Uyarra, Elvira

Working Paper

The impact of universities on regional innovation: A critique and policy implications

Manchester Business School Working Paper, No. 564

Provided in Cooperation with:
Manchester Business School, The University of Manchester

Suggested Citation: Uyarra, Elvira (2008) : The impact of universities on regional innovation: A critique and policy implications, Manchester Business School Working Paper, No. 564, The University of Manchester, Manchester Business School, Manchester

This Version is available at:
https://hdl.handle.net/10419/50728

The University of Manchester
Manchester
Business School

Working Paper Series

The Impact of Universities on Regional Innovation: A Critique and Policy Implications

Elvira Uyarra

Manchester Business School Working Paper No 564

Manchester Business School
The University of Manchester
Booth Street West
Manchester M15 6PB

+44(0)161 306 1320
http://www.mbs.ac.uk/research/workingpapers/

ISSN 0954-7401

Author(s) and affiliation

Elvira Uyarra
Institute of Innovation Research-Manchester Business School
The University of Manchester
Harold Hankins Building, Booth Street West
Manchester M13 9PL, UK
Elvira.uyarra@mbs.ac.uk

Abstract
The impact of universities on the economic wellbeing and innovative potential of regions has been the object of intense scholarly and policy interest in the last years. Despite this interest, a clear picture is missing in relation to the roles universities are seen to play, the benefits of HEI activities and the mechanisms through which they occur. This paper proposes a review and a critique of current views on the role of universities and their associated policy implications. This paper argues that the literature provides a fragmented account of HEIs regional engagement and highlights the need for an integrated approach combining firm-level considerations, with institutional and strategic issues affecting universities engagement, and regional specific determinants shaping localised interactions.

Keywords
HEIs, regional development, regional innovation systems, knowledge spillovers, entrepreneurship, knowledge transfer, university industry links

How to quote or cite this document
Uyarra, E (2008). The impact of universities on regional innovation: a critique and policy implications *Manchester Business School Working Paper, Number 564*, available: http://www.mbs.ac.uk/research/workingpapers/

The impact of universities on regional innovation: a critique and policy implications[i]

Elvira Uyarra
Institute of Innovation Research-Manchester Business School
The University of Manchester
Harold Hankins Building, Booth Street West
Manchester M13 9PL, UK
Elvira.uyarra@mbs.ac.uk

Abstract
The impact of universities on the economic wellbeing and innovative potential of regions has been the object of intense scholarly and policy interest in the last years. Despite this interest, a clear picture is missing in relation to the roles universities are seen to play, the benefits of HEI activities and the mechanisms through which they occur. This paper proposes a review and a critique of current views on the role of universities and their associated policy implications. This paper argues that the literature provides a fragmented account of HEIs regional engagement and highlights the need for an integrated approach combining firm-level considerations, with institutional and strategic issues affecting universities engagement, and regional specific determinants shaping localised interactions.

Key words
HEIs, regional development, regional innovation systems, knowledge spillovers, entrepreneurship, knowledge transfer, university industry links

1. Introduction

This paper provides a review and a critique of the way in which universities are seen to influence regional innovation. Whilst it is commonly accepted that universities are key repositories of new knowledge and human capital and thus potential sources of innovation and economic development in national and regional economies, the roles they are seen to play have changed significantly over the past twenty five years. The rapid expansion of Higher Education, pressing funding constraints, and an alleged change of paradigm (towards 'mode 2' of knowledge production) have shifted the emphasis from capitalising knowledge assets towards greater focus on building ties between the higher education sector and the rest of the economy. In this context, Etzkowitz et al.(2000: p.319) note how public funding for university research has become "dependent on the perception of whether it will make a direct contribution to the economy". More recently, attention has been directed towards the idea of universities nurturing regional innovation, as well as their wider contribution to cultural and community development (National Committee of Enquiry into Higher Education, 1997).

Evidently, universities are complex organisations which undertake a variety of different activities that can have an economic impact. Besides their role as employers and purchasers, these include knowledge creation, human capital creation, transfer of existing know-how, research-led technological innovation, capital investment,

regional leadership, impact on the regional milieu and support to knowledge infrastructure (Drucker and Goldstein, 2007). Thus despite having long been recognised as key actors in economic development, what is new is the increased number of additional roles they are expected to play. As Arbo and Benneworth (2007; p.18) put it, "more and more aspects of the academic enterprise are thus perceived as being significant to the regeneration and transformation of the regions".

This interest has also found a clear reflection in policy action. Encouraged by cases such as Route 128, Silicon Valley or Cambridge, many countries across the OECD have launched policies aimed at promoting university entrepreneurship and the exploitation of intellectual property emerging from their research. In the UK a 'third-stream' of funding has operated since 1999, with the objective of rewarding and encouraging universities to enhance their interaction with business, industry and the public services. This funding—now brought together under the umbrella of the Higher Education Innovation Fund and awarded on a formula-driven basis—is granted according to universities performance in relation to not only commercialisation activities but also wider regional economic and cultural engagement. This regional role can also be observed in universities' increasing engagement in local and regional economic partnerships and strategies, in the proliferation of science parks and incubation facilities linked to universities, in their presence in regional science and industry councils in England and most recently in their shaping of 'science cities' in a number of English regions. This policy interest however raises concerns about the abilities of universities to respond to multiple policy expectations.

Despite this policy interest, a clear picture is missing in relation to the regional benefits of HEI activities and the mechanisms through which they occur, a gap which has led to the recent launch by the ESRC and the HE funding councils of England, Wales, Scotland and Northern Ireland, of a joint initiative 'Impact of Higher Education Institution on Regional Economies'[ii]. This paper is developed in the context of this initiative.

The paper aims to contribute to the debate by seeking to reflect a sizable literature within economics, geography and innovation studies that has over time documented different set of roles of universities, different spatial aspects of interactions, as well as different mechanisms for university engagement. To make this task more manageable, the examination is limited on regional 'knowledge' impacts (Varga, 2002)—thus excluding the 'expenditure' impacts of universities through employment and purchasing of good and services (Kelly et al, 2006)[iii]. This said, the paper identifies five evolving 'models' for universities. First, universities are considered by early impact studies primarily as producers of scientific knowledge—'knowledge factories'(Youtie and Shapira, 2008)—which can have a direct local economic impact. Second, university-industry links studies take a 'relational' approach, suggesting wider indirect benefits of public research and acknowledging a variety of links and processes for knowledge sharing between firms and HEIs. More recently, the commercial exploitation of universities research has become a policy imperative. This more 'entrepreneurial' aspect of universities is encouraged via dedicated organisational arrangements in universities. Fourth, innovation system studies see universities as boundary-spanning institutional 'nodes', whose influence will be shaped by the specific regional innovation system in which it is embedded. Finally, universities are further ascribed a 'developmental' role in recent regional policy

literature, as actively engaged actors in the economic development of the local and regional areas in which they are located. It is not our aim to be exhaustive, nor are these dimensions mutually exclusive, rather our aim is to identify some relatively stylised differentiation of the way in which universities are portrayed in the literature in relation to their contribution to regional development. This stylised differentiation primarily serves a heuristic purpose, and allows us to identify commonalities and interfaces between different approaches in terms of the nature, determinants, and geography of these linkages, as well as to perceive gaps in the literature.

The paper is structured as follows: after this introduction, each of the university 'models' is discussed. In each section, the paper reviews the evidence around the regional impacts of universities, the means through which they manifest, the conditions and determinants influencing this impact, as well as shortcomings of the different approaches. Upon reviewing the literature, the paper provides a discussion of some policy relevant key themes. Finally, some conclusions and policy implications are drawn, as well as some suggestions for informing a future research agenda.

2. Localised impact of research. Universities as 'knowledge factories'

As sources and repositories of knowledge, universities are seen as contributing to increased levels of R&D and innovation in regional firms. Particularly in the context of the post-war funding expansion for university research, the expectation was that this funding would automatically translate into innovation outputs (patents, product or process innovations). Youtie and Shapira (2008) refer to this as the 'knowledge factory' role attributed to universities, characterised by an assembly-line-like transformation process of research inputs into scientific and economic outputs.

Research such as Mansfield's (1991) for the US and Beise and Stahl's (1999) for Germany indeed suggested that academic research could explain a significant proportion of product or process innovations. Mansfield (1991) found that about 10% of the new products and processes commercialized during 1975-85 could not have been developed -without substantial delay- without recent academic research. Beise and Stahl (1999), in a large survey of German firms, observed that a similar proportion of product- or process-innovating firms introduced innovations between 1993 and 1995 that would not have been developed without public research. Cockburn and Henderson (2001) estimated that the rate of return to public funding of biomedical sciences (in terms of increased private sector R&D) was as high as 30% per year. Problematically though, rate of return assessments work backwards from existing innovations to demonstrate the influence of university research on their development, and yet it is very difficult to attribute new products to particular scientific findings (David et al. 1992), particularly when no counterfactual is considered. From a policy viewpoint, the measurement of average (rather than marginal) rates of return is problematic in terms of science funding allocation decisions (Scott et al. 2002; Cockburn and Henderson 2001). Some recent studies, rather than assessing the wide economic returns, have restricted their analysis to the relation between public research and specific intended industrial outcomes such as R&D levels or new products (see, e.g. Guellec and Van Pottelsberghe, 2003). Some have assessed whether public and private R&D are complements or substitutes, with David et al (2000) suggesting a complementary rather than a crowding out effect of public R&D.

Geographical proximity and face-to-face interaction can amplify these impacts, as shown by knowledge spillover studies. Jaffe's (1989) seminal work provided evidence of spillover effects from universities. Using a knowledge production function, he noted a significant effect of university research on corporate patents (used as proxy for innovative output) in 29 US states in 1972–1977, 1979 and 1981, particularly in the areas of drugs and medical technology, electronics, optics, and nuclear technology (see also Feldman and Florida, 1994). Jaffe also found evidence of university research having an effect on industrial R&D spending. Proximity effects have also been observed in the spatial concentration of patent citations (Jaffe et al., 1993). However, how localised these impacts are in these studies is difficult to discern, as the definition of proximity employed to measure knowledge spillovers varies considerably across studies. Most studies tend to adopt too large spatial levels of aggregation (such as US Federal states) to provide sufficient evidence of localized knowledge spillovers. Other studies have centred on metropolitan units or cities. For instance Anselin et al. (1997) observed significant spillovers from university research on 'high technology' innovations at the level of U.S. metropolitan statistical areas. Using similar data, Anselin (2000) concluded that these local spillovers effects were specific to certain industries, university impacts being particularly strong in the electronics and instruments sectors.

One critique of these studies is that they are unable to separate the impact of different university activities and to identify the different mechanisms or pathways by which knowledge spillovers are transmitted. The measures of innovation outputs adopted only capture some of the impacts of universities, neglecting other means in which they contribute to economic development (Drucker and Goldstein 2007). Finally, these approaches tend to assume a unidirectional transfer of knowledge from firms to universities, thus ignoring that knowledge flows between science and industry are not linear but bi-directional and reciprocal (Cockburn and Henderson 1996; Meyer-Krahmer and Schmoch 1998). From a policy perspective, it is assumed that the sole presence of research intensive universities will positively influence innovation activities of nearby firms (serendipity playing an important role). The risk of universities becoming 'cathedrals in the desert' and of being of no use for local firms is overlooked. Lack of 'absorptive capacity' (Cohen and Levinthal 1990) to assimilate and exploit this knowledge and generally communication barriers may prevent knowledge transfer, thus requiring boundary-spanning efforts to overcome these barriers.

3. University Industry links: a 'relational' approach

In contrast with earlier linear views, it is accepted that the relationship between public research and the economy is much more complex (Scott et al. 2002). The literature on university-industry links reflect a more 'relational' role of universities. It recognises that the benefits of the linkages, and the channels in which knowledge flows, are multiple and varied. Different firms may use different channels to different extent to derive value from public research. Indeed, as shown below, it is mainly firms of certain size and resources that have the absorptive capacity to benefit from university research. Collaboration with universities can also yield wider innovation impacts, namely: increased stock of useful knowledge, training of skilled graduates, new

scientific instrumentation and methodologies, networks of social interaction, scientific and technological problem solving, and firm creation (Salter and Martin 2001).

University industry links studies have sought to gauge the different mechanisms of interactions, the frequency and importance of these links, as well as the factors influencing their likelihood and intensity. The different 'pathways', 'channels', 'processes' or 'linking mechanisms' through which knowledge occurs have been categorised on the basis of their degree of formalisation, resource deployment, the length of the agreement, their suitability for transferring tacit knowledge, and the 'relational involvement' of the interactions, etc. (Bonaccorsi and Piccaluga 1994; Faulkner and Senker 1994; Schartinger 2002; Perkmann and Walsh, 2007; Meyer-Krahmer and Schmoch 1998; Agrawal, 2001; Cohen et al. 2002). Their *frequency* and relevance has been in turn mapped and assessed on the basis of surveys or detailed case studies targeting industrial firms (Cohen et al. 2002; Cosh et al. 2005; Faulkner and Senker 1994; Cockburn and Henderson 1996; Grossman et al. 2001) or university departments and individual scientists (Lee 1996; Mansfield and Lee 1996; Howells et al. 1998; Meyer-Krahmer and Schmoch 1998; Agrawal and Henderson 2002; D'Este and Patel 2007). A few studies have focused on both the university and the firm side (Lee 2000; Schartinger 2002). Some have taken as unit of analysis the collaborative projects themselves (Carayol 2003; Montoro-Sanchez et al. 2006).

Using data from the Carnegie Mellon survey of industrial R&D, Cohen et al. (2002) concluded that firms use a variety of channels in their interacting with universities. The most important mechanisms for knowledge transmission were open channels, such as publications, conferences, informal links and consultancy activities. Patenting and licensing activities were of relatively lower importance. Similar findings were reported by the IPC-CBR innovation benchmarking survey of UK and US firms (Cosh et al. 2005), which revealed the use of a broad range of links in the two countries. The most often cited links were informal contacts, followed by more conventional interactions such as publications, recruitment of graduates and the attendance of conferences, whereas among the least often cited were licensing and patenting. Internships were more often cited as a key interaction in the US than in the UK. With this exception, UK firms showed a higher frequency of use of most mechanisms than the US. Interestingly, when prompted in relation to the relative importance of those links, US companies regarded licensing, joint R&D, and post doctoral and graduate recruitment and internships as more important for innovation. The survey concluded that what distinguishes the UK and the US is more the *depth and quality* than the *frequency* of these interactions. This is further supported by the fact that US businesses tend to devote additional innovation related expenditures to support their university links.

In a survey of 1528 academic researchers in the UK D'Este and Patel (2007), reported that consultancy, contract research, and meetings and conferences were the most frequent interactions (with 56% and 65% of university researchers engaged respectively at least once in these activities). Both patenting and the creation of physical facilities (including spin-offs) were activities of comparatively lower frequency relative to other types of interaction. In a survey of over 200 professors in MIT comparing the relative importance of patents vis-à-vis other channels of knowledge transfer, Agrawal and Henderson (2002) also concluded that patenting was a minority activity. Meyer-Krahmer and Schmoch (1998), using a survey of German

university departments in a number of technology fields, found that collaborative research and informal contacts were the most important types of interaction. Using two different surveys addressing innovative firms and university departments in Austria, Schartinger (2002) demonstrated that the main channel of knowledge transfer from universities to the business sector occurs through the mobility of human capital.

A differential use of these channels to draw knowledge from universities can be observed in different types of firms. For instance, Schartinger (2002) finds the *research intensity* of a sector, i.e. the share of R&D expenditures in total turnover, to be a major determining variable for interaction activities with universities in terms of contract research. The effect of past investment in R&D is related to the idea of firms requiring 'absorptive capacity' to benefit from university research (Cohen and Levinthal 1990). The *size* structure of the industry is also important. Cohen et al 2002) found the influence of universities to be disproportionately greater for larger firms. Schartinger (2002) in turn found that sectors with high shares of medium-sized enterprises had higher interaction activities in joint research with universities than other sectors. Laursen and Salter (2004) also observed that the *age* of the firms influences their propensity to draw from universities, with young research-active organizations drawing more heavily from university research. Finally, surveys by Laursen and Salter (2004) and Fontana et al (2006) suggest the *openness* of firms to the external environment to significantly affect the probability of interacting with universities. On the side of the universities, the characteristics of the departments and the individual researchers (research income, previous experience in collaborative research and academic status) also influence the frequency and variety of interactions (D'Este and Patel, 2007).

Proximity has also been found to influence the incidence of links. Certain linkages by certain firms may be more local than others, although there is little conclusive evidence of a distance decay effect across the multiple channels of interaction. Schartinger (2002) indicates that in the case of contract research (including consultancy), potential interaction partners tend to be sought for locally. In the case of the other types of interactions analysed, however, distance did not seem to matter much. Large and small firms may also have very different requirements. Whereas large companies would be more attracted to work with a university because of its reputation for world-class research in a particular area of interest, small firms may demand more routine services and consultancy which are more likely to be sourced from their local university (Siegel et al. 2007b). Arundel and Geuna's survey of the effects of proximity between public research organisations and Europe's largest firms (Arundel and Geuna 2001) showed that the importance of proximity for sourcing knowledge from public research increases with the quality and output of domestic public research organisations and the importance given to public science by the respondents.

These studies reveal a complex and varied mix of channels of interaction. One implication is that a narrow policy emphasis on certain linkages such as patenting and licensing activities may obscure not only the presence of other types of university–industry interactions that are less visible (and thus less quantifiable by generally employed metrics) but equally or even more important (D'Este and Patel 2007), but also neglect the interconnections and complementarities that may exist between different types of relations. Informal personal relations for instance often precede or

initiate formal collaborations (Azagra-Caro et al. 2006). Furthermore, certain channels of communication, such as consulting activities, seem to be under researched (Scott et al, 2002.

Whilst providing a more accurate picture of the multiple transfer mechanisms, these seem to take place in a vacuum, i.e. without accounting for the regional economic configurations in which they are embedded. University-industry links cannot be studied in isolation, for other institutional factors, often place-specific, are instrumental in determining the likelihood and frequency of knowledge interactions. Finally, university-industry links literature tends to overlook organisational aspects of knowledge transfer activities, including management structures, skills and incentive mechanisms influencing knowledge commercialization by scientists. The next section focuses on this aspect.

4. Organisational aspects of the 'entrepreneurial' university

Success cases in US universities have encouraged research not only on the channels of interaction, but also on the organisational aspects of these channels, in particular around the intellectual property (IP) exploitation by universities. This literature (mainly US-centred) explores the institutionalisation of IP management by universities, including the introduction of management and organisational arrangements around IP exploitation and their interaction (and potential conflict) with traditional academic practices. The interest in promoting a more 'entrepreneurial university' (Etzkowitz 2000; Clark 2001; Siegel et al. 2007b) has been particularly noticeable following the passing of the Bayh-Dole Act in the US (Mowery et al. 2001; Mowery, 2004) and has materialised in a sharp increase in technology transfer activity by universities, as measured by patent applications and licensing income[iv]. The Bayh-Dole Act gave universities the right to patent new discoveries and required them to license inventions resulting from federally sponsored research to the private sector. It effectively transferred ownership of intellectual property rights to universities. This policy drive to encourage entrepreneurialism in the US has been followed by a number of EU countries by e.g. modifying national legislation concerning universities' use of IP (Mowery and Sampat 2004). According to Geuna and Nesta (2006), these reforms have taken place despite limited evidence on the impacts, benefits and risks of IP exploitation by universities. In the US, concerns have been raised in relation to the potential impact of the Act on academic freedom and openness, teaching quality and on the balance of fundamental vs more practical research (Mowery et al. 2001; Nelson 2001; Sampat 2006; Greenberg 2007)

The difference of these approaches vis-à-vis the ones reviewed above, is the shift from acknowledging the impact of different pathways or channels on innovation, and towards *actively promoting* them. The literature on commercialisation takes a more normative turn in suggesting mechanisms that need to be put in place to enable these linkages. Universities' research intensity and firms' absorptive capacity are necessary but not sufficient conditions, for "university-industry links may not develop because academics and businessmen effectively speak different languages" (Siegel et al. 2007a). It follows then the need to set up intermediary mechanisms such as industrial liaison/technology transfer offices (TTOs) to overcome communication barriers and effectively link academic scientist and those who could potentially commercialise research (Siegel et al. 2007a).

Academic entrepreneurship challenges universities to reorganise and re-examine universities' organizational structures and practices (Siegel et al. 2007a). Certain organisational practices would influence the effectiveness and speed (Markman et al, 2005) of commercialisation, and thus licensing revenues. Bercovitz et al. (2001), in their analysis of Johns Hopkins, Pennsylvania State, and Duke University, noted that different organizational structures—in terms of more or less centralised information processing capacity, coordination capability and incentive alignment—resulted in differences in technology transfer performance in the three universities.

Along a similar line, Siegel et al (2003) identified a number of organisational practices having a key influence on the relative productivity of US TTOs. Key practices included TTO staffing and compensation, and reward systems for staff members. The former relate to TTOs being adequately resourced, including the need to attract and remunerate personnel with the appropriate IP and private sector skills (Jain and George, 2007). Belenzon and Shankerman (2007) identified performance-based pay to be a key factor influencing productivity within US TTOs. The second key challenge is how to incentivise researchers to disclose their inventions and engage in the commercialisation of IP. Despite universities being compelled to commercialise their inventions under certain legislation, some fail to encourage the disclosure of research inventions, with many technologies "going out the back door" (Markman et al., 2006, cited in Link et al, 2007). Lach and Shankerman (2003) found that US universities offering higher incentives in the form of inventors' royalty shares distribution generated higher levels of licensing income. Researchers may however feel pressured to pursue profitable lines of inquiry rather than those lines which advance knowledge (Feller, 1990). Using data for the Catholic University of Leuven, Van Looy (2006) however reported a coincidence between those researchers engaged in entrepreneurial activities and those active in publications, also suggesting the absence of a simple trade-off between technology transfer and traditional academic activities (see also Rafferty, 2008).

Concerns have been raised about the expectations of universities over the benefits of commercialisation activities, particularly given the large resources required in setting up and managing TTOs. Universities may be lured by the prospect of obtaining hefty revenues from patenting and licensing activities. Yet prospects of high economic returns of patent and licensing activities are largely a 'myth' (Nelson 2001). Only a modest number of universities generate substantial revenues, producing a highly skewed distribution of income (Howells et al. 1998; Geuna and Nesta 2006)[v], with the cost of running TTO offices generally outweighing their revenues. The heavy focus on intellectual property protection may even hinder collaborative arrangements by imposing additional transaction costs on firms, making it more expensive and time consuming (Nelson 2001). Indeed, it has been argued that the increase in formal IP management by universities following the passage of the Bayh-Dole Act has not been accompanied by a similar rate of technology transfer from universities to industry (Henderson et al. 1998; Sampat 2006; Fabrizio 2007; Valentin and Jensen, 2007).

Some of these academic entrepreneurship activities and instruments have a greater focus on transferring knowledge to *regional* firms. Besides TTOs, instruments set up for promoting technology transfer from universities have also included the establishment of science parks. Although some of them predate the entrepreneurial

university agenda (Lawton-Smith 2007), science parks have received notable attention as a tool of technology transfer and regional development policy, hoping they would create new jobs, technology-based firms and help revitalise the local economy. In practice, however, their role have been found not to be significant in pursuing many of these objectives (Massey et al, 1992), in many cases acting as a commercial property developer rather than technology transfer instrument. Inconclusive evidence has been reported on the impact of the parks on tenant firms innovative activity (Westhead, 1997) and the quality of links between the park's firms and universities (Massey et al., 1992).

One key corollary of these organisational approaches is that universities face a strategic choice regarding which mode of commercialisation to emphasize (Siegel, 2007), for different organisational and managerial practices would be required to support different forms of linkages. Gill et al (2007) note that whereas a centralised structure around a technology transfer office providing IP services to firms would be more appropriate for the transfer of 'packaged' IP, more relational or 'people centred' links would be better supported by more decentralised arrangements. This again casts doubts about the adequacy of using technology transfer offices as key conduit through which all communication between universities and external organisations is channelled.

This also entails that universities may need to choose between licensing or spin-offs, or other commercialisation mechanisms more focused on fostering regional economic development such as incubators and science parks. It may not be realistic to focus on all mechanisms, or at least this is what emerges from Belenzon and Shankerman's (2007) analysis of US universities. They suggest that there is a trade-off between maximising income from university inventions and promoting local and regional development objectives. Using panel data on U.S. universities for 1995-99, they observed that universities with a stronger local development focus in their technology transfer activity earn less licensing income from a pool of inventions. Universities, they argue, should focus on maximising income from inventions and use the extra revenues to finance local economic development in other ways. Another option for certain universities, according to Siegel et al (2007b), is to adopt a more targeted commercialisation or market segmentation approach to enable better matches between the knowledge and technology transfer activities on offer and the different types of local industry. This would be more advisable than a broader and more generic approach targeting all possible sectors.

This notwithstanding, little attention is paid to the otherwise obvious fact that technology transfer activities will take place in a particular regional context, influencing the 'entrepreneurial' activities of universities and the local economy it may seek to influence. Indeed, the capacity of regions to benefit from technology transfer activities from universities will not only depend on the organisational and strategic arrangements of universities, but also on other institutional and structural aspects of the regions in which they are located. The mix of regional actors that conform the regional innovation 'system' and generally the variance in 'absorptive capacities' or 'demand deficiencies' at the regional level will influence this impact (Agrawal 2001; Lambert 2003; Azagra-Caro et al, 2006). Another key bias of this literature is that it is overwhelmingly based on US data, with few studies testing these assumptions in the EU. Finally, it is not clear how these organisational issues play out

in different types of universities, beyond some evidence of different performance of public vis-à-vis private universities in the US (Belezon and Schankerman, 2007).

5. Universities within systems of innovation

Innovation surveys, such as those based on the Community Innovation Survey (CIS), demonstrate that firms rarely innovate on their own but involve interactions with wider networks of market and non-market institutions, including universities (Laursen and Salter 2004)[vi]. These linkages would also be influenced by the particular institutional, policy and economic context in which they are embedded. This is the key tenet of the national systems of innovation (Lundvall 1992; Nelson 1993) and regional systems of innovation approaches (Braczyk et al. 1998; Evangelista et al. 2001; Doloreux 2002). Universities are here portrayed as 'boundary-spanning' institutions, interacting with government and industry in innovation activities (Etzkowitz and Leydesdorff 1997; Etzkowitz et al. 2000).

The focus shifts here from the types and avenues of knowledge interaction, to the institutional configuration of these links and their embeddedness in particular (regional) innovation systems. It considers that the impact that a university can make on a particular territory would depend on the configuration of the innovation system of the region, particularly the alignment between knowledge producing universities and the demand side of the regional knowledge using community (Cooke 2005), the articulation of regional policies and the ability of universities to effectively mobilise stakeholders for innovation. An emerging concern is therefore the need to align or match regional knowledge producing networks with regional firms[vii]. To achieve this alignment, commercialisation activities of universities are here further institutionalised and broadened to conform to the so-called 'third mission' or third stream activities[viii].

Universities adopt this 'third-mission' of economic development as an additional function alongside the scientific research and higher education functions. This is for instance highlighted by the triple helix literature, which depicts the dynamics of interactions and negotiations among universities, industry and government—the three components of the triple helix model (Etzkowitz and Leydesdorff, 1997, Etzkowitz, 2000). What we find according to the model is a new form of hybrid, cross-institutional relations among the three spheres (public, private and academic) (Etzkowitz and Leydesdorff, 1997). A number of authors have been more cautious in relation to the 'boundary-spanning' capacity of universities to resolve organizational contradictions and conflicting goals between institutions of the triple helix, or even openly sceptical about what they see as 'mission impossible' (Kruecken 2003; Nedeva and Boden 2006).

The extent to which universities can effectively perform this 'third mission' would be influenced by institutional and governance mechanisms of the wider regional innovation support systems (Hassink 2002; Kitagawa 2004). In order to ensure better integration of policies to improve regional 'absorptive' capacities, regional networks between universities and between universities and other actors are encouraged. These systemic relations are increasingly orchestrated via for instance the setting up of new intermediaries and organisations. In the UK and in other European regions, Regional Development Agencies are key mechanisms for promoting university-industry links.

Other initiatives include the Higher Education Regional Associations (HERAs) in the UK (Brickwook and Brown, 2005). Regional innovation support partnerships would then encompass wider networks of regional actors such as TTOs, science parks, regional development agencies, public research labs, and other intermediary organizations.

The configuration and emphasis of these regional innovation partnerships would naturally differ from region to region. Firms in different regions use universities to different degrees, a reflection of the diversity of systems of innovation (Todtling and Trippl, 2005; Braczyk et al, 1998; Asheim and Coenen, 2005; Koschatzky and Sternberg, 2000). In a comparative survey of 11 European regions, Koschatzky and Sternberg (2000) noted a higher incidence of university collaboration in the case of metropolitan areas, such as Barcelona, Stockholm, and Vienna vis-à-vis other regions. In a comparison of the innovative behaviour of manufacturing firms in Wales, West Midlands (UK), Catalonia (Spain) and Georgia (US), Roper et al (forthcoming) found a greater use of external knowledge sources for Georgian firms, particularly in relation to their linkages with universities.

Despite a general tendency to draw on limited cases of successful institutional interactions (Cooke, 2005; Gunasekara, 2006a), a number of authors have recently documented the impact of universities in non-core, 'ordinary' regions (see also Benneworth and Charles 2005; Gunasekara, 2006c; Benneworth and Hospers 2007; Coenen 2007). Coenen (2007) reports the experiences of two different regional systems, the North East of England and the region of Scania in Sweden in which the university has served as a focal point for innovation policy. In the former case, within a broader strategy for industrial restructuring of the North East via diversifying in knowledge intensive clusters such as life sciences, and in the latter via a more targeted support to the food sector. In the light of the diversity of regional systems of innovation, this author advocates the adoption of broader frameworks that can be applied to 'ordinary', less successful regions, and that go beyond technology transfer strategies centred exclusively on science parks and incubator centres.

Whilst identifying a wider set of institutional and socioeconomic considerations influencing the impact of universities on the economy, and the different impacts of universities in different regions, the emphasis in these approaches is still biased towards academic entrepreneurialism, centred on knowledge capitalisation, and biased towards particular types of innovative regional economies. These approaches emphasize the impact of universities *on* the region, rather than how universities could work with regional partners to capture value *for* the region (Benneworth, 2007). Beyond 'regenerative roles' based on knowledge capitalisation and knowledge transfer, they argue, universities can play other, more 'developmental' roles, involving a stronger and more engaged regional focus of *all of their* activities such as human capital formation, associative governance and culture (Gunasekara, 2006b). To this aspect we now turn.

6. 'Engaged' universities: widening the 'entrepreneurial university?'

Recent literature on the 'engaged university' (Chatterton and Goddard 2000; Gunasekara, 2006a; 2006c; OECD 2007) depicts a broader and more adaptive role for universities. They are seen as enablers or 'animateurs' of regional development,

embedding a stronger regional focus in their missions within broad-based coalitions of state and non-state actors. This includes the contribution of higher education to social, cultural and environmental development, by means of formal and informal participation and external representation as an institutional actor in regional networks of learning, innovation and governance (Boucher 2003).

Here the focus shifts from considering knowledge transfer processes and systems to a greater focus on 'regional needs' and adaptive responses by universities. This more responsive role also implies a greater alignment between the different university functions and regional development trajectories. Rather than undertaking the traditional missions of teaching and research and a separate 'regional' third mission, the regional focus of universities is here embedded in all the key functions: promoting social inclusion and mobility, providing a base for skill development, and stimulating innovation through basic scientific research[ix].

Such alignment of the three missions would require adequate joining up of policies and incentives at various levels of governance. Rather than being regionally 'bounded', universities are seen here as complex organisations, nested within national policy frameworks, trying to join up processes at different levels and integrate the teaching, research and community elements of university regional engagement (Charles 2006). Arbo and Benneworth (2006) develop a model of multi-layered governance for regional development featuring at its core the mutual influence between HEIs activities and the regional policy. Universities are expected to act as integrative network nodes in a global-regional innovation system in which the key aspect here is the capacity to combine external resources and influences with local needs (Bathelt et al. 2004; Benneworth and Hospers 2007).

Albeit not new, this 'civic' role of universities has been of greater interest recently for policy makers and university managers, who increasingly see it as a core element in their organisational mission. John Goddard refers to this phenomenon as the "re-emergence of the civic university" (THE, 7th February 2008). A primary focus on national needs (in response to national funding sources) and blue-sky research, he argues, has given way in the 90s to greater attention to the local and regional context, partly triggered by greater awareness of the importance of universities for local business communities and the quality of the local environment for the attraction of talent (Chatterton and Goddard, 2000). The 2001 Higher Education-business interaction survey (Charles and Conway 2001) already revealed an increasing consideration by universities of the local and regional area as significant to their mission.

These developmental efforts are not unproblematic. The OECD (2007) study "Higher Education and Regions" reported the experience of 14 regions across 12 in mobilising higher education in support of regional development. The study found relatively few cases of successful engagement. These were generally small-scale, short term, bottom-up initiatives, championed by key individuals. The study also identified a number of barriers preventing the mainstreaming or embeddedness of these types of engagement practices into wider regional policies. These included poor alignment or joining up of national policies at the regional level, limits to leadership within HEIs, limited capacity of local and regional agents to get involved with higher education and inadequate funding and incentives (including non-existent or inadequate metrics

and monitoring of outcomes). In a comparative assessment of universities in Australia, Gunasekara (2006a) similarly cites the commitment of university senior management towards regional engagement, the history of linkages with the region, and the political and economic conditions among the main factors influencing regional impact.

Incentives and performance measurement of university engagement in third strand policies are seen by these studies as outdated and inadequate. Measurement is based on a limited set of metrics often unable to capture 'developmental' activities, and even likely to distort behaviour towards activities that are easily measured. Further, formula based instruments such as the Higher Education Innovation Fund (HEIF) in the UK would be likely to reward universities with better demonstrable performance, rather than directing funding to addressing HEIS with greater challenges in terms of regional development (OECD, 2007).

Limits to engagement also relate to the particular geography and diversity of higher education, and the number, scale and synergies between higher education institutions within local or regional innovation systems (Boucher, 2003). New or modern universities gave economic development a higher priority than the older universities in the 2001 Higher Education and Business engagement survey (86% versus 44%) (Charles and Conway, 2001). The OECD (2007) also suggested younger universities tend to present external mechanisms better suited to engage with the region than older institutions. Age also influences location: longer established higher education institutions have emerged and grown generally in larger cities, whereas newer institutions, often with a specific remit to serve particular territories, tend to be more geographically dispersed. Furthermore, the type and degree of regional engagement is likely to differ according to the number of university establishments in a region, the significance of competition and/or collaboration between them and the extent to which they are embedded in a coherent regional development strategy (Boucher 2003; Kitagawa 2004). Collaboration between universities is constrained by competition for research funding, lack of support from and coherence of national policies, weak interest and the difficulty to agree on a clear division of tasks (OECD, 2007; May et al, 2007).

This discussion reflects some key challenges for universities, not least their ability to balance a broad range of new tasks against its traditional core mission. A 'missing middle' seems to exist "between the *possibilities* represented in attempts to embed universities in their localities and the *realities* of actual implementation". (May and Perry, 2006). Furthermore, an evidence base is lacking, beyond a handful of cases, on the benefits and impacts associated with different forms of engagement.

7. Discussion and conclusion

Whilst is it is commonly accepted that universities make a contribution to the economic wellbeing of countries and regions, what is new is the increased number of additional roles they are expected to play. Naturally, the extent to which universities perform these roles would vary from country to country, and from university to university. Given that, the paper suggests several models of universities portrayed in the literature, highlighting a different set of roles, influenced by different factors (economic, structural, organisational, institutional, political), and manifested in

multiple mechanisms and scales of engagement. A summary is provided in table 1. The issues drawn out in this paper make a contribution as there are few studies bringing together the diverse strands of literature.

The missions ascribed to universities are seen as progressively expanding from traditional activities such as teaching and research to include market-oriented and knowledge transfer activities, as well as non-economic contributions to the region's development. Further, linear or unidirectional impacts in the form of spillovers have given way to bi-directional links, often mediated by intermediaries such as TTOs and science parks. University-industry links become part, in RIS studies, of territorially embedded, knowledge-sharing, networks of firms, universities and other organisations. Broader and more responsive development coalitions of regional stakeholders are highlighted by advocates of the 'engaged' university as a means not only of capitalising knowledge but also aimed at capturing value for addressing broader regional socio-economic needs. Finally, considerations of space as functional distance influencing the impacts of university research have given way to a more endogenous or organic view of the territory influencing and embedding linkages, and a certain 'upscaling' of activity (Benneworth, 2007), from university industry links, to territorially embedded knowledge networks and to multi-level relations intended to capture and adapt knowledge to regional needs.

Whereas the idea of university industry interaction is not new, what is new is that these interactions have become more formal, frequent and planned (Vedovello 1997). Indeed, mainly descriptive and empirical studies on the economic impact of universities have been followed by more normative type analyses of how best to achieve this goal. The boundary-spanning role of universities is arguably best played out within certain organisational arrangements and institutional configurations embedding universities, industry and government. Furthermore, beyond knowledge capitalisation, universities can play a more developmental role if properly mobilised around problem oriented, multi-level development coalitions, involving different and closely interconnected mixes of universities activities (research, teaching, knowledge transfer, regeneration). In this case, third mission funding, rather than directed at single institutions, or at a regional level, may be better targeted at a more diverse configuration of networks at multiple geographies (cities, multi-regional, local) addressing different sets of specific needs.

These multiple roles do not substitute one another, rather they are cumulative. Indeed, universities often reflect all these goals to lesser or greater extent: it is not unusual for universities to include in their mission an aspiration be worldwide leaders in research, the active promotion of research commercialisation and 'good citizenship', i.e. the promotion of economic development and entrepreneurship in their regions. This raises concerns over potentially unrealistic expectations over the capacity of universities to fulfil all these roles. As Youtie and Shapira (2008, p.1202) point out, "some universities attempt to address these imperatives by 'bolting-on' new activities, but without fundamental restructuring and reorientation". Furthermore, it is unclear how much changing expectations placed upon universities are a reflection of policy aspirations and how much they reflect changing economic environments, evolving specialisation strategies of and division of labour between universities or different regional contexts.

The literature reviewed in this paper provides a rich albeit fragmented and partial account of HEIs regional engagement, and signals the need for further research, one that provides an integrated approach combining firm-level considerations, with institutional and strategic issues affecting universities engagement, and regional specific determinants shaping localised interactions. Furthermore, a remaining question is how to reconcile and manage the expectations on universities' impacts with the expansion and increasing diversity of higher education institutions. Universities differ in size, status, specialization and focus and thus a more nuanced approach to characterising universities according to well-informed, evidence-based typologies is needed. Policy and research fails to fully comprehend the diversity of universities, and yet this is fundamental to policy design for, clearly, not all universities should "aim for the same goals" (HM Treasury, 2007; p.44).

Table 1. Summary: Roles, determinants and engagement modes of universities.

Model	*Main Role of universities*	*Main Unit of analysis*	*Directionality of engagement*	*Dominant methodology*	*Key factors influencing impact*	
Knowledge 'factory'	Producer of scientific knowledge	Innovation outputs	Unidirectional (implicit)	Industrial surveys Citation count Production function analysis	Research intensity/inputs	Mansfield (1991); Beise and Stahl (1999
					Geographical proximity	Jaffe (1989); Feldman and Florida); Anselin (1997); Anselin (2000)
					Industry sector	Anselin (2000); Jaffe (1989); Feldman and Florida (1994) ;Cockburn and Henderson (2001)
Relational university	Exchange of knowledge	Linkages	Bi-directional (implicit)	Industrial surveys Case studies	Size of firm	Schartinger (2002); Cohen et al (2002); Fontana et al (2006)
					R&D intensity	Schartinger (2002) Fontana et al (2006)
					Age of firms	Laursen and Salter (2004); Cohen et al (2002)
					Openness of firms	Laursen and Salter (2004); Fontana et al (2006)
					Technical field / Industrial sector	Meyer-Kramer and Schmoch (1998); Cohen et al (2002); D'Este and Patel (2007)
					Scientists' research excellence/ experience	D'Este and Patel (2007)
Entrepreneurial university	Active commercialisation role	Intermediaries (ILOs/TTOs)	Bi-directional (explicit)	Surveys of university TT managers	Organisational structures/forms	Bercovitz et al (2001); Gill et al (2003); Siegel et al (2003), Markmann et al, 2005
					Managerial practices	Siegel et al (2003); Jain and George (2007); Belenzon and Shankerman (2007)
					Faculty behaviour/ incentives	Siegel et al (2003); Lach and Shankerman (2003);
Systemic university	Boundary-spanning role	Systems/ networks	Triple-helix (univ, ind and government)	National and regional innovation surveys Case studies	Regional system configuration	Koschatzky and Sternberg (2000); Todtling and Trippl, 2005; Braczyk et al, 1998
					Regional policy	Kitagawa (2004); Coenen (2007)
					Institutional capacity of universities	Etzkowitz and Leydesdorff (1997); Etzkowitz (2000)

Engaged university	Developmental role	Spaces of governance	Responsive	Case studies	No. and synergies between universities	Boucher (2003); OECD (2007)
					University leadership	Gunaseraka (2006), Chatterton and Goddard 2000
					Joined up policies/ incentives	OECD (2007); Gunaseraka (2006)
					Type of universities (age, location)	OECD (2007); Boucher (2003); Charles and Conway, 2001)

References

Agrawal, A. and R. Henderson (2002). "Putting Patents in Context: Exploring Knowledge Transfer from MIT." Management Science **48**(1): 44-60.

Agrawal, A. K. (2001). "University-to-industry knowledge transfer: literature review and unanswered questions." International journal of management reviews **3**(4): 285.

Anselin, L., A. Varga and Z. Acs (1997). "Local Geographic Spillovers between University Research and High Technology Innovations." Journal of Urban Economics **42**(3): 422-448.

Anselin, L., A. Varga and Z. Acs (2000). "Geographical Spillovers and University Research: A Spatial EconometricPerspective." Growth and Change **31**(4): 501-515.

Arbo, P. and P. Benneworth (2007). "Understanding the regional contribution of higher education institutions: A literature review." OECD Education Working Paper, **No. 9**.

Arundel, A. and A. Geuna (2004). "Proximity and the use of public science by innovative European firms." Economics of Innovation & New Technology **13**(6): 559-580.

Asheim, B.T. & Coenen, L. (2005): Knowledge bases and Regional Innovation Systems: Comparing Nordic Clusters. Research Policy, 34, 1173-1190

Azagra-Caro, J. M., F. Archontakis, A. Gutierrez-Gracia and I. Fernandez-de-Lucio (2006). "Faculty support for the objectives of university-industry relations versus degree of R&D cooperation: The importance of regional absorptive capacity." Research Policy **35**(1): 37-55.

Bathelt, H., A. Malmberg and P. Maskell (2004). "Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation." Progress in Human Geography **28**(1): 31-56.

Beise, M. and H. Stahl (1999). "Public research and industrial innovations in Germany." Research Policy **28**(4): 397-422.

Belenzon, S. and M. Schankerman (2007). The impact of private ownership, incentives and local development objectives on university technology transfer performance, Discussion Paper. Centre for Economic Performance, London

Benneworth, P. and D. Charles (2005). "University spin-off policies and economic development in less successful regions: Learning from two decades of policy practice." European Planning Studies **13**(4): 537-557.

Benneworth, P. and G. Hospers (2007). "The new economic geography of old industrial regions: universities as global/local pipelines." Environment and Planning C, forthcoming.

Bercovitz, J., M. Feldman, I. Feller and R. Burton (2001). "Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins, and Pennsylvania State Universities." The Journal of Technology Transfer **26**(1): 21-35.

Bonaccorsi, A. A. and A. Piccaluga (1994). "A theoretical framework for the evaluation of university-industry relationships." R & D management **24**: 3.

Boucher, G. (2003). "Tiers of Engagement by Universities in their Region's Development." Regional studies **37**(9): 887.

Braczyk, H. J., P. N. Cooke and M. Heidenreich (1998). Regional Innovation Systems : The Role of Governances in a Globalized World.

Carayol, N. (2003). "Objectives, agreements and matching in science-industry collaborations: reassembling the pieces of the puzzle." Research Policy **32**(6): 887-908.

Charles, D. (2006). "Universities as key knowledge infrastructures in regional innovation systems." Innovation **19**(1): 117.
Charles, D. and C. Conway (2001). Higher Education-Business Interaction Survey. Report Commissioned by the Higher Education Funding Council CURDS, University of Newcastle. .
Chatterton, P. and J. Goddard (2000). "The Response of Higher Education Institutions to Regional Needs." European Journal of Education **35**(4): 475-496.
Clark, B. (2001). "The Entrepreneurial University: New Foundations for Collegiality, Autonomy, and Achievement." Higher Education Management **13**(2): 9-24.
Cockburn, I. and R. Henderson (1996). "Public-private interaction in pharmaceutical research." PNAS **93**(23): 12725-12730.
Cockburn, I. and R. Henderson (2001). "Publicly Funded Science and the Productivity of the Pharmaceutical Industry." NBER Innovation Policy & the Economy **1**(1): 1.
Coenen, L. (2007). "The role of universities in the regional innovation systems of the North East of England and Scania, Sweden: providing missing links?" Environment and Planning C: Government and Policy **25**: 803–821.
Cohen, W. and Levinthal, D. (1990) "Absorptive Capacity: A New Perspective on Learning and Innovation", Administrative Science Quarterly, vol. **35**, pp. 128-152.
Cohen, W. M., R. R. Nelson and J. P. Walsh (2002). "Links and Impacts: The Influence of Public Research on Industrial R&D." MANAGEMENT SCIENCE **48**(1): 1-23.
Cooke, P. (2005). "Regionally asymmetric knowledge capabilities and open innovation exploring 'Globalisation 2' - A new model of industry organisation." Research Policy **34**(8): 1128-1149.
Cosh, A., A. Hughes and R. Lester (2005). UK PLC Just How Innovative Are We?, Cambridge MIT Institute.
David, P. A., D. Mowery and W. E. Steinmueller (1992). "Analysing The Economic Payoffs From Basic Research." Economics of Innovation and New Technology **2**(1): 73.
David, P. A., et al. (2000). 'Is public R&D a complement or substitute for private R&D? A review of the econometric evidence' Research Policy **29**(4-5): 497-529.
D'Este, P. and P. Patel (2007). "University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?" Research Policy **36**(9): 1295-1313.
Doloreux, D. (2002). "What we should know about regional systems of innovation." Technology in society **24**(3): 243.
Drucker, J. and H. Goldstein (2007). "Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches." International Regional Science Review **30**(1): 20-46.
Etzkowitz, H. (2000). "The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm." Research Policy **29**(2): 313.
Etzkowitz, H. and L. Leydesdorff (1997). Universities and the Global Knowledge Economy: A Triple Helix of University-industry-government Relations, Pinter.
Etzkowitz, H., A. Webster, C. Gebhardt and B. R. C. Terra (2000). "The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm." Research Policy **29**(2): 313-330.
Fabrizio, K. R. (2007). "University patenting and the pace of industrial innovation." Ind Corp Change **16**(4): 505-534.
Faulkner, W. W. and J. Senker (1994). "Making sense of diversity: Public-private sector research linkages in three technologies." Research policy 23: 673-695.

Feldman M. and Florida R. (1994): The Geographic Sources of Innovation: Technological Infrastructure and Product Innovation in the United States, Annals of the Association of American Geographers 84, 210-229

Fontana, R., Geuna, A. and Matt, M. (2006) Factors affecting university–industry R&D projects: The importance of searching, screening and signalling Research Policy Vol.35, Iss. 2, 309-323

Geuna, A. and L. J. J. Nesta (2006). "University patenting and its effects on academic research: The emerging European evidence." Research Policy **35**(6): 790-807.

Gill, D., T. Minshall, C. Pickering and M. Rigby (2007). Funding Technology: Britain Forty Years on., University of Cambridge Institute for Manufacturing.

Greenberg, D. S. (2007). Science for Sale: The Perils, Rewards, and Delusions of Campus Capitalism, Chicago University Press.

Grossman, J. H., P. P. Reid and R. P. Morgan (2001). "Contributions of Academic Research to Industrial Performance in Five Industry Sectors." The Journal of Technology Transfer **26**(1): 143-152.

Guellec, D. and B. Van Pottelsberghe (2003). 'The impact of public R&D expenditure on business R&D' Economics of Innovation & New Technology **12**(3): 225.

Gunasekara, C. (2006a). "Reframing the Role of Universities in the Development of Regional Innovation Systems." The Journal of technology transfer **31**(1): 101.

Gunasekara, C. (2006b). "The generative and developmental roles of universities in regional innovation systems." Science and Public Policy **33**(2): 137.

Gunasekara, C. (2006c). "Universities and associative regional governance: Australian evidence in non-core metropolitan regions." Regional Studies **40**(7): 727 - 741.

Hassink, R. (2002). "Regional innovation support systems: Recent trends in Germany and East Asia." European Planning Studies **10**(2): 153-164.

Henderson, R., A. B. Jaffe and M. Trajtenberg (1998). "Universities as a source of commercial technology: A detailed analysis of university patenting." Review of Economics & Statistics **80**(1): 119.

HM Treasury (2007) The Race to the Top: A Review of Government's Science and Innovation Policies. Lord Sainsbury. October 2007

Howells, J., M. Nedeva and L. Georghiou (1998). Industry-academic links in the UK.

Jaffe, A. B. (1989). "Real Effects of Academic Research." The American Economic Review **79**(5): 957-970.

Jaffe, A. B., M. Trajtenberg and R. Henderson (1993). "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations." The Quarterly Journal of Economics **108**(3): 577-598.

Jain, S. and G. George (2007). "Technology transfer offices as institutional entrepreneurs: the case of Wisconsin Alumni Research Foundation and human embryonic stem cells." Ind Corp Change **16**(4): 535-567.

Kelly, U., McLellan, D. and McNicoll, I. (2006) "The economic impact of UK higher education institutions" Universities UK Spring 2006.

Kitagawa, F. (2004). "Universities and regional advantage: Higher education and innovation policies in English regions." European Planning Studies **12**(6): 835-852.

Koschatzky K. and Sternberg R. (2000): "R&D Cooperation in Innovation Systems – Some Lessons from the European Regional Innovation Survey (ERIS)", European Planning Studies 8, 487-501

Kruecken, G. (2003). "Mission impossible? Institutional barriers to the diffusion of the" third academic mission" at German universities." International Journal of Technology Management **25**(1): 18.

Lach, S. and M. Schankerman (2003). Incentives and Invention in Universities. Cambridge, NBER Working Paper Series, no.9727. .
Lambert, R. (2003). Lambert Review of Business-University Collaboration. London, HM Treasury.
Laursen, K. and A. Salter (2004). "Searching high and low: what types of firms use universities as a source of innovation?" Research Policy **33**(8): 1201-1215.
Lawton-Smith, H. L. (2007). "Universities, innovation, and territorial development: a review of the evidence." Environment and planning. C, Government & policy **25**: 98.
Lee, Y. S. (1996). "`Technology transfer' and the research university: a search for the boundaries of university-industry collaboration." Research Policy **25**(6): 843-863.
Lee, Y. S. (2000). "The Sustainability of University-Industry Research Collaboration: An Empirical Assessment." The Journal of Technology Transfer **25**(2): 111-133.
Link, A. N., et al. (2007). 'An empirical analysis of the propensity of academics to engage in informal university technology transfer' Ind Corp Change **16**(4): 641-655.
Mansfield, E. (1991). "Academic research and industrial innovation." Research Policy **20**(1): 1-12.
Mansfield, E. (1995). "Academic research underlying industrial innovations: sources, characteristics, and financing." Review of Economics & Statistics **77**(1): 55.
Markman, G. D., P. T. Gianiodis, P. H. Phan and D. B. Balkin (2005). "Innovation speed: Transferring university technology to market." Research Policy **34**(7): 1058-1075.
Massey, D. B., P. Quintas and D.wield (1992). High-Tech Fantasies: Science Parks in Society, Science and Space, Routledge.
May, T. and Perry, B. (2006) *The Embedded University in the 'Science Economy': Capacities, Contexts and Expectations.* Final report to the ESRC funded Network 'The Impact of HEIs on Regional Economies' programme
May, T. and Perry, B. The Greater Manchester Urban Knowledge Arena. Report to the Contact Partnership
Meyer-Krahmer, F. and U. Schmoch (1998). "Science-based technologies: university-industry interactions in four fields." Research Policy **27**(8): 835-851.
Molas-Gallart, J., A. Salter, P. Patel, A. Scott and X. Duran (2002). Measuring third stream activities. Final report to the Russell Group of universities. Brighton, SPRU.
Montoro-Sanchez, A., E. M. Mora-Valentin and L. A. Guerras-Martin (2006). "R&D cooperative agreements between firms and research organisations: A comparative analysis of the characteristics and reasons depending on the nature of the partner." International Journal of Technology Management **35**(1-4): 156-181.
Mowery, D. C. (2004). "The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments." The Journal of technology transfer **30**(1): 115.
Mowery, D. C. and B. N. Sampat (2004). "The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments?" The Journal of Technology Transfer **30**(1): 115-127.
Mowery, D. C., R. R. Nelson, B. N. Sampat and A. A. Ziedonis (2001). "The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980." Research Policy **30**(1): 99-119.
Nedeva, M. and R. Boden (2006). "Changing Science: The Advent of Neo-liberalism." Prometheus **24**(3): 269 - 281.
Nelson, R. R. (2001). "Observations on the Post-Bayh-Dole Rise of Patenting at American Universities." The Journal of Technology Transfer **26**(1): 13-19.
OECD (2007). Higher Education and Regions: Globally Competitive, Locally Engaged. Paris, OECD.

Perkmann, M. and K. Walsh (2007). "University-industry relationships and open innovation: Towards a research agenda " International Journal of Management Reviews, **9**(4): 259-280.
Rafferty, M. (2008). "The Bayh-Dole Act and university research and development." Research Policy **37**(1): 29-40.
Roper, S., Youtie, J., Shapira, P. and Fernandez-Ribas, A. "Knowledge, Capabilities and Manufacturing Innovation: A US-Europe Comparison". Forthcoming in Regional StudiesSalter, A. J. and B. R. Martin (2001). "The economic benefits of publicly funded basic research: A critical review." Research Policy **30**(3): 509-532.
Sampat, B. N. (2006). "Patenting and US academic research in the 20th century: The world before and after Bayh-Dole." Research Policy **35**(6): 772-789.
Schartinger, D. (2002). "Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants." Research Policy **31**(3): 303.
Scott et al., S., A., Steyn, G., Geuna, A., Brusoni, S., Steinmueller, E.W. (2002). The economic returns to basic research and the benefits of university–industry relationships: a literature review and update of findings, SPRU: Report for the Office of Science and Technology.
Siegel, D. S., D. Waldman and A. Link (2003). "Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study." Research Policy **32**(1): 27-48.
Siegel, D. S., M. Wright and A. Lockett (2007b). "The rise of entrepreneurial activity at universities: organizational and societal implications." Ind Corp Change **16**(4): 489-504.
Siegel, D. S., R. Veugelers and M. Wright (2007a). "Technology transfer offices and commercialization of university intellectual property: performance and policy implications." Oxf Rev Econ Policy **23**(4): 640-660.
TIMES HIGHER EDUCATION, "Bigger than the Beatles" 7 February 2008.
Uyarra, E. (2007) "Key dilemmas of regional innovation policies" Innovation: The European Journal of Social Science Research, vol.20 iss.3.
Valentin, F. and R. Jensen (2007). "Effects on academia-industry collaboration of extending university property rights." The Journal of Technology Transfer **32**(3): 251-276.
Van Looy, B., et al. (2006). 'Publication and patent behavior of academic researchers: Conflicting, reinforcing or merely co-existing?' Research Policy **35**(4): 596-608.
Varga, A. (2002). Knowledge Transfers from Universities and the Regional Economy: A Review of the Literature. Innovation, Entrepreneurship and Regional Economic Development: International Experiences and Hungarian Challenges. A. Varga and L. Szerb. Pécs University of Pécs Press.
Vedovello, C. (1997). "Science parks and university-industry interaction: Geographical proximity between the agents as a driving force." Technovation **17**(9): 491-502.
Westhead, P. (1997). 'R&D'inputs' and'outputs' of technology-based firms located on and off Science Parks' R&D Management **27**(1): 45-62.
Youtie, J. and Shapira, P. (2008) Building an Innovation Hub: A Case Study of the Transformation of University Roles in Regional Technological and Economic Development Research Policy, vol. **37**, 1188-1204

[i] This paper is part of the ESRC and the HE Funding Councils' sponsored IRIN project. The paper has benefited from discussions within the IRIN project, particularly early discussion and literature mapping with Davide Consoli. The author is grateful for useful feedback and criticism provided by Kieron

Flanagan and Phil Shapira.

[ii] This Initiative's aim is to better understand the key economic and social impacts generated by UK higher education institutions on their host regions and on other regions of the UK. See http://ewds.strath.ac.uk/iheirei/Home.aspx

[iii] Also left out are economic geography studies on the impact of universities on the location of high technology activities (for a review see Varga, 2002).

[iv] Some authors have questioned the assumption of a cause and effect relation between the technology transfer activity following the Bayh-dole Act and the increase in patents. They argue that the positive trend in patenting activity preceded the act (although was possibly magnified by it), and may owe more to opportunities in the bio-medical field than to policy action.

[v] Indeed, the 2008 Higher Education Business and Community Interaction Survey carried out by the Higher Education Funding Council for England, has reported that an annual increase of 22 per cent in the resources invested in IP protection has been accompanied by just 1 per cent IP generated income rise for universities.

[vi] Indeed, these studies demonstrate that universities are generally ranked very low in frequency of use relative to other sources of knowledge.

[vii] An emphasis that has been challenged for depicting regions as closed, self-referential and self-sufficient systems (Coenen, 2007; Uyarra, 2007)

[viii] These activities, however ill-defined, are concerned with "the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments" (Molas-Gallart et al, 2002; p.iii).

[ix] According to Chatterton and Goddard (2000: p.475) "the emerging regional development agenda can be argued to require regional engagement to be formally recognised as a 'third role' for universities and colleges not only sitting alongside but fully integrated with mainstream teaching and research."