The regional role of universities in technology transfer and economic development

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Abstract

Amidst growing policy interest across both developed and developing nations in regional innovation systems as focal points of leverage for economic development, this paper explores the state of the literature on the role that universities perform in the development of regional innovation systems. The predominant focus in the literature has been on institutional analysis of university-industry technology transfer. This is important but tends to underestimate the potentially broad-based 'third role' of universities in regional systems. An analytical framework is proposed for considering the role of universities in the development of regional innovation systems and explanation of variation in the roles performed by universities in different regional settings. This framework is systemic in nature, drawing on the triple helix model of university, industry, government relations, the emerging literature on university engagement and seminal thinking in the regional innovation systems literature. Although not without its limitations, this framework enhances current approaches which have tended to concentrate on transactional and institutional analysis.

Keywords: universities, regional innovation, regional development

There is growing policy interest in the drivers of regional innovation systems as engines of economic development and in strategies to promote greater opportunity for both developed and less developed regions. For some years now, and with increasing vigour, the European Union has pursued a number of key priorities that have been focused on regional renewal (EU 1999). Institutionalised through mechanisms including the Cohesion Fund and the European Regional Development Fund, these priorities have centred on: improving regional competitiveness, promoting regional economic and social cohesion and urban and rural development. In particular, the Structural Funds have emphasised the importance of regional partnerships between public sector, business, higher and further education and business support organisations. In the UK, the Lambert Report (Lambert 2003) and the recent Innovation Report (DTI 2003) have both highlighted the need to strengthen the development of regional innovation systems, notably, through the development of "innovation-driven regional strategies" (DTI 2003:7). Canada's Innovation Strategy (CME 2003; Industry Canada 2002) adopts a similar focus, though targeted towards cluster formation and supportive capability development, including the engagement [by communities] "of local leaders from the academic, private and public sectors in formulating their innovation strategies" (Industry Canada 2002: 13). Against this backcloth, the role of universities in the development of regional innovation systems assumes heightened importance. Specifically, the

question of how we should analyse their role at a regional level becomes key, as does explaining variation in the roles performed by universities across different regional settings.

This paper explores the literature on the role of universities in regional systems and proposes an analytical framework for considering this issue. The first section of the paper recalls the nature of regional innovation systems and draws out a number of key elements that are widely acknowledged in the literature as representing the essentials of a regional system. The second section examines the major theoretical turning points in constructing the role of universities in regional systems. The third section of the paper proposes a framework for analysing universities' roles in regional innovation systems and explaining variation in the roles performed by universities in different regional settings. This framework draws on the triple helix model of university, industry, government relations, the emerging literature on university engagement and the key elements of regional systems outlined previously. The final section contains some reflections on the application of the framework.

Regional innovation systems

The seminal writers on national systems of innovation argued that innovation systems could be analysed at several levels – supranational, national, sectoral, technological, local and regional (Edquist 1997a, 1997b; Freeman 1995; Lundvall 2001, 1992; Carlsson et al 1995). The significance of the regional analysis of innovation has grown from a number of factors, including:

- the integration of national, regional and technology policy since the early 1980s (Koschatzky 2000; Rothwell and Dodgson 1992) and the consequent importance of the local market for innovation and competitive advantage (Lundvall et al 2001; Patel and Pavitt 1994). As capitalism takes the form of an increasingly integrated global economic system, the region grows in significance as a meaningful site for understanding the systemic nature of innovation and for shaping the innovation environment from a policy perspective (Florida 1998). This is due, in part, to the growing importance of regional clusters and networks, greater regional specialisation, the utilisation of 'tacit' local knowledge and the need for regions to promote flexibility and adaptation when confronted with uncertainty (ALGA/NE 2002:2);
- a shift from firm-centred, incentive-based, state-driven and standardised regional economic development policies to bottom-up, region-specific, longer term and plural-actor policies (Amin 1999; Markusen et al 1999);
- a shift in the dominant production paradigm from large, internally coherent and hierarchical organisation to a 'vertically disintegrated' and geographically concentrated organisation of production, where competition and collaboration co-exist through a variety of mechanisms, such as new kinds of sub-contracting, customer-supplier relations between large corporations and dynamic smaller firms (and also among the latter themselves) (Cooke 1998; Hansen 1992), and
- the so-called 'garden argument' (Pacquet 1994): if the economy is regarded as a garden with a variety of trees and plants, for the gardener (the government) there is no simple rule likely to apply to all plants. Growth, therefore, is best orchestrated from its sources at the level of cities and regions. At this level, policymakers can better tailor policy to demand and create 'good business climates' (Nauwelaers and Wintjes 2000; Tsipouri 1999; Jessop 1994).

These factors explain the increasing importance of regional innovation systems in industrial policy (OECD 2001, 1999b; Rothwell and Dodgson 1992) and in the academic study of regional development and innovation.

Regional innovation may be understood as innovation at a sub-national level (Edquist 1997). Regional innovation systems represent the intersection of the systems of innovation approach with spatial agglomeration of industry in a geographically specific area (OECD 1999b). Cooke (1998:24-25) has conceptualised regional innovation systems as comprising "…a collective order based on microconstitutional regulation conditioned by trust, reliability, exchange and cooperative interaction" within a cohesive spatially bounded geographical area. The literature on the learning region (Cooke and Morgan 1998; Morgan 1997; Florida 1995) and on the learning economy (Lundvall and Johnson 1994) echoed this conceptualisation, emphasising the importance of spatially bounded interactive learning, in multiple modes, within inter-firm and firm-institution networks, contextualised and energised by knowledge-based competition. Interactive learning and innovation are outcomes of a regional innovation system.

Four elements are widely acknowledged in the literature as key constituents of a regional innovation system. The four key elements are: the spatial agglomeration of firms and other organisations in a bounded geographical space, in a single industry, or in complementary industries; the availability of a stock of proximate capital, particularly, human capital; an associative governance regime and the development of cultural norms of openness to learning, trust and cooperation between firms (Cooke 2002; Niosi and Bas 2001; Morgan 1997; Florida 1995; Lundvall and Johnson 1994). The nature of these four elements is discussed in this section. (A fifth element, interactive innovation, emerges from the effective operation of the other four elements.)

Regional agglomeration is the first key element of a regional innovation system. The seminal works on regional innovation systems referred to the presence of "dense networks of social, professional and community relationships" (Saxenian 1994, 1990), "regional innovative environments" (Camagni 1991), "geographically concentrated networks of enterprises" in industry sectors (Hansen 1992), "regional concentrations of innovative economic activity" (Porter 1990) and a 'nexus of competencies' (Niosi and Bas 2001) in regional, sectoral clusters. These descriptions of regional agglomeration involve spatial clustering and networking amongst groups of firms, in one or more industry sectors in a geographical space (OECD 1999b; 1997; 2000). DeBresson and Amesse (1991:349) insist that: "No firm, large or small, can innovate or survive without a network". They point out that studies of incubator firms, spin offs and start-ups invariably show that locational proximity and accompanying deep interaction, learning and knowledge acquisition are crucial to nurturing innovative ventures.

The existence and quality of proximity capital is a second important element of a regional innovation system (Cooke 2002). Proximity capital, which can be hard or soft, financial or human, refers to different kinds of infrastructures that support the innovative activities of firms and other organisations (Cooke 2002: 11; Hassink 2002; Krugman 1997). These infrastructures include: venture capital, business support services, transport, telecommunications, and a skilled workforce that supports the knowledge needs of regional firms, particularly, in knowledge-based industries (Hassink 2002). Crevoisier (1997) highlighted the importance in agglomerations (especially, involving SMEs) of localised, trust-

based means of raising venture capital, perhaps through local entrepreneurs or 'business angels'.

The skills base of a region that is relevant to the innovation needs of firms and other organisations (Niosi and Bas 2001; Keeble et al 1999) and the existence of appropriate communication links such as road, rail, airport and telecommunications services are regarded as "crucially important in proximity to industrial agglomerations" (Cooke 2002:11). Florida's (1995) discussion of the characteristics of learning regions, highlights the valence of a proximate skills base that meets regional knowledge needs, emphasising the importance of a region's human infrastructure of knowledge workers who can apply their intelligence in production (Florida 1995:532). Recent studies of regional innovation systems have emphasised the importance of a proximate skilled workforce in attracting inward investment, with consequent benefits in stimulating the development of indigenous enterprises (Grimes 2003; Castells 2000; Dunning 1998).

Associative regional governance is a third key element of a regional innovation system that centres on regional innovation capacity building strategy (Cooke 2002: 11, 16; Chatterton and Goddard 2000). Regional governance signifies a shift from state regulation to regional self-regulation (Hirst 1994), which is underpinned by a soft infrastructure or 'social capital' (Putnam 1993). Regulatory institutions of economic activity are being decentralised, in part, as national governments place increasing emphasis on regional policy (OECD 2001; Goddard and Chatterton 1999). Consequently, at a regional level, an array of intermediate organisations is emerging, centred on regional development and administration, that create, in any particular locality, an 'institutional thickness' (Amin and Thrift 1994). These bodies, which, typically, include local authorities, regional development agencies, other government agencies that provide innovation support programs and peak business, industry and labour groups, shape regional innovation strategy.

Cooke (2002) argues that the key function of regional governance is to develop policies and strategies that support cluster development as well as identifying and addressing gaps in innovation support infrastructure; notably, venture capital and basic and applied research (Cooke 2002: 9, 13). To work effectively, the key institutions in the governance set-up must exhibit strong competencies in inclusivity, networking and consultation as well as having access to accurate and timely information and analysis of regional performance and, importantly, gaps in infrastructure and emerging internal and external threats and opportunities (Cooke 2002: 15). Thus, associative governance is defined by Cooke (2002) as "a networking propensity whereby key regional governance mechanisms, notably, regional administrative bodies, are interactive and inclusive with respect to other bodies of consequence to regional innovation" (Cooke 2002: 11).

Openness to learning, trust and cooperation between firms are important cultural norms that lubricate interactive learning in a regional innovation system (Cooke 2002; Cooke and Morgan 1998; Morgan 1997). This is the fourth key element of a regional system. Referring to the importance of cultural norms that support learning and interactive innovation, Cooke (2002: 14) points to the degree of embeddedness of a region, its institutions and its organisations as a key superstructural issue. Embeddedness is defined as:

> "the extent to which a social community operates in terms of shared norms of cooperation, trustful interaction, and untraded interdependencies, as distinct from

> competitive, individualistic, arms length exchange, and hierarchical norms" (Cooke 2002a: 14).

Lawton Smith et al (2001) encapsulate this element in the notion of "local cultural cohesion" (Lawton Smith et al 2001: 97), echoing Keeble et al's (1999) study of Oxford and Cambridge (UK), which highlighted the importance of cultural norms of openness to learning, trust and cooperation between firms and other organisations in shaping innovative environments. Niosi and Bas (2001) also refer to the propensity and capacity to cooperate with, and learn from, other institutions in the regional system such as local universities, government laboratories and venture capital firms as a core competency of a region.

The literature, therefore, points to four key elements of regional innovation systems. These elements are:

- the spatial agglomeration of firms and other organisations in a single industry, or in complementary industries;
- a stock of proximate capital that supports the innovative needs of regional agglomerations, particularly, a stock of human capital;
- an associative governance regime, and
- cultural norms of openness to learning, trust and cooperation between firms.

These four elements constitute what Cooke (2002:17) describes as a "locational systemness" that marks a regional innovation system. This is echoed in Saxenian's landmark work on regional networks (Saxenian 1994), in Porter's (1990) notion of cluster synergies in industry precincts and Kanter's (1995) notions of networker and knowledge based regions.

The role of universities in the development of regional innovation systems

Theorisation of the role of universities in regional innovation systems has evolved in the last twenty years, from the innovation systems approach, which highlighted the importance of knowledge spillovers from the educational and research activities of universities in regional knowledge spaces towards the development of a third role performed by universities in animating regional economic and social development (Etzkowitz 2002a, 2002b; Etzkowitz et al 2000; Etzkowitz and Leydesdorff 2000, 1999, 1997; Leydesdorff and Etzkowitz 1998; Holland 2001; Chatterton and Goddard 2000; Goddard and Chatterton 1999).

Universities have long been recognised as providers of basic scientific knowledge for industrial innovation through their research and related activities, where 'industrial' connoted the agricultural and manufacturing sectors (Guston 2000; Smith 1990; Hart 1988). Neoclassical economic theory explained the productive performance and competitive advantage of firms largely in terms of relative resource endowments (Hall 1994). The role of knowledge and of institutions involved in the creation of knowledge was seen as exogenous, though not unimportant, to the production system (Freeman 1995).

Knowledge creation, almost exclusively scientific in nature, and predominantly applying to agriculture, manufacturing and mining, was viewed similarly as an exogenous factor in a firm's production function. The development and diffusion of knowledge was viewed in linear terms, known as the science push model (Smith 1990) in the sense that knowledge was created outside the production system, either in universities or the laboratories of large firms and then 'pushed' out to industry for applied development and adoption (Webster 1999). The

notion of university-industry linkage, whereby the two institutions jointly or cooperatively developed knowledge was weak, applying largely to the conduct of trials or other experiments by universities to prove concepts during research (Smith 1990).

The emergence of the national systems of innovation approach (Freeman 1991; Lundvall 1992) shifted this conceptualisation of the role of universities in economic production, bringing universities 'inside the tent'. Innovation systems were envisioned as dynamic complexes of interaction among industry, government, business support institutions, knowledge creation institutions and labour, capital and product markets, for the creation, diffusion and adoption of knowledge (Lundvall 2001, 1992; Freeman 2000; Edquist 1997a, 1997b). In addition to an emphasis on the role of universities in supporting interactive innovation through research and education, the national systems of innovation literature highlighted the role that universities performed in fostering regional agglomeration through knowledge spillovers resulting from their research and educational activities (OECD 2001, 1999b; Camagni 1991; Lawson 1999, 1997) and, over the long run, fostering the development of supportive regional cultural norms (Lawton Smith et al 2001,1998). The seminal works on innovation systems, therefore, re-focused the locus of action in knowledge creation, diffusion and adoption from an exogenous position (to the firm) toward a clear endogenous location within firms, networks of firms and networks of firms and other organisations such as universities (Edquist 1997a; Lundvall 2001, 1992; Freeman 1997), increasingly, at a regional level.

However, the primary institutional spheres shaping regional economic development remained industry and the state (Etzkowitz 2002b; Etzkowitz and Leydesdorff 1999) and there were doubts expressed by some authors regarding the beneficial effect of knowledge spillovers resulting from the proximity of universities to regional clusters (Feldman and Desrochers 2003; Malecki 1997:127). The conceptualisation of the role of universities in the systems of innovation approach separated academic and commercial practices (Etzkowitz 2002b: 13). This left control of the commercial opportunities from academic research in the hands of industry. Control over the direction of research and the choice of research topic was left to the academic scientist. But, in recent years, even this choice was circumscribed by the state, through reductions in government funding, the introduction of competitive grant schemes linked to industry participation and exhortations that universities should source a larger share of revenue from industry (Garrett-Jones 2002).

Contextualised amidst the reduction of government funding for universities and growing pressures on universities and governments to foster knowledge-based innovation in national and regional economies (Hagen 2002), the triple helix model (Etzkowitz and Leydesdorff 1997; Sutz 1997) sharpened the focus on the role of universities in regional economies, pointing to the emergence of hybrid university, industry, government relationships that involved the multiplication of resources and capital formation projects (Etzkowitz 2002b: 14). As Etzkowitz put it:

> "The objective is to multiply the value of intellectual property derived from academic research through the stock market, either directly through the formation of a new firm or indirectly through a stream of royalty income from an existing firm" (Etzkowitz 2002b: 14).

The triple helix model conceptualised a non-linear, interactive model of innovation as a recursive overlap of interactions and negotiations among universities, industry and

government – the three helices conceptualised in the model (Etzkowitz and Leydesdorff 1997). A key insight offered by this model is the hybrid, recursive, cross-institutional nature of relations among the three helices. The institutional spheres of the state, the university and industry were formerly separate entities that interacted across strongly defended boundaries. Increasingly, individuals and organisations within the helices are taking other roles than were traditionally ascribed to them. This results in a blurring of boundaries between academia and industry and an overlapping of the institutional spheres as one sphere 'takes the role of the other' (Etzkowitz and Leydesdorff 1999: 113; Etzkowitz and Leydesdorff 1997; Sutz 1997).

More recently, the literature on the engaged university (OECD 1999a; Holland 2001; Chatterton and Goddard 2000) also focused on the third role of universities in regional development, but it differed from the triple helix model in its emphasis on adaptive responses by universities that embedded a stronger regional focus in their teaching and research missions. This approach does not eschew hybrid, boundary-spanning mechanisms that are generative of economic growth; rather, it takes a broader, developmental focus that covers a range of mechanisms by which universities engage with their regions. A key point is that the university engagement literature places less emphasis on academic entrepreneurialism, compared with the triple helix model.

The developmental focus in the literature on university engagement is grounded in the concept of the learning economy which emerged from studies of national systems of innovation (Lundvall and Johnson 1994; Lundvall 1992). Lundvall and Johnson (1994) define the learning economy as an economy where the success of individuals, firms and regions reflects the capability to learn (and forget old practices); where change is rapid and old skills become obsolete and new skills are in demand; where learning includes the building of competencies, not just increased access to information; where learning is going on in all parts of society, not just high-tech sectors; and where net job creation is in knowledge intensive sectors. The learning region depends upon network knowledge that refers not only to the skills of individuals, but also to the transfer of knowledge from one group to another to form learning systems.

Echoing these observations, Chatterton and Goddard (2000: 479-481) explain that three shifts intersect with and shape the development of regional learning systems. Firstly, they point to the increasing regionalisation of production. The geography of capitalist activity has entailed the resurgence of the region, through the integration of production at a regional level and the decentralisation of large corporations into clusters of smaller business units. At the same time, in the context of a lifelong learning agenda, learning and teaching activities have moved away from a linear model of transmission of knowledge based upon the classroom and are becoming more interactive and experiential, drawing upon new learning approaches that are locationally specific, for example, project work and work-based learning.

Thirdly, in the wake of the declining regulatory capacity of the nation-state, the institutions that order economic activity are being regionalised and an array of intermediate organisations is emerging that signals a shift from state regulation to regional self-regulation. These organisations constitute the basis for associative governance (Hirst 1994). In the light of this regionalisation of the economy, universities are confronted with new client bases in both teaching and research. Traditional relationships with large corporations and nationally-based firms and research organisations are being supplemented by a new regional client base comprised of clusters of firms and regionally-based supply chains of small and medium sized firms (Chatterton and Goddard 2000: 481). These developments have important implications

for the skills required of graduates, particularly by SMEs, and the management of the interface between degree courses and the labour market.

The importance of network knowledge and interactive learning, which are inherently bounded in time and space, call for university teaching and research to be more closely connected with local and regional knowledge imperatives. In particular, "the university acts as a conduit through which research of an international and national nature is transferred to specific localities through the teaching curriculum" (Chatterton and Goddard 2000: 481). Further, as the institutions of economic regulation become more regionalised, the historical role of universities in nation-building, through the participation of academic staff in numerous public bodies, must also be adapted. Thus, universities, through their resource base of people, skills and knowledge increasingly play a significant role in regional networking and institutional capacity building. Staff, either in formal or informal capacities, may act as "regional animators" (Chatterton and Goddard 2000: 481) through representation on outside bodies ranging from school governing boards and local authorities to local cultural organisations and development agencies. Hence, universities make an indirect contribution to the social and cultural basis of effective democratic governance. The university engagement approach, therefore, points to a developmental role performed by universities in regional economic and social development that centres on the intersection of learning economies and the regionalisation of production and regulation.

Authors within this body of thinking appear to pay more attention to discussing the adaptation of teaching roles to reflect regional imperatives and the contribution of universities as 'critical friends' in regional governance, than universities as generative agents of growth.

The focus of the engaged university approach was summarised by Braskamp and Wergin (1998) as the campus being in the world and the world in the campus. Forrant (2001) argues that:

> "…Any university intent in playing a strong role in economic development beyond simply the theoretical will have a sustained, positive impact on the regional economy only when its activities are guided by a reflective and on-going institution-wide and region-wide discourse" (Forrant 2001:614).

Unlike the triple helix model, this approach is not concerned, fundamentally, with the position of universities in economic regulation, relative to industry and the state; but rather with their orientation within existing institutional patterns. Hence, the university engagement literature signals that universities are adapting their educational, research and community service activities to support regional industry needs as well as the needs of other actors and individuals in their communities (Chatterton and Goddard 2000). This involves seeking out regional partners to develop and commercialise research (Chatterton 2000); informing their teaching role by regional needs; providing support and, perhaps, leadership in regional governance (Goddard and Chatterton 1999) and making a broad range of contributions to civil society, for example, in cultural and community development, through voluntary work undertaken by staff and students, as well as offering public access to facilities such as libraries, museums and sports centres.

There is, therefore, a discernible line of development in the theoretical literature that has seen an increasing emphasis on the role performed by universities in animating regional innovation systems.

A conceptual framework for analysing the role of universities in regional systems

The contributions made by universities to the development of regional systems may be analysed using a two-dimensional matrix comprising the four key elements that define a regional innovation system and the nature of a university's engagement with these four elements. A possible framework for analysing the role of universities in the development of regional innovation systems consists of two parts: firstly, a distinction drawn between generative and developmental roles performed by a university; and secondly, the application of these roles to the four key elements of a regional innovation system.

The generative and developmental nature of university roles in based on the triple helix model and the university engagement approach. It was shown earlier that there are significant differences (and also, points of overlap) between the triple helix model and the university engagement literature in the conceptualisation of the third role of universities in regional economic development. These differences are summarised in Table 1 below. On the one hand, the triple helix model takes a generative orientation, arguing that, as primary institutional spheres, universities are key drivers of economic development through a range of boundary-spanning, knowledge capitalisation mechanisms, such as incubators, new firm formation and science parks, as well as university research centres and participation in the governance of firms. On the other hand, the university engagement literature, while acknowledging the importance of academic entrepreneurial activities in enabling technology transfer and economic growth, points to a broader, developmental role performed by universities through adapting their traditional roles in teaching and research to better support regional knowledge needs. These categories are not mutually exclusive but there are some differences between them.

Table 1 Analysing universities' contribution to the development of regional innovation systems

Key element of regional innovation system	*Generative role*	*Developmental role*
Regional agglomeration, or clustering, of industry	• Knowledge capitalisation and capital formation projects, centred on firm formation and co-location of new and existing firms near the University.	• Entrepreneurial activities, as well as regionally-focused teaching and research, not necessarily linked to capital formation projects.
Human capital formation	• Integration of education and knowledge capitalisation activities, specifically, firm formation, through teaching incubators. • Development of generic, advanced training programs to support firm formation and cross-institutional mobility by organisations and people. •	• Stronger regional focus on student recruitment and graduate retention. • Education programs developed/adapted to meet regional skills needs. • Learning processes regionally-informed.

Associative governance	• Driver of regional innovation strategy, centred on knowledge capitalisation and capital formation projects; by analysing strengths and weaknesses and bringing together industry and government to forge innovation strategy.	• Shaping regional networking and institutional capacity, through staff participation on external bodies; provision of information and analysis to support decision-making and brokering networking between national and international contacts and key regional actors.
Regional cultural norms	• Tradition of university/industry linkages, involving knowledge capitalisation.	• Tradition of university/industry linkages, involving knowledge capitalisation and other research collaborations.

Table 1 summarises the differences in the roles performed by universities in the development of regional innovation systems, based on the triple helix model and the university engagement literature.

Regional agglomeration is the first key element of a regional innovation system. The role of universities in shaping regional agglomeration is focused on the development of existing or emergent regional industry clusters (Cooke 2002). The triple helix literature points to the generative role of universities in driving regional agglomeration directly, through firm formation and other capital formation projects, notably, incubators, science parks, trilateral university research centres and technology transfer offices that animate knowledge capitalisation. These academic entrepreneurial activities, supported by industry and government, "ignite a self-generating process of firm formation, no longer tied to a particular university" (Etzkowitz 2002a: 125). The university engagement literature takes a developmental approach, which, while accepting the importance of entrepreneurial activities as important drivers of development, points to other mechanisms through which universities foster agglomeration; notably, regionally-focused teaching programs that involve workplace-based research projects and the dissemination of national and international research results to regional actors.

The second element of a regional innovation system is the existence of a stock of proximate physical, financial and human capital. In regard to universities, human capital formation is the primary focus in considering this element. The triple helix literature anchors the role of universities in firm formation. This has two key aspects. Firstly, the embedding of human capital formation in incubation activities that 'create organisations'; and secondly, the development of generic, advanced training that supports the fluidity of employees' career maps and the increasing level of lateral relationships between firms. The triple helix model argues that universities are increasingly in the business of 'training organisations'. Education is now embedded in academic entrepreneurship. But, the growing importance of firm formation makes fluid the (previous) stability of firms and workforces, as firms and their

people move between institutional spheres. Hence, there is a growing need for generic, advanced training that enables cross-institutional movements (Etzkowitz 2002a; Etzkowitz and Leydesdorff 1999).

The university engagement literature takes a developmental view of the role that universities perform in human capital formation, arguing that universities are making their teaching and research programs more responsive to regional knowledge needs, in a broad sense. In doing so, it is suggested that universities undertake a number of activities: paying greater attention to student recruitment and graduate retention at a regional level; developing programs that engage with regional knowledge needs and introducing learning approaches that are more regionally-focused, drawing on the characteristics of the region to aid learning (OECD 1999a; Holland 2001, 1999; Chatterton and Goddard 2000).

The development of an associative governance framework in a region is the third key element of a regional innovation system. In the context of regional innovation systems, regional governance centres on the development of policies and strategies to support the innovative activities of firms and other organisations; although, the university engagement literature defines this element somewhat more broadly, encompassing a range of social and economic infrastructures, such as health, education and social and cultural strategies. An associative approach to regional governance involves the development of inclusive, trust-based cooperation among the key actors in the governance set-up of a region, which promotes the creation of a coherent vision and strategies for innovation (Cooke 2002). The triple helix model suggests that universities perform a driving role in identifying strengths and weaknesses in a regional innovation environment and leading, or co-leading, the development of innovation strategies based on knowledge capitalisation and other capital formation projects (Etzkowitz 2002a, 2002b; Sutz 1997). The university engagement literature, while accepting that universities may well perform this role, points to broader, developmental contributions made by universities to regional networking and institutional capacity, through staff participation in external bodies; the provision of information and analysis on regional issues and opportunities (Chatterton and Goddard 2000: 490); and brokering networking between national and international contacts and key regional actors (Goddard and Chatterton 1999; Garlick 1998).

The development of supportive regional cultural norms of openness to learning, trust and cooperation between firms is the fourth key element of a regional innovation system that emerged from the literature. These cultural norms are important lubricants of interactive learning and innovation in a regional system (Cooke 2002a; Lundvall and Johnson 1994). There is broad alignment between the triple helix model and the university engagement literature regarding the role that universities perform in shaping the development of supportive cultural norms in a regional innovation environment. Both bodies of literature highlight that a tradition of university-industry linkages that is focused on knowledge transfer, through entrepreneurial activities such as incubation, firm formation and science parks, are key mechanisms that may spawn norms of inter-firm collaboration and trust (Etzkowitz 2002b; Lawton Smith et al 2001, 1998; Keeble et al 1999; Saxenian 1994).

As evident from this discussion, the dual categorisation of university roles is not mutually exclusive. There are points of overlap as well as some differences. At the broadest level, both the triple helix model and the university engagement literature are concerned with the role that universities perform in supporting regional economic and social development. This is core to both approaches. Furthermore, both bodies of literature accept the importance of

academic entrepreneurial activities as important drivers of development. Both bodies of literature also accept that these activities may shape the development of supportive regional cultural norms. However, while there is a consistent theme of generative development driven by universities in the triple helix literature, the university engagement literature takes a broader approach to conceptualising universities' roles. Authors in the university engagement perspective highlight the importance of adaptiveness, responsiveness and engagement with regional needs. But the fundamental relationships between the state, industry and universities in economic regulation are not necessarily transformed. On the other hand, authors discussing the triple helix model point to the co-equal role of universities with industry and the state, driving development through knowledge capitalisation and capital formation projects. This approach is generative, both within a region and in the university. It is generative of economic development in the region as well as leading to the multiplication of resources within the university through the university's and faculty members' participation in capital formation projects (Etzkowitz 2002b: 14). While the triple helix model and the literature on university engagement are concerned with the third role of universities in regional economic development, therefore, there are differences in emphasis. This is a key basis upon which the framework proposed here is constructed.

Factors explaining the roles performed by universities in the development of regional innovation systems

While the framework proposed above is useful to analyse the nature of the role that a university performs in a regional system, a related and arguably, more interesting, analytical issue is the explanation of variation between universities in the contributions that they make to the development of regional innovation systems in different regions. The literature points to a number of possible explanatory factors, which are summarised in Table 2.

Table 2 Summary of explanations of the roles that universities perform in the development of regional innovation systems

Explanatory factor	*Definition*
University orientation to regional engagement	Nature of senior management commitment to regional engagement and mechanisms through which this is operationalised.
History of university-region linkages	Nature of historical linkages between a university and regional actors.
Complementarity of fields	Degree of alignment between the research strengths of a university and regional knowledge needs.
Champions	Presence and influence of university and regional advocates of university-region/industry linkages.
Nature of regional industry base	Types of industries and businesses in a region, and their demand for university knowledge linkages.
Political and economic conditions	Influence of specific government policies and/or practices directed to the region and the university. Influence of specific economic conditions in the region.

Table 2 indicates that there are a number of institutional and related factors that shape the role that universities perform in the development of regional innovation systems. These factors, which may be classified broadly as 'university related' and 'region related', will vary across universities and there may be additional factors that are peculiar to one or more institutions.

However, the literature has tended to focus on 'what' universities do rather than 'why' they do what they do and hence the factors distilled from the literature are, at best, indicative. Existing studies indicate that the orientation of a university's management to regional engagement has a pervasive influence on the role that the university performs in the development of a regional innovation system (OECD 1999a). A university with an entrepreneurial approach to engagement (Van Looy et al 2003:211; Feldman and Desrochers 2003), that places a strong emphasis on industry linkages, institutionalised through a focus on the commercialisation of inventions may be expected to perform a broader role in regional agglomeration than a university that eschews or minimises the importance of knowledge capitalisation (Keeble et al 1999). Etzkowitz contrasts the "ivory tower model" of universities, emphasising isolation, de-emphasising practical concerns and insisting upon the protection of academic freedom, with an entrepreneurial model that embraces a reverse linear model of innovation starting from societal needs as the basis for research projects (Etzkowitz 2002b: 19, 145; Etzkowitz et al 2000). Thus, MIT was conceived as a science-based university committed to the industrial development of its region. The university pioneered the venture capital firm as a transmission-belt between academia and industry, supplying seed capital and business counsel to academic firm-founders (Etzkowitz 2002b:2).

The history of university-region linkages is a second university-related factor that explains the role that a university performs in the development of a regional system, notably, in regional agglomeration, human capital formation and in shaping regional cultural norms (Lawton Smith et al 2001, 1998; Klofsten et al 1999; Braczyk et al 1998; Saxenian 1994). It is evident in the literature that some universities are more embedded in their regions than others as a consequence of a longer historical tradition of engagement. Saxenian's (1994, 1988) studies of Silicon Valley and Boston's Route 128 explained variation in regional innovation, in part, by reference to the different historical trajectories of university engagement, which in turn had influenced behavioural norms in these regions differentially. Similarly, Lawton Smith et al's (2001) comparative study of innovation in the Cambridge and Oxford regions pointed to differences in regional norms resulting from different traditions of university-region engagement in explaining the differential impacts of the universities in the development of regional innovation systems. The authors found that Cambridge University had had a deeper tradition of formal and informal engagement with regional firms compared to Oxford, where the emphasis on engagement tended to be operationalised, largely, through formal technology transfer institutions that had developed in more recent years. The historical pattern of university-industry linkages, therefore, fostered a 'culture of research collaboration' (Keeble et al 1999:323) that remained a key element in the regional innovation milieu.

History matters and may explain the influence that some universities have on regional agglomeration, human capital formation and cultural norms (Lawton Smith et al 2001, 1998; Forrant 2001; Keeble et al 1999). However, it is important to recognise that history involves more than a set of repeated individual transactions with a collection of firms and other organisations. The studies canvassed here point to a broad, deep and synergistic penetration by a university that has had the effect of transforming its proximate region and the university itself.

A third factor shaping the role that universities perform in the development of regional innovation systems is the complementarity between regional knowledge needs and the areas of research strength and expertise held by the university (Etzkowitz 2002b; Bade and Nerlinger 2000; Wever and Stam 1999; Garlick 1998). Firms seek out knowledge from universities that hold the most suitable expertise even though this may be outside the geographical boundaries of the region within which the firms are located (Bade and Nerlinger 2000). Where there is a high degree of complementarity of fields between regional knowledge needs and the research strengths of a proximate university, it may be expected that the university will perform a broader role in fostering regional agglomeration and human capital formation. Etzkowitz's (2002b) study of MIT, for example, highlights the importance of the science-based research strengths of that University as a key explanation of its role in the development of the regional system.

The role performed by a university in regional agglomeration and associative governance is influenced by the presence of champions within the university and in the region who play a key leadership role in advocating strong university-industry/region linkages (Garlick 1998:63). This factor spans the university and the region. A number of studies have highlighted the importance of champions in shaping the role that a university performs in the development of a regional system (Feldman and Desrochers 2003; Etzkowitz 2002a, 2002b; Santoro and Chakrabarti 2002). Santoro and Chakrabarti (2002) point to the importance of experienced and skilled champions in both the firm and the university who steer the formation and implementation of research partnerships and other linkages with regional governance, particularly involving the research role of a university. Feldman and Desrochers's (2003) study of regional engagement by Johns Hopkins University, on the other hand, highlighted that, in some cases, champions who resisted external engagement stymied the role performed by the University in the regional system. The role of champions, therefore, can enhance or contain the role that universities perform in regional agglomeration and in governance.

In his study of regional engagement by Australian universities, Garlick (2000) explored the link between the maturity of regional leadership and the contribution that universities were making to their regions. He found that stronger cases of university engagement (measured in terms of the activities that universities were undertaking in the region) tended to occur in regions with clearly articulated regional strategies that envisaged a broad role performed by the university in the governance of the regions (Garlick 2000:108-9). Regional actors welcomed and championed university engagement and involved university staff in the development of regional strategies in formal and informal ways.

The industry base of a region influences the demand for, and sources of, external knowledge and hence the contribution that a university makes to agglomeration and human capital formation (Van Looy et al 2003; Niosi and Bas 2001). The literature indicates that concentrations of knowledge-based industry sectors and, within these sectors, start-ups and SMEs in science-based industries, hold the greatest promise for university-industry linkages (Niosi 2002; Niosi and Bas 2001). But Van Looy et al (2003) argue that the development of endogenous innovation is predicated on the presence of a critical mass of research *and* production competences, pointing to a clear link between the public institutions of higher education and the technology-output in a particular geographical area or region (Van Looy et al 2003:210). Similarly, Castells and Hall's (1994) study of the US computer software industry found that the more an economic activity depends upon information-trained, information-oriented labour, the more the labour itself depends for its development on its

continuing relationship with a creative milieu able to generate new ideas and new techniques through the spatially-clustered interaction of firms and universities.

Knowledge-based high technology industries appear to exhibit a stronger demand for external knowledge than other industry sectors, including service industries within the high technology sector (Bagchi-Sen et al 2001; Sternberg 2000a). This is evident in the predominance of innovation studies concerned with the role of universities that have focused on knowledge-based industries, such as biotechnology (Bagchi-Sen et al 2001) and, within these sectors, start-up firms and SMEs. For example, Sternberg's (2000a) study of German regional manufacturing innovation found a link between concentrations of new technology-based firms and SMEs and knowledge contribution made by public research institutions and universities, particularly in physics, chemistry and pharmaceutical sciences.

Political and economic conditions in a region influence the role that a university performs in regional agglomeration. For example, buoyant economic conditions prevailing in a region influences the demand for university-industry linkages because these conditions tend to attract industry partners that are exploring new ventures (Piergiovanni and Santarelli 2001; Wever and Stam 1999:392). On the other hand, a declining regional economy may explain a poor level of engagement by a university with interactive innovation in a regional system. Political support for a region or a particular university in a region may also influence the role that a university performs in agglomeration.

The literature suggests that the influence of this factor may occur in various ways, including the proactive use of economic regulatory mechanisms that create differential incentives and opportunities (Cooke 1992), for example, through targeted state intervention to support less favoured regions (Morgan and Nauwelaers 1999); the availability of federal funding for knowledge creation and diffusion activity to develop the endogenous innovation potential of regions, particularly in high technology manufacturing industries (Sternberg 2000a, 2000b); and the quality of innovation support infrastructures available in a region (Hassink 2002, 2001). The key point made by these studies is that, at subcentral level, political and economic conditions may have differential impacts on the fortunes of regions and, by implication, on the role that universities perform in regional agglomeration. There are, therefore, a number of institutional and regional factors that influence the roles that universities perform in the development of regional innovation systems. Six factors were identified from the literature as possible explanations of the role that a university performs in a regional system.

This section has provided a systemic, holistic framework for analysing the role that universities perform in the development of regional innovation systems and for explaining variation in the roles performed by universities in different regional settings. Whereas much of the existing literature has tended to focus on particular types of transactions between universities and firms or particular types of contribution, for example, to cultural development, this framework enables a broad-based consideration of the influence that universities may exercise at a regional level. Further, whereas the emphasis hitherto has tended to be on 'what' universities do rather than 'why' they do what they do, this paper highlights the importance of institutional and regional variation in the nature of universities' roles, suggesting, from the literature, a number of possible explanatory factors.

Reflection on the framework

The strength of the proposed analytical framework turns on the robustness of the triple helix model of university, industry, government relations and the engaged university approach. Both offer important insights into the behaviour of universities at a regional level. However, there is also need for caution. The triple helix model does not have wide empirical foundations, even though the case of MIT has been explored in some detail as a landmark case of this approach in action. It is also problematic in its treatment of goal conflict across the three helices, arguably, understating the importance of differences in their core missions. Furthermore, the triple helix model does not represent fully the implications of differences in power across the three helices and in their relative capabilities to exercise influence over their environments, particularly, in regard to knowledge capitalisation and capital formation, as well as leading strategy development. To a lesser degree, the university engagement literature also underestimates the implications of power differences, as well as goal conflict and capabilities in advancing the adaptive and responsive nature of university roles. These issues warrant further investigation. There is also potential to extend the framework to include other elements of regional systems and to categorise the role of universities in a more nuanced way using interpolations of the bodies of thinking upon which it is based.

However, the framework offers a useful analytical construct to consider, in a broad-based way, both the nature of universities' contributions to the development of regional innovation systems and explanation of variation in the contributions made by universities in different regional settings. This can be done within and across regions and nations, with judicious attention to considering like with like. To some degree, it may be suggested that the categorisation of a university's role as either generative or developmental (or, tending towards one or the other) is less pertinent than turning attention to the question: Why does this university tend to adopt a stronger generative approach, for example, to human capital formation than that university in that region? This type of question is of particular relevance for policy analysis in an environment where the role of universities is being considered, increasingly, in the context of place. The framework developed in this paper makes a contribution to this level of analysis.

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