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National innovation policy and global open innovation: exploring balances, tradeoffs and complementarities

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The aim of this article is to suggest a framework for examining the way national policy mixes are responding to the challenges and opportunities of globally distributed knowledge networks, cross-sectoral technology flows and consequently open innovation processes occurring on an international scale. We argue that the purpose of public research and innovation policy remains one of developing and sustaining territorial knowledge bases capable of growing and supporting internationally competitive industries. But the rules of the game have changed. Public policy now needs to carefully balance between: a) promoting the formation of international linkages for knowledge sourcing and information exposure; b) providing incentives for domestic industry intramural R&D for building absorptive capacity and knowledge accumulation; and c) sustaining domestic networking to allow accumulated knowledge to diffuse and recombine.

IN RECENT YEARS, a lot of attention has been devoted to the concept of open innovation. This interest has followed in the wake of work by Henry Chesbrough (2003), in which it is argued that various forms of external linkages are increasingly substituting long-term intramural corporate R&D and innovation efforts. Work initiated by the OECD in 2006 extended the concept by linking it to globalization, seeking to reveal how business strategies reflected the global landscape of technology and talent, and asked, without really having the tools necessary to provide the answers, how this landscape should be reflected in innovation policy at different territorial levels (OECD, 2008). The primary purpose of the following is to suggest, and demonstrate by way of policy tool reviews, how the question of *national* policy can be reframed in a context of *global* open innovation.

At the outset it should be noted that open innovation is not as new a phenomenon as Chesbrough himself would claim, and the interest in this from the business and management perspective is part and parcel of an at least decade-long transition from internal knowledge bases of firms to globally distributed knowledge networks. Further, it is not one clear-cut practice, but a set of practices through which firms may search, source and collaborate to different degrees, dependent on the sectoral contexts in which they operate, and the institutional contexts in which they are located.

In the US context, upon which Chesbrough's work is based, it also appears to be more a shift back towards models of industrial organization dominating prior to the growth and consolidation of the 'Fordist' (Boyer, 2004) regime of vertically

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integrated mass production. During the first decades of the 20th century, industrial enterprises in the United States co-operated and sourced R&D services from dedicated, external R&D labs (Teece, 1988, Hollingsworth, 1991). Associative behavior — from gentleman's agreements through cartels and co-ordination linked to trade associations — was common, and critical to the survival of what was then an industrial structure dominated by small firms (Hollingsworth, 1991: 291–292).

The years following the Second World War saw this landscape change dramatically. In the 1950s and 1960 the 'Fordist' regime grew and consolidated, and with it came a strong emphasis on intramural R&D in so-called 'first generation R&D organizations' (Roussel *et al*, 1991). These intramural R&D efforts contributed a large part of the knowledge foundation for what would later become the information, communication and technology (ICT) revolution. But, as pointed out by Chesbrough, they suffered from weak private returns due to massive production of spillovers upon which venture capitalists and entrepreneurs where able to feed. The US Fordist regime was severely challenged by the economic downturn of the 1970s, and changes in particular on the financial system side were implemented to downsize corporate hierarchies (Jensen, 1993) and force a stronger focus on shareholder — private — returns.

Throughout the 1980s, overall market saturation forced flexibility, responsiveness and product diversification, and notions of 'best practice' industrial organization shifted away from the USA, towards Japan and certain regions of Europe. According to Piore and Sabel (1984), the second industrial divide claimed to be unfolding would reward smaller, networked and thus more flexible modes of production and innovation, such as those found, for example, in certain industrial districts of Northern Italy. Building on this legacy, different innovation system approaches gained increasing popularity during the 1990s in both academic and policy-making communities. These approaches emphasized knowledge diffusion and interactive learning as the basis for industrial development and innovation, and shifted focus further away from technology-push research efforts. In industry, a similar transition occurred; away from the 'first generation' R&D-lab oriented organization, through the intermediate market-pull second generation model and 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).

At present, the awareness and importance of implementing strategies for external knowledge sourcing appears to yet again be increasing; in this round linked to the challenges and opportunities of global production and innovation networks. While firms are driven to change by the emergence of such new opportunities and challenges, it is still national-level tools which represent the most immediate form of intervention into innovation behavior in business life — and which most directly impact the properties of national and regional innovation systems. The aim of this article is therefore not to provide an exhaustive analysis of how different forms of policy may impact patterns of global open innovation, but about the new conditions within which national innovation policy is set.

The main aim is to suggest a framework for examining the way national policy mixes are responding to the challenges and opportunities of globally distributed knowledge networks, cross-sectoral technology flows and consequently open innovation processes

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occurring on an international scale. We consider the policies of Austria, Belgium (Flanders), Denmark and Norway. As most advanced, small, open economies, these are characterized by specialized innovation systems, particularly sensitive to the balance between national and international interfacing and unable to base industrial development on large domestic markets and national science systems competent in many fields (Narula, 2002; Meyer, 2008). Specifically, we look at the existing types of policies impacting the openness of companies at various geographical levels. We contrast these against, and consider complementarities towards, policies seeking the build-up of knowledge within corporate enterprises and make several suggestions on how to improve the current policy mix to achieve a better balance.

In order to do this, open innovation and the openness of companies is put into a broader theoretical framework. Hence the article will start by expanding the concept of open innovation, drawing on contributions ranging from management studies to innovation studies. Based on this we develop an analytical framework focused on complementarities and interactions between different categories of tools we argue theoretically are required. We then apply this framework on policy tools in the selected countries. This analysis is based on a review of Trend Chart reports[1] and other policy documents in the four countries, which together with the suggested policy mix analysis framework provided the basis for discussions with leading policy-makers.

In order to maintain focus and fully demonstrate the usefulness of the analytical framework we suggest, we here only address policies and tools explicitly formulated to nurture innovation. And, while accepting that such clearly exist, we do not consider other policy areas with more indirect or unintended impacts. Examples of such policy areas include labor market regulations, which influence the degree of commitment vs. flexibility in the relationship between specific firms and its employees; and different financial incentives aimed at attracting economic activity from abroad. The important issue of large-scale public commitment to specific technologies or sectors is also left aside, as this opens large debates far beyond the issue of specific tools and tool mixes.

In general we find that a variety of policy measures are already in place that nurture open innovation practices directly by means of promoting networking, collaboration and the commercialization of research. Yet, the framework we develop below gives us reason to question the extent to which the reviewed policy tool mixes are sufficiently balanced between different target areas.

Global open innovation

Concepts such as open innovation and innovation systems build on the recognition that inter-organizational linkages are critical to the innovative capabilities of firms and the growth of economies. The increasing importance of such linkages is driven by a variety of factors (Hagedoorn, 1993; Lichtenthaler and Ernst, 2007), including complexity in technological content of products, processes and services, and the patterns of territorial specialization which appear to follow from globalization. The latter points to the cumulative, path-dependent dynamics of knowledge development within territorial systems, and thus their need for external linkages.

Cutting-edge knowledge necessary for innovation tends to be dispersed across different actors, actor groups (Rothaermel *et al*, 2006) and environments. Industrial knowledge bases are only rarely disciplinary knowledge bases, feeding primarily on academic research. Rather, they are *synthetic* knowledge bases fed by inputs spanning from generic technologies such as biotechnology, nanotechnology or ICTs, to highly specialized knowledge that is accumulated only through experience or interaction with demanding customers or specialized suppliers. The more *complex* knowledge bases, products or processes become, the higher is the direct or indirect dependence on various external sources of information, ideas and knowledge. These external sources may in turn be representatives of completely different technologies or 'sectors' as traditionally understood; causing sectoral systems of innovation to blend with each other. Phil Cooke (2007) refers to this as the decreasing role of cumulative innovations within sectors (along established paths), and the growing importance of *recombinant* innovations across sectors (establishing new paths). Innovation in highly dynamic industries therefore often requires that the firm reaches beyond its own organizational boundaries, and beyond the boundaries of its immediate set of value chain partners (Nooteboom, 2001; Katila and Ahuja, 2002).

This entails that companies need to establish interfaces serving functions ranging from mere information scanning to in-depth collaboration; targeting diverse environments and actor groups. And firms may often need to keep these diverse interfaces open simultaneously (Herstad *et al*, 2008), operating in parallel and serving different functions in innovation and learning processes. We refer to this commonly as *heterogeneous interfacing*. For instance, the ability to meet demanding user requirements is more likely than not to require interaction far beyond that with the user, for example, with the science system. In this example, there is no 'either/or' in the relationship between user-driven and science-enabled innovation; rather, they are complementary in their effect on triggering and enabling innovativeness.

Several empirical contributions point to the relevance of this line of reasoning. At a general level, Jensen *et al* (2007) found that firms able to combine different modes of learning (i.e. the interactive, supply-chain oriented 'doing–using–interacting' with the more linear, science–technology–innovation mode) showed superior innovation performance compared to companies applying either one mode in isolation. Laursen and Salter (2006) found innovativeness to be associated with the simultaneous use of different external information sources, that is, with broad or diverse search channels.

Adding to this picture is work arguing that mature technologies sourced from outside one's own sector have an impact on innovativeness at least equal to that of new technologies from within (Katila and Ahuja, 2002). Another contribution (Laursen and Salter, 2004) even found the use of university information to correlate with the use of non-science system information, consistent with Herstad *et al* (2008) who found firms in sectors defined by others as science-based (Marsili and Verspagen, 2002) to form the most diverse external interfaces. At the regional level, a recent study concluded that the lack of specialized, experience-based territorially embedded competencies provided a main obstacle to industrial development based on spillovers from world-leading scientific research occurring in the same region (Karlsen *et al*, forthcoming).

With respect to internationalization, studies have found that both multinationality in itself and the interaction between asset dispersion and host environment diversity impact performance positively (Frenz and Ietto-Gillies, 2007; Goerzen and Beamish, 2003), indicating the superior search capacities of multinationals present in different contexts. Debates in geography (see e.g. Cotic-Svetina *et al*, 2008; Bathelt *et al*, 2004) have similarly argued that interaction with distant partners may be at least as important for innovation as the local collaboration stressed by the 'localized learning school'. Consistent with this, Herstad *et al* (2008) found that it is predominantly *international* linkages *within* the value chain which are associated with superior innovation performance.

Against this background we consider small, open economies. These are by necessity characterized by limited consumption markets, specialized business-to-business markets and supplier infrastructures, and specialized research infrastructures which are either immature (Meyer, 2008) or strong in a limited number of areas only. In addition, the amount of variety available domestically is limited both upstream and downstream in the value chain (see Narula, 2002; Patel and Pavitt, 2000), by both customer and supplier bases. This means that companies will increasingly look towards establishing not only heterogeneous but also international interfaces — to interact with the most demanding or competent customers, the cheapest or most competent suppliers, to seek ideas and knowledge within world-leading research environments and seek new markets for their technologies (Lichtenthaler and Ernst, 2007). Complexity combines with globalization and forces firms to internationalize — at earlier and earlier stages of their life-cycle.

In sum, all this implies that territorial innovation systems are 'forced open', that they can no longer be built solely as sets of user–producer relationships and that an excessive, singular focus on localized learning from the policy system may be harmful. Useful knowledge has not necessarily become more evenly spread out across space, as Chesbrough (2003) claims; rather, linkages tend to be created between specialized knowledge development nodes located in places which are increasingly more geographically dispersed and interdependent. This we refer to as the transition towards *globally distributed knowledge networks.* Knowledge flows across actors and space as embodied in machinery or components, and between industries or firms with very different degrees of R&D-intensity and knowledge-base characteristics (see Hauknes and Knell, 2009). Low-tech firm users are linked to high-tech knowledge providers, and vice versa; innovation in individual firms — by necessity — becomes linked to interfacing with lead users located elsewhere; and to interfacing with leading suppliers, research institutes or universities that are more and more likely to be located outside of the immediate surrounding environment. Some of these nodes serve as gravitation points to which knowledge and ideas flow, and contribute to creating knowledge-rich external environments.

These environments are increasingly regional rather than nationally distinct. Their dynamics are dependent on strong pipelines towards external environments containing knowledge or complementary capabilities beyond what effectively can be developed and held within the regions themselves (Gertler and Levitte; 2005; Jacobsen and Onsager, 2005; Bathelt *et al*, 2004). Regional or national innovation systems deconstruct as sets of user–producer interaction, but may under the right circumstances and given the right policy mix reconstruct as gravitation points (Cooke, 2007) or 'flow nodes' (Amin and Thrift, 2002) linking sets of global knowledge pipelines (Bathelt *et al*, 2004; Maskell *et al*, 2006) horizontally (see e.g. Frenken *et al*, 2007).

The notion of knowledge pipelines has traditionally been linked to the activities of multinational enterprises (UNCTAD, 2005). It is now extending into the study of international search and collaboration more generally (Knell and Srholec, 2008; Coe *et al*, 2008) and the large transfers of technology occurring as 'embedded' in components and machinery (Hauknes and Knell, 2009). The question of home and host economy impacts from foreign direct investment (FDI) has been thoroughly scrutinized, not least through different econometric attempts at measuring the extent to which technology is transferred in either direction and spills over into home and host contexts.

The empirical evidence stemming from this is at best mixed (Görg and Greenway, 2004; Kvinge, 2007; UNCTAD, 2005), and riddled with problems such as that of knowledge heterogeneity (Kaiser, 2002). This combines with biases built into statistical models and available data (Döring and Schnellenbach, 2006; Henderson, 2007), and the fact that the nature of the context into which a spillover may be induced mediate its impact. Policies focusing on the creation of regional knowledge diffusion infrastructures, the composition of the surrounding industrial structure and the inter-firm mobility of knowledge workers in regional and national labor markets are examples of such mediators. Yet, studies have argued quite convincingly that the *potential* for positive spillovers is larger when own companies expand their networks abroad through outgoing FDI, than when foreign companies enter (Van Pottelsberghe de la Potterie and Lichtenberg, 2001). Consistent with this, a recent empirical study using European Community Innovation Survey data found that whereas foreign ownership increases the likelihood of foreign collaborative linkages but decreases the likelihood of national ones; domestically controlled firms which do collaborate internationally tend to combine this with stronger national linkages than those such firms which do not. This points towards the role of international collaborative linkages established from *within* national systems as channels for knowledge transfer into these (Knell and Srholec, 2008).

Public policy assessment framework

The discussion above points towards the need to balance three categories of tools, and 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 through these linkages develop specialized knowledge which spills over into their surroundings and by way of diffusion — again supported by policy — is recombined and transformed.

The first category of tools, focusing on domestic embedding and the basis for spillovers, are those that increase intramural R&D activity and therefore the internal knowledge accumulation and latent spillover capacity of enterprises. Since spillovers entail that individual firms are unable to appropriate all the gains from own R&D *and* may be able to draw knowledge from a larger external ‘pool’ nurtured by spillovers from other firms, their existence may lead companies to invest less than socially desirable in internal knowledge development and accumulation (Arrow, 1962). This is commonly referred to as the *market failure* problem. As everyone in the longer run cannot cut their own R&D activity to live off spillovers from everybody else, support for intramural R&D is vital to reduce the risk of downward spirals in knowledge investments which collectively may result in ‘tragedies of the commons’. We therefore deviate strongly from Chesbrough’s (2003) focus on how intramural R&D can be avoided by harnessing the ‘knowledge common’, and point out that these commons must be maintained by means of such intramural R&D. Policy should therefore compensate for, not reinforce, incentives to substitute own R&D with external sourcing.

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In addition, internal activities have been argued to be critical for the ability of companies to absorb knowledge from the external environment. Hence, public policy should focus on the build-up and maintenance of private-sector organizationally embedded knowledge bases. These act to secure a steady stream of spillovers; by forming the basis for spin-offs and strengthening absorptive capacity. They will also constitute a gravitational pull within global knowledge networks; that is, increase the likelihood of foreign R&D activities resulting in *reverse technology transfers* back to the domestic activities.

The second set of tools is targeting linkages and networking. At the system level, these are to serve as channels for knowledge diffusion and recombination. *System failures* may result in inadequate linkages across organizational boundaries; in lock-in to specific collaboration partners or sources of ideas and information, or excessive overall ‘closure’ of learning processes. In the case of the closure of learning processes, both private and social returns may be increased through tools focusing on increased interaction and permeability. But it is no longer evident that policies attempting to maximize the social returns at territorial economy levels equal policies containing innovation activities and focusing linkages within those same territorial levels.

This leaves us, third, with the trade-off between nurturing *domestic* (i.e. local, regional or national) linkages, and incentives for the formation of *international linkages* in various forms. It is a trade-off because the attention and absorptive capacity of firms are subject to budget constraints; and excessive emphasis in either one direction can be assumed to draw attention away from the other (Laursen and Salter, 2006). But enablers of international linkages are also complementary to the two other policy-tool categories, which points towards the importance of balance. As the aim of these linkages is to expose the territorial system to variety beyond what is contained within the system as such, the outcome is contingent on both domestic intramural R&D (gravitational pull and absorptive capacity) and on domestic linkages (diffusion into the domestic economy).

Against this background, linkage support must balance between building narrow and heterogeneous, or broad, interaction patterns. Examples of support for heterogeneous linkage formation would include support for project consortia consisting of clients, suppliers and, for example, research institutes engaging in mutual exchanges of knowledge, or collaborative project funding without specific requirements as to partner type. Examples of support for narrow linkage formation include schemes targeting the bilateral relationship between universities and industrial firms, or between firms and lead users. The balance is important because firms will very often need to direct attention towards diverse external knowledge domains; whereas, for example, funding schemes may require allocation of financial and human resources towards research institute or university interaction only. This may create attention-allocation problems, whereby incentives built into public policy serve to concentrate the focus of firms on an excessively narrow set of (domestic) knowledge domains, at the expense of more heterogeneous, international interfaces. Intensity may also come in the form of incentives for outsourcing of R&D to science system actors, which in itself trigger little or no learning in the sourcing firm (Fey and Birkinshaw, 2005).

An explorative assessment of small, open economy policy mixes

In this section, we examine innovation policy tools in four European countries: Austria, Belgium (Flanders), Denmark and Norway. The analysis is based on Trend Chart reports and other policy documents in the four countries, which were reviewed according to the analytical framework described above. The resulting characterizations of tool mixes provided the basis for discussions with high ranking policy-makers in each of the mentioned countries.[2] The analysis here does not in any way claim to be exhaustive in its coverage of overall innovation policy or specific innovation policy measures in the four countries, as the main purpose is to provide a general overview of the balance and potential complementarities between different categories of tools.

Industry intramural R&D, knowledge accumulation and absorptive capacity

Cohen and Levinthal (1990) defined absorptive capacity as ‘the ability to recognize the value of new information, assimilate it, and apply it to commercial ends’. They suggest that absorptive capacity is largely determined by the level of prior related knowledge. As a consequence, internal R&D has been treated as a primary determinant of absorptive capacity. Recent contributions have pointed out that factors such as employee vocational and tacit competencies, internal routines, motivation and intra-organizational communication exert a strong influence on the ability of organizations to assimilate, transform and exploit external ideas and knowledge on a broader basis (Zahra and George, 2002). Both conceptualizations of absorptive capacity converge in recognizing how this capacity is defined by cumulative, internal processes which build up a specialized knowledge, the diversity of which *directly impact* absorptive capacity scope and thus dynamic organizational capabilities (Bosch *et al*, 1999). They are therefore also consistent with the so-called resource-based view of the firm, and numerous recent contributions pointing to the role of such cumulative, specialized and multifaceted knowledge development as the basis for competitiveness at both firm and territorial system levels respectively (Karlsen *et al*, forthcoming; Jensen *et al*, 2007; Asheim and Gertler, 2005).

In all four countries, there are various programs that provide support to businesses in building innovation strategies, generally targeted at start-ups and other SMEs. An example here is Innovation Feasibility Studies in Austria, in which support is given for SMEs to have studies carried out by expert organizations to help create plans for developing the firm’s innovative capabilities and innovation management strategies.

Denmark perhaps stands out in its efforts to place more academically educated personnel in businesses, particularly those with little or no such personnel. ‘Highly educated employees in business’ is one of four target areas for the Danish Agency of Science, Technology and Innovation’s innovation policy framework. Knowledge pilots are subsidies to small businesses to hire academic personnel. This measure is primarily aimed at small firms that typically do not have any employees with an academic background. Industrial PhDs are a means of co-operation between a business and university where a PhD student spends half of their study working at the university and half at the company (in both cases working full-time on their PhD). The objective here is both to increase the use of researchers in the business sector and also educate more business-oriented researchers.

Belgian postdoctoral fellowships have a similar objective, by encouraging recent PhDs to apply their scientific skills in industry. This can be done in collaboration with existing companies, but also to prepare a spin-off. In addition, Belgium encourages the employment of R&D personnel through tax exemptions.

The Norwegian measure, Competence Development Program, does not directly support placement of academic personnel in businesses, but works with business to better target training and education programs towards building competencies vital for business innovation. In addition, a program of industrial

PhDs similar to that of Denmark has recently been implemented, under which PhD students conduct research projects relevant to the enterprise in which they are placed but remain publicly funded. In Norway, direct support for intramural R&D is primarily given in the form of tax credits, under the *skatteFUNN* scheme. This scheme was recently given a very favorable evaluation based on its identified ability to trigger R&D in companies, but threshold levels for funding make this scheme relevant primarily for SMEs.

In Flanders, a system of R&D grants is established which do not assume collaboration with others, although it is strongly encouraged. R&D grants are much less used as a policy instrument in Austria, where R&D tax credits are the most important measure in terms of amount of funding.

Thus, in particular in Denmark and Norway, we find innovation policy mixes characterized by a strong emphasis on collaboration, and a correspondingly low direct emphasis on the internal knowledge development activities of corporate enterprises. However, clearly *collaborative* (Fey and Birkinshaw, 2005) R&D projects will also strengthen the internal knowledge accumulation of participants. Yet, what is intended to nurture collaborative ventures may end up inducing arms-length *contract* R&D. Such may solve specific problems effectively, but have a very limited impact on knowledge development on the industry side of the equation (Fey and Birkinshaw, 2005), leaving little impact on absorptive capacity and potentially increasing the dependence on sourcing through hollowing out (Novak and Eppinger, 2001: 194). This can, for example, be the case if what is designed as industry–science collaborative schemes primarily result in research being undertaken by public research, at arm's length.

Norwegian interview respondents point out that this is often the case, as firms are deemed incapable of conducting tendered R&D projects and funding is therefore made contingent on this work being conducted externally, by a research system partner. Yet, a better long-term solution to what is the initial problem would be if funding allowed for the build-up of enough competencies to allow for collaboration, and thus absorption and accumulation on the industry side. But gaining acceptance for funding researcher positions in industrial firms may be far more difficult than gaining acceptance for tools, in essence resulting in industrial firms funding research at universities or institutes, that is, public funding for public knowledge accumulation.

National linkages

The main economy-level rationale for supporting national- (and regional-) level linkages is the recognition that diffusion of specialized knowledge developed within corporate enterprises may recombine with knowledge developed elsewhere in the economic system, and thus form the basis for ongoing, endogenous processes of renewal and growth. Hence, the main purpose of nurturing such linkages is not only to provide innovation support to specific industrial firms (thus increasing their private returns from R&D), but also to strengthen the evolutionary dynamics of the economic system as a whole by reducing those system failures which may mediate between knowledge components developed and their potential social returns if recombined.

Against this background it is not surprising to find that national policy tools focus heavily on promoting national linkages. All four countries have recognized the value of creating forums or platforms for knowledge exchange and development, and the important role that policy can play in overcoming regional and national level system failures.

We can distinguish between open networks and centers of excellence. Networks are more loosely formed, with the main goal of bringing firms and public research institutions together. Centers of excellence are typically more well-defined in terms of objectives and participants, essentially creating a platform of open innovation to develop new technologies within specific areas.

There are a number of similarities in policy programs across the four countries, though arguably with differences in their main focus. Centers and networks in Norway are a key element in efforts to strengthen regional innovation systems. Examples here are schemes such as the VRI, ARENA Innovation in Networks and NCE Norwegian Centres of Expertise programs for regional system-building and regionalized, sectoral support.

In addition, a set of national level Centers of Research Driven Innovation have been established, linking leading industrial sectors to academic communities with strong competencies in related fields for the purpose of strengthening distinct sectoral systems.

In Denmark, the overriding objective has similarly been to nurture interaction between firms and public research. In Innovation Networks, administration and matchmaking activities of the networks are publicly financed, along with the bulk of public research institutions' involvement in the network.

In Flanders we find a strong focus on building technology transfer capabilities and commercial application of public sector research. An important policy tool here is the Flemish Cooperative Innovation Network (VIS), which supports a variety of projects towards facilitating technology transfer, provision of technological services and the commercial application of research results. VIS also funds Thematic Innovation Stimulation projects, which are networks of companies facing mutual technological problems.

A main objective of Austrian measures is to build strong competencies within key technology areas. Arguably, Austria is the country with the greatest emphasis on centers of excellence in their innovation policies, with a range of programs. Among these

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are the K plus Centres of Competence, Christian Doppler Laboratories and programs targeting specific technologies such as IT, life sciences and automotives.

Also Flanders has created several centers of excellence such as IMEC, an institute of microelectronics; IBBT, an institute concentrated around broad band technology; and VIB, an institute of biotechnology.

An additional policy tool to promote external interfacing is through the funding of R&D projects. Here there are large differences across the four countries. In Norway and Denmark there is a strong focus on knowledge diffusion in R&D funding programs, with collaboration strongly encouraged and in many cases required in order to obtain funding. In particular, focus is on improving interaction between the business sector and public research, on making public research more responsive to business needs and on how project results can be disseminated outside of the project. Part of this picture is a preference towards securing control of intellectual property rights (IPRs) and accumulation of knowledge *outside* the specific business partners involved, that is, at involved research institutes and universities. In Norway, ownership of IPRs resulting from collaborative industry–science system R&D partly publicly funded is, for example, awarded to the institution conducting the largest proportion of the R&D, often the science system partner. This may create a disincentive towards seed, venture and buyout capital entry at later stages of development.

Several activities seek to promote the use of research and other intellectual property in firms' innovation activities. This includes the commercialization of public research through patents and spin-offs, increasing use and application of public research by businesses, promoting the commercial use of basic research wherever undertaken, and the facilitation of commodification and trade in knowledge. It also include schemes attempting to trigger industry funding of research at universities and institutes, that is, contract R&D. Measures exist in all four countries to provide matchmaking, financial and business support for the commercialization of research results. Examples are A plus B (Academia Business Spinoffs) in Austria, Proof of Concept and Innovation Incubators in Denmark, University Interface Services and Research Mandates in Flanders, and FORNY and Incubator Grants in Norway.

Chesbrough (2003) argues for increased trade in research and other intellectual property; that is, that firms should increasingly seek to license in technologies or purchase available patents; and correspondingly sell or license out own technologies that they are unable to exploit themselves. However, the lack of forums to identify potential buyers and sellers may severely limit a type of trade which, by its very nature, can cover only codified knowledge and modular technologies. Consequently there may be a role for policy in supporting such markets, though this is a relatively new area in terms of actual measures. All countries have created technology transfer offices at universities and other public research institutions. Denmark has also recently piloted a patent exchange,[3] 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.

Some novelties deserve special attention, and nuance the picture somewhat. Initiatives have been taken in Denmark and Norway to promote the greater use of external design services and design-based approaches in firms' innovation activities. Design Denmark is a policy initiative (Danish Government, 2007) 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. User-driven innovation involves using advanced, systematic methods to examine and uncover user/customer needs. Denmark has introduced a program for user-driven innovation, where businesses can obtain funding for the (collaborative) development of new user-driven methods.

International linkages

As pointed out above, recent research findings suggest that international linkages formed by firms may be equally important to the internal dynamics of territorial systems, as are the internal system linkages in themselves. This appears to be a *clearly neglected dimension* of innovation policy (Cotic-Svetina *et al*, 2008), which translates into a lack of direct focus on external linkages. 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 a territorial innovation system perspective, suboptimal exposure to diversity. To avoid this, public policy should be sensitive to the need for international linkages which may be difficult to identify, risky to establish and costly to maintain compared to the low marginal costs of continuing use of established domestic ones. Thus, as a minimum, policy should be aware of the danger that attention towards national communities nurtured by existing linkage tools may draw attention away from international ones.

Types of measures or activities to promote international linkages include a variety of business support services to help firms enter new markets, find international partners or participate in EU and other international programs. Such exist, for example, in the form of foreign offices operated by Innovation Norway, which assist Norwegian firms in establishing activities and developing local networks. Incentives exist in all four countries to attract foreign researchers.

In addition, each country works actively to establish closer ties with selected neighboring countries. Both Denmark and Norway are involved in Nordic collaborations (along with Sweden, Finland and Iceland) to establish and nurture stronger ties among the Nordic countries. Flanders collaborates with the Netherlands; for example, to increase the integration of the Aken–Eindhoven–Leuven region. Austrian innovation policy tries to capture the many opportunities presented by the emerging economies of Central and Eastern Europe (CEE). The program, Technology Initiative II — Internationalization East, supports a variety of initiatives to build closer ties between Austria and CEE countries, including support for R&D collaboration. With a clear exception in R&D collaboration, many of these schemes and initiatives do, however, share the common characteristic of being top-down policy community-oriented processes rather than creating bottom-up, industry-driven processes. Consequently they only indirectly influence those firm or industry level linkages which more immediately would be conducive to knowledge transfer and innovation.

In terms of funded R&D projects that support international linkages, we can distinguish between international projects (e.g. EU funded programs) and national projects allowing or even requiring international participation. Policy-makers interviewed generally viewed international projects as the most appropriate vehicle for establishing international linkages. These can either be funded by the EU or with each individual country funding national participants. They do, however, come with the disadvantage of large consortia and difficulties for individual firms to establish themselves as focal points. In Norway, business associations also point to perceptions among firms that large consortia imply less control over intellectual property not controlled by formal IPR measures; which in turn reduces the willingness for active collaboration. It was also stressed that program design should be made as simple as possible. This is particularly important for securing the participation of SMEs.

The four countries vary greatly in terms of opportunities for international participation in nationally funded projects. In Austria, international participation is possible and can in some cases be funded, though this is rare in practice. Funding of international partners is also possible in Denmark though, as with Austria, use of this option has been fairly limited. However, Denmark has recently increased efforts to promote international participation by creating greater awareness of the possibility to fund foreign participants and by including international participation as an assessment criterion for obtaining funding.

National funding of foreign partners is generally not possible in Norway, with the exception of the *skatteFunn* tax credit program through which firms may obtain a larger tax credit if they collaborate with domestic or foreign research partners. Under the program of industrial research and development contracts, small firms may also receive funding for collaborative research involving a foreign customer firm; and representatives of the program in Innovation Norway have stated as an objective that the scheme should be extended to include more ‘multilateral’ sets of user–producer relationships than the existing bilateral focus. Such an extension would be clearly consistent with the notion of heterogonous knowledge interfaces.

Similar schemes do not exist in Flanders. In addition, R&D funding requires project returns to accrue directly to Flanders. This has in some cases created problems as Flanders (and Belgium) is highly internationalized and many firms receiving funding have large affiliates outside of Belgium.

Conclusion

An increasingly complex industrial landscape is forcing increasingly complex and distributed modes of learning and innovation (Asheim and Isaksen, 2002; Jensen *et al*, 2007), which forces the development of new, multifaceted innovation policy logics (Cooke, 2005, 2006). While its content must continuously adapt to a changing industrial landscape, the objective of public research and innovation policy remains one of developing and sustaining territorial (i.e. national, regional) knowledge bases capable of growing and supporting internationally competitive industries. This build-up and evolution can no longer depend solely on the internal dynamics of national or regional innovation systems, nor can it be built on industry–science interaction alone. This particularly applies for small, open economies such as those considered here. We therefore argue that a ‘loosening up’ of what is at present very strong policy emphasis on containing interaction within national boundaries and focusing these on science–industry linkages is necessary to avoid negative technological lock-ins.

This apparent ‘inwardness’ of linkage-building seems to represent a main weakness of national innovation policy tools in the reviewed countries; and there seems to be a great need to prepare innovation policy-making not only for the challenges of globalization, but also its opportunities (see e.g. Huang and Soete, 2008).

However, it is of vital importance to remember that the purpose of external linkages is to feed into

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knowledge development processes and therefore, through spillovers, expose territorial innovation systems to variety beyond what they can generate endogenously. The introduction of such incentives *in themselves* may represent centrifugal forces which, over time and in interaction with other centrifugal forces such as the globalization of value chains, many cause even core R&D to shift abroad. With this may follow loss of spillovers and hollowing out of territorial innovation systems, rather than the intended strengthening of spillover size, increase in spillover diversity and establishment of these systems as a gravitation point in international networks. This takes us back to the recognition that international networking should be supplemented by a strengthening of incentives for development and accumulation of specialized, synthetic knowledge by and within corporate enterprises.

The second weakness appears to be the balance between heterogeneous and intensive interfacing. We have argued, and pointed to research findings supporting this argument, that firms increasingly rely on sourcing information from and collaborating with diverse external sources; all in the process of developing their internal knowledge bases. User-driven innovation is, for example, not a phenomenon contained within the user–producer relationship, but will more often than not require the producer to interact with a broad range of other actors to source components and develop solutions that meet user requirements.

Presumably science-driven firms are similarly dependent on a wide range of external, non-science information sources. This indicates that it is in the *intersections* between scientific advances, market preferences and specialized, cumulative knowledge development at the industry side that the dynamics of territorial innovation systems are located. Yet, in the wake of Barcelona and Lisbon processes, policy-makers appear primarily occupied with the question of how to force stronger, more intensive linkages between industry and academic research. Our call is for industry to form heterogeneous, international interfaces and use these to feed into domestic, specialized knowledge development. Policy seems to have shifted distinctively in the opposite direction; in some cases even to the extent that increased industry sourcing from the science system is considered an objective in itself.

There are of course nuances to this argument; problems related to the actual implementation of policy mixes along the lines we suggest here and a wide variety of possible measures and target areas which could follow. For instance, EU-funded projects serve to correct somewhat for both excessive focus on domestic, intensive linkages at the level of national innovation policy; as such those projects involve heterogeneous collaboration patterns at an international level.

Part and parcel of the focus on domestic linkages is also increasingly advanced tools designed for the purpose of constructing regional advantages; that is, for regional innovation system-building. Such tools, reflecting a growing trend of regionalization of innovation policy, do not attempt to contain value chain or research system collaborative linkages within regional systems. Rather, they seek to build a larger knowledge infrastructure around technologically related industries, on top of a specialized regional labor market, for the purpose of ensuring technological experimentation at the intersection between, and outside, those global value chain nodes that are established (see e.g. Asheim *et al*, 2007; Frenken *et al*, 2007; Boschma *et al*, 2009). And they may in the process maintain a foundation for the development of new global value chain nodes.

In many cases it will also be considered problematic to allow national funding to go partly into foreign hands. However, costs may be very low compared to potential gains through increased exposure to diversity, spillovers and the formation of potentially durable network linkages. This argues for a high degree of flexibility in allowing international involvement in nationally funded projects; that is, allowing national-level R&D and innovation funding to supplement EU-level programs in crossing national boundaries and serving as door-openers and enablers of durable pipelines. Territorial specialization, particularly in small countries, will often mean that firms may encounter problems finding relevant partners domestically. The problem of such supply-side limitations is likely to increase; and relate not only the availability of lead customers but also suppliers, research institutes, universities and firms in other industries. It is part and parcel of globalization, and the embedding of innovation in distributed knowledge networks within which well-linked nodes that are able to exert a gravitational pull will prosper and grow.

So, by way of concluding, we again stress the importance of keeping a clear eye on the ultimate purpose of national-level innovation policy; this purpose is not international linkages *per se*, nor is it national or regional ones — it is the development and maintenance of territorially embedded knowledge bases upon which industrial development may continue to build.

Notes

1. For Austria: Leo and Ziegler (2007); Belgium: Reid *et al* (2007); Denmark: Siune and Aagaard (2007); and Norway: Kallerud and Hauknes (2007).
2. Participating institutions were for Austria: Ministry for Traffic, Innovation and Technology and the regional funding agency *Tiroler Zukunftsstiftung*; for Belgium (Flanders): BELSPO (Federal Science Policy Office), Flemish Ministry of Economy, Science and Innovation (EWI) and the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT); for Denmark: the Danish Agency for Science, Technology and Innovation (FI) and the Danish Enterprise and Construction Authority (EBST); and for Norway: the Ministry of Trade and Industry and the Norwegian Research Council.
3. See <http://www.techtrans.dk>, last accessed 18 February 2010.

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