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The role of Higher Education Institutions in building regional innovation systems

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Abstract. Many studies focus on applying scientific technologies in manufacturing, or investigating the regional impact of contract and co-operative research of Higher Education Institutions (HEIs). However, HEIs' role as builders of the regional innovation system (RIS) has generally been under-researched. We review literature on the role of HEIs in fuelling the RIS and offer suggestions for deliberate actions that stimulate regional development. For further research we suggest to perform a network analysis addressing factors that relate to characteristics of: (1) HEIs; (2) regional firms; (3) the collaborative relationship; and (4) the environmental context in which HEIs and firms are embedded.

JEL classification: I23, O18, O33, R11

Key words: Higher Education Institutions, regional development, learning, regional innovation system

1 Introduction

The literature on the role of Higher Education Institutions (HEIs) in regional development has become quite extensive (see e.g., Benneworth and Hospers 2007; Huggins and Johnston 2009). A broad spectrum of studies has been undertaken, among which studies that focus on the application of scientific technologies in manufacturing studies (e.g., Goldfarb and Henrekson 2002; Lockett et al. 2003), that investigate the impact of contract and co-operative research (Etzkowitz and Leydesdorff 2000; Huggins and Johnston 2009), and studies about the 'learning region' (Strauf and Scherer 2008), and 'knowledge communities' (Henry and Pinch 2000). It is clear that the focus on forces that enable knowledge development and sharing between HEIs and regional networks of firms and other organizations continues to be an emerging and developing field of study.

Despite the progress made over the last decade, there is still much that we do not know yet. This paper is not trying to discuss these gaps in the literature or to review, once more, what we

know about the role of HEIs on regional development with respect to generating patents and commercializing scientific output, generating productive capacity and competitiveness (for an overview see McGregor et al. 2006), attracting high quality undergraduate human capital (Faggian and McCann 2006, 2009a, 2009b), or creating output and employment (Armstrong 1993; Harris 1997; Felsenstein 1996; Glasson 2003; Hermannsson et al. 2009), and backward linkages (see Warren et al. 2008; Bergman 2010 for reviews). Instead, our focus is on one particular aspect of this role that we believe has generally been under-researched (Boucher et al. 2003; D'Este and Patel 2007; Ramos-Vielba et al. 2010). Specifically, we focus on the study of the way in which the regional innovation system is stimulated by HEIs, namely, to what extent and in what ways can HEIs fuel interorganizational learning within the region? This is what Boucher et al. (2003) refer to as the non-economic contribution of HEIs to the region, and what Etzkowitz and Leydesdorff (2000), among others, have referred to as focusing on the 'triple helix of innovation'. Through our review, we have found this to be a topic that is frequently discussed but seldom empirically studied. Yet it is an important area of research.

Only by examining the impact of HEIs on the regional innovation system can we understand such issues as to how participation of HEIs in interorganizational learning evolves, how incentives can be created for HEIs to contribute to the regional innovation system and ultimately how collective outcomes of regional development and growth might be generated. This last point is especially relevant to policy-makers and those having a regional perspective that goes beyond the performance of individual organizations. Both, among policy-makers and among scientists, consensus exists that currently the regional embeddedness of HEIs in the region is far from optimal (Morgan 2007). In this respect, Morgan (2007) refers to 'cathedrals in the desert'. There is a mismatch between academic knowledge and knowledge that directly contributes to economic development, which causes an innovation paradox (Lagendijk and Rutten 2003; Dankbaar 2004; Wetenschappelijke Raad voor het Regeringsbeleid 2008), namely, investments in university R&D contribute only to a limited extent to social and economic innovation, development and growth of a region or country. Many writers stress the desirability to improve the contribution of HEIs in innovation systems and in (inter)organizational learning in particular, in order to alleviate the innovation paradox (Power and Malmberg 2008).

We review the limited theoretical and empirical literature on the role of HEIs in fuelling the regional innovation system and offer our suggestions regarding what we have learned from the modest number of studies that have been conducted and what directions are open for further research.

2 Literature review

2.1 Analytical approaches to HEIs' impact on regional development

Research into the explicit contribution of HEIs to the development of the region in which they are located has been limited, but is growing (Huijts 2003; Nieuwenhuis et al. 2003). Many studies about the role of HEIs in regional development viewed HEIs purely as sources of academic knowledge (first role), and providers of academic education (second role), rather than as regional system builders (third role) (Benneworth et al. 2009). This view has its origins in the nineteenth century, when European universities deliberately chose to be 'elitist', without any influence from societal actors who wanted to use science for their own purposes and interests. This attitude lives on in contemporary research universities that guarantee the academic freedom and independence of professors, and that focus on the creation of new knowledge in order to advance the current state of the art in the international scientific community and its journals. Von Humboldt's vision that universities underpin at a distance the development of the state has been dominant and

influential until today (OECD 2007, p. 35). In contrast, as regional system builders HEIs could undertake direct interaction with societal partners. This could range from creating spin off firms that focus on new high-technologies, consulting for local industry, delivering advice to politicians and policy-makers, informing general public debates and shaping the national spatial distribution of social opportunities and services (Benneworth et al. 2009). However, initiatives like these are still rarely explored and investigated in research studies.

Likewise, much of the current focus of innovation policy remains rooted in supporting initiatives that stimulate scientific research excellence and the application of technological science in manufacturing (Christopherson et al. 2008). Consequently, studies of the regional impact of universities tend to focus on 'key economic performance indicators', like the generation of patents, employment and backward linkages and the identification of the amount of successful commercialization of scientific output. However, this line of thinking reflects a linear perspective on the innovation process, in which innovation begins with research, followed by development, which in turn leads to production and commercialisation. There are no feedback loops in the system, and there is a clear division of labour between the different stages, particularly between activities geared towards 'knowledge seeking' and 'knowledge use' (Clark 1995, p. 250). This 'pipeline' notion has proved to be of limited validity in a world characterized by imperfect information. Innovation is inevitably an iterative process full of trial and error and incremental adaptation at every stage. In particular, a central claim of later innovation theories, widely corroborated by practice, is that making users active partners in innovation leads to higher uptake of new products and services because continuous feedback leads to innovations that better fulfil user needs (e.g., Gardiner and Rothwell 1985; Lundvall 1988; Rothwell and Gardiner 1989). This evolutionary, non-linear view of innovation has gained widespread acceptance (some key contributions are: Von Hippel 1976; Rothwell and Zegveld 1985; Kline and Rosenberg 1986; Clark 1995; Douthwaite 2002; Douthwaite et al. 2002).

Hence, innovation involves interaction between different actors. Innovation is much too dynamic to be understood in terms of linear flows and processes (Power and Malmberg 2008). Research (patents, commercialization), is only one element of the whole process of innovation. Much of the current policy discussion about the impact of HEIs on national and regional development fails to fully embrace the complexity of the innovation process and the variety of impact HEIs can have (Christopherson et al. 2008). Thus, we need an alternative framework to analyse the innovation processes that are induced by HEIs in society.

An obvious analytical approach with which to explore the way in which HEIs fuel interorganizational learning within the region, is the regional innovation systems (RIS) body of research. The regional innovation systems approach came forth from the national innovation system (NIS) literature, that in turn has its origins in the studies of Freeman (1987), Lundvall (1988, 1992), and Nelson (1993). This literature conceives of nations as composed of actors including companies, universities and research institutes, whose activities are governed by institutions (routines, habits and practices), of various kinds. The central idea is that interactive processes between varied and diverse actors, networks, continuous learning processes and innovation-conducive institutions such as policy incentives and trust will give rise to economic growth, technological dynamism and competitiveness. Conventional national innovation systems frameworks tend to focus predominantly on national processes and actors, whereas the phenomenon to be studied in this paper has to encompass dynamics of regional connections along with local processes. We therefore adopt the regional innovation systems approach, which is capable of explicitly addressing issues deriving from regional development.

The regional innovation systems approach laid the ground for two dominant approaches that theorize the role of HEIs in regional innovation systems, namely, the triple helix model (Etzkowitz and Leydesdorff 2000), and the university engagement approach (Chatterton and

Goddard 2000; Holland 2001). The triple helix model of university, industry and government relations (Etzkowitz and Leydesdorff 2000), conceptualizes a non-linear interactive approach to innovation in which interactions between universities, industry and government lead to innovation processes that involve benefits for all actors. A key notion in this line of research is that the relationships between the three stakeholder groups are hybrid, recursive and cross-institutional (Gunasekara 2006). The focus is on "the network overlay of communications and expectations that reshape the institutional arrangements among universities, industries, and governmental agencies" (Etzkowitz and Leydesdorff 2000, p. 109). Each actor should take the role of another, for example, HEIs play a role as source of firm formation, and industry plays a role as developer of training and research, while government supports these developments by adapting the regulatory system (Etzkowitz and Klofsten 2005)

The literature on the engaged university (Chatterton and Goddard 2000; Holland 2001), takes a slightly broader view, in that it explicitly embeds a stronger regional focus in the teaching and research missions. Writers in this line of research advocate the active and initiating role of universities in regional development. Academic entrepreneurialism is thought to be essential. Furthermore, this approach includes a range of mechanisms by which universities engage with their regions. In his large-scale research of the impact of universities, Goddard (1997) explicitly focuses on the impact of universities on the region by the deliberate creation of social capital, social, political and cultural life, lifelong learning, community development, development of local artefacts and culture (architecture) and integration of the region in the international society.

Table 1 gives an overview of the analytical approaches to HEI involvement in the literature.

Table 1. Analytical approaches to HEI involvement

	Traditional (linear) approach	Regional innovation system (non-linear, evolutionary) approach	
Central idea	Efforts in R&D generate innovation and commercialization and subsequently lead to better economic performance.	Interactive processes between varied and diverse actors, networks, continuous learning processes and innovation-conducive institutions such as policy incentives and trust give rise to economic growth, technological dynamism and competitiveness.	
View on innovation	Clear division of labour between stages in the production process Linear flow of processes: no feedback loops in innovation process	Innovation is iterative process characterized by trial and error and incremental adaptation at every stage Continuous interaction between different actors is crucial Actively include users in innovation process Continuous feedback loops from users to manufacturer	
View on the role of HEI	HEI as sources of academic knowledge and providers of academic education Focus on key economic performance indicators: research excellence (papers) and application of science in manufacturing (patents)	HEI as regional system builders in direct interaction with societal partners Focus on system emergence Innovation as inter-stakeholder learning Emphasis on the role of institutions as being conducive to regional innovativeness	
		The triple helix model	The engaged university
Interactions between actors		Relationships between universities, industry and government are hybrid, recursive and cross-institutional	Active and initiating role of universities in regional development

2.2 *Empirical studies*

Empirical studies that have paid attention to the third role of HEIs in Europe and in the US show that in general HEIs demonstrate a growing willingness to participate in regional development instead of maintaining an 'ivory tower' position (Colyvas and Powell 2006). The continuous growth of the number of students within their own region, combined with the need for additional financial resources, have fuelled this process (Charles 2003). In addition, a number of new HEIs were created in lagging regions that considered themselves as active participants in the process of regional development, welcoming the available public funds for this goal (Ruivo 1994; Glasson 2003). Table 2 presents an overview of the literature on the system building role of universities.

During 2004–2007 the Organization for Economic Cooperation and Development (OECD) undertook a large scale comparative study of how issues related to HEIs and their regional engagement were addressed in the OECD area (OECD 2007). This extensive study investigated the regional impact of HEIs in 14 regions in 12 countries. The OECD (2007) studied the embeddedness of HEIs in the region by investigating the deliberate contribution of universities to regional innovative processes, the degree of participation of scientists in col-

Table 2. The system building role of universities: An overview

Studies	Countries/regions	Focus of the study	Conclusions with respect to system building capacity
Puuka (2008)	OECD 14 regions in 12 countries*	Regional system building capacity	Current national incentive structures hamper regional engagement
Boucher et al. (2003)	OECD 14 regions in 12 countries*	Regional system building capacity	Level of competition and hierarchy between regional actors determines degree of system building capacity
Warren et al. (2008)	US	Regional system building capacity	A well functioning, supportive innovation systems can be very stimulating to entrepreneurial efforts of HEIs
OECD (2007)	OECD 14 regions in 12 countries*	Embeddedness of HEIs in the region, deliberate involvement	Growing bonds between universities and regional actors became visible, but many possibilities for collaboration remained underutilized.
Geuna et al. (2004)	France, Strasbourg	Deliberate involvement of HEI in region	Long tradition of contract research by universities, thereby indirectly impacting or the region
Dahlstrand and Jacobsson (2003)	Sweden, Gothenburg region	Contribution of HEIs to regional development	The contribution of HEIs to regional development resides in the first place in the creation of 'configuring clusters of capabilities'
Kjearsdam and Enemark (1994)	Denmark, Aalborg region	Contribution of HEIs to regional development	University functions as a 'catalyst' in regional development. In project-based educational system students execute projects together with local firms, institutions and organizations.
Doutriaux (2003)	Canada, 11 high-tech clusters	Contribution of HEIs to regional development	Universities are not drivers, instead they are catalysts for entrepreneurial behaviour of students.

Note: * The 14 regions are: Finland, Jyväskylä region; Mexico, Nuevo Léon; Sweden, Värmland; UK, North East England; Denmark/Sweden, Öresund region; Australia, Sunshine Coast; Spain, Canary Islands and Valencia; the Netherlands, Twente; Korea, Busan; Canada, Atlantic Canada; Denmark, Jutland-Funen; Norway, Trøndelag; Brazil, North Parana.

laborative projects with industry and the broader involvement of the university in the development of social capital. In nearly all cases studied, growing regional bonds became visible, but at the same time, many possibilities for collaboration remained underutilized. As best practices the report mentions that in the Jyväskylä region in Finland, the university has considerable impact at regional development. Monterrey Tech University in Nuevo Léon (Mexico) contributes in an impressive way on regional development, among others by its 700 community centres of learning. Another example of good practice is the delivery of professional services by Karlstad University in Värmland (Sweden). The four universities in North East of England work together in an organization named Universities for North East (Unis4NE), the London Higher Education Consortium, Aalborg University, the Öresund Region in Denmark and Sweden and the University of the Sunshine Coast (Australia).

On the basis of the results from this study Puuka (2008) concluded that national systems structure might hamper the capacity of HEIs to engage in regional development. Current incentive structures do not promote regional engagement. Based on the results from the same OECD study Boucher et al. (2003) indicated that the role of HEIs as an institutional actor that has linkages with other regional actors depends on a number of factors. These 'tiers of engagement' are found to depend on the level of competition and hierarchy in the relationship between HEIs and other regional actors. In core regions with traditional as well as new technologically oriented HEIs, the level of competition between HEIs with respect to scientific rigour and excellence is high and this severely limits their regional engagement. Newly set-up HEIs in economically lagging peripheral regions are found to be most engaged in regional development. This is not surprising, because usually these HEIs were created by the national government with the specific intention to increase economic growth of the region. In addition, Arbo and Benneworth (2007) note that HEIs can have different capacities with respect to the degree in which they influence the strategic organization of an educated labour force within the region. In extreme cases HEIs co-ordinate the regional human capital system, identify knowledge and skills gaps, and tailor their courses to improve the regional employability of students.

In contrast with the findings of Boucher et al. (2003), Warren et al. (2008) find that peripheral HEIs in the US have to undertake much more effort to exploit their regional consultancy services than core region HEIs. Warren et al. (2008) ascribe this result to the lack of entrepreneurial transaction environment, that is, the lack of a regional innovation system that generates and promotes linkages and networking between regional firms and HEIs. This makes it more difficult for peripheral HEIs to achieve equivalent results to HEIs that are located within well established regional innovation systems. Hence, the focus of Warren et al. (2008) is less on how HEIs themselves can improve the regional innovation system, but the study shows that well functioning, supportive innovation systems can be very stimulating to entrepreneurial efforts of HEIs.

A deliberate strategy of undertaking applied research by HEIs is not of recent origin. Some universities have a long tradition of contract research, like for instance, the Université Louis Pasteur in Strasbourg. The number of contracts in the medical, biological and chemical field is still growing. Universities like Louis Pasteur value the relation with the business world, especially its effect on the innovation of the curriculum, although the number of scientific publications lags behind (Geuna et al. 2004).

In the United Kingdom, the Labour government explicitly invited universities to contribute to the development of their own region as from 1997 onwards (Lawton Smith 2003). In a series of White Papers, co-operation in the field of research between universities and regional bodies was encouraged (DTI 2001; DTI DfEE 2001). Universities that choose to be involved are eligible for financial support by The Higher Education Funding Council for England (HEFCE). In particular, the 'Cluster policy steering group', directed by Lord Sainsbury has contributed to this goal by bringing together groups of industries and universities. Regional development

agencies have a mandate to involve universities in regional plans. These agencies co-operate with the 'modern universities' (former polytechnics) in the first place, primarily because of their receptiveness. In the United States, regional bonds traditionally have been stronger because of the system of 'endowments' and the 'land grant'-tradition, reinforced by the Bayh-Dole Act in 1980.

In other countries, governments have established universities with an explicit regional mission, for instance the Hautes Ecoles Spécialisées in Switzerland. During the period 2004–2008, the South Korean government invested 14 billion dollars in the enforcement of the regional impact of HEIs. More than 100 institutes participated in the New University for Regional Innovation. The Centre of Expertise programme in Finland (turnover 500 million euro) and the poles of competitiveness in France are also worth mentioning. Elsewhere, universities and local institutions have created specialized institutions; for instance the 'knowledge houses' in the North East of England are supporting the small and middle firms in the first place. The Georgia Tech's Economic Development Institute offers the most influential programme in the US. Monterrey International Centre of Knowledge (Nuevo Léon) is associated with Monterrey Tech University and has many regional bonds.

The growing number of explicit university-business bonds raises the question of the potential impact of this policy, in addition to the already existing regional impact of a more implicit nature. According to Dahlstrand and Jacobsson (2003), who have studied the Gothenburg region, the contribution of higher education institutions to regional development resides in the first place in the creation of 'configuring clusters of capabilities' (Dahlstrand and Jacobsson 2003). Research in Canada in order to reveal the impact of 11 high-tech clusters demonstrates that in no single case the university acted as a 'driver'. Instead, universities acted as 'catalyst'. The large impact of the universities of Calgary and Waterloo cannot be attributed to this universities' policy, but to the entrepreneurial behaviour of the students (Doutriaux 2003). The University of Aalborg is also a substantial 'catalyst' related to its project-based educational system. During the past 35 years, students have executed more than 100.000 projects together with local firms, institutions and organizations (Kjearsdam and Enemark 1994; OECD 2007).

2.3 Actions HEIs can undertake to stimulate RIS

From the above empirical studies we can distil several deliberate actions that can be undertaken by HEIs to stimulate regional development. Essentially these actions pertain to the different roles of the HEIs in the regional innovation system. Thus, each of the traditional roles of research and education will have to be reinterpreted and expanded, in order for the HEIs to become system builders. In Table 3 we review the roles of HEIs and see what deliberate actions can be undertaken to contribute to regional development.

Note that next to the concrete actions that are classified in Table 3, intangible effects of the presence of HEIs in the region can be identified as well. Intangible effects stem from the fact that universities are powerful symbols of learning and expertise. Their presence can be important to regional branding. Related to this is the idea that a region with a reputation for world class research can have spillover and reputation effects, by attracting high tech firms to the region and thereby stimulating the regional economy (Power and Malmberg 2008). The HEIs in the region create social capital, attract students who spend money in the regional economy, contribute to social, political and cultural life, community development, architecture and integration in international society (Felsenstein 1996; Goddard 1999; Thanki 1999).

The first domain in which HEIs can actively contribute to regional system building is research. Research can be employed in several ways. The content of the research can be directed to areas that underpin the region's economic base, that is, part of the research undertaken by HEI

Table 3. Ways in which HEIs can deliberately contribute to regional development

Domains	HEI – industry collaboration mechanisms (adapted from Ramos-Vielba et al. 2010 and D'Este and Patel 2007)
Research	• Content of research has a regional focus • Research agreement between regional actors – commissioned by industry/policy; undertaken by university researchers only; original research – undertaken by several parties jointly; original research – commissioned by industry; undertaken by university researchers only; no original research
Education	• Build training relationships with firms – Training of postgraduates and internships at firms (e.g., joint supervision of PhDs) – Temporary exchange of personnel – Training of firm employees provided by the university • Adapt education programs to meet firm's needs • Strong regional focus on student recruitment and graduate retention
Active collaboration with (regional) public and private actors	• Industry sponsored meetings and conferences • Setting up spin-off or start-up companies • Creation of physical facilities with industry funding / use or renting of facilities or equipment

can be regionally-focused (Chatterton and Goddard 2000; Gunasekara 2006). Furthermore, the form of research projects can be such that it involves regional actors. We can distinguish between different forms of research agreements that vary in terms of the party that is undertaking the research and whether the project generates new insights from an academic point of view, or not.

On one side of the spectrum are contract research agreements that are commissioned by industry or policy-makers and are undertaken by university researchers. Projects in this category usually pertain to original academic research that creates new knowledge. Also the collaborative development of innovative instruments and engineering design tools falls into this category of research agreements (Keane and Allison 1999; Goddard 1999; Glasson 2003; Drucker and Goldstein 2007). A middle group consists of joint research agreements that involve research directed to generating academically new insights and that is undertaken collaboratively by several parties. Collaborative centres where university staff and personnel from companies do joint research in so-called third spaces or academic workplaces are a good example of projects in this category (Harloe and Perry 2004; Wetenschappelijke Raad voor het Regeringsbeleid 2008). At the other side of the spectrum are consultancy projects that are commissioned by industry and do not involve original research. In the latter category HEIs are essentially exploiting and capitalizing on existing knowledge (Goddard 1999; Keane and Allison 1999; Etzkowitz et al. 2000; Glasson 2003; Gunasekara 2006; Drucker and Goldstein 2007). Communication channels between HEIs and firms can be kept open by creating regional learning centres or Lernladen (Gnahs et al. 2008), which are specialized knowledge institutes that are easy accessible for firms.

The traditional role of education brings forward the second domain of activities that can be adapted in the light of the new role of regional development. Training relationships between HEIs and industry can be built. Professors may identify opportunities for students to serve as interns in firms (Etzkowitz et al. 2000). 'Placements' within the region can be created for alumni in order to prevent bright graduates from leaving (Goddard 1999; Keane and Allison 1999; Glasson 2003). In this way HEIs act as attractor, educator and retainer of students, shaping them into knowledge-based graduates for firms in the region (Boucher et al. 2003), and providing the

region with a pool of skilled labour (Power and Malmberg 2008). Firm employees can enrol in university courses, or specific in-house training programmes targeted to firm employees can be set up by university personnel. Another type of interaction that is associated with a very intensive flow of knowledge is the temporary appointment of university members to the business sector (Schartinger et al. 2001). Existing education programs can be adapted to meet regional skills needs (Goddard 1999; Gunasekara 2006). Furthermore, student recruitment could adopt a strong regional focus (Gunasekara 2006).

Finally, several activities can be distinguished that enhance HEI-industry relationships and that cannot be categorized under research or education and that mainly originate from formal and informal participation as an institutional actor with other regional actors in linkages networks of learning, innovation and governance (Keane and Allison 1999; Boucher et al. 2003). We label this type of activity as active collaboration with (regional) public and private actors. Attendance of university researchers at industry sponsored meetings and conferences is an example, as well as making the university premises available for local activities (Goddard 1999; Keane and Allison 1999; Drucker and Goldstein 2007). Staff participation on external bodies can induce regional networking between HEIs, industry representatives and policy-makers. It also supports decision-making and brokering networking between national and international contacts and key regional actors (Gunasekara 2006; Benneworth and Hospers 2007). Other collaborations between HEIs and industry can be in the form of academic entrepreneurship or spin-off firms, that generate new economic activity, revenues and jobs in the region (Etzkowitz et al. 2000; Lockett et al. 2003; Power and Malmberg 2008; Erdös and Varga 2009). Yet another type of collaboration that is associated with knowledge flows is creating or renting university facilities or equipment to industry (Ramos-Vielba et al. 2010).

Whether a certain mechanism for deliberate action is suitable to adopt by a certain HEI depends on a number of factors. These factors influence the ability of HEIs to engage in regional system building in which regional stakeholders work together to develop the overall capacity of human resources in the region (Boucher et al. 2003, p. 895). Studies on the contribution of HEIs to the regional innovation system have revealed several conditions for the expansion of the contribution of universities to regional development. These conditions are predominantly related to a broad set of factors that relate to characteristics of HEIs, characteristics of the regional firms, aspects of the collaborative relationship, and characteristics of environmental context in which HEIs and firms are embedded. Figure 1 illustrates these factors. In the remainder of this paper

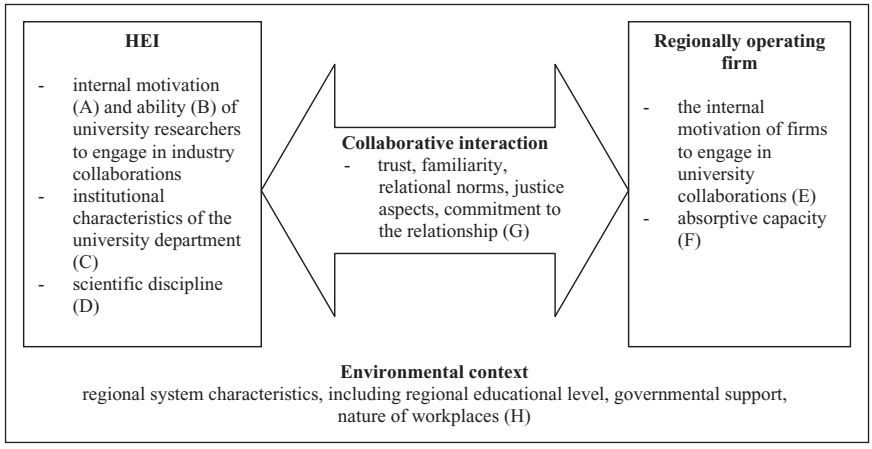

Fig. 1. Factors influencing HEI-industry collaborative interaction

we will elaborate on each of these factors and suggest directions of further research and a possible research design.

3 Directions open to further research

There are several important and promising areas open to further research. Most studies about the role of HEIs on regional system building are case studies of the relations of a single university within a region (Boucher et al. 2003; Drucker and Goldstein 2007). These studies reveal an increasing involvement of HEIs in regional policy and development. Interestingly, Holland (2001) shows that HEIs main motivations to engage in regional development stem from pressures external to the HEI. For instance, political pressure or budget cuts force HEIs to pursue business collaboration. These external motivations are not likely to be strong enough to generate a change in behaviour. Research shows that HEIs perceive a tension between excellence in teaching and research and regional engagement (Marmolejo and Puuka 2006), and there is an internal motivation to let excellence in research prevail over excellence in education and engagement in the region. Extensive research in the field of radical innovation management and stimulation of creativity suggests that internal motivations generate more effects than external motivations (Udwadia 1990; Colarelli et al. 2004). Therefore, HEIs that are internally motivated to contribute to regional development, for example, by seeing the opportunity to enhance and strengthen the HEIs' mission and their research performance, are likely to be more successful in this role (item A in Figure 1). Further research is needed to explore whether internally motivated HEIs generate more success in system building than externally motivated HEIs and in what ways their internal motivation can be fuelled. A first step in this direction is the study of D'Este and Patel (2007), that shows that individual characteristics of university researchers have a strong impact on the variety and frequency of the interaction with firms. The reasons of university researchers to interact with industry include access to additional research income, applicability of research, access to industry skills and facilities, and keeping abreast of industry problems. These reasons can be seen as motors of internal motivation of HEI researchers to support regional development. In addition, Rosenfeld (1997) and Tomes and Phillips (2003) point out that the ability of university researchers to co-operate with industry and participate in local networks needs attention as well. The success of collaborative programmes puts heavy demands upon project management qualities of university researchers (item B in Figure 1).

Several authors have suggested that institutional characteristics of the university department (item C in Figure 1), play a role in determining the success of university firm interactions (Schartinger et al. 2001; D'Este and Patel 2007). Among relevant institutional characteristics are the size of a university department, which increases the resources available for collaborative projects (Schartinger et al. 2001; D'Este and Patel 2007). Furthermore, a high share of senior researchers signals the predominance of more experienced researchers with established academic careers and these are associated with decreased HEI-industry interaction (Schartinger et al. 2001). University department policy and regulations can also create important incentives or disencouragements of collaborative projects. Regional connectivity has to be a part of the HEIs' strategic policy to spur HEI-industry interactions (Rosenfeld 1997; Tomes and Phillips 2003). Most collaborative projects of HEIs and firms are small-scaled and depend on the enthusiasm of individuals. Possibilities for increasing scale of operations that is implied by the development of 'socially engaged HEIs' depends on a strong vision and support by the HEI's government and adequate funding policy (Goddard 1997).

The scientific discipline (item D in Figure 1), constitutes another characteristic of the HEI that has an influence on involvement of HEIs in industry collaborations (Klevorick et al. 1995; D'Este and Patel 2007). In general, researchers engaged in basic research are less involved in

collaborative research projects than those engaged in applied fields (Estabrooks et al. 2008). Further research should investigate the factors that determine possibilities for HEIs to be engaged in regional development as well as factors that internally motivate HEIs to be active in this field.

In addition to the first point about the importance of internal motivation, it can be said that to a large degree, regional networks are self-governed by all stakeholders. Whether it is feasible for a particular HEI to undertake substantial effort leading to the development of the regional innovation system and support of regional development and growth depends on many conditions. One of these conditions is whether joint research with a regional network partner is of mutual interest and hence there is an internal motivation for both parties (items A and E in Figure 1). When a mutual interest is present each partner will be involved in the problem formulation, the generation of data and the implementation of the results. Innovative ideas and products will then be available for all participants in the network (open innovation).

Table 3 shows that HEIs can implement their new role by deliberately adapting their current roles of education and research in a way that regional development will be supported. Furthermore, HEIs should undertake an additional effort by defining collaborative projects with public and private actors. However, the role of the specificities of recipient firms has only received scant attention in the literature (Dosi et al. 2006; Meusburger 2008, 2009; Colombo et al. 2010). The 'absorptive capacity' literature (Cohen and Levinthal 1989, 1990; Zahra and George 2002), shows the importance of capabilities of the receiving firms to detect, absorb, and utilize the scientific knowledge generated by local universities (item F in Figure 1). Meusburger (2009) states that the communication process between the producer of knowledge (e.g., a university), and the receiver (e.g., a firm), fails in many cases or takes too much time to remain competitive, because the receiver of information has not sufficient prior knowledge to understand and utilize the information offered. This is particularly the case with respect to high grade knowledge that requires prior knowledge, skills and experience to be understood by the recipient. The receiver of the high grade knowledge has to be able to understand the information that is offered, evaluate its importance and integrate it to its own knowledge base and transform it into action (Meusburger 2009, p. 36). In other words, when sources of knowledge are available for end-users, the end-user has to be able to absorb the new scientific knowledge. Typically, internationally competitive companies access the best research institutions and consultancies all over the world and do not have a problem with detecting, absorbing and utilizing university generated knowledge. It is the smaller regional firms that have room for improvement in this respect. We will need to gain understanding about the processes at firm level that enhance this absorptive capacity of regionally operating firms. Almost certainly intensive interaction between universities and firms is needed to ensure successful exchange of knowledge with this category of firms, but there might be additional and alternative ways to increase their absorptive capacities.

Furthermore, research has paid little attention to the actual collaboration processes and we have insufficient understanding of how HEI-industry interactions are formed (Thune 2007). It might be the case that not only absorptive capacity of firms, but also social aspects in the relationship between HEI and firms including trust, familiarity, relational norms, justice aspects and a long term commitment to the relationship are of key importance in successful interaction (item G in Figure 1). Hence, further research is needed to gain more understanding about the micro-dynamics of HEI-industry relationships, in particular the learning processes at play within firms as well as the nature of the collaborative processes within the relationship.

Our paper explored the regional system building initiatives that can be undertaken by HEIs, including activities that focus on increasing the prior knowledge and skills of the end-user. However, the regional innovation system that is available at one point in time has to be taken into account as an important factor determining whether knowledge interactions between HEIs and firms will be successful or not (item H in Figure 1). Differences in absorptive capacity between

regions originates from differences in the innovative capacity regions, levels of research intensity, regional level of educational attainment, the qualification structures of work places and so on (Maskell and Malmberg 1999; see Meusburger 2008 for a review). Hence, the regional (innovation) system in which HEIs and firms are embedded differs between regions and has large implications about how well (high grade) knowledge from universities is absorbed by firms and how well system building activities from HEIs will be taken up and be successful. Further research should be able to identify the degree in which general factors that determine the overall regional innovation system, such as regional research intensity and regional qualification structure of work, moderate the extent to which HEIs can actively build the regional innovation system. In the meantime, it is of critical importance that policy-makers still invest into activities that upgrade the overall regional innovation system and do not leave this task completely to HEIs.

Finally, it is critical to be able to measure the results of regional engagement work of HEIs. With the exception of the study of Ramos-Vielba et al. (2010), there is a lack of sound indicators that give information about the current status and that allow for monitoring the situation over time. Developing measures of the effectiveness of institutional engagement in regional development is essential to provide input for the improvement of HEIs (Marmolejo and Puuka 2006). Further research should be undertaken in order to overcome current technical and political difficulties.

4 Research design

A research design that addresses these issues will consist of two phases that employ different methodologies. First, an explorative study needs to be carried out that is containing a limited number of semi-structured, in-depth interviews with HEI researchers as well as with representatives of regionally operating firms and of regional government agencies. The interviews will promote a more comprehensive understanding about the internal motivation to interact of all parties involved, in particular, the sending and the receiving end of knowledge interactions. On the one hand we need to identify the motors of internal motivation of HEI researchers to engage in regional developmental activities and industry interaction, as well as the mechanisms by which interaction takes place. On the other hand we need to gain understanding about processes at the level of regionally operating firms that enhance their internal motivation as well as the ability to interact with HEIs and absorb and implement the available knowledge. Additionally to the focus on both sender and receiver, it is important to gain understanding about the nature of the collaborative processes. What is the importance of informal links between HEI researchers and representatives of regional firms – in terms of trust, relational norms and justice aspects – for the formation of formal interactions. Thune (2007) provides a good basis for a set up of a qualitative study. Based on the interviews and the available literature about proxies of interaction activities (e.g., D'Este and Patel 2007; Thune 2007; Ramos-Vielba et al. 2010), several sound indicators can be developed that provide information about the current HEI-industry interaction mechanisms, the nature of the collaboration and the motivating factors for each actor.

Second, we propose a more explanatory and confirmatory approach by means of a survey among a large number of academic researchers as well as firm representatives. Schartinger et al. (2001) and Ramos-Vielba et al (2010) administered two surveys targeted at research teams at universities and R&D departments of firms. Although this being a good initiative the research design of these studies does not provide dyadic information on whether joint research with regional network partner is of mutual interest. We need to improve our understanding of who in academia interacts with whom in industry, and how and why. Even dyad-focused research is too

limited for this goal, because it treats the network as a collection of two-party relationships, rather than as a multiorganizational social system (Michel 1969). Consequently, a social network analysis involving all regional actors is needed to assess the internal motivation of all parties to engage in regional system building activities and the current status of HEI-industry interaction. The survey should also generate data about the extent in which the involved actors assess whether the results of certain interaction mechanisms are in line with the predetermined reason for undertaking the interaction, namely, to what extent is the internal motivation fuelled by a successful interaction and what are the characteristics of the collaborative relationship. Furthermore, data about the general characteristics of the regional innovation system should be gathered, including regional research intensity, regional educational attainment and regional qualification structure of work, since these factors could moderate the extent to which HEIs' interaction with industry is successful and the degree in which HEIs can actively contribute to the regional innovation system. Data on factors such as scientific discipline and the institutional characteristics of the university department is needed for constructing control variables.

Preferably, the research design should adopt a longitudinal perspective. Motivation of HEIs and firms to engage in interaction, absorptive capacity of firms, mechanisms of interaction and exchange, aspects of the collaborative relationship and characteristics of the regional innovation system should be monitored over time. This approach can provide further insights into the current status of, and the changes in, the regional innovation system and its actors as well as its underlying collaborative processes.

5 Concluding remarks

This literature review and the emanating issues for further research are focused at coming to grips with the regional innovation system building role of HEIs. The answers to the research questions that we formulated contribute to better understanding of the ways in which deliberate regional development activities of HEIs can be promoted and in which way we will be able to monitor whether new initiatives actually do lead to further development of the regional innovation system over time. At the same time, we will need to gain understanding about the processes at firm level that enhance absorptive capacity of firms and about the role of informal aspects in a collaborative relationship between HEIs and firms. In this way we might be able to generate an optimal alignment of HEIs, firms and governmental institutes so that all regional engagement activities of HEIs can be optimally absorbed by the region and its firms.

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Resumen. Muchos estudios se centran en la aplicación de tecnologías científicas a procesos de manufactura, o a la investigación del impacto regional de los contratos y la cooperación en investigación por Instituciones de Educación Superior (HEI, siglas en inglés). Sin embargo, el rol de las HEI como impulsoras del sistema de innovación regional (RIS) ha sido apenas investigado. Hacemos aquí una revisión de literatura sobre el papel de las HEI como motor del RIS y ofrecemos sugerencias de acciones concretas que estimulen el desarrollo regional. En cuanto a investigaciones posteriores sugerimos realizar un análisis de redes que incluya los factores relacionados con las características de: (1) HEIs; (2) empresas regionales; (3) la relación de colaboración; y (4) el contexto ambiental en el que se desenvuelven las HEI y las empresas.

要約　科学技術の工業への応用または、Higher Education Institutions (HEIs：英国高等教育機関）との契約や共同研究が地域に与える影響の調査を主眼としている研究は多くみられるが、地域イノベーションシステムの立役者として HEIs が果たす役割については、概して、これまで十分に検証されたことはない。本論文では、地域イノベーションシステムを促進する HEIs の機能についての文献をレビューし、地域開発を促進する計画的な活動に向けた提案を行う。そして、研究をさらに進めるために、(1) HEIs、(2)地域の企業、(3)提携関係、(4) HEIs および企業が置かれている環境的文脈、以上の特性にかかわる要素について、ネットワーク分析を実施することを提言する。