verspagen, 2002; Verspagen and Schoenmakers, 2000). Yet, Europe has yet to implement the ‘EU patent’, and develop supportive institutional infrastructures (Dewatripont, Sapir, van Pottelsberghe de la Potterie, and Veugelers, 2010). Along these lines there are also challenges related to seed and venture capital availability (Blind and Georghiou, 2010), as member state financial markets have not been able to support the establishment of a seed and venture industry of comparable size to that of the US (Herstad, 2008). This would explain why open innovation patterns – in particular the venturing part of it – in Europe differ from those found in the US. As such capital serve to absorb industrial knowledge spillovers and to provide incentives for external technology commercialization (Herstad, forthcoming), its availability is key to structuring specific economy patterns of open innovation.

Last, research, higher education and innovation policies remain flavoured by their member state histories, traditions and policy systems. This may partly be interpreted as enabling necessary adaption to domestic and sub-national regional conditions; yet it is worrisome against the background of the strong orientation towards the build-up of dense domestic linkages or channelling industry investments towards public research institutions inherent in such policies.

As mentioned, the EU 2020 Strategy addresses each of the four dimensions of the policy assessment framework for open innovation proposed by Herstad et al. (2010). Particular emphasis is put on inter-disciplinary collaboration and a much broader collaboration between different actor groups in society. Several initiatives across all four policy dimensions aim at broadening the scope for knowledge exploration and exploitation in this sense. However, there is a still a strong focus on fostering knowledge exchange within the borders of the European Union, between European member states. This gives rise to the question “how open is open innovation”? Assuming that knowledge flows are increasingly global and not restricted to Europe´s borders, it might be interesting to also consider different approaches to increase the knowledge exchange between European and non-European actor groups. Even though international collaboration – particularly in the area of research - is being supported through various measures within the 7th Framework Program, considering the other innovation related policy initiatives this aspect still seems to be somewhat restricted.

References

Policy Documents

Council of the European Union (2008): Council Conclusions on the Definition of a “2020 Vision for The European Research Area”. 2891st Competitiveness Council Meeting, Brussels, December 1st and 2nd, 2008.

DG Enterprise and Industry (2011): http://ec.europa.eu/enterprise/policies/innovation/policy/design-creativity/index_en.htm (last accessed on February 20th, 2011).

DG Research and Innovation (2006): FP7: the future of the European Union research policy. http://ec.europa.eu/research/fp7/index_en.cfm (last accessed on February 20th, 2011).

European Commission (2000): Towards a European Research Area. COM(2000) 6 final, January 18th, 2000, Brussels.

European Commission (2007): Enhancing the patent system in Europe. COM(2007) 165 final, April 3rd, 2007, Brussels.

European Commission (2007): A lead market initiative for Europe. COM(2007) 860 final, December 21st, 2007, Brussels.

European Commission (2008): “Think Small First”, A “Small Business Act” for Europe. COM(2008) 394 final, June 25th, 2008, Brussels.

European Commission (2009): Design as a driver of user-centred innovation. SEC(2009)501 final, April 7th, 2009, Brussels.

European Commission (2009a): Summary Report - Cross-Border Venture Capital in the European Union - European Commission work on removing obstacles. Brussels: December, 2009.

European Commission (2009b): INNO-Policy TrendCharts - Innovation Policy Progress Reports, 2009. http://www.proinno-europe.eu/trendchart/annual-country-reports.

European Commission (2009c): Availability and Focus on Innovation Voucher Schemes in European Regions. Prepared by DG Enterprise and Industry, Unit D2 “Support for Innovation”, November 2009, Brussels, http://www.eurada.org/site/files/Eurada%20News/Supporting%20documents/312/Voucher%20scheme.pdf.

European Commission (2010): EUROPE 2020 - A strategy for smart, sustainable and inclusive growth. COM(2010) 2020 final, March 3rd, 2010, Brussels.

European Commission (2010): Proposal for a COUNCIL DECISION on guidelines for the employment policies of the Member States - Part II of the Europe 2020 Integrated Guidelines. COM(2010) 193 final, April 4th, 2010, Brussels.

European Commission (2010): Europe 2020 Flagship Initiative, Innovation Union. COM(2010) 546 final, October 6th, 2010, Brussels.

European Commission (2010): An Integrated Industrial Policy for the Globalisation Era - Putting Competitiveness and Sustainability at Centre Stage. COM(2010) 614, Brussels.

European Union (EU) (2006): DECISION No 1982/2006/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013). In: Official Journal of the European Union, L412, pp. 1-41.

European Union (EU) (2006a): DECISION No 1639/2006/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 October 2006 establishing a Competitiveness and Innovation Framework Programme (2007 to 2013). In: Official Journal of the European Union, L310, pp. 15-40.

European Union (EU) (2006b): REGULATION (EC) No 1080/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 July 2006 on the European Regional Development Fund and repealing Regulation (EC) No 1783/1999. In: Official Journal of the European Union, L210, p. 1-11.

OECD. 2001. Science, Technology and Industry Scoreboard. Paris: OECD.

OECD (2005): OSLO Manual - Guidelines for collecting and interpreting innovation data - Third edition. Paris: Organisation for economic co-operation and development.

OECD (2008): Open innovation in global networks. Paris: Organisation for economic co-operation and development.

Literature

Acemoglu, D., 1996. Credit constraints, investment externalities and growth. In: Booth u. a., 1996. pp. 41-62.

Acemoglu, D., 2002. Technical Change, Inequality, and the Labor Market, Journal of Economic Literature 40, pp. 7-72.

Acemoglu, D., Aghion, P. and Zilibotti, F., 2006. Distance to frontier, selection and economic growth. Journal of the European Economic Association 4(1), pp. 37–74

Acs, Z. J., Braunerhjelm, P., Audretsch, D. B., and Carlsson, B. (2009): The knowledge spillover theory of entrepreneurship. In: Small Business Economics, 32(1), pp. 15-30.

Adams, J. D. (2002). Comparative localization of academic and industrial spillovers. Journal of Economic Geography, 2, 253-278.

Aerts, K., & Czarnitzki, D. (2006). The impact of public R&D-funding in Flanders. status: published, IWT-Studies. Brussels.

Aerts, K., & Schmidt, T. (2008). Two for the price of one?Additionality effects of R&D subsidies: A comparison between Flanders and Germany. Research Policy, 37(5), 806-822.

Aglietta, M., & Breton, R. (2001).Financial systems, corporate control and capital accumulation. Economy and Society, 30(4), 433-466.

Agrawal, A., Cockburn, I., & McHale, J. (2006). Gone but not forgotten: knowledge flows, labor mobility, and enduring social relationships. Journal of Economic Geography, 6(5), 571-591.

Aho, E., Cornu, J., Georghiou, L., and Sublrá, A. (2006): Creating an Innovative Europe, Re-port of the Independent Expert Group on R&D and Innovation appointed following the Hamp-ton Court Summit and chaired by Mr. Esko Aho. http://ec.europa.eu/invest-in-research/pdf/download_en/aho_report.pdf (last accessed in January, 2006).

Allen, F., & Gale, D. (Eds.).(2000). Comparing financial systems. Cambridge: MIT Press.

Almeida, P., & Kogut, B. (1999).Localization of knowledge and the mobility of engineers in regional networks. Management Science, 45(7), 905-917.

Almus, M., & Czarnitzki, D. (2003). The effects of public R&D subsidies on firms' innovation activities: The case of Eastern Germany. Journal of Business and Economic Statistics, 21(2), 226-236.

Arbussa, A., and Coenders, G. (2007): Innovation Activities, Use of Appropriation Instruments and Absorptive Capacity: Evidence from Spanish Firms. In: Research Policy, Vol. 36, pp. 1545-1558.

Arnold, L. (1997): Wachstumstheorie. München: Franz Vahlen Verlag.

Arrow, K. J. (1962a). The Economic Implications of Learning by Doing. The Review of Economic Studies Ltd., 29(3), 155-173.

Arrow, K.J. (1962b), Economic welfare and the allocation of resources for invention, in: R.R. Nelson (ed.), The rate and direction of inventive activity: economic and social factors, Princeton, N.J., 609-625.

Arundel, A. and I. Kabla (1998). "What percentage of innovations are patented? Empirical estimates for European firms." Research Policy 27(2): 127-141.

Arundel, A. (2007): Innovation Survey Indicators: What Impact on Innovation Policy? In: Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs. Paris: OECD publishing, pp. 49-64.

Asheim, B. T. (1996). Industrial districts as 'learning regions': a condition for prosperity. European Planning Studies, 4, 379-400.

Asheim, B. T., & Coenen, L. (2006).Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks. Journal of Technology Transfer, 31, 163-173.

Asheim, B. T., & Gertler, M. (2005).The geography of innovation: Regional innovation systems. In J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), The Oxford Handbook of Innovation (pp. 291-317). New York: Oxford University Press.

Asheim, B. T., & Isaksen, A. (2002).Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. Journal of Technology Transfer, 27, 77–86.

Assink, M. (2006). Inhibitors of disruptive innovation capability: a conceptual model. European Journal of Innovation Management, 9(2), 215-233. doi: 10.1108/14601060610663587.

Athey, S., & Stern, S. (1998). An empirical framework for testing theories about complementarity in organizational design. NBER Working Paper, 6600.

Bailetti, A. J., & Callahan, J. R. (1992). Asessing the impact of university interactions on an research-and-development organization. R & D Management, 22(2), 145-156.

Baker, W.E. and Sinkula, J.M. (2002), "Market orientation, learning orientation and product innovation: delving into the organization's Black Box", Journal of Market-focused Management, Vol. 5 No. 1, pp. 5-23.

Balconi, M., & Laboranti, A. (2006). University-industry interactions in applied research: The case of microelectronics. Research Policy, 35(10), 1616-1630.

Baldwin, J. R., & Gu, W. L. (2004). Trade liberalization: Export-market participation, productivity growth, and innovation. Oxford Review of Economic Policy, 20(3), 372-392.

Bathelt, H., Malmberg, A., & Maskell, P. (2004).Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. Progress in Human Geography, 28(1), 31-56.

Bekkers, R., & Freitas, I. M. B. (2008).Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? Research Policy, 37(10), 1837-1853.

Belderbos, R., Carree, M. A., & Lokshin, B. (2004). Cooperative R&D and firm performance. Research Policy, 33(10), 1477-1492.

Benito, G. R. G., Larimo, J., Narula, R., & Pedersen, T. (2002). Multinational enterprises from small economies: Internationalization patterns of large companies from Denmark, Finland and Norway. International Studies of Management and Organization, 32(1), 57-78.

Berg-Jensen, M., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. Research Policy, 36, 680-693.

Black, B. S., & Gilson, R. J. (1998). Venture capital and the structure of capital markets: banks versus stock markets. Journal of Financial Economics, 47(3), 243-277.

Blankart, C. B. (2008). Öffentliche Finanzen in der Demokratie. Vahlen.

Blind, K., Edler, J., Frietsch, R. & Schmoch, U., 2006. Motives to patent: Empirical evidence from Germany. Research *Policy*, 35(5), pp.655-672

Blind, K., and Georghiou, L. (2010): Putting innovation at the centre of Europe. In: Intereconomics, 2010(5), pp. 264-269.

Borras, S. (2003): The Innovation Policy of the European Union. Cheltenham: Edward Elgar.

Bosch, F. A. J. V. d., Volberda, H. W., and Boer, M. d. (1999): Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. In: Organization Science, 10(5), pp. 551-568.

Branstetter, L. G. and M. Sakakibara (2002). "When do research consortia work well and why? evidence from Japanese panel data." The American Economic Review 92(1): 143-159.

Breusch, T. S., and A. R. Pagan. 1980. The Lagrange multiplier test and its applications to model specification in econometrics. Review of Economic Studies 47: 239–253.

Burr, W., Stephan, M., Soppe, B., and Weisheit, S. (2007): Patentmanagement - Strategischer Einsatz und ökonomische Bewertung von technologischen Schutzrechten. Stuttgart, Schäffer-Poeschel Verlag.

Busom, I. (2000). An empirical evaluation of the effects of R&D subsidies,. Economics of Innovation and New Technology, 19(2), 111-48.

Caloghirou, Y., G. Hondroyiannis, et al. (2003). The performance of research partnerships. Managerial and Decision Economics 24(2-3): 85-99.

Caloghirou, Y., Ioannides, S., & Vonortas, N. S. (2003). Research joint ventures. Journal of Economic Surveys, 17(4), 541-570.

Cappelen, Å., Fjærli, E., Foyn, F., Hægeland, T., Møen, J., Raknerud, A., et al.. (2008): Evaluering av SkatteFUNN - sluttrapport. In: SSB Rapporter 2008/2.

Carlsson, B. (2006). Internationalization of innovation systems: A survey of the literature. Research Policy, 35, 56-67.

Carlsson, B., & Eliasson, G. (2002).Industrial dynamics and endogenous growth. Industry & Innovation, 10(4), 435-455.

Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge aquisition. Management Science, 52(1), 68-82.

Chesbrough, H. (2006a) Open Business Models: How to thrive in the new innovation landscape. In: Harvard Business School Press.

Chesbrough, H. (2006b) Open innovation: The new imperative for creating and profiting from technology. Boston, Massachusetts: Harvard Business School Press.

Chesbrough, H. (2011 forthcoming): Open services innovation. Rethinking Your Business to Grow and Compete in a New Era. Jossey-Bass.

Chiesa, V., and A. Piccaluga (1998): Transforming rather than transferring scientific and technological knowledge - the contribution of academic 'spin out' companies: the Italian way. In: Oakey, R., and During, W. (eds). New technology-based firms in the 1990s. Volume V. London, Paul Chapman: pp. 15-31.

Chiesa, V., & Manzini, R. (1998).Organizing for technological collaboration.A managerial perspective. R&D Management, 28(3), 199-212.

Cohen, M. D., March, J. G., & Olsen, J. P. (1972).A Garbage Can Model of Organizational Choice. Administrative Science Quarterly, 17(1), 1-25.

Cohen, W. M., and Levinthal, D. A. (1989): Innovation and learning: The two faces of R&D. In: Economic Journal, 99(397), pp. 569-596.

Cohen, W. M., and Levinthal, D. A. (1990): Absorptive capacity - a new perspective on learning and innovation. In: Administrative Science Quarterly, 35(1), pp. 128-152.

Cohen, W., R. R. Nelson, et al. (1996). "Appropriability conditions and why firms patent and why they do not." NBER Working Paper, Cambridge, Massachusetts.

Conway, S. (1995). Informal boundary-spanning communication in the innovation process: An empirical study. . Technology Analysis & Strategic Management, 7, 327-345

Cooke, P. (2005): Regionally asymmetric knowledge capabilities and open innovation: exploring 'Globalisation 2' - a new model of industry organisation. In: Research Policy, 34, pp. 1128–1149.

Cooke, P. ed. (2006): Constructing Regional Advantage. Brussels: European Commission, DG Research and Innovation.

Cooper, R.G. & Kleinschmidt, E.J., 1995. Benchmarking the Firm's Product Development Critical Success Factors in New Product Development. *Journal of Product Innovation Management*, 12(5), pp.374-391.

Cotic-Svetina, A., Jaklic, M., & Prodan, I. (2008). Does collective learning in clusters contribute to innovation? Science and Public Policy 35(5), 335-345

Cox, D. et al (2009): Evidence on the main factors inhibiting mobility and career development of researchers. http://ec.europa.eu/euraxess/pdf/research_policies/rindicate_final_report_2008_11_june_08_v4.pdf

Cuijpers, M., Guenter, H. & Hussinger, K., 2011.Costs and benefits of inter-departmental innovation collaboration.Research Policy. (forthcoming)

Cyert, R. M., & March, J. G. (1963). A behavioural theory of the firm. New Jersey: Prentice Hall.

Czarnitzki, D. (2006). Research and development in small and medium-sized enterprises: the role of financial constraints and public funding. Scottish Journal of Political Economy, 53(3), 335-357.

Czarnitzki, D., Ebersberger, B., & Fier, A. (2007). The relationship between R&D collaboration, subsidies and R&D performance: empirical evidence from finland and germany. Journal of Applied Econometrics, 22, 1347- 1366.

Czarnitzki, D., Hanel, P. & Rosa, J.M., (2011).Evaluating the impact of R&D tax credits on innovation: A microeconometric study on Canadian firms.Research Policy, 40(2), pp.217-229.

Dachs, B., Ebersberger, B., & Pyka, A. (2008). Why do firms cooperate for innovation? A comparison of Austrian and Finnish CIS3 results. International Journal of Forsight and Innovation Policy, 4(3/4), 200-229.

Dahl, M. S., & Pedersen, C. Ø. R. (2004). Knowledge flows through informal contacts in industrial clusters: myth or reality? Research Policy, 33(10), 1673-1686.

Daimer, S., Edler, J., and Howells, J. (2010): Germany and the European Research Area. In: Studien zum deutschen Innovationssystem, Nr. 13-2011, Expertenkommission Forschung und Innovation (EFI), Berlin.

Danneels, E. (2002). The dynamic of product innovation and firm competencies. Strategic Management Journal, 23, 1095-1121.

Danneels, E. (2003). Tight-loose coupling with customers: The enactment of customer orientation. Strategic Management Journal, 24(6), 559-576.

David, P. A. (1993). Intellectual property institutions and the panda's thumb: Patents, copyrights, and trade secrets in economic theory and history. Global Dimensions of Intellectual Property Rights in Science and Technology. M. E. M. Mitchel B. Wallerstein, and Robin A. Schoen: 19-61.

De Jong, J.P.J., W. Vanhaverbeke, T. Kalvet & H. Chesbrough (2008), Policies for Open Innovation: Theory, Framework and Cases, Research project funded by VISION Era-Net, Helsinki: Finland.

Demirgüc-Kunt, A., & Maksimovic, V. (2002).Funding growth in bank-based and market-based financial systems: Evidence from firm level data. Journal of Financial Economics, 65, 337-363.

DeSarbo, W. S., Di Benedetto, C. A., & Song, M. (2007). A heterogenous resource based view for exploring relationships between firm performance and capabilities. Journal of Modelling in Management, 2(2), 103-130.

Dewatripont, M., Sapir, A., van Pottelsberghe de la Potterie, B., and Veuglers, R. (2010): Boosting innovation in Europe. In: Intereconomics, 2010(5), pp. 269-273.

Dougherty, D. (1992). A practice-centered modell of organizational renewal through product innovation. Strategic Management Journal, 13, 77-92.

Dreher, C. (1997): Technologiepolitik und Technikdiffusion - Auswahl und Einsatz von Förderinstrumenten am Beispiel der Fertigungstechnik. Baden-Baden, Nomos Verlagsgesellschaft.

Duguet, E. (2004). Are subsidies a substitute or a complement to privately funded R&D? Evidence from France using propensity score methods for non-experimental data. Revue Economie Politique, 114(2), 263-292.

Dyer, J. H. (2000). Collaborative advantage.Winning through extended enterprise supplier networks. New York: Oxford University Press.

Ebersberger, B. (2004). Why do Companies Innovate less than they could – About Hampering Factors (in Finnish Miksi yritysten innovaatio loppuu kesken? Innovaation esteistä). In: Lemola, T. (ed.) Teknologiapolitiikka, Helsinki,

Ebersberger, B., & Bloch, C. (2008).Empirical analysis of open innovation. In S. Herstad, C. Bloch, B. Ebersberger & E. van de Velde (Eds.), Open innovation and globalisation: Theory, evidence and implications (pp. 38-80). Helsinki: Eranet Vision.

Ebersberger, B., & Herstad, S. (2010). Product innovation and the complementarities of external interfaces.Knowledge in Organizations Conference, May 30th - June 3rd, Monte Verita, Switzerland.

Ebersberger, B., & Lööf, H. (2005). Innovation Behaviour and Productivity Performance in the Nordic Region Does Foreign Ownership Matter? The Royal Institute of Technology Centre of Excellence for Science and Innovation Studies. Stockholm.

Ebersberger, B., Bloch, C., Herstad, S.J. & van De Velde, E. (2011) Open Innovation practices and their effect on innovation performance, International Journal of Innovation and Technology Management (forthcoming).

Ebersberger, B., Herstad, S., Lehtoranta, O. (2011) Bridging the global and the local? Multinational enterprises, labor market mobility and localized learning, mimeo.

Ebersberger, B., Lööf, H. (2005) Corporate Innovation Activities, Does Ownership Matter? Evidence from the Innovation Surveys of the Nordic Countries, Nordic Innovation Center.

ECMI.(2006). Statistical Package European Capital Markets Institute.

Edler, J. (ed.) (2007): Internationalisierung der deutschen Forschungs- und Wissenschaftslandschaft, Karlsruhe, Berlin

Edquist, C. (1997). Systems of innovation: technologies, institutions and organizations. London: Pinter.

Ergas, H. (1987): The Importance of Technology Policy. In: Dasgupta, P., and Stoneman, P. (eds.): Economic Policy and Technological Performance. New York: Cambridge University Press.

Eurostat (2004) The Fourth Community Innovation Survey (CIS IV) - The Harmonized Survey Questionnaire, Luxembourg,

Fey, C. F., & Birkinshaw, J. (2005).External sources of knowledge, governance mode and R&D performance. Journal of Management 31(4), 597-621.

Fleming, L. (2001). Recombinant uncertainty in technological search. Management Science, 47(1), 117-132.

Freeman, C., and Soete, L. (2009): Developing Science, Technology and Innovation Indicators: What We Can Learn from the Past. In: Research Policy, Vol. 38, pp. 583-589.

Frenz, M., & Ietto-Gillies, G. (2009). The impact on innovation performance of different sources of knowledge: Evidence from the UK Community Innovation Survey. Research Policy, 38(7), 1125-1135.

Frietsch, R., and Jung, T. (2009): Transnational Patents – Structures, Trends and Recent Developments, Expertenkommission Forschung und Innovation (EFI), Studien zum deutschen Innovationssystem Nr. 7-2009, http://www.e-fi.de/fileadmin/Studien/StuDIS2009./7_2009_Patentreport_ISI.pdf, Berlin.

Fritsch, M. (2003). Does R&D Cooperation Behavior Differ between Regions? Industry & Innovation, 10(1), 25 - 39.

Gambardella, A. (2005). Patents and the division of innovative labor, Oxford University Press. 14: 1223-1233.

Gassler, H., Polt, W., and Rammer, M. (2006): Schwerpunktsetzungen in der Forschungs- und Technologiepolitik - eine Analyse der Paradigmenwechsel seit 1945. In: Österreichische Zeitschrift für Politikwissenschaft, Vol. 35, Nr. 1, pp. 7-23.

Gereffi, G., Humphrey, J., & Sturgeon, T. J. (2005).The governance of global value chains. Review of International Political Economy, 12(1), 78 - 104.

Geroski, P. A. (1995). Markets for technology : knowledge, innovation and appropriability. Handbook of the economics of innovation and technological change. P. Stoneman and D. F. Ball. Oxford, Blackwell.

Giuliani, E., and Bell, M. (2005): The micro-determinants of meso-level learning and innovation: Evidence from a Chilean wine cluster. In: Research Policy, 34, pp. 47-68.

Godø, H., Gulbrandsen, M., Herstad, S., Mariussen, Å., Røste, R., Spilling, O.R., and Ørstavik, F. (2008): Innovation systems, innovation modes and processes of commercialization. Vol. 4/2008, Oslo: NIFU STEP.

Gonzalez, X., & Pazo, C. (2008). Do public subsidies stimulate private R&D spending? Research Policy, 37(3), 371-389.

Grabher, G. (1993). The weakness of strong ties.The lock-in of regional development in the Ruhr area. In G. Grabher (Ed.), The embedded firm: on the socio-economics of industrial networks. London: Routledge.

Graf, H. (2010). Gatekeepers in regional networks of innovators.Camb. J. Econ.

Grande, E. (2000): Multi-level governance: institutionelle Besonderheiten und Funktionsbedingungen des europäischen Mehrebenensystems. In: Grande, E., and Jachtenfuchs, M. (eds.): Wie problemlösungsfähig ist die EU? Regieren im europäischen Mehrebenensystem. Nomos, Baden-Baden, pp. 11-30.

Grandori, A., & Soda, G. (1995). Interfirm networks - antecedents, mechanisms and forms. Organization Studies, 16(2), 183-214.

Granovetter, M. S. (1973). The Strength of Weak Ties. The American Journal of Sociology, 78(6), 1360-1380.

Green, J. R. and S. Scotchmer (1995). "On the division of profit in sequential innovation." The RAND Journal of Economics: 20-33.

Griliches, Z. (1979). "Issues in Assessing the Contribution of Research and Development to Productivity Growth." Bell Journal of Economics 10(Spring: 1): 92-116.

Grimpe, C., & Kaiser, U. (2010). Balancing internal and external knowledge aquisition: The gains and pains from R&D outsourcing. Journal of Management Studies, in press.

Grimpe, C., & Sofka, W. (2009). Search patterns and absorptive capacity: Low- and high-technology sectors in European countries. Research Policy, 38(3), 495-506.

Hagedoorn, J. (1993). Understanding the rationale for strategic technology partnering: Inter-organizational modes of co-operation and sectoral differences. . Strategic Management Journal, 14, 109-122.

Hall, B. H. and R. H. Ziedonis (2001). "The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995 " RAND Journal of Economics 32(1): 101-128.

Hamel, G. (1991). "Competition for competence and interpartner learning within international strategic alliances." Strategic Management Journal 12(S1): 83-103.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits. Administrative Science Quarterly, 44(1), 82-111.

Hao, K., & Jaffe, A. (1993). Effect Of Liquidity On Firms' R&D Spending. Economics of Innovation and New Technology, 2(4), 275-282.

Hargadon, A., & Sutton, R. I. (1997).Technology brokering and innovation in a product development firm.Administrative Science Quarterly, 42(4), pp.716-749.

Harris, R. I. D., & Li, Q. C. (2005). Establishment Level Empirical Study Of Links Between Exporting, Innovation, and Productivity. Report to UKTI. Report to UKTI. http://www.ukti.gov.uk/uktihome/aboutukti/localisation/108529.html

Hatzichronoglou, T. 1997. Revision of the high-technology sector and product classification, STI Working Papers 2, OECD, Paris.

Hauknes, J., & Knell, M. (2009).Embodied knowledge and sectoral linkages: An input-output approach to the interaction of high- and low-tech industries. Research Policy, 38(3), 459-469.

Helper, S., DacDuffie, J. P., & Sabel, C. (2000). Pragmatic Collaborations: Advancing knowledge while controlling opportunism. Industrial and Corporate Change, 9(3), 443-487.

Herstad, S. (2008): Financial systems, open innovation and technological regimes: A theoretical discussion. In: Godø, H., Gulbrandsen, M., Herstad, S., Mariussen, Å., Røste, R., Spilling, O.R., and Ørstavik, F. (eds.): Innovation systems, innovation modes and processes of commercialisation (Vol. 4/2008, pp. 31-58). Oslo: NIFU STEP.

Herstad, S. (forthcoming). Paradigms, regimes and the shifting notions of institutional best practice.Journal of the Knowledge Economy, 2(1 (2011)).

Herstad, S., & Paalshaugen, Ö. (2010). Decoupled diversity: On innovation in the Norwegian capital region. Conference paper, 5th international seminar on regional development policies, October 14th and 15th, Grimstad, Norway.

Herstad, S., Bloch, C., Ebersberger, B., & van De Velde, E. (2010). National innovation policy and global open innovation: Exploring trade-offs, balances and complementarities. Science and Public Policy, 37(2), 113-124.

Herstad, S.J. Bloch, C., Ebersberger, B., & van De Velde, E. (2008).Open Innovation and Globalization; Theory, Evidence and Implications, Helsinki. Available at: http://www.visioneranet.org/files/391/openING_report_final.pdf.

Hipp, C. & Grupp, H., 2005. Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. Research Policy, 34(4), p.517-535.

Howells, J. (1999). Research and technology outsourcing. Technology Analysis & Strategic Management, 11(1), 17-29.

Howells, J., Gagliardi, D., & Malik, K. (2008). The Growth and Mangement of R&D Outsourcing: Evidence from UK Pharmaceuticals. R&D Management, 38(2), 205-219.

Huang, C., and Soete, L. (2008): The global challenges of the knowledge economy: China and the European Union. In: Science and Public Policy, 35(10), December, pp. 771–781.

Huber, P., Ebersberger, B., Reinstaller, A., & Unterlass, F. (2010). Study on mobility patterns and career paths of EU researchers. Report prepared for DG Research, Brussels.

Isaksen, A., & Karlsen, J. (2009).Combined and complex mode of innovation in regional cluster development - analysis of the lightweight material cluster in Raufoss, Norway. Paper presented at the Orkestra workshop, San Sebastian, May 13th - 14th, 2009.

Isaksen, A., & Karlsen, J. (2011). Different modes of innovation and the challenges of connecting universities and industry: Case studies of two regional industries in Norway. European Planning Studies, forthcoming.

Iversen, E. (2010) Patent-regimes and the formation of technological knowledge: a review of issues, in PhD dissertation, University of Tasmania (2011).

Iversen E. (2011) The impact of patenting on collaboration: Evidence from a Norwegian panel of two waves of the Community Innovation Survey, presented at the Second Asia-Pacific Innovation Conference, Singapore (May 2011)

Janne, E. M. and M. Frenz (2006). Do firms patent to protect or transfer knowledge in support of their innovations? An analysis of the fourth UK Community Innovation Survey. Intellectual Property Rights for Business and Society. London.

Jensen, M. C. (1993). The modern industrial revolution, exit and the failure of internal control systems. Journal of Finance (July 1993), 831-880.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of Financial Economics, 3(4), 305-360.

Jensen, M., Johnson, B., Lorenz, E., and Lundvall, B.A. (2007): Forms of knowledge and modes of innovation. In: Research Policy, Vol. 36, pp. 680-693.

Kaiser, U. (2004). Private R&D and Public R&D subsidies: Microeconometric Evidence from Denmark. Business, CEBR Discussion Papers (p. 26).

Karlsen, J., Isaksen, A., & Spilling, O. R. (forthc.). The challenge of constructing regional advantage in peripheral areas: The case of marine biotechnology in Tromso, Norway. Entrepreneurship & Regional Development, forthcoming.

Katila, R. (2002). New Product Search over Time: Past Ideas in Their Prime? The Academy of Management Journal, 45(5), 995-1010.

Katila, R., & Ahuja, G. (2002). Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction. The Academy of Management Journal, 45(6), 1183-1194.

Katz, R., & Allen, T. J. (1982).Investigating the not invented here syndrome - a look at the performance, tenure and communication patterns of 50 R&D project groups. R & D Management, 12(1), 7-19.

Kessler, E. H., Bierly, P. E., & Gopalakrishnan, S. (2000). Internal vs. external learning in new product development: effects on speed, costs and competitive advantage. R & D Management, 30(3), 213-223.

Klein Woolthuis, R., Lankhuizen, M., & Gilsing, V. (2005). A system failure framework for innovation policy design. Technovation, 25(6), 609–619. Elsevier. doi: 10.1016/j.technovation.2003.11.002.

Knell, M. (2008). Embodied technology diffusion and intersectoral linkages in Europe. Europe Innova Sectoral Innovation Watch deliverable WP4. European Commission, Brussels.

Knell, M., & Srholec, M. (2008). Technological collaboration and foreign ownership across industries in Europe.

Kolenikov, S., & Angeles, G. (2009). Socioeconomic Status Measurement With Discrete Proxy Variables: Is Principal Component Analysis a Reliable Answer? Review of Income and Wealth, 55(1), 128-165.

Kolenikov, S., & Angeles, G. (2004). The use of discrete data in PCA: theory, simulations, and applications to socioeconomic indices. Chapel Hill: Carolina Population Center, University of North Carolina.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identiy, and learning. Organization Science, 7(5), 502-518.

Lach, S. (2002). Do R&D subsidies stimulate or displace private R&D Evidence from Israel,. Journal of Industrial Economics, 50(4), 369-390.

Landesmann, M. A. (2006) Small States in European Political Economy: Reevaluating the Autrian Model. Paper presented conference Small States in a Global World, Harvard University, April 7 2006.

Lane, P. J., & Lubatkin, M. (1998).Relative absorptive capacity and interorganizational learning. Strategic Management Journal, 19(5), 461-477.

Laursen, K., & Salter, A. (2004). Searching high and low: What types of firms use universities as a source of innovation? Research Policy, 33, 1201-1215.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. Strategic Management Journal, 24, 131-150.

Lazonick, W. (2006).Evolution of the New Economy Business Model.Business and Economic History Online.

Lazonick, W. (2007).The US stock market and the governance of innovative enterprise.Industrial and Corporate Change, 16(6), 983-1035.

Lazonick, W., & O'Sullivan, M. (2000).Maximizing shareholder value: A new ideology for corporate governance. Economy and Society, 29(1), 13-35.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in new product development. Strategic Management Journal, 13, 111-125.

Lettl, C., Herstatt, C., & Gemuenden, H. G. (2006).Users' contribution to radical innovation: Evidence from four cases in the field of medical equipment technology. R&D Management, 36, 251-272.

Levin, R. C., A. K. Klevorick, et al. (1987). "Appropriating the returns from industrial research and development." Brookings Papers on Economic Activity: 783-831.

Lhuillery, S., & Pfister, E. (2009). R&D cooperation and failures in innovation projects: Empirical evidence from French CIS data. Research Policy, 38(1), 45-57.

Lichtenthaler, U., & Ernst, H. (2007).External technology commercialisation in large firmsR&D Management, 37(5).

Lichtenthaler, U., 2005. External commercialization of knowledge: review and research agenda. International Journal of Management Reviews, 7(4), p.231–255.

Lichtenthaler, U. (2011): Open innovation – Past research, current debates and future directions. In: Academy of Management Perspectives

Lock, J., Albaiges, J., Edler, J., Kolar, J., and Lemkin, I. (2009): ERA-NETs on stage – 2010, Review of the ERA-NET Plus instrument. ftp://ftp.cordis.europa.eu/pub/fp7/coordination/docs/5lock_en.pdf (last accessed in August, 2008).

Lokshin, B., Hagedoorn, J. & Letterie, W., 2011. The bumpy road of technology partnerships: Understanding causes and consequences of partnership mal-functioning. Research Policy, 40(2), pp.297-308.

López, A. (2008). "Determinants of R&D cooperation: Evidence from Spanish manufacturing firms." International Journal of Industrial Organization 26(1): 113-136.

Love, J. H., & Roper, S. (2002). Internal versus External innovation: A Study of R&D Choice with Sample Selection. International Journal of the Economics of Business, 9(2), 239-255.

Lukas, B. A., & Ferrell, O. C. (2000). The effect of market orientation on product innovation. Journal of the Academy of Marketing Science, 28(2), 239-247.

Lööf, H., & Hesmati, A. (2005). The Impact of Public Funding on Private R&D investment. New Evidence from a Firm Level Innovation Study. Policy, CESIS Electronic Working Paper Series (pp. 1-26). Stockholm.

Lundvall, B.-Å. (1992). National Systems of Innovation: towards a theory of innovation and interactive learning. London: Pinter.

Majchrzak, A., Cooper, L. P., & Neece, O. E. (2004).Knowledge reuse for innovation. Management Science, 50(2), 174-188.

Malerba, F., & Orsenigo, L. (1993).Technological regimes and firm behaviour. Industrial and Corporate Change, 2(1), 45-71.

Mansfield, E. (1986). "Patents and innovation: an empirical study." Management Science: 173-181.

Marshall, A. (1920). Industrial Organization, Continued. The Concentration of Specialized Industries in particular Localities. In A. Marshall (Ed.), Principles of Economics, Book IV, Chapter X (Ninth ed.). London: Macmillan.

Marsili, O., & Verspagen, B. (2002). Technology and the dynamics of industrial structures: An empirical mapping of Dutch manufacturing. Industrial and Corporate Change, 11(4), 791-815.

Mazzoleni, R. and R. R. Nelson (1998). "The benefits and costs of strong patent protection: a contribution to the current debate." Research Policy 27(3): 273-284.

Maskell, P., Bathelt, H., & Malmberg, A. (2006). Building Global Knowledge Pipelines: The Role of Temporary Clusters.European Planning Studies, 14(8), 997-1013.

Maurseth, P. B., and Verspagen, B. (2002): Knowledge spillovers in Europe: A patent citations analysis. In: Scandinavian Journal of Economics, 104(4), pp. 531-545.

Merges, R. P., R. R. Nelson, et al. (1992). On limiting or encouraging rivalry in technical progress: The effect of patent scope decisions, University of California at Berkeley, Center for Research in Management, Consortium on Competitiveness & Cooperation.

Mills, E., and Livingston, J. (2005): Traversing the valley of death. In: Forbes Online. http://www.forbes.com/2005/11/17/utilities-emerging-tech-cz_1117energy_programs.html (last accessed on November 17th, 2010).

Miotti, L., & Sachwald, F. (2003). Co-operative R&D: why and with whom? An integrated framework of analysis. Research Policy, 32, 1481-1499.

Mowery, D. (1983). "The relationship between the contractual and in-house forms of industrial research in American manufacturing, 1900-1940." Explorations in Economic History 20(351-374).

Mudambi, S. M., & Tallman, S. (2010). Make, buy or ally? Theoretical perspectives on knowledge process outsourcing through alliances. Journal of Management Studies, in press.

Murovec, N., Prodan, I. (2009): Absorptive Capacity, Its Determinants, and Influence on Innovation Output: Cross-cultural validation of the structural model. In: Technovation, Vol. 29, pp. 859-872.

Narula, R. (1996). Multinational Investment and Economic Structure. London: Routhledge.

Narula, R. (2002). Innovation systems and 'intertia' in R&D location: Norwegian firms and the role of systemic lock-in. Research Policy, 31(5), 795-816.

Negassi, S. (2004). "R&D co-operation and innovation a microeconometric study on French firms." Research Policy 33(3): 365-384.

Novak, S., & Eppinger, S. D. (2001). Sourcing by design: Product complexity and the supply chain. Management Science, 47(1), 189-204.

Ocasio, W. (1997).Towards an attention-based view of the firm. Strategic Management Journal, 18, 187-206.

O'Sullivan, M. (2000): Contests for corporate control. New York: Oxford University Press.

Owen-Smith, J., and Powell, W. W. (2004): Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. In: Organization Science, 15(1), pp. 5-21.

Pavitt, K. (1984). Sectoral patterns of technical change - towards a taxonomy and a theory. Research Policy, 13(6), 343-373.

Pavitt, K. (1998). The social shaping of the national science base. Research Policy, 27 (8), 793-805

Peneder, M. (2007). A sectoral taxonomy of educational intensity. Empirica 34, 189-212.

Perez, C. (2002). Technological Revolutions and Financial Capital. Cheltenham, UK / Northampton, MA, USA: Edward Elgar.

Piore, M. J., & Sabel, C. F. (1984). The second industrial divide : possibilities for prosperity. New York: Basic Books.

Plant, A. (1934). "The Economic Theory concerning Patents for Inventions." Economica 1(1): 30-51.

Porter, M. (Ed.). (1992). Capital Choices: Changing the America Invest in Industry: Harvard Business School.

Prahalad, C. K. and G. Hamel (1990). "The core competence of the corporation." Harvard Business Review 68(3): 79-91.

Reinstaller A., Hölzl, W., Janger J., Unterlass F., Daimer S., Stehnken, T. (2010). Barriers to internationalisation and growth of EU's innovative companies. PRO INNO Europe: INNO- Grips II report, Brussels: European Commission, DG Enterprise and Industry.

Reinstaller A., Unterlass F. (2010). Sectoral Innovation Modes and the State of Economic Development: Implications for Innovation Policy in the New Member States. In: Radosevic S., Kaderabkova, A. (eds.). The Challenge for European Innovation Policy: Cohesion and Excellence viewed from a Schumpeterian Perspective. Aldershot: Edward Elgar Publ.

Romer, P. M. (1990): Endogenous Technological Change. In: The Journal of Political Economy, 98(5), pp. 71-102.

Roper, S., Du, J., & Love, J. H. (2008). Modelling the innovation value chain. Research Policy, 37(6-7), 961-977.

Rosenberg, N. (1994): Exploring the Black Box: Technology, Economics, and History. New York, Cambridge University Press.

Rosenkopf, L., & Nerkar, A. (2001). Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. Strategic Management Journal, 22(4), 287-306.

Scherer, F. M. (2005). "The propensity to patent." Patents: Economics, Policy, and Measurement 1: 198.

Schmidt, T. (2005). Absorptive capacity - one size fits all? ZEW working paper (05-72).

Schmiedeberg, C. (2008). Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. Research Policy, 37(9), 1492-1503.

Schumpeter, J.A. (2006): Theorie der wirtschaftlichen Entwicklung. Reprint of the original first edition from 1912, edited and introduced by Jochen Röpke and Olaf Stiller, Berlin, Duncker & Humblot.

Shapira, P., Edler, J., Gagliardi, D., Verbeek, A., Lykogianni, E., and Knell, M. (2009): Analysis of R&D international funding flows and their impact on the research system in selected Member States'. University of Manchester (MIoIR), IDEA Consult, and NIFUSTEP. Prepared for Rindicate (SPA7), DG Research, European Commission. Brussels.

Shapiro, C. and R. D. Willig (1990). "On the Antitrust Treatment of Production Joint Ventures." The Journal of Economic Perspectives 4(3): 113-130.

Shaw, B. (1994). User-supplier links and innovation. In M. Dodgson & R. Rothwell (Eds.), The Handbook of Industrial Innovation. Cheltenham: Edward Elgar.

Sinkula, J.M. (2002), "Market-based success, organizational routines, and unlearning", The Journal of Business & Industrial Marketing, Vol. 17 No. 4, pp. 253-69.

Smith, K. (2000). What is the knowledge economy? Knowledge intensity and distributed knowledge bases: United Nations University.

Soete, L., and Arundel, A. (1993): An integrated approach to European innovation and technology diffusion policy. Brussels: Commission of the European Communities.

Soete, L. et al. (2009): The role of community research policy in the knowledge-based economy. Expert Group Report, European Commission: Brussels, October, 2009.

Sofka, W., & Grimpe, C. (2010). Specialized search and innovation performance - evidence across Europe. R & D Management, 40(3), 310-323.

Soriano, F., and Mulatero, F. (2010): Knowledge Policy in the EU: From the Lisbon Strategy to Europe 2020. In: Journal of the Knowledge Economy (2010) 1, pp. 289-302.

Spilling, O.R., and Godø, H. (2008): Barriers to commercialization of knowledge in emerging technological regimes - a comparison of marine biotechnology and mobile commerce. In: Godø, H., Gulbrandsen, M., Herstad, S., Mariussen, Å., Røste, R., Spilling, O.R., and Ørstavik, F. (eds.): Innovation systems, innovation modes and processes of commercialisation (Vol. 4/2008, pp. 103-126). Oslo: NIFU STEP.

Spithoven, A., Clarysse, B., and Knockaert, M. (2010): Building Absorptive Capacity to Organise Inbound Open Innovation in Traditional Industries. In: Technovation, Vol. 30, pp. 130-141.

Srholec M, Verspagen B. (2008), The voyage of the Beagle in innovation systems land: explorations on sectors, innovation, heterogeneity and selection, UNU-MERIT Working Papers Series # 2008-008, UNU-MERIT, Maastricht.

Sturgeon, T. J. (2003). What really goes on in Silicon Valley? Spatial Clustering and dispersal in modular production networks. Journal of Economic Geography, 3, 199-225.

Sturgeon, T. J., Biesebroeck, J. V., & Gereffi, G. (2008). Value chains, networks and clusters: Reframing the global automotive industry. Journal of Economic Geography, 8, 297-321.

Sutton, R. I., & Hargadon, A. (1996). Brainstorming groups in context: Effectiveness in a product design firm. Administrative Science Quarterly, 41(4), 685-718.

Teece, D. J. (1988).Technological change and the nature of the firm. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg & L. Soete (Eds.), Technical Change and Economic Theory (pp. 257-281). London: Pinter Publishers.

Teece, D.J., 1998. Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. California Management Review, 40(3), p.55–79.

Tether, B. S. (2002). Who co-operates for innovation and why? An empirical analysis. . Research Policy, 31, 947-967.

Tether, B. S., & Tajar, A. (2008). Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. Research Policy, 37(6-7), 1079-1095.

Tirol. (2006) Wirtschaftsförderungsprogramm des Landes Tirol - InnovationsassistentIn, Förderrichtlinie 15. Dez. 2006 http://www.standort-tirol.at/data.cfm?vpath=formulare/innovationsassistentin/programminformation/richtlinie_innovationsassistentin25117&download=Yes

Verspagen, B., and Schoenmakers, W. (2000): The spatial dimension of patenting by multinational firms in Europe. In: Journal of Economic Geography, 4(1), pp. 23-42.

Veugelers, R., & Cassiman, B. (1999). Make and buy in innovation strategies: evidence from Belgian manufacturing firms. Research Policy, 28(1), 63–80.

von Hippel, E. (1988). The Sources of Innovation. Oxford: Oxford University Press.

von Hippel, E. (1994). "Sticky Information" and the Locus of Problem Solving: Implications for Innovation. Management Science, 40(4), 429-439.

Von Hippel, E. (2005). Democratizing Innovation. Cambridge, Massachusetts: MIT Press.

Wallsten, S. J. (2000). The effects of government-industry R&D programs on private R&D: The case of small business innovation research program. RAND Journal of Economics, 31(1), 82-100.

Wang, H. C., He, J. Y., & Mahoney, J. T. (2009). Firm-specific knowledge resources and competitive advantage: The roles of economic and relationship-based employee governance mechanisms. Strategic Management Journal, 30(12), 1265-1285.

Weigelt, C. (2009). The impact of outsourcing new technologies on integrative capabilities and performance. Strategic Management Journal, 30(6), 595-616.

Whitley, R. (Ed.). (1992). European Business Systems: Firms and markets in their national contexts. London: Sage Publications.

Whitley, R. (Ed.). (1999). Divergent Capitalisms: The social structuring and change of business systems. New York: Oxford University Press.

Whittington, R. (1990). The Changing Structure of R&D: From Centralisation to Decentralisation. In R. Loveridge & M. Pitt (Eds.), The Strategic Management of Technological Innovation (pp. 183-203). London: Wiley.

Williamson, O. (1975). Markets and Hierarchies: Analysis and Antitrust Implications. New York: The Free Press.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization and extension. Academy of Management Review, 27(2), 185-203.

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. Journal of the American Statistical Association, 57, 348-368.

Zellner, A. (1963). Estimators for seemingly unrelated regression equations: Some exact finite sample results. Journal of the American Statistical Association, 58, 977-992.

Zellner, A., & Huang, D. S. (1962). Further properties of efficient estimators for seemingly unrelated regression equations. International Economic Review, 3, 300-313.

Ørstavik, F. (2008): 'Nordic design' in innovation policy: Embedding Collaborative Social Relations in Developmental Constellations - Lessons from a case study. In: Godø, H., Gulbrandsen, M., Herstad, S., Mariussen, Å., Røste, R., Spilling, O.R., and Ørstavik, F. (eds.): Innovation systems, innovation modes and processes of commercialisation (Vol. 4/2008, pp. 59-80). Oslo: NIFU STEP.