ROUTLEDGE

NETWORKING REGIONALISED INNOVATIVE LABOUR MARKETS

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REGIONS AND CITIES

EDITED BY ULRICH HILPERT AND HELEN LAWTON SMITH

Networking Regionalised Innovative Labour Markets

A map which shows where innovation is clustered worldwide is also a map of the location of highly skilled and talented labour. New technologies, their creative applications or synergy across different areas of scientific research or technology development always create opportunities for the employment of particularly creative labour. This book explores the kinds of institutions and structures that need to exist to make sure that such skills are both offered and employed in particular 'Islands of Innovation'.

Networking Regionalised Innovative Labour Markets illustrates the theme of how existing concentrations of skills in scientific, technological and managerial elites are reinforced through inter-regional mobility using exemplars from a range of countries and regions. These include the US, UK, Italy, Germany, and Central and Eastern Europe.

The book's originality lies in its in-depth assessments of the factors associated with the extent to which some regions hold their positions in networked Islands of Innovation. It is shown that those Islands of Innovation that attract highly skilled workers from abroad, particularly those from foreign Islands of Innovation, perform better for example in the US, Italy and the UK. In contrast, even the most innovative Czech regions tend to lose highly skilled workers vis-à-vis the most innovative regions of the world, mainly to regions in the USA.

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Edited by Markku Sotarauta, Ina Horlings and Joyce Liddle

61. **Networking Regionalised Innovative Labour Markets**
Edited by Ulrich Hilpert and Helen Lawton Smith

62. **Re-framing Regional Development**
Evolution, innovation and transition
Edited by Philip Cooke

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Contents

Figures

Tables

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Preface

Innovative and creative people are playing an increasing role in stimulating regional development. As regions become more advanced, both highly skilled labour and university-trained personnel are of greater importance. In a similar way to the process of regionalisation that built 'Islands of Innovation', such labour is concentrated in particular regions and locations. To explore this theme, this book takes continental and regional differences into account in order to further understanding of regionalised innovative labour markets, exploring patterns and processes in Europe and the USA.

Drawing on evidence from the book's contributors, three tendencies can be identified:

1. the concentration of innovative labour in a limited number of locations;
2. the tendency for the highly skilled to further concentrate in Islands of Innovation;
3. the pattern that once the highly skilled have migrated between Islands of Innovation, they frequently return to the innovative location from which they started.

These patterns have clear consequences. Some regions can continue their paths of successful development based on their strong innovative labour markets. Other regions that are not Islands of Innovation face the twin challenges of trying to retain those people who are likely to move to Islands of Innovation and that of trying to attract the most creative scientific personnel. Moreover, retention and recruitment of such professionals are fundamental to collaborative networking with partners elsewhere in Europe and/or the US.

This book therefore deals, in the first instance, with three processes: the regionalisation of innovative labour markets, migration of the highly skilled, and the impact that migration has on knowledge fusion and the building of collaborative networks within and between Islands of Innovation. Its chapters concern both the role of innovative labour markets in advancing regional development and the migration of researchers and engineers to particular regions or locations. In examining these issues, its contributors take into account the extent to which particular regionalised labour markets are capturing continental and global flows of people.

It is this capture through recruitment by firms and other organisations that forms networks of regionalised innovative labour markets. As a consequence of the exchange of labour between Islands of Innovation, particular bodies of knowledge will accrue in these regions. Networked regional innovative labour markets enable firms and other organisations to capitalise on the knowledge and competences of the highly skilled. This process further contributes to the regionalisation of competences, knowledge and innovation, the synergy based on leading-edge research at already outstanding locations, and the continuation of such processes for the foreseeable future. Thus emerging and continuing networks of recruitment are important for regional participation in global economic development.

Exploring such themes contributes to an understanding of how regional labour markets and regional development are embedded in inter-regional networks. The editors' objective is to provide opportunities for the book to be read in four ways:

- with regard to the topic of networking regional innovative labour markets, as explained above;
- with a particular interest in the relationship between development at Islands of Innovation and innovative labour that is attracted to these locations;
- with a particular interest in the problems and opportunities of regions that are not major locations of innovation but aim to attract innovative labour in order to modernise their products and industrial structures;
- with regard to network building, the recruitment of star scientists and university-trained labour, and how this relates to the sustenance of Islands of Innovation.

The focus on regional innovative labour markets also allows for a policy perspective. It is vital to foster in particular regions the kind of socio-economic development that provides employment opportunities for innovative and creative people. For example, funding scientific and technological research through government agencies on a regional, national or even European level creates a supply of and a potential demand for innovative labour. Both are increased by the formation of spin-off firms from leading-edge research or by programmes that support an application of scientific findings and new technologies in more traditional industries and products. All of these involve the kinds of transformation of knowledge and creation of competences that underpin socio-economic development. The challenge for policymakers at all levels is to capture the opportunities for innovation that the highly skilled present.

The study of regional innovative labour markets thus indicates a close relationship between government policies and the location, development and utilisation of skills. In addition, it suggests that focusing on the conditions under which regional labour markets develop provides an additional and important framework for the development of innovation policies. This may become particularly important for regions in the light of a shortage of innovative labour, which is likely to come in the near future.

Ulrich Hilpert, Jena
Helen Lawton Smith, Birkbeck

Part I

Introduction – Exchange of knowledge and the building of networks

1 Networking innovative regional labour markets

Towards spatial concentration and mutual exchange of competence, knowledge and synergy

Ulrich Hilpert

While scientific findings and new ideas about applications or creative minds are not bound to particular regions or territories, one can also discern a clear tendency of the concentration of innovative individuals, research-based enterprises and high-tech firms. There is also a concentration of innovative labour at a small number of clearly identifiable regions and locations. The close relationship between leading-edge scientific research, outstanding academic institutions and high-technology innovation demands very specific conditions and follows very particular paths of development. Such processes demand highly innovative labour, collaboration and an exchange of ideas and competences, which refer to a particular region's profile in scientific research and technology and a particular stock of innovative knowledge. Thus, scientific findings and new ideas about applications develop a close relationship to regions and locations; since they demand particular situations, they can be generated only at a small number of regions and locations.

Those regions, where science-based innovation is clustered and one can identify a concentration of research capabilities, innovative labour or funding that is won by institutions of science and academic labour, stand out like islands in a sea where research is realised only occasionally. Such Islands of Innovation (Hilpert 1992) concentrate about two-thirds of the funding and capabilities that exist in countries that hold strong positions in scientific research and technologies. At these locations, new findings are predominantly generated and applied, the most innovative labour is attracted and employed, and existing competences are used for university teaching. This provides a basis for the next generation of top scientists who continue the relationship with such locations. One can also identify the exchange of information through collaboration in scientific and technological research, and networks of research are established among such Islands of Innovation. These outstanding locations form magnets for researchers from locations which do not perform as Islands of Innovation. Thus, the concentration of activities and territorial localisation of innovative dynamics at such Islands make them particularly important for understanding both regional processes of techno-industrial innovation and national situations. Finally, they help us to understand the role of networks of innovative development.

Since Islands of Innovation are the centres of competence, they are also the locations where knowledge is applied or a kind of new knowledge is generated, which again maintains both their position as Islands and their situation within the networks. Synergy across different areas can also be developed best where opportunities for cross-disciplinary exchange are possible, which again points towards Islands of Innovation. The vast employment of creative researchers and academics draws international attention and makes reference to the fundamental importance of scientists and engineers. Moreover, it indicates the relationship between scientific labour and innovation in general and how this relationship characterises the situation of Islands of Innovation in particular. At Islands of Innovation there is not just more research in general and more leading-edge research in particular, but there are also more opportunities for synergy based on both the exchange of ideas and collaboration among outstanding researchers either at the same location or at different Islands of Innovation. Of course, this relationship with innovative labour draws attention to problems of recruitment, job seekers, regional innovative labour markets which provide such jobs and the relationship between mobile researchers and job opportunities at Islands of Innovation.

The fundamental contribution of scientific labour to processes of innovation and its concentration at Islands of Innovation increases interest in the exchange of knowledge and competence and its contribution to an advantageous situation within networks of innovation. This may provide the basis for strong competition on innovative labour, it may cause a brain drain from regions which cannot arrange for situations and conditions similar to Islands of Innovation; it may also provide the basis for a fruitful exchange of ideas, knowledge and personnel, which can even accelerate the processes of innovation at these outstanding locations and may spread to regions where such new knowledge and technologies are applied in more traditional industries. In any of these cases, innovative labour markets as they exist at Islands of Innovation become interrelated and form networks, which provide the basis for new processes and development.

Nevertheless, the questions remain to be answered: What does it mean for Islands of Innovation, in current situations as well as during longer periods of development, when innovative labour is exchanged rather than constantly bound to the region? What does it mean in comparison with those regions that do not participate in the exchange of innovative labour and thus embodied innovative knowledge? Consequently, innovative regional labour markets *and* the networks formed are important in understanding processes of innovation as well as the situation of Islands of Innovation. As the creation of regional innovative labour markets shows extremely close relationships with public funding of research, which provides jobs in academic research and additional employment in spin-off enterprises, it allows a deeper understanding of the network systems and how they emerge since the regional concentration of competences, knowledge and synergy indicates the fundamental role of innovative labour employed in a region. It allows for a better understanding of how innovation may spread or be concentrated at particular Islands of Innovation. The networking of innovative labour markets as well as their relationship with Islands of Innovation may indicate where advanced manufacturing industries and high-tech industries in future may flourish and what contribution will be made by mobile innovative labour.

Search for incorporated competences: labour and knowledge

Regional bodies of knowledge and competences in a situation of the internationalisation of science and research

The increasing role of high tech-industries for economic development introduces an expansion of innovative labour markets, which emerge regionally and predominately follow the emergence of Islands of Innovation. Since new and science-based industries also indicate an ongoing process of industrial modernisation and change, the demand for very highly skilled labour clearly grows faster than the economic growth shown in the Gross Domestic Product (GDP) (Regets 2007).[1] Since high tech industry is concentrated at particular locations, the demand for university-trained labour emerges unevenly on a regional basis at selected locations, which are usually places with universities and higher education institutions. Regional universities will be first to supply such labour, but there is need for additional scientists or engineers from outside. Enterprises prefer regional recruitment as it is a less cost-intensive opportunity to hire the required knowledge-workers (Rolfe 2001). Thus the demand for labour after graduation, in general, is met by regionally produced graduates; about 60 to 70 per cent of recruitment is realised regionally (Angel 1989; Saxenian 1985; Hilpert and Bastian 2007). Knowledge spillovers and the foundation of new enterprises based on university research are clearly related to skilled labour; both activities increase the demand for skilled labour (Abel and Deitz 2009). When demand exceeds the local production of graduates with specific and particularly high levels of competences, this creates a demand for very highly skilled labour and a search for opportunities to supply it from outside. Thus a tendency is introduced to integrate local or regional situations into an exchange of labour and a growing relationship within a network of innovative labour markets.

Immigrant engineers and scientists who follow the attraction of innovative labour markets complement the local innovative labour force (Regets 2007; Mahroum 1999) and they provide a basis for creative synergy based on divergent sources of knowledge. Situations that are open to such immigration attract more talent and support high-tech industries as well as introduce a convergence between regions, industries and disciplines (Florida 2002). This can be identified in the ways innovative labour markets work. Open regional innovative labour markets attract scientists and engineers from outside and constitute a human capital that helps firms to acquire an important element of competitiveness (Williams *et al.* 2004; Dickinson *et al.* 2008). Long-term economic growth benefits a lot from openness towards foreigners and innovative ideas and knowledge (Straubhaar 2000). Such enterprises and locations continue in their attractive situation when vital and innovative regional labour markets continue to exist, expand and be available to people who are employed elsewhere but are interested in changing locations in order to secure better jobs.

Once processes of innovation become highly dynamic there is a fast-growing demand for appropriately skilled labour and this soon leads to a situation characterised by a shortage of innovative labour. There are strategies for overcoming labour shortages such as offering short-term jobs; this increases the international exchange of labour and commuting (Criscuolo 2005; Williams *et al.* 2004). It is an increasing phenomenon that can be identified with larger companies being active in different places in different countries; companies prefer to use it because it will keep stocks of knowledge within the company (Millar and Salt 2008; Lawton Smith and Waters 2005). When it helps to overcome a particular situation characterised by a shortage in innovative labour (Rolfe 2001), it focuses on the regional situation in question and it increases knowledge, which is transferred among such locations (Ackers 2005a). In addition, it may contribute to both transregional networking and interrelationships among individual regional labour markets. Short-term activities (such as those based on visits or scholarships) allow job seekers to learn about the situation and opportunities for development in different places or how such activities support their career after they return home (Williams *et al.* 2004; Avveduto 2001; Mahroum 2000a).

In the USA, such short-term stays were most frequent among foreign-born individuals who came to the country for their education and stayed on afterwards; but these individuals also came from countries with a developed education system (for example, India).[2] India, as an example, exports a large number of highly skilled personnel; among other skilled labour there is a remarkable brain drain of doctors, engineers and scientists (Khadira 2001).[3] This tendency increases when scientific labour markets become more internationalised. Based on regional profiles of competences, the individual specialisation of innovative labour markets tends to be rather clear and often limited by technology or size. Thus job opportunities for scientists and engineers exist at a well-identified number of places and match the fact that scientific labour shows a relatively higher mobility than other labour (Ackers 2005a). To pass through the selection procedure, job seekers have to provide in general an equivalent standard of skills to a PhD (Rolfe 2001) and a record of research work.[4] With regard to science-based enterprises or scientific research teams, a highly internationalised scientific community and the exchange of knowledge and research methods allows for an easy integration into a regional innovative labour force. An increasing international convergence in science and innovation reduces the barriers to choosing foreign countries or locations for employment opportunities. Based on the universality of science and already existing networks of collaboration, highly skilled job seekers can easily work at different locations and choose from among offers those that provide the most interesting opportunities and working conditions.

When scientists and engineers follow the attraction of innovative labour markets to continue their career abroad, this is indicative of the pool of highly skilled labour which can be recruited to overcome a shortage of such labour (Williams *et al.* 2004) and which can support innovative regional development, particularly at Islands of Innovation where the most attractive innovative labour markets exist and where such labour markets are open to foreign knowledge-workers. This also provides for a transfer of new approaches and ideas to a region, which allows for new areas of synergy that did not exist before in a similar way. A match of competences, in addition, gives further access to research contacts and existing networks of knowledge exchange through networking. Thus, recruitment from abroad is not just an opportunity to overcome a shortage of academic labour, but it is also, and sometimes in particular, an opportunity to establish new areas of technological activities. Innovative labour markets allow for a variety of potential paths of innovation based on embodied knowledge.

The production and employment of university degrees as a basis for collaboration and exchange of innovative competences

Locations that manage to attract labour from abroad will benefit from the synergy which is generated locally; this will increase their attraction as potential locations for collaboration with Islands of Innovation where leading-edge research is carried out. Better solutions, reduced duplication of research and increased efficiency of global knowledge production is expected (Regets 2007). Such skills make high-level skill migrants to be of high interest to firms (Dickinson *et al.* 2008; Bélanger 2002); migrant scientists and engineers contribute new views, skills and knowledge, and they become a source of innovative synergy (Mahroum 2000a). This is particularly important for a region because codified knowledge is commodifiable, whereas individuals, creativity and a situation that allows for synergy across different areas of research or disciplines is not. Locations that attract such personnel provide a situation that is advantageous for all who participate in it; thus some locations can develop a basis for new ideas related to the territory (Berry and Glaeser 2005). Since knowledge is widely bound to the individuals, innovative labour markets are particularly important to gain access to such competences by recruiting innovative scientists or engineers and, in addition, they also contribute to the regional stock of knowledge (Williams *et al.* 2004; Mason and Nohara 2008) based on an increasing international dimension of recruitment (Avveduto 2001).

When applying relevant policy instruments to labour markets, public policies become enabled to either bring such innovative people to the region or keep them at the location to further contribute to socio-economic development. Individual incomes develop along with the innovative capability of a regional situation, as can be seen from the higher salaries in a region with a higher percentage of foreign-born doctorate holders (Regets 2007). In addition, recruiting high-level skilled personnel through migration contributes to raising productivity (Dickinson *et al.* 2008). Research may generate new firms and the creation of innovative labour markets helps to initiate high-tech-based regional development. Nevertheless, countries and regions have different opportunities to recruit from mobile scientists and engineers. For example, the United Kingdom has an advantage in attracting people from abroad without facing a higher return to their home countries (Mason and Nohara 2008); moreover, more than one-third of the fellowships granted within the EU programme *Marie Curie* were given to those going to the UK (Ackers 2005b).[5]

The geographic clustering of research activities is important to establish international research and technology centres to support regional development. In return, such clustering contributes to the global benefit of leading-edge research. The processes of clustering specialised research competences requires the international migration of highly skilled labour (Regets 2007; Ackers 2005a; Avveduto 2001), which further contributes to its recognition and enables it to continue to attract outstanding personnel (Mahroum 2000b). Such centres are built nationally and internationally. Once they are recognised as global centres they continue to grow when they use this situation to enhance resources for future development (Mahroum 2000a), which again makes these locations particularly interesting for high-level collaboration.[6] However, even long-distance networks of peers depend on the circulation of scientific labour among places of leading-edge research (Mahroum 2000b; see also Breschi and Lissoni 2009) to further generate new knowledge and continue to contribute to the excellence of existing centres.

Increasingly, linking with external competences is a key element of success since it allows for the development of new and innovative knowledge (Bercovitz and Feldman 2006). Therefore, firms' collaboration with other establishments and with external research institutes is usually associated with innovation (Simonen and McCann 2008a). Networks of collaboration follow from identified collaborators; such networks are introduced and reintroduced through knowledge workers who follow the opportunities of innovative labour markets. This is even more identifiable when such labour markets exist at locations that are associated with high levels of techno-scientific competences. Thus, enterprises and researchers can find collaborators at different locations, and this can be particularly innovative when they merge their competences for synergy. Language competences and career opportunities are placing the UK and the US in a particularly advantageous situation. In general, English-speaking universities are prepared to continue to attract students and staff from abroad (Marginson 2006) to maintain their positions as centres of excellence while accepting the best and maintaining contacts for collaboration after they have left. Based on a highly innovative labour force, transregional collaboration is then an opportunity to overcome limitations through purely regional partners and their background in scientific and industrial research. Open innovative labour markets provide policy instruments to gain access to embodied knowledge and to merge it with local competences for the generation of synergy.

Distant synergy through the exchange of labour: concentration and dissemination of new knowledge and techno-industrial change

Highly skilled personnel need not reside at the same place – they can collaborate and transfer knowledge and findings through the internet and cyberspace.

Although the places where knowledge is produced and used might be distant (Straubhaar 2000), proximity is virtual and based on communication using modern technologies. Such attitudes towards distant communication are more widely spread among highly mobile researchers (Millar and Salt 2008) who keep in touch with previous research fields.[7] This phenomenon is more frequently found in professions that demand career mobility (Mahroum 2000b). Since researchers tend to continue collaboration after they may have changed jobs or locations, there is an exchange of knowledge, which provides the basis to merge competences across distance and space; they reach out across countries and continents, in particular when job opportunities from abroad are accepted (Regets 2007). Thus they build networks when continuing to collaborate across distances and, in addition, they learn to understand how others work and think (Criscuolo 2005).

Scientific knowledge and research allows for much more collaboration across distances than is found in areas where collaboration among people with embodied tacit knowledge is fundamental. Consequently, in science-based enterprises a strong extra-regional orientation can be identified among the members of scientific advisory boards (SAB).[8] Although there is usually a close relationship with the research carried out at the local or regional university, in contrast, collaboration also indicates a strong extra-regional orientation (Hilpert and Bastian 2007; Audretsch and Stephan 1996). In this, relationships are continued which already existed when the founders and researchers were still engaged in university research (Audretsch and Stephan 1996); the more enterprises are science-based, the more they can take advantage of the outstanding position of their university or will locate their start-up enterprise in a place where attractive collaborators exist.

This makes an exchange of personnel easier and since a growing demand for innovative labour provides jobs in particular regions, it also attracts innovative labour from other regions or from abroad. Some regions manage to participate particularly well in mobile innovative labour when they attract personnel from many countries of the world (Mahroum 1999; Laudel 2005; Favell *et al.* 2006; Rolfe 2001), whereas other regions have difficulties in recruiting innovative labour. Thus, in the USA, politicians of states with larger state universities worry that graduates from the regional or local university might search for jobs in innovative labour markets elsewhere instead of contributing to locally developing growth industries (Gottlieb and Joseph 2006). In contrast, Islands of Innovation are particularly characterised by their advantageous situations for creative researchers, which serves regional development and manages to build close linkages with other innovative locations. Recruitment opportunities and the geographic concentration of innovative competences make such places outstandingly important for high-technology enterprises that try to benefit from leading-edge knowledge and research.

The mobility of scientists and engineers allows the building of relationship with locations by providing attractive jobs and thus improving the position within networks which make knowledge flow between places (Franco and Filson

2000; Mahroum 2000b). While several regions may try to draw attention to their development, some emerge as magnets and centres of scientific research (Mahroum 2000a). Thus Islands of Innovation are not just clusters of knowledge workers, they are also in a particularly strong position to increase their participation in knowledge and recruitment. Synergy across different locations is clearly concentrated in such outstanding situations and allows for continuing participation in future areas of innovation, which are related to recruitment at research universities and science-based enterprises (Williams *et al.* 2004; Mahroum 1999; Ackers 2005b). These will, again, contribute to the regional stock of knowledge and improve the region's attractiveness in terms of receiving offers of collaboration. An exchange of personnel is particularly attractive among Islands of Innovation where the stock of knowledge will be improved because it is based on innovative regional labour markets offering attractive conditions. A prominent position within innovative networks, as in the case of Islands of Innovation, provides for strong opportunities to recruit leading researchers who may build their own research groups which in turn will be linked to outstanding research elsewhere. Recruitment of outstanding scientists and engineers, of course, puts the USA in a particular advantageous position because its institutions can create a situation that is particularly receptive to new ideas and labour from abroad; furthermore, working conditions as well as career opportunities are often even more advantageous than in the researchers' European home countries (Marginson 2006; Ackers 2005b).

A circulation of creative scientists and engineers who embody attractive knowledge and competences is concentrated on Islands of Innovation; the ongoing exchange according to variations of regional profiles still allows for a continuation of individual paths of innovation based on recruitment (Ackers 2005a; Williams 2004; Mahroum 1999; Avveduto 2001). The circulation of brains forms an important condition for participation in distant synergy based on the network among Islands of Innovation and attractive economic development (Meyer *et al.* 2001¸ Saxenian 2002). Innovative regional labour markets are a necessary condition for attracting labour and participating in the exchange of knowledge and ideas (Audretsch and Stephan 1996). When there is a lack of innovative regional labour markets in their home countries researchers need to leave in order to achieve their ambitions in academic research and life. At locations that are already highly innovative, they further contribute to opportunities, which enable such places to participate in the networks even more strongly and make these places, again, even more different from other regions (Farwick 2009; Coulombe and Tremblay 2009; Jakszentis and Hilpert 2007; Avveduto 2001; Ackers 2005a). The strengthening of conditions for research at these locations and the continuing clustering of competences will further attract innovative labour to migrate, in particular, to Islands of Innovation (Meyer *et al.* 2001, Khadira 2001; Laudel 2005). As national situations provide for regulations, research funding and systems of science they are also important for the participation of regions in international networks that generate distant synergy. For some countries it becomes rather difficult to establish attractive innovative labour markets that provide a basis for building Islands of Innovation. An attractive participation in innovative networks and distant synergy might become rather difficult to create outside of European or American Islands of Innovation.

Scientists and engineers following job opportunities: regional concentration for participation in a global body of knowledge

Building a body of knowledge through regional innovative labour markets: the extra-economic factors of high-tech development

There are extra-economic factor that play an important role in economic development and which can strongly support regional development. These include human resources, education, quality of life, and informal networks among government, business and education (Malecki 1989). Capable federal systems allow regional governments to provide for education and research, which supplies the highly skilled labour demanded. If regional governments also provide for attractive jobs in research, they can keep knowledge and competence within the region and, in the end, such public policies are fundamental to new firms that vigorously search for such labour. In Islands of Innovation, which are clearly the centres of such development, such jobs are offered for highly qualified personnel to generate new knowledge and to develop new products. Unlike science-based economic activity, production is more equally distributed over different types of regions (Williams *et al.* 2004; Angel 1989). Federal systems, such as those in the US and Germany, allow individual states or länder to allocate substantial funding to suit the regional industrial structure (Bercovitz and Feldman 2006; Hilpert 1998). Here, capable regional governments can make use of suitable locations and research structures to create opportunities for existing industries or start-up enterprises. Thus a rich variety of profiles become possible, and attracted personnel will provide particular paths of development.

Islands of Innovation also clearly indicate and benefit from a division of labour between Islands of Innovation and other locations. While innovative processes demand certain situations, there are more traditional jobs available at many other locations, often related to high-performance manufacturing. Accordingly, managerial skills vary a lot. Highly skilled managers concentrate where knowledge workers are employed; they increasingly concentrate in metropolitan areas (Berry and Glaeser 2005; Florida 2002). Innovative metropolitan areas demonstrate an advantage because of their potential to combine distant competences and their ability to provide a strong position within innovative networks (Williams *et al.* 2004). Larger innovative labour markets and the agglomeration of universities and research institutes, as well as of research-based enterprises, create the advantageous situations of metropolitan areas. Based on such outstanding competences, size also matters for Islands of Innovation because it provides for dynamic innovative development based on highly skilled labour. Since all kinds of skills are increasingly segregated in different regions, opportunities for regions are distinguished according to their highly skilled labour force and characterised by the degree of innovativeness in their regional labour markets.

Based on leading-edge research, such locations can further benefit from additional spin-off enterprises from the firms which themselves were recently founded. A highly skilled labour force provides an appropriate base from which to increase the likelihood of such promising start-up firms (Berry and Glaeser 2005). Thus, an innovative regional labour market forms an important basis for new start-up enterprises, which further contribute to the expanding demand for highly skilled labour. Such innovative metropolitan areas with growing innovative clusters benefit also from a significantly higher labour mobility, much more than in surrounding or less innovative regions, and they contribute to an interregional networking across different areas of technological expertise (Power and Lundmark 2004). In addition, they are mutually strengthened by the exchange of innovative labour between Islands of Innovation.

Large Islands of Innovation with a wide profile of creativity in divergent areas possess the advantage of size, which means that more innovative personnel will provide more attractive opportunities and synergy, which, in turn, means that wider innovative areas of research and innovation will increase opportunities to merge different competences (for example, bioinformatics, bioelectronics or application of nano-technologies).[9] Strong research institutions attract research money, attention and personnel – which again contributes to the continuation of a location's strength in research. In the USA, one can find such locations concentrated along a line from Boston via New York City and Philadelphia to Washington DC, at the Research Triangle of North Carolina, in the Great Lakes region, in Texas and in California. In total, 20 metropolitan areas accounted for almost half of US expenditure on research and development (R&D) in 2006; by then these top 20 metropolitan areas had an average of almost US $160 million R&D funding compared to more than 150 agglomerations which had less than US $10 million (Abel and Deitz 2009). These strong areas and locations are also those where Islands of Innovation emerge (Hilpert 1992), which attract scientists and engineers, generate high-technology start-up or spin-off firms and where innovative collaborations are concentrated to build an important knot in the network that also transfers knowledge and exchanges personnel.

Such entrepreneurial scientists and engineers are much sought after; they usually prefer places with tax incentives, public support and venture capital. The San Francisco Bay Area has a reputation for attracting companies from outside. There were already 350 high-technology firms from Europe in the area during the 1990s (Mahroum 1999). It is the combination of a variety of factors that matters; high-tech firms are attracted by the availability of highly skilled labour, knowledge-intensive services and the proximity of potential partners and research institutes (Bercovitz and Feldman 2006). They are also particularly attracted by the regional innovative labour market (Simonen and McCann 2008a) and by choosing the location they further contribute to the creation of new and innovative jobs.[10]

High tech is labour intensive (Favell *et al.* 2006; Herzog *et al.* 1986) and thus responds to employment opportunities; where attractive jobs and career opportunities are provided, processes of socio-economic development based on high tech can flourish. At the few locations where innovative labour agglomerates, Islands of Innovation can emerge and continue. The way that public policies take the skills of the regional labour force into consideration and provide jobs in research and at universities can have an important impact on both the participation in the diffusion of knowledge and in the intensity of starting new science-based firms (Franco and Filson 2000). Building innovative labour markets provides the access to knowledge and competence required for attractive innovation-based development. When knowledge-workers are attracted to the region, they also transfer knowledge and provide access to networks of knowledge and innovation as well as to future new knowledge.

Once regions can positively participate in labour mobility, their access to knowledge dissemination is improved and regional learning processes are strengthened (Power and Lundmark 2004; Lawton Smith and Waters 2005). A lack of support through public policies can have a widely weakening effect on the entire country's research and innovation system. A national culture which is tied to public policy which prefers already developed products rather than investment in research and innovative structures, as is the case in Italy (Morano-Foadi and Foadi 2003), is unprepared for economic change and participation in high-technology products. Thus, the already existing gap between countries and regions is ever widening, because when Islands of Innovation are based on their innovative labour markets they can build upon this and continue an already strong position.

The migration of highly innovative labour frequently follows from such attractive jobs as are available. Consequently, nation states with fewer barriers to foreign scientists and engineers can participate better in the flow of international highly skilled migrants (Favell *et al.* 2006; Mahroum 1999). Public policies play an important role in building centres of excellence in all technologically leading countries; once attractive jobs are offered and made available, mobile post-docs will be interested in taking these opportunities. Innovative labour markets and their relationship to universities and public research institutes provide for an appropriate policy instrument that is widely based on or initiated by government research policies.[11] Spin-off enterprises from publicly funded research (Bercovitz and Feldman 2006) will further contribute to regional innovative labour markets and provide the basis for strong economic development and, in addition, may attract larger firms to locate there or to open up subsidiaries. When such situations can attract innovative labour and locations are able to continue in such an outstanding position a tradition of excellence may be introduced. This may help to establish a path of development that is appropriate to participation in future development and their position in international research networks can be further strengthened by recruitment from abroad.

US universities and centres of excellence have been extremely successful in building on such a position. They continue the country's and the location's strong position in science and innovation, despite the increasing 'production' of elites outside of the USA (Laudel 2005). Their position in international networks and their share of elite scientists is continued by the recruitment of gifted students or post-docs from abroad. Once these scientists move to the USA there are few who return home. Despite the fact that different areas of specialisation may indicate variations in such tendencies, in general, a scientific elite also attracts further scientists and engineers to seek jobs and to come to these countries or Islands of Innovation. Thus it is the size of innovative labour markets that allows for an agglomeration of innovative labour, and once this is realised an increasing excellence will be discernable. This may also help to concentrate excellence at such locations. This, in the end, means that such locations will participate frequently in collaboration with other outstanding locations or Islands of Innovation, and knowledge is made available predominantly at these places.

Participation in a global body of knowledge and new findings through the agglomeration of innovative labour

The role of a growing innovative labour market is not simply to increase the number of jobs available, but to contribute substantially to regional development. It creates a dynamic impact on the processes of the regionalisation of attractive socio-economic development, which further increase situations of uneven regional participation in techno-industrial innovation (Hilpert 2003). Islands of Innovation, with their high level of human capital and an agglomeration of know-how, provide particularly strong advantages for such processes which are related with innovative regional labour markets and which support regional innovative development.[12] The exchange of ideas, including opportunities of application and synergy, continues to increase, along with the growing number of firms and people attracted to a particular location. This enables a location to become an Island of Innovation and thus external relations again become outstandingly important for such firms (Simonen and McCann 2008b) as this provides an additional source of knowledge and synergy. After firms have started as spin-off firms from scientific research, they generate an additional regional research and development impact of their own.[13] While the founding of such fast-growing firms increases, there is a rapid and constantly expanding regional demand for innovative labour, which is oriented towards innovative labour elsewhere to complement the regional labour force and the regional body of knowledge.

An even wider socio-economic effect is generated when there is a regional mix of industries; there, highly skilled labour can complement lower skilled workers and existing enterprises may benefit from new capital investment (Regets 2007). This helps to link mature industries to new and innovative opportunities within a region via the application of new technological development (Franco and Filson 2000). This again privileges metropolitan areas with a strong and highly diversified industrial base, which is ready to make use of innovative development. In such metropolitan areas, simultaneously there can be both highly innovative processes and industrial modernisation.

Since high-tech workers migrate more frequently than others and particularly choose metropolitan areas and other central locations (Favell *et al.* 2006; Herzog *et al.* 1986; Florida 2002), there is a transfer of knowledge and competences predominantly among these locations and thus opportunities concentrate there (Mahroum 1999). Skill-based and knowledge-based economic development clearly concentrates in a small number of metropolitan areas, which frequently host the most prestigious universities – those who are members of the American Association of Universities (AAU).[14] Thus these locations become centres of excellence in certain areas of research, attract the personnel to suit this profile and contribute to the orientation of human capital (Abel and Deitz 2009). A high level of skills generally provides the basis for further improvement of the local human capital (Berry and Glaeser 2005). First-class universities become important for location decisions because there highly skilled labour is repeatedly generated, allowing high-technology firms to grow based on knowledge, human capital and innovation (Bercovitz and Feldman 2006; Malecki 1989; Herzog *et al.* 1986).

Frequently, there is also a clear specialisation of the metropolitan high-tech industry and a strong area for the local universities, which mutually complements one another (Abel and Deitz 2009); this helps to continue industrial development based on new knowledge and findings. Such relationships vary between countries and national or regional cultures. In the USA, these are particularly frequent and close; there research projects sponsored by enterprises, the orientation of graduate students in projects which are also of interest for firms, certain courses which are developed and summer support for faculty members (Bercovitz and Feldman 2006) are much more frequent than in Europe and help to develop a regional situation with very close relationships between university and industry. Since also in the USA most academic research is funded by government agencies (Bercovitz and Feldman 2006), enterprises can take advantage of both the stock of knowledge built through scientific research and the competence which the scientists gained beforehand. In addition, universities have a strong interest in spin-off enterprises from their research, in which they hold shares (Bercovitz and Feldman 2006). A constant flow of knowledge and competence as well as labour, which is appropriately educated by universities, further contributes to regional development. Firms and universities mutually benefit from their strength: universities provide knowledge, human capital and access to scientific networks while enterprises pay higher amounts of royalties when they continue to grow. They provide the kind of jobs that university degree holders seek after having completed a first-class education.

Industries expand their demand for such labour and contribute to the building up of regional human capital stock to a high level. Migration of highly skilled labour, in addition, provides advantages for enterprises at places of destination; there, a strong increase in this labour force contributes to the regional human capital while costs for improving human capital are reduced (Williams *et al.* 2004). Clusters that indicate such tendencies are particularly those which emerge as Islands of Innovation; opportunities for innovative development are more likely the more diverse the regional structure is. Thus, labour markets that attract such personnel contribute strongly to regional competitiveness and growth (Power and Lundmark 2004). Established research institutions that provide attractive jobs can be used as a policy instrument which will, in particular, bring younger scientists and engineers to a region, whereas it is much more difficult to attract older and well recognised scientists or engineers. Forming innovative human capital from a lower level takes time and demands funding over a longer period, thus it provides a path of development as far as time and budgets allow for long-term strategies.

To develop such additional units and locations successfully, they need to complement a national research system that is oriented in modern knowledge production. As an example, Italy has a system to which few resources are provided and which is less productive than those of other industrial European countries. A lack of modern infrastructure, low income and difficult bureaucracy combine with a system where careers are often not based on excellence but on subordination to often mediocre supervisors (Morano-Foadi and Foadi 2003). As a consequence, the necessary conditions to keep creative personnel in the country or to concentrate them at selected places are insufficient and Islands of Innovation that can play a strong role in international knowledge dissemination and an exchange of scientists and engineers can hardly be identified. Thus locations whose participation in knowledge dissemination and exchange of personnel is extraordinarily strong are those that have already established an innovative regional labour market that is ready to further absorb outstanding talent.

The transfer of embodied knowledge and competence is highly uneven among countries and locations and even more so when it comes to elite scientists. While the USA and Switzerland are gaining outstanding academics, Germany, France and Canada retain equal balances; the UK, Australia and Japan tend to lose more elite members than they gain, but developing or newly industrialising countries (in particular, India) are clearly losers (Laudel 2005). There researchers usually change the job location shortly after they receive their PhD, thus building a brain drain towards the USA where they find attractive working conditions. Moreover, in the end, the best tend to stay (Laudel 2005; DaVanzo 1983) because conditions often allow them to become elite scientists. This clearly narrows and concentrates opportunities to attract innovative labour and to transform a location into an Island of Innovation. Other locations and countries will participate in their knowledge and competence only when there is an internationalisation of national science labour markets that provide for brain circulation (Ackers 2005b). While the US situation is characterised by a single system and open regulations, Europe has a number of individual scientific systems and national regulations that affect a similar participation in trans-Atlantic or global knowledge transfer.[15] Countries may then face problems in their level of education and in building Islands of Innovation which enable participation in the global body of knowledge. Consequently, there are limited opportunities for the concentration of strong elites and the regional concentration of jobs and innovative labour. These locations lack opportunities for building Islands of Innovation and participating in the exchange of knowledge and knowledge-workers.

Appropriate labour markets and employment opportunities attract critical skills predominantly to Islands of Innovation where they further contribute additional competences.[16] Thus there is a strong and increasing correlation between the initial share of people with college degrees and their growth in the following years; degree holders search for and find jobs in places where employment of such personnel is already high (Berry and Glaeser 2005). Metropolitan regions, where plenty of opportunities exist, generate more advantageous situations and exchange innovative labour. Regulations and appropriate policies that favour scientific and technological excellence clearly contribute to such processes. Attractive jobs and working conditions at public universities and research institutes may further attract creative academics from abroad.

The development of innovative regional labour markets: Islands of Innovation in networks of knowledge exchange

Expanding innovative regional labour markets' support to dynamic industries

Once labour is attracted to a location, the size of the labour market plays an important role in the dissemination of regional knowledge and innovative synergy. Geography matters when spreading knowledge. It can be intensified through face-to-face contacts; then, proximity is an important means to support innovation (Breschi and Lissoni 2009; Criscuolo 2005), and innovative labour markets allow such labour to be kept within the region. Some enterprises or research networks pay strong attention to this problem, which relates to temporary mobility and collaboration at a particular location (Breschi and Lissoni 2009). Innovative high-technology firms are typically different from other enterprises. They are labour-intensive and employ a higher percentage of engineers. They show a particularly close relationship with science and its application, and research and development is critical to their success (Herzog *et al*. 1986). These firms maintain a close relationship with university-educated labour. Larger innovative regional labour markets are clearly at an advantage because they provide for a faster rotation of knowledge-workers, which meets there is a tendency for highly skilled workers to be mobile but to remain within a local labour market (Power and Lundmark 2004).

The scientific attractiveness of certain outstanding locations attracts the international awareness of engineers and scientists and provides a motivation to take jobs at these locations (Williams *et al.* 2004; Bélanger 2002; Mahroum 2000b; Morano-Foadi and Foadi 2003). Well-established Islands of Innovation maintain their position because they are particularly strong in attracting such labour (Mahroum 1999), which helps to continue their position in knowledge production. The more innovative job opportunities exist in the area, the more attractive are the places for scientists and engineers who are both oriented in a global labour market and willing to migrate (Khadira 2001; Malecki 1989). Since in large regional innovative labour markets there are more opportunities emerging, knowledge-workers continue to find themselves in a better position. This situation still exists, although even university-trained labour tends to become quasi-immobile beyond the region, and the increase of new ideas may build a close territorial relationship over longer periods of time (Lawton Smith and Waters 2005; see also Ackers 2005a; Breschi and Lissoni 2009). Finally, this contributes to a situation where knowledge becomes spatially bound (Breschi and Lissoni 2009).

Firms that are active in highly innovative industries are those that are closely related to the application of new scientific findings; thus they need to have access to foreign technological development to remain internationally competitive (Criscuolo 2005). This can be identified with regard to individual technologies and areas of scientific research, but it is similarly important when processes emerge across sectors and different scientific disciplines. Large Islands of Innovation with a rich variety of opportunities for innovation and wide areas of competences embodied in the regional labour force clearly have an advantage (Ackers 2005a). Their dynamic processes as well as their global orientations make such competences and collaborations available for further development and further synergy related to the region.

In particular, metropolitan areas with strong research universities are in a position to agglomerate research institutes and research firms that offer attractive jobs. Skilled entrepreneurs and science-based start-up enterprises follow a path of innovation that is based on the employment of further skilled people (Berry and Glaeser 2005; Lawton Smith and Waters 2005; Florida 2002). Large Islands of Innovation clearly provide an advantage because of their larger, highly skilled labour force, which is engaged in the production of new ideas (Lawton Smith and Waters 2005). Thus there is a tendency for cities and regions that already have a high level of highly skilled labour to attract even more innovative personnel who will participate strongly in the new jobs that are generated in such situations (Berry and Glaeser 2005; Power and Lundmark 2004), as these are usually to be found in urbanised areas. Furthermore, they provide for additional knowledge transfer and access to knowledge from outside the location; international recruitment of highly skilled personnel further contributes to this situation because those people generally move to urban centres (Millar and Salt 2008; Coulombe and Tremblay 2009).[17] The percentage of college graduates and people with 16 years of schooling is increasingly uneven among metropolitan areas; this contributes to the establishment of highly divergent human capital (Berry and Glaeser 2005) and provides a basis for clearly different regional opportunities to transform into an Island of Innovation.[18] There are more opportunities for innovative people. The agglomeration of enterprises allows for higher job mobility within a region and labour gains expertise while changing jobs (Power and Lundmark 2004; Angel 1989). Metropolitan areas collect and organise human capital in a way that, in the end, will be closely associated with growth in such regional or urban situations (Florida 2002).

Large US Islands of Innovation (for example, Boston, the San Francisco Bay Area, Los Angeles, the Capitol Area) clearly show such advantages.[19] Based on an innovative regional labour market formed out of research institutions and research-based enterprises, Islands of Innovation also provide for a distribution of knowledge among the companies in the region based on an exchange of personnel and thus inducing knowledge-spillover (Power and Lundmark 2004; Simonen and McCann 2008a; Bercovitz and Feldman 2006). This may be of particular importance when new projects are developed which require different competences and frequent face-to-face contacts (Millar and Salt 2008) or when smaller firms need to find partners; here a local density of competences and research capabilities may provide an advantage (Simonen and McCann 2008b). A regional system that is clearly based upon research universities (Abel and Deitz 2009) attracts academics from outside to take jobs in a particular location or region. In addition, high-tech companies that rotate highly skilled labour add to the regional innovative potential; both help to disseminate knowledge and, in addition, further contribute to regional creativity and innovation.

This helps create a situation of geographic concentration of the different elements necessary for strong innovative development. The innovative labour forces of Islands of Innovation are predominantly based on the degree production of leading universities, which are often located in the same places. These universities frequently attract gifted students from other regions or from abroad (Avveduto 2001). Although skilled labour and degrees that are required at Islands of Innovation are frequently produced by outstanding universities at such locations, nevertheless, there is a fast growing demand for additional labour from outside, which allows for a maintenance of their position.[20]

Capable and highly recognised research universities can contribute strongly to the regional human capital stock,[21] when opportunities in regional innovative labour markets provide jobs in the region. In the US a doubling of degree graduates is considered to be associated with a 12 per cent increase in a metropolitan area's human capital stock (Abel and Deitz 2009; Angel 1989). Similarly, in Oxford and Cambridge firms recruit staff predominantly from within the regional labour market (Lawton Smith and Waters 2005). The more outstanding a region's research university and its teaching, the better the personnel and the more likely knowledge spillovers are when local high-technology enterprises hire them.

A basis is provided for the development of a very special industrial structure, which is based on such labour and the strongly growing demand for it. Such demand is increasingly supplied by outstanding local universities or through attracting appropriate personnel from other locations. Islands of Innovation concentrate leading-edge research, start-up enterprises from such research and the human capital that is required for such processes. Other locations will have problems in arranging similar situations and more traditional industries may continue. The more such labour concentrates and helps to form Islands of Innovation in metropolitan areas, the more their opportunities for future development are divergent from other regions. Networked labour markets that help to exchange such personnel and to merge knowledge and competences for synergy are a key instrument in achieving such goals.

Thus internationally recognised research universities in a region help to provide for leading-edge research, spin-off high-tech firms, excellent teaching opportunities and high-level human capital stock based on the production of university graduates. The links between academic research and research-oriented enterprises make a fundamental contribution to a regional innovative labour market. Such a market makes efficient use of vital processes of socio-economic development, which again requires further knowledge-workers from elsewhere. Such outstanding regional processes of innovative development, widely based on university-trained labour, provide the basis for a self-generated acceleration of dynamic innovative processes and further strengthen the position of Islands of Innovation, which become even stronger magnets for innovative personnel. This self-acceleration also generates a fast-growing regional innovative labour market, which reinforces the effects abovementioned. In addition, it augments regional job opportunities and contributes to the stay rates of highly innovative personnel. The mutual relationship between regional opportunities and inter-regional networking among Islands of Innovation provides self-sustaining opportunities for science-based innovation, which, in the end, makes these Islands even more different from other regions and particularly highlights the role of regional innovative labour markets.

Innovative labour enables Islands of Innovation and integrates them into innovative networks

Based on the agglomeration of innovative labour, the Islands of Innovation's difference from other locations will become even more significant. Once a significant number of scientists leave a country to take jobs abroad or at Islands of Innovation in North America or Europe, there is a loss of knowledge and scientific expertise in the sending countries (Ackers 2005a), which weakens their innovative situation. It also affects their teaching, which is highly important for the education of future generations of knowledge-workers. Nevertheless, some places (for example, Singapore) manage to create attractive opportunities for scientists and engineers and provide for transfer of knowledge and the emergence of a skilled and educated workforce (Ackers 2005a), which will allow it to participate in the global exchange of knowledge and personnel.

While this may weaken the position of locations in some countries (for example, Italy, Portugal and the Czech Republic), neither strong nor weak situations are usually induced through migration. The differences between countries and their innovative regions are continuously growing. Italy, as an example, has to produce 12,000 researchers a year, but actually produces only 4,000, of whom several hundred leave the country each year. In addition, working conditions are not sufficient to attract highly creative personnel to the country or its locations (Morano-Foadi and Foadi 2003). This means the country is inadequate to realise the aim of building innovative industry-university networks (Morano-Foadi and Foadi 2003) and also does not provide a basis to build a national Island of Innovation ready to participate in the exchange of scientists and engineers. While these countries face a growing disadvantage, which makes it particularly difficult for them to link up with global development, a small country like Sweden has been able to clearly focus its limited resources on the largest cities and the largest innovative regional labour markets to improve specific areas such as information technologies and the knowledge-base in general (Power and Lundmark 2004). Accordingly, there is an increasing segregation based on available skills in the region (Berry and Glaeser 2005), which clearly strengthens the position of Islands of Innovation.

Regional innovative labour markets and the regionalisation of innovation mutually contribute to advanced regional development. Since experienced personnel with well-established contacts in social networks are required for innovation-based development (Malecki 1989), regional innovative labour makes a significant difference. Metropolitan areas, in particular, are in an advantageous situation because they generally have access to universities and refer to agglomerated economies in the area, which allows firms to recruit the best people at entry level (Florida 2002; Angel 1989; Herzog *et al.* 1986). In addition, they attract students from other places after they receive their degrees (Gottlieb and Joseph 2006). Increasing international migration to places with attractive job opportunities provides for a reserve of highly skilled personnel who can frequently be recruited internationally[22] (Williams *et al.* 2004). Some are already *in situ* because they are educated at universities in the location; others come to the location because they search for jobs where innovative labour markets exist and seek to join a situation characterised by a concentration of those who hold a PhD or Master's degree (Gottlieb and Joseph 2006). Once they move, they are most likely to search for jobs in innovative labour markets in other Islands of Innovation (Gottlieb and Joseph 2006); this attitude is particularly widespread among those who earned a PhD for while about half of them leave an area after they receive their PhD (domestic born: 52 per cent; foreign born: 41 per cent), almost three-quarters of those who finish with an MA stay (domestic born: 67 per cent; foreign born: 75 per cent) (Gottlieb and Joseph 2006).

Thus innovative labour markets have both international and transregional attraction. Since certain locations or regions provide attractive innovative labour markets, innovative labour seeks appropriate and attractive jobs at these places. Metropolitan areas with strong growth in innovative industries and services also attract from other areas within the same country (Coulombe and Tremblay 2009). Since high tech-industries in particular show a tendency to cluster in metropolitan areas which emerge as Islands of Innovation, they contribute to a growing demand for highly skilled labour and provide jobs on the regional innovative labour market (Berry and Glaeser 2005). As a consequence, there is an increasing inter-regional difference in terms of high-tech industries, research universities and attractive jobs for knowledge-workers.

While the demand for labour in areas such as life sciences or software engineering is very strong (Abel and Deitz 2009), there are few places that can offer particularly attractive jobs and working conditions. Such advantages are more difficult to provide and may need more time to develop when a particular level of scientific research is involved. A study of about 4,000 collaborations of approximately 600 biotech enterprises in Europe and the US showed a less than 5 per cent share with partners from regions located outside of Europe or North America (Hilpert and Bastian 2007). While this may allow for the better international flow of knowledge and better job opportunities for scientists and engineers (Regets 2007), the most developed and advanced countries and regions will particularly benefit from this participation in leading-edge knowledge because of better living conditions and higher incomes. Islands of Innovation will be especially advantaged because of their strong innovative labour markets. In the end, it is not just high-level human capital and high-tech industries that provide for regional innovation and economic development (Simonen and McCann 2008b; Florida 2002), but it is particularly outstanding competences and an appropriate mix of specialisation that provides for the continuation of strong, innovation-based development.

Consequently, innovative processes in US-American and some European industries can be related to additional knowledge-workers who immigrated from countries like India (Khadira 2001). Innovative labour markets play an important role for such development because highly skilled people increasingly tend to be attracted by initially high incomes and high-skill posts (Berry and Glaeser 2005; Ackers 2005a; DaVanzo 1983). Thus large concentrations (for example, the Boston area, the San Francisco Bay Area) benefit from the concentration of brains, the exchange or attraction of international researchers and their position in transcontinental networks. Outstanding research universities provide appropriately skilled engineers and researchers and strengthen the position of Islands of Innovation, as well as providing linkages with the universities in the region.

Universities and researchers frequently transfer knowledge to innovative enterprises within the region through newly-founded high-tech enterprises and through the production of graduates who apply their knowledge when employed by firms in the region. Thus the transfer of human capital supports a regional relationship between high-tech firms and established industry (Bélanger 2002; Audretsch and Stephan 1996). Due to the amount of job opportunities and firms' interest in hiring innovative personnel, there is a high level of staff turnover in urban areas (Power and Lundmark 2004), which also helps informal knowledge spillover through face-to-face-contacts (Simonen and McCann 2008b; Criscuolo 2005). This contributes to the fast dissemination of knowledge within the region. It is interesting that job mobility tends to increase with the transition towards production (Millar and Salt 2008). Furthermore, through the regional recruitment of academic labour, firms hope to receive guidance from the scientific community (Audretsch and Stephan 1996), which can be particularly strong in Islands of Innovation with internationally outstanding research universities. Since such locations and universities generally recruit strong personnel, enterprises find exceptional human capital to define the future path of innovative activities.

Thus it is the relationship between existing situations and the opportunities to establish a highly innovative labour force that is decisive for future innovative development. Both the research structures characterised by outstanding research universities and regional innovative labour are found in only a few locations.

Here, history or long periods of development allow for particularly attractive development, and when appropriate activities for economic exploitation are realised and public activities support strength in science and research there are opportunities to continue this path of development in the future. Although such situations, which are fundamental to processes of development on Islands of Innovation, are not available in most locations, some manage to introduce such attractive regionalisation of innovation and are successful in establishing an Island of Innovation. The path towards such an advantageous situation, as well as the continuation of such paths, demands a number of elements of which innovative labour is particularly critical in making the process dynamic and self-accelerating. Innovative regional labour markets allow the attraction of such personnel to a region, and it allows the generation of synergy across both different areas of research and different competences within the region. Nevertheless, only a few can enter this road towards science-based innovation and only a small number continue on the path as outstanding Islands of Innovation.

While the transfer of brains to Islands of Innovation in Europe or the US may contribute to a deficit in other countries (for example, India, China or Taiwan), it may also provide opportunities for economic and technological advancement. Thus Taiwanese engineers have introduced close linkages from Silicon Valley to their places of business in the Hsinchu region, including capabilities in state-of-the-art design and manufacturing; Indian engineers have used their contacts with Bangalore or Hyderabad for mutual benefit when outsourcing parts of their business (Saxenian 2002; Meyer *et al.* 2001). This may introduce a new form of the international division of labour, which for the sending country provides for intensified ties with foreign research institutions and the possible return of foreign-educated personnel. Receiving countries will increase their research activities (partly based on imported human capital) and benefit from the international flow and dissemination of knowledge (Regets 2007; Meyer *et al.* 2001). Simultaneously, there is a decreasing impact on the human capital in the sending regions (Farwick 2009) and there may be a negative impact on the competitive edge of enterprises and national economies if they are unable to retain creative potential (Khadira 2001).

Innovative regional labour markets are clearly an attraction to academics and researchers who wish to work and live in places that are stimulating and which allow for both a high quality of life and plenty of opportunities. While such labour markets are characterised by local situations created by research-based enterprises and vital academic research, the internationalised characteristics in such places include work regulations and the use of immigrant labour. In addition, the political and social recognition given to innovation and science makes a fundamental contribution to the attraction of such places and the jobs offered. Finally, the situation in question can be introduced in only a few places and only then when strong support for academic research provides the basis for a regional innovative labour market, which can become part of an international network and thus generate new scientific research and spin-off enterprises. This accelerates the existing difference *vis a vis* other regions. The attraction of innovative labour provides opportunities to establish Islands of Innovation and continue this path of development.

An instrument of public policy: networking innovative regional labour markets for mutual knowledge exchange

Once innovative regions or Islands of Innovation are perceived as socio-economic spaces that participate in wider processes of advanced industrial development, their relationship with processes and competences at other Islands of Innovation becomes vitally important. Collaborations and exchanges of knowledge emerge as networks; a constantly repeated collaboration between centres of excellence is fundamental in establishing a relationship between participating regions. Shared knowledge and the exchange of competences in collaborative projects creates mutual advantage, which provides for highly innovative industries and for participation in leading-edge research as well as recent scientific findings. Attractive job offers that are based on innovative regional labour markets are appropriate to bring additional innovative labour to the region; this provides the basis for both the transfer of embodied knowledge and networking opportunities.

Such situations, characterised by modern industrial conditions, can be provided in only a few locations in the world. They demand high-tech industries or industries which are ready to apply high-tech and new scientific findings, a relationship with outstanding scientific research structures and the ability to exploit strong positions in networks of techno-scientific research. It is interesting that all new technologies or scientific areas relate to a rather limited number of locations and these continue this exclusive position of participation in mutually innovative advantages, even over many years and decades. Moreover, the locations of new and innovative processes frequently converge although the areas may differ fundamentally. Some locations obviously manage to participate in almost every new development and they emerge as centres of innovation in the world.

Nevertheless, such Islands of Innovation have divergent profiles in high-level specialisation. These competences often complement mutually but there are hardly any regions that show very similar fields of leading expertise and highly similar level concentrations. The relationship between science and enterprise may vary and the amount of funding acquired is different; there may also be different products developed or patents registered and divergent positions in networks. Innovative labour thus provides for highly divergent opportunities of development while also demanding knowledge and access to new findings, which allow for both individual paths of development and contributions to collaborative networks. An intensive search for specialised labour that complements the individual situation at an Island of Innovation is fundamental in developing such opportunities. Once the labour is attracted to a particular region or location, the new and additional ideas provide for new areas of synergy.

Innovative regions and Islands of Innovation, in particular, are embedded in networked labour markets. Job seekers and headhunters search across different regional innovative labour markets to find a perfect match. Regional situations and regional innovative labour markets may present rather specific situations, but they cannot be perceived separately from one another. As the exchange of innovative labour allows for synergy, and does so particularly on large Islands of Innovation that provide for a rich variety of possible synergy among different areas of research, recruitment activities tend to merge innovative regional labour markets into a network, which is formed on the basis of individual regional attempts and opportunities.

Thus innovative labour provides a fundamental element in processes of innovation and innovative regional labour markets are appropriate policy instruments for building innovative situations or even Islands of Innovation. Once these regions are able to attract a sufficient number of creative knowledge-workers they are ready to participate in a network that exchanges both knowledge and competence for further innovation and synergy. This demands several necessary conditions and thus appears to be widely exclusive; in addition, the network of techno-industrial innovation thus formed is hardly accessible to other regions or locations. The availability of innovative labour and attractive working conditions as well as government regulation that is open to scientists and engineers from abroad, are important conditions if Islands of Innovation are to flourish and grow. These conditions allow knowledge-workers to realise their ideas and competences in collaboration with others at the same location or across distances. Thus one would have to regard a deficient labour force as an excluding condition which negates dynamic innovation and attractive socio-economic development. This refers to a situation built on participating Islands of Innovation and which reaches out across countries and continents; occasionally, it also appears as a transcontinental network of recruitment and collaboration. Although individual Islands of Innovation emerge from regional innovative labour markets, which were created on the basis of public funding of both leading-edge research and high-level university education, the process of innovation generated within these innovative networks needs to overcome national borders and systems and to address itself almost exclusively to those who propose mutual advantage at the leading edge of techno-industrial innovation.

Since such regional situations neither change rapidly nor can be arranged easily within a short period of time, the pattern of concentration of innovation at a few locations (usually in the USA and the European Union) is likely to continue without fundamental change and will continue to be identified in the foreseeable future. A critical role of innovative regional labour markets for building such situations and for positioning themselves within innovative networks demands a particular set of processes of both recruitment and migration of innovative labour: networks can be identified that highlight the outstanding position of Islands of Innovation and highly innovative labour would predominantly be located and exchanged among Islands of Innovation. Although one might also expect innovative activities elsewhere, the dominance of these few American and European locations and their innovative regional labour markets may become obvious – and may indicate problems for other locations and countries in building an Island of Innovation and participating in the kind of knowledge and competences that are transferred through highly innovative networks of collaboration and recruitment.

Finally, one needs to understand that though this geography of innovation is built on Islands of Innovation and their regional labour markets, there remains the question as to which path of innovative development they may follow and whether innovative labour markets provide additional instruments for appropriate policies to have a positive influence on advanced socio-economic development. Thus, in the end, it is not sufficient to study both the regionalisation of innovative labour markets and the migration of such labour to Islands of Innovation, rather it is necessary to discover more about the role of innovative labour markets in building Islands of Innovation and how to continue this situation in the future – there is demand for both the attractive conditions needed to attract innovative migrants *and* for institutions to be prepared to reproduce highly innovative labour based on their own capacities.

Notes

1. This exceeds the net inward migration as indicated by the UK at least since the late 1990s (Dickinson *et al.* 2008). There, attractive jobs attract foreign labour to take advantage of the opportunities offered by innovative regional labour markets. In the year 2000, there were more than 18,000 IT specialists entering the UK of whom more than 11,000 came from India (Khadira 2001).
2. Stay rates increase over time with the demand for university-educated labour in high tech-industries and among those who plan to stay some time before they return to their home countries. The stay rate in the US increased from 41 per cent in 1968 to 68 per cent in 2001, and particularly applied to those who held a certificate in computer sciences, electronics or physical sciences. The share included Asian countries like China (96 per cent), India (86 per cent), Taiwan (40 per cent) and Korea (21 per cent). About two-thirds of doctorates stayed in the US after receiving their PhD (Finn 2003).
3. This can be shown by science and engineering faculties in the US. In 1997 there were, out of 224,707, a total of 21,545 foreign born, while Indian faculty was the largest group counting for 6,876 (Khadira 2001).
4. In Europe, different systems and levels provide a problem for potential employers. As a consequence, the chemical industries have developed a sheet of equivalent qualifications and have produced a list of comparable qualifications (Rolfe 2001).
5. There is also a clear concentration of Italian professors drawn to the US and the UK (Morano-Foadi and Foadi 2003). Both systems are fairly open to academics from abroad and as English is the international language of science it makes changes of location easy.
6. However, in companies, increasing employment of highly skilled personnel from abroad is thought to question the company's national identity (Millar and Salt 2008). Nevertheless, the location benefits from this highly skilled labour and from international collaboration with other Islands of Innovation.
7. There are highly successful long-distance networks of peers who have engaged in a certain research project and create a 'global space' (Mahroum 2000b). Drug development and biotechnology is also frequently characterised by an organisation of autonomous institutes that is spread over continents (Criscuolo 2005; Audretsch and Stephan1996). Such co-invention networks emerge even when any kind of social relationship can be excluded (Breschi and Lissoni 2009).
8. For example, in biotechnology more than one-third of board members were not from the region where the enterprise was located (Audretsch and Stephan 1996).

9. The closer new enterprises are to leading-edge research the better are their opportunities to become an early mover. Consequently, one out of three spin-out firms from early movers become an early mover again (compared to one out of fifteen new enterprises which are not related to previous early movers) (Franco and Filson 2000).
10. They also indicate attractive development; while all high-technology firms in Silicon Valley had average sales of US $242,000 per employee, Indian-run firms had sales of US $216,000 and Chinese-run firms had sales of US $317,000 per employee (Saxenian 2002; see also Malecki 1989). In general, the location is internationally highly attractive, which may be indicated by the fact that already in the early 2000s one-quarter of the chief executives of companies were of Chinese or Indian origin, bringing additional experience and competence into the region (Williams *et al.* 2004), which further contributes to its attraction to other knowledge-workers (Mahroum 2000b).
11. Islands of Innovation provide attractive jobs and form magnets for highly skilled labour. Thus, the internationalisation of the academic labour force in certain scientific disciplines (Williams *et al.* 2004; Mahroum 1999a) indicates a participation in knowledge distribution and networks of leading-edge knowledge production. Countries like the USA clearly have an advantage when compared to Germany or other European countries with more restrictive regulations. In the USA, the centres of excellence attract mobile academics who search for jobs in attractive places. Since these locations are so outstanding and the regulations for foreign-born scientists and engineers are rather flexible, the number of post-docs originating from abroad exceeds 50 per cent. Similar tendencies can be identified at Oxford and Cambridge or in France at the CNRS (Mahroum 1999).
12. Thus high-tech enterprises as parent firms are raising the probability of generating a spin-out related to early mover know-how by 0.5 to 0.19. An even stronger increase can be identified in the general probability of generating a spin-out (by two-thirds to 0.18) and the technical know-how in the region is finally tripled (Franco and Filson 2000).
13. In cases where there is a regional linkage to medium- or low-tech firms there might be an even more vital impact. Based on the comparatively low level of technology applied, the innovative push is particularly high when they can benefit from new technologies or from high-tech enterprises in the region (Franco and Filson 2000).
14. In the USA, 38 per cent of the metropolitan areas demand more human capital than they produce. These areas absorb the surplus that is generated at 62 per cent of the metropolitan areas which produce above regional demand. Since these areas consume more degree holders than their universities and colleges can produce (Abel and Deitz 2009), a situation can be identified where just 20 metropolitan areas count for 35 per cent of total higher education degrees in the country (Abel and Deitz 2009).
15. In some countries, returnees face a very difficult situation. In Italy, as an example of a larger industrial country, when it comes to scientists' careers there are constant complaints about the disadvantages for those who left the country; their well published and internationally experienced competences are often insufficiently valued (Ackers 2005b).
16. Islands of Innovation require a clearly internationalised, highly skilled labour force. Universities demonstrate this situation particularly strongly; at Stanford over 50 per cent and at Harvard and MIT over 55 per cent are from overseas (Mahroum 1999). This frequently provides for a transfer of knowledge through networks of collaboration, and a close relationship with research-based enterprises of the region provides for application through spin-off enterprises.
17. Such regional diversities mirror an overall tendency, which is particularly clear in the US. There, a shift towards the production of ideas can be identified and this is replacing the manufacturing and distribution of goods (Abel and Deitz 2009). Such tendencies indicate a division of labour in favour of Islands of Innovation.

18. This is impressively demonstrated by the US metropolitan areas (Berry and Glaeser 2005). While in 1970 the population of an average metropolitan area had about 11.2 per cent graduates and people with 16 years of schooling (whereof 50 per cent were in the range of 8.7 to 13.1 per cent), in 1980 the percentage rose to 16.4 per cent (the range from the 25th to the 75th percentile increased to 6.3 per cent), in 1990 the percentage increased to 22.6 per cent (the range from the 25th to the 75th percentile increased to 9.6 per cent), and in 2000 there were 62 metropolitan areas with less than 7 per cent and 32 with more than 30 per cent. While in 1970 none had more than 30.8 per cent, in 2000 there were 49 metropolitan areas that had above this share.
19. There is often a close relationship between knowledge and its application to a particular situation. While this relationship might be rather similar among Islands of Innovation, a transfer of skills and approaches learned at particular institutions in leading countries may not produce similar results in different research environments when scientists and engineers return home (Ackers 2005a).
20. This is clearly indicated by the number of foreign-born science and engineering faculty in the US. In 1997, out of 224,707 academics there were 21,545 foreign born (Khadira 2001). Although this is a clear minority, it is an important complement to the national labour force and those available at Islands of Innovation. They allow for an expansion of scientific research and innovation in these regions, which could not have been realised without them.
21. Thus regarding degrees granted by the university of California at Berkeley, the share of students from China increased from 10 per cent in the early 1980s to 35 per cent in the late 1980s, reaching 53 per cent by the mid-1990s (Saxenian 2002). Since most graduates find jobs within the region, they contribute to a region's human capital. In Silicon Valley, 32 per cent of the Indian employees, 23 per cent of the Chinese, but only 11 per cent of their white colleagues had advanced degrees. Similarly, 55 per cent of the Indian, 40 per cent of the Chinese and 18 per cent of the whites held degrees (Saxenian 2002; see also Saxenian 1985).
22. This may also have a negative impact on countries and regions that are in need of such labour to develop their own capabilities in modern industries (Meyer *et al.* 2001).

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Part II

Islands of Innovation and networks of innovative regional labour markets

2 Labour for regional innovation

The role of researchers for development and patterns of recruitment

Ulrich Hilpert

The dynamic globalisation of new markets intensifies the competition between economic locations and regions, which try to enhance their market positions by using their individual advantages in factor endowment. Advantages in factor endowment can arise from immobile factors, such as physical infrastructure and institutions (both of which imply the consequences of geographic disparities), or mobile factors, such as a (skilled) labour force, published knowledge or financial capital.

This is why theoretical approaches towards regional, national or global systems of innovation, with their inherent preference for the orientation of innovative actors to a given location or region, have recently been complemented by studies emphasising mobile factors, such as labour mobility, networks of cooperation in research, development and production, and the recruitment patterns of companies and research institutions, transcending this static geography of innovation and pointing towards a spatially dynamic understanding of processes of innovation.

The future of biotechnology firms hinges greatly on networks that enable them to enhance their success in cutting-edge research, product development and the recruitment of scientific and managerial personnel. Just to start up a new biotechnology firm and get it going, the need for knowledge and resources in the main research disciplines takes networking. In addition to this, small biotechnology firms need to collaborate due to the variety of competencies it takes to handle the multiple technological tasks that are required in maintaining the development of biotechnology products. A high number and concentration of research institutes eases the recruitment of scientists and provides a degree of job security for workers already employed in a region. A well organised network of academic-industry links also facilitates the retention of scientific manpower.

It is important to understand that regions are not isolated, nor is the development of new technologies or products exclusively related to a particular location. Rather it is the result of a collaboration, the exchange of knowledge, and the different competencies that merge when it comes to new opportunities based on scientific findings and new technological applications. Therefore, migration of knowledge across regions, countries and continents is an important element of any kind of advanced industrial development; and particularly important in science-based development. Only regions that recognise the strategic importance of researchers and related patterns of recruitment can participate in such processes of knowledge migration, forming continental networks of regions and, with regard to the new life sciences and biotechnologies, of a wider transatlantic nexus of US and EU regions.

Travelling knowledge and welcoming locations: the role of innovative labour and its regionalised demand

The attraction of innovative labour to seek jobs in selected places

A well established method of participation in new and leading-edge knowledge is to make use of the mobility of scientists and engineers by recruitment to fill attractive positions (Franco and Filson 2000). Since particularly creative scientists are in demand, their decision to take jobs elsewhere or to stay for a period of joint research moves a significant stock of knowledge across distances, and this will also contribute to the reputation of the location where they continue their high-level research (Ackers 2005; Mahroum 2000a).[1] Because the migration of researchers always inhibits direct flows to regions that are best suited to applications and this might significantly alter situations within these spaces (Mahroum 2000b), there is always a tendency to form centres. At such locations, a critical mass of scientists, technicians and engineers is agglomerated as a basis for facilitating personal interaction and exchange of tacit knowledge, which even in academic research may play an important role (Criscuolo 2005). Only such locations, which become magnets for international recruitment (Williams *et al.* 2004; Mahroum 2000a; Mahroum 1999), can attract highly skilled personnel and participate in both the exchange of knowledge with similar locations and institutions and in networks of collaboration. Due to working conditions and attractive job offers such locations, and Islands of Innovation in particular, are successful in attracting a global faculty, which is based on excellence and helps to attract cooperative projects, research funds and further awareness from the international scientific community (Marginson 2006). Openness, career structures and a reputation of excellence attract academics and scientists. Cambridge and Oxford are highly successful in attracting such labour internationally, which accounts for 15 per cent of all expatriate academics (Williams *et al.* 2004).

Once universities have established a high reputation, they have a good opportunity to continue such a position in the future (Mahroum 1999). Similarly, enterprises and the foundation of new enterprises can benefit from this reputation and the stock of knowledge accumulated in the region or at the location. While building such a position is difficult and takes time, examples like Singapore or Taiwan indicate that it is possible to reverse a brain drain and change the national role of education and research according to the country's opportunities (Marginson 2006). It is important that sufficient effort is made to attract scientists and engineers of high reputation to accept jobs in areas of national economic interest. Among the top 500 universities, only a minority of 29 universities is located in countries with a per capita GDP of less than US $15,000, of which just 15 are in countries where the GDP is below the global average of US $8,200 (ARWU 2003): eight in China, three in Brazil and two in India (Marginson 2006). The USA, in contrast, dominates the rankings in general and in quality, having 90 universities among the top 200 worldwide.

The quality of research and the reputation of international centres reflect tendencies in recruitment. Top scientists and engineers tend to go to the most attractive places. While there is a clear domination of the international situation by the US and Europe, there are, of course, enormous differences. In the US the New England states and the West Coast dominate; in Europe there is a clear advantage to the Northern countries. Spain, Portugal and Greece clearly underperform, and even Italy, which is still among the strong industrialised nations, performs rather weakly. Since countries where science-based industries are not as strong as in Europe or the US (such as Japan, Korea or Brazil) still underperform in terms of research (Marginson 2006), the existing locations of innovative labour markets, and the direction of brain drain, will see little fundamental change in the foreseeable future.

Inter-regional exchange of labour and brain circulation

Exchange of labour provides a strong basis for knowledge spillovers and for social relationship among researchers who have worked together and may continue within networks or individual projects across distances (Criscuolo 2005).[2] Nevertheless, many European post-docs who have spent a number of years abroad face problems when they plan to return to their home countries and take part in the national scientific community (Ackers 2005). This also means that the knowledge and experience that was gained during the time spent abroad cannot be transferred for the benefit of these countries or their regional development. Thus, there is an identifiable asymmetry, which is not merely in comparison to countries like India or China when scientists move to the US, but can also be identified with regard to European countries (for example, Italy or Germany) when scientists leave their country for the US. However, some European countries simultaneously gain from such an exchange; more than half of all fellowships of the EU-funded Marie Curie programme went to the UK (36 per cent), France (20 per cent) or Germany (10 per cent) (Ackers 2005).

This tendency can be identified frequently, but it has certain variations that clearly refer to the individual situation of a region. A strong research structure, or even performing as an Island of Innovation, changes the situation significantly and has a fundamental impact on how innovative labour is valued. Here, clearly different opportunities result from different situations, and different innovative opportunities exist to the extent that a strong human capital stock is built. Thus, in contrast to other locations, the exchange of personnel by means of taking jobs elsewhere is particularly attractive among Islands of Innovation. This provides for the continual accumulation of knowledge at selected locations where innovative labour markets provide attractive jobs and working conditions. A prominent position within innovative networks provides strong opportunities to recruit leading researchers, who may build their own research groups that will be linked to outstanding research elsewhere.

Similar conditions of work at different places may induce brain circulation (Mahroum 1999) among locations; between those places and individuals there is an exchange of routine and knowledge that is based on high-level skills (Ackers 2005; Williams *et al.* 2004). Some locations attract highly talented personnel and once they are ready to recruit from other locations they are also ready to balance the losses to other top locations that they may have to face (Mahroum 1999). A transfer of knowledge and competence is most effective when the mobility of scientists and engineers allows for a transfer of personally embedded skills. This enables receiving locations to become net winners of human capital transfer (Williams *et al.* 2004; see also Rolfe 2001). Research experience abroad also supports individual research strategies, helps to develop creative ideas and, finally, often provides for a reorientation of research activities themselves (Avveduto 2001). Mobile scientists and researchers bring new ideas to a region and, when it demands some sort of adjustment and change at the receiving location (Mahroum 2000a), it helps to bring about structural change.

Even strongly industrialised countries face such problems (Ackers 2005); in the case of Italy, as an example, 2.3 per cent of graduates are working abroad, but just 0.3 per cent of European graduates work in Italy. Among Italian professionals working abroad, about one-third have left for the US, one-quarter for the UK, and far behind is France with about 11 per cent. In the end, about three-quarters of Italian professors working abroad go to three countries; about 60 per cent leave to go to the US or the UK because of better resources for research, economic conditions or better career opportunities (Morano-Foadi and Foadi 2003). A lack of innovative regional labour markets at home drives them out of the country where they aim to realise their ambitions concerning academic research and life. Thus Italian governmental efforts to attract Italian academics to return and to change the brain drain into brain circulation have failed widely (Morano-Foadi and Foadi 2003) and Italian industries and regions have fallen behind.[3]

Thus the circulation of scientists and engineers has a positive impact on innovation and economic development (Meyer *et al.* 2001) where regional innovative labour markets allow opportunities for an exchange of labour rather than a brain drain. Such employment opportunities for scientists are predominantly offered at highly attractive places, providing plenty of attractive opportunities. This is the case mainly among Islands of Innovation, which provide rather similar conditions of work. There, the existing innovative labour markets offer attractive jobs. The bigger such regional innovative labour markets are, the more contracts will be attracted; here, universities play an important role in attracting scientists and making talent available to firms regionally or trans-regionally (Audretsch and Stephan 1996).[4] This also attracts highly innovative labour from other locations and countries (Saxenian 2002), and although this may be rather limited in numbers, it weakens these places' capabilities to participate in collaborative networks and to build an Island of Innovation.[5] Clearly, internationally outstanding

Islands of Innovation have a strong position in networks of recruitment and are fundamental in terms of the migration of job seekers towards innovative labour markets.

This means that the migration of skills is now directed towards many locations and centres of innovative development, but it is still not multidirectional. Flows continue from less developed countries to Europe and the US (Meyer *et al.* 2001, Khadira 2001), where the most advanced centres provide the most attractive jobs. In addition, there is strong competition for highly skilled labour between the leading countries (Ackers 2005) and their Islands of Innovation. This works to the advantage of the US, to where most of the academic elite still migrate, although the European situation is improving (Avveduto 2001);[6] in the US they add to a rich science system that they join, for the most part, before they become members of the elite themselves (Laudel 2005). Immigrant flows to the US in general demonstrate educational achievement more than the average. In the late 1990s only 500,000 out of 7 million immigrants had no more than a primary education; a high proportion had very high educational qualifications because job seekers coming to the US have better education than the average persons in their home countries (Straubhaar 2000).

Matching competences at innovative locations

Once high-technology personnel migrate from outside Europe or the US to take a job, there is only a limited orientation to return to their home countries. Although business relations may have developed with the countries of origin, the individuals stay where they have established their work and life because differences in standards of living, business culture and technological infrastructure may differ greatly (Khadira 2001). Gifted scientists are likely to move to different places if they cannot find appropriate jobs (Ackers 2005), but they may continue their research contacts with previous institutions. There is also a large proportion of South-East Europe's intellectual elite that leaves their home countries (Ackers 2005).[7] A strong attraction to search for education and jobs abroad will reduce the opportunities for sending countries to take advantage of leading-edge knowledge, and they risk losing future generations of scientists and potential development based on their research and findings (Ackers 2005).

Finally, this is also the case within countries, where highly skilled labour migrates from the periphery to more prosperous regions or Islands of Innovation (Farwick 2009; Coulombe and Tremblay 2009; Jakszentis and Hilpert 2007). When locations develop as Islands of Innovation or international centres of research, the distribution of scientists develops rather unevenly and makes it rather difficult for peripheral countries or regions to provide incentives that attract leading scientists or build Islands of Innovation (Ackers 2005; Mahroum 2000a; Hilpert 1991). Thus, aside from European or US-American Islands of Innovation it might be difficult to establish attractive innovative labour markets that provide a basis for building Islands of Innovation and an attractive participation in innovative networks.

Networking helps to match competences and the recruitment of researchers may help to identify competences elsewhere, which may in turn serve future scientific investigation. There is clearly a tendency for emerging centres of expertise, which are rich in resources and tend to be highly specialized (Ackers 2005) but need additional competences from elsewhere, to engage in new areas of innovation that reach out across different fields of expertise. Since scientists aim at extending their networks through travel, certain sites are in a position to attract the best (Mahroum 2000b); while such collaboration maintains and continues to improve the existing high reputation of universities and innovative locations it also contributes to the process of international networking. However, when it comes to the exploitation of patents, it is often an advantage to be close to collaborators, because while patents provide widely codified knowledge, the tacit knowledge associated with these new findings and its exploitation is difficult to transfer (Breschi and Lissoni 2009).

An exchange of labour, which is identifiable first of all among Islands of Innovation and widely creates the impression of a brain circulation, forms a basis for networking among the regional innovative labour markets which attract highly skilled labour to selected places. It also means that the knowledge that is embodied within these individual researchers, who change jobs and places, is transferred from one place to another but it is made available predominantly among Islands of Innovation. A network of recruitment allows advantageous access to new and innovative knowledge for those regions that possess open regional innovative labour markets. Skilled labour, which is ready to change location, and places that are prepared to allow foreigners to take jobs, are the basis for networking among such regional labour markets. Thus there is a transfer of knowledge and it is made available at different places in a variety of situations to support the regions' processes of innovative development. One might also expect that such processes of knowledge diffusion privilege high-tech locations and Islands of Innovation in particular, where knowledge production and the generation of knowledge-workers based on university education are located. This provides jobs, attracts attention and will stimulate highly skilled labour to consider taking jobs at such places. While leading-edge research is related to such Islands of Innovation, the lion's share of research funding is used for research at these locations ,which helps to create additional innovative jobs and, finally, also helps create spin-off enterprises based on university research or scientific institutes.

While innovative labour markets emerge and flourish in particular regions – usually at Islands of Innovation – this should also show, when directions of migration are taken into consideration, where innovative labour tends to accept jobs. This has a fundamental impact on where such labour markets are likely to emerge and which regions may be in a position to participate. Participation in both innovative labour markets and knowledge dissemination is open only to selected places and will be even more concentrated on such places the more opportunities are to be expected at such locations. Large regional innovative labour markets, a wide variety of innovative development, or close linkages with internationally outstanding research, provide significant attractions. The scientific research itself is, of course, frequently based on public funding and institutional support from a variety of sources. Different governmental systems provide different public policies; federal structures allow for strong sub-national governments (for example, in the USA or Germany) while centralised systems (for example, in France or the United Kingdom) have a clearly different system of resource allocation. Thus the way such regional innovative labour markets are built and make a positive impact on regional or national socio-economic development will vary, but the importance of exchanging knowledge and recruiting innovative personnel will continue. Finally, one might expect there to be a close relationship between the allocation of research funds and the emergence of innovative regional labour markets; in other words, a strong concentration of public research that follows from the concentration of scientific excellence should end up in Islands of Innovation, which further contribute to their outstanding recognition and the attraction of innovative labour. This leads to the question: will innovative labour be exchanged and circulated between the regional labour markets of Islands of innovation? Such exchanges will give the impression of a system of networked innovative labour markets.

Developing regionally concentrated innovative labour markets: demand for creative academic labour when building Islands of Innovation

Science-based processes of innovation, economic development and dynamic enterprises are almost directly related to research capabilities and the exploitation of new findings. No matter whether it refers to the generation of new patents which may be the basis for licensing, or laboratories which are contracted for experiments and investigations as the basis of their business, or whether enterprises provide individual products for particular markets, they will always demand highly trained labour. Biotechnology provides a good example for a closer understanding of such processes of development and the role of labour for regional participation in innovation. The availability of such labour is important for enterprises to grow and contribute to regional economies. Research capabilities and a situation that includes universities to produce needed graduates play an important role – this indicates how closely linked university research and regional innovative development are.

Based on new research findings and the leading edge of research, such locations are forming regional labour markets that exist in only a few places. In these locations the kind of labour available provides the basis for conducting scientific research and contributing to further innovation and development. So, only places with attractive innovative labour markets can provide the labour that is fundamental to such development and attract continuing research funding as the basis for new findings and scientific breakthroughs. Regional innovative labour markets that attract a particular kind of university-trained personnel provide the basis for research and indicate its strength by their success in the regional agglomeration of research funds. Since research projects can be realised only when appropriate academics of high competence are available, the agglomeration of funds will also indicate that Islands of Innovation relate to already existing regional innovative labour markets.

It is interesting that such situations, which are built from strong capabilities in academic research, continue to exist over a long period of time. Both outstanding competences and excellence in research provide the basis for further research funding and attract researchers to the region. Strong academic researchers and the public funding of university research build a mutual relationship and, in addition, a critical number of researchers is required to develop a dynamic situation of regional innovation. There are only a limited number of locations that are prepared to provide innovative labour markets that attract academics of high creativity to seek employment and contribute to the regional body of competence formed by the coming together of highly qualified individuals.

One could identify such locations already in the 1980s and 1990s when technologies such as aircraft and outer space, artificial intelligence and biotechnology were taken into consideration (Hilpert 1992). The regional labour markets were mostly characterised by job opportunities at universities and public research institutes. The researchers employed attracted about two-thirds of national funds to these locations, and so they increased both the number of research jobs and the regional innovative labour markets. In science-based innovation, these processes are continued strongly and are still based in the same locations, even after a period of 25 years – although there has been a dramatic increase of the funds spent (see Table 2.1). These geographically clearly limited Islands of Innovation expanded their innovative labour markets when creating new research jobs and accordingly, based on excellent personnel, were successful in winning further and increasing research funding.

There are about seven of these regions providing innovative labour markets in the US and about ten regions in Europe. Although public funding in the US has

Table 2.1 Distribution of biotechnology research funding in the US and Germany: share of Islands of Innovation

Period	*NIH funding to US Islands of Innovation in million dollars*	*NIH funding to US Islands of Innovation (%)*	*Total NIH funding in million dollars*	*BMBF funding to German Islands of Innovation in million DM/ €***	*BMBF funding to German Islands of Innovation (%)*	*Total BMBF funding in million DM/ €***
1976–1980	365.9	75.8	482.8	107.5	77.6	138.5
1986–1990*	5,371.9	75.8	7,085.6	309.2	73.0	423.5
2001–2005*	41,906.3	64.2	65,252.8	550.8	68.8	800

* Figures for USA: Second period from 1986 to 1991 and from 2000 to 2003 for the last period.
** Figures from 2001 to 2005 in €, before in DM.
Source: NIH, Hilpert 1992, own calculations

increased more than 130 times since the early 1970s – from funding of US $482.8 million between 1976 and 1980 to US $65,252.8 million between 2000 and 2003[8] – the regions where innovative labour predominantly found attractive jobs are still the same. Similarly, in Europe the labour markets of Islands of Innovation have continued for over a quarter of a century and this is also indicated in relation to the research funds they have been granted. Likewise, the well developed innovative labour markets at Islands of Innovation attracted university-trained personnel and so they continued in their leading position. National funding in Germany has increased more than 11 times since 1976 and funding in life sciences from the European Union has been received in addition. So, even if there are different institutional situations and changes identifiable in Europe and the US, there are converging tendencies towards building regional innovative labour markets, which help to concentrate similar shares of public funding, even over a long period of several decades.

It is significant that this situation remained substantially unchanged, although a large number of additional jobs were created and research jobs spread elsewhere when the amount of funding increased. This clear pattern of the regionalisation of jobs and innovative labour markets continued, even when the number of jobs for researchers and the variety of locations at which such personnel was required increased, and when the European institutional setting changed. Regional innovative labour markets were established on the basis of academic research and reinforced through strong government funding. The creation of additional jobs continued when academic research provided the basis for centres of economic exploitation, which created further regional demand for innovative labour during the years that followed. Based on innovative labour, which was employed in the regions, these strong Islands of Innovation continued their role as outstanding centres in a selected number of regions, and were based on academic labour, which agglomerated continuingly at these locations. In addition, individually they were in a position to retain their strong position among newly emerging innovative labour markets.

So, the geography of innovation and innovative labour markets indicate very little change, even over a quarter of a century. Innovative jobs, in general, are still offered at the same locations. The window of opportunity, which was opened in the 1960s and 1970s, allowed for the establishment of such competences in academic research, but it did not provide for such opportunities at many locations and only a few locations were sufficiently prepared to develop as an Island of Innovation. Situations and positions in international innovation networks were reinforced, once the intensive streams of public funding further strengthened the already growing Islands and their innovative labour markets.

Inter-linking the regional innovative labour markets of universities

Regional development, which is related to both new scientific findings and a participation in new technologies, relates strongly to a region's capability to attract academic labour for creative research. The intention among such academics to start new spin-off enterprises from university research is an important element in both building a regional body of competence and innovative knowledge. The strength of Islands of Innovation, based on their research capability, is also related to university education. Outstanding research findings and the recognised records of important research achievements, as well as their continuing strong position in the academic world, is used as a basis for teaching and for the education of students and junior researchers. So, among such researchers who make the Islands of Innovation strong, there are also many who come from universities that are also located at Islands of Innovation. Although there are universities in other locations that participate in research networks, they play a clearly less important role when it comes to recruitment at Islands of Innovation.

Similar to the concentration of research funds at Islands of Innovation, the Islands' dominant position in academic education clearly has to be taken into account. Their strength in research is based on an academic labour force that predominantly has been educated at leading institutions within the islands. When such top personnel search for jobs they do so at locations that are highly attractive in terms of opportunities, reputation and recognition within the scientific community – and thus these are institutions previously successful in winning research funds and creating research jobs. Regions have different, and often better, opportunities when they recruit such researchers from universities where students and junior researchers have access to successful research programmes, and where they can participate in leading-edge projects. When innovative regional labour markets are able to attract such labour to join a university in a particular region, they will benefit from additional competences because both additional knowledge and competence will be added to the regional body of competences, and this will help to continue winning additional research funds in the future. So, recruitment of personnel and building an Island of Innovation, or the continuation of such a strong position, is mutually interrelated.

Islands of Innovation recruit their university researchers from places and institutions that are well known for their research strength. This creates a situation in which such locations are exchanging personnel and where the innovative labour markets of Islands of Innovation are forming a unified situation (see Figure 2.1). It is interesting how similar the situation is at the different Islands of Innovation in Europe and the USA. As the data show, about two-thirds of university researchers who have been recruited from outside by Islands of Innovation are attracted from other Islands. All other locations that are not among such outstanding locations contribute just one-third. Even more impressive is the fact that there is no significant difference between Europe and the USA. Although there are differences among individual Islands of Innovation because of specific situations, as in the Öresund or the newly established innovative situations at Jena in Eastern Germany or at Sevilla, the European picture indicates a general tendency with few variations from the general results. The US situation clearly converges with the European data; it again shows that recruitment from Islands of Innovation is

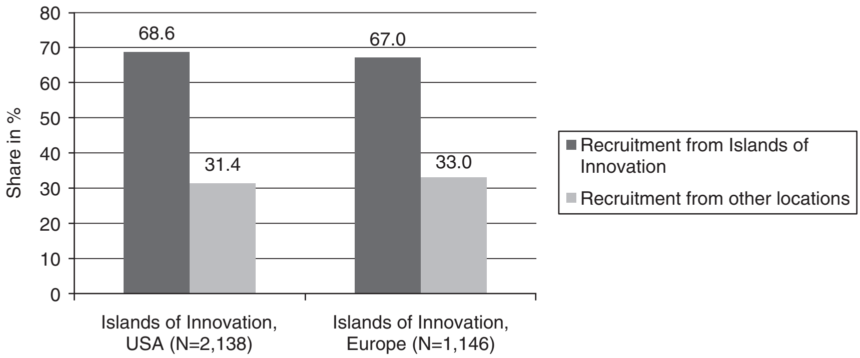

Figure 2.1 Recruitment of academics at Islands of Innovation

between 60 and 70 per cent. In Los Angeles and San Diego the figure is more than 90 per cent.

The innovative labour markets of Islands of Innovation jointly form the labour market for such personnel. They provide similarly attractive jobs and they compete for labour that is required to continue their position as a leading institution or region. Thus, they also exchange labour, knowledge and competences to provide synergies at different places. The labour itself is not limited to individual regional labour markets, but takes into account the entirety of opportunities, which are formed from the networked innovative labour markets of the Islands of Innovation. Such labour markets are no longer local or regional; they are multi-regional and academic job seekers take the range of these locations into consideration.

Based on innovative labour markets, at Islands of Innovation personnel are brought together who further contribute different educational backgrounds and ideas to existing innovative situations. They find jobs and when they participate in research projects their additional education and experience is part of the collaboration in academic research. This exchange of competences, knowledge and experiences in research strategies is also the basis for synergy and a source of the creation of further synergies in future. High levels of expertise and competences merge when the transfer of knowledge among Islands of Innovation takes place based on job opportunities and on the exchange of academic labour. Thus, universities and academics are oriented in a labour market that consists, first of all, of the individual regional labour markets of Islands of Innovation, but second, are continuously integrated into a joint network of innovative regional labour markets.

Those who search for jobs and those who provide jobs are both involved within this network. While top locations aim to provide excellent conditions in order to recruit the best personnel available, academics aim to find positions at locations that provide the best conditions for realising their expectations in research and income. Geographic distances between the locations in question clearly play a

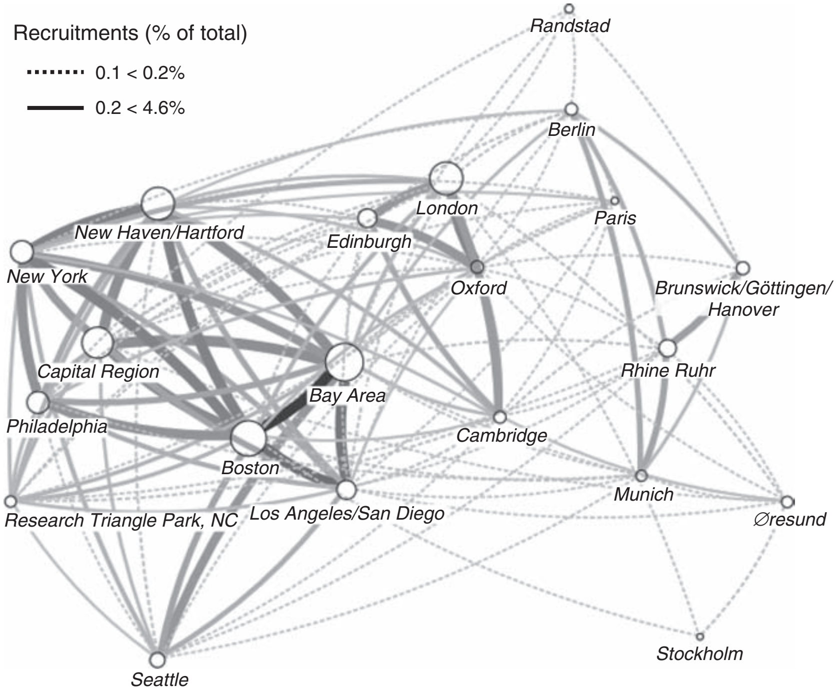

Figure 2.2 Patterns of recruitment among Islands of Innovation (N=2,235), equal to 68.1 % of all recruitments (N=3,284)

minor role, while it is also apparent that only a small number of locations is prepared to become a part of the network of innovative labour markets. Identifying the places where academics work and change jobs indicates the network of corresponding locations and again draws attention to the outstanding positions of Islands of Innovation. Universities' recruitment activities establish a network that is formed out of such locations and job seekers come predominantly from within this network (see Figure 2.2).

The network formed among locations based on the recruitment of academics impressively demonstrates both that a small number of locations are fundamental for exchanging personnel from leading-edge scientific research, and, in addition, that there are a few locations that perform as the main knots in the net of recruitment, exchange of labour and embodied knowledge dissemination. These Islands of Innovation are also those that demonstrated the strongest shares in research funding, and, in addition, such locations (for example, Boston, the San Francisco Bay Area, Oxford, Cambridge and Munich) also enjoy a high reputation in the international scientific community. Based on networks and the frequent interregional exchange of personnel among the major locations, research strategies are not merely a continuation of existing regional traditions in research, but they are permanently creating new findings and synergies, and they apply competences which are acquired through education that is also enjoyed at other outstanding places.

Nevertheless, these networks are not entirely open and they do not include all Islands of Innovation within one single network. While the network of innovative labour markets is fairly open for job seekers and universities as employers, the networks have clear differences when North America and Europe are taken into consideration. In North America, the network of Islands of Innovation and the network of innovative labour markets respectively are formed by a dozen regions. They are the home of most of the academics engaged in biotechnology and these are also the places where most of the academics received their PhDs as their entry into the academic world. Only very few are to be found who received their PhD from outside of these North American Islands of Innovation and even fewer from outside the country (for example, European Islands of Innovation) (see Figure 2.3). Less than 6 per cent gained their PhD from a European Island of Innovation before they accepted a position in the USA; and even fewer than this came as a post-doc to the USA from other areas in the world. Innovative personnel are usually educated at US Islands of Innovation or, if recruited from elsewhere, in general they were educated at other US locations.

Similarly, there is a clear exchange of personnel among European Islands of Innovation, but there is little relationship with the North American network of innovative labour markets. About 3 per cent came as post-docs from US Islands of Innovation and a marginal number from other locations (see Figure 2.3). Again, about two-thirds of the researchers recruited from institutions at Islands of Innovation are attracted from other Islands. There are no significant variations across the different European countries. However, regional and national situations play a different role; while in the US only about one-quarter of the post-docs were recruited regionally, in Europe regional recruits account for about one-half of researchers who are employed at Islands of Innovation. Another difference from the USA is that in Europe there is less exchange of post-docs across the

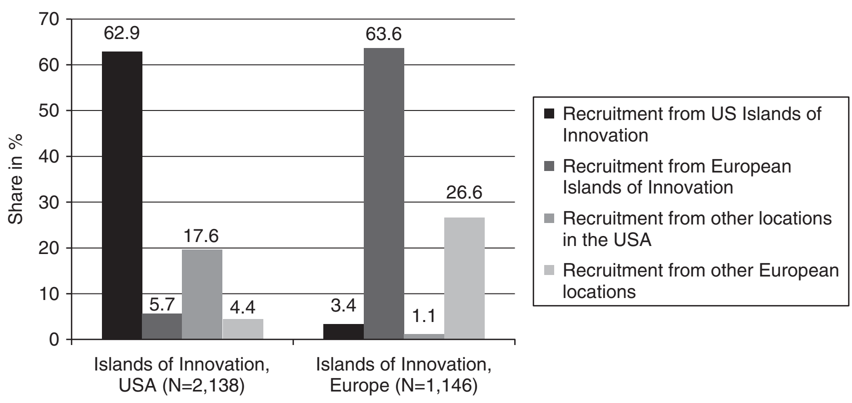

Figure 2.3 Recruitment of academics at Islands of Innovation by type of sending location

regions of a country; while these account for about two-thirds of the exchange of academic personnel in the USA, in Europe they constitue just over one-third, and due to cultural differences, income opportunities and different languages in Europe, the exchange across the continent is less intensive. Although there is little recruitment of innovative labour across the Atlantic Ocean, which comprises 5 per cent and is fairly equal to the cross-country exchange, there is also quite limited exchange between the different European countries. In the end, both situations are characterised by the fact that around 90 per cent of post-docs are recruited within the own country, either regionally or nationally. Thus, in Europe the network of innovative labour markets that exists at Islands of Innovation is not as continentally spread as in North America. Finally, there are two different networks formed out of regional innovative labour markets; however, there is some exchange between Europe and the US, which is mostly characterised by Europeans who are attracted by American job opportunities.

Participation in innovative networks demands strong regional innovative labour markets. Universities clearly play an important role when academic labour is attracted to contribute to a region's competence and innovative opportunities. Although the exchange of personnel among Islands of Innovation is extremely frequent, there are clearly different networks, which may result from the attitudes of job seekers. In general, North American academics take job opportunities in innovative labour markets within the network of American Islands of Innovation and Europeans similarly taking job opportunities within Europe, and also frequently within a country with the same culture and language. Thus, regions participate in continentally defined networks of innovative labour markets when they are able to create such jobs – but still there is a difference between Europe and the US when it comes to both the level of integration into the network of innovative labour markets and the intensity of sub-continental limitations based on culture and language.

Enterprise recruitment patterns and participation in research networks

Once additional scientific expertise is brought to a region and contributes to the competence of the university, the technological potential of the region and its economic capability increases. Highly capable academic labour helps to increase the research funds that are won and outstanding university research helps to increase both the potential for spin-off enterprises based on the findings of scientific research and the recognised quality of university education based on this research. Both the foundation of science-based enterprises and the education of students are rooted in the university's academia, and while both contribute to the innovative potential of the region, they share a need for such competence and its supply by university-educated personnel. This relationship is particularly close, since academics who have started their own biotechnology enterprise have close relationships with the particular areas of expertise realised regionally in research and teaching, and will find the personnel appropriate to their needs within the region.

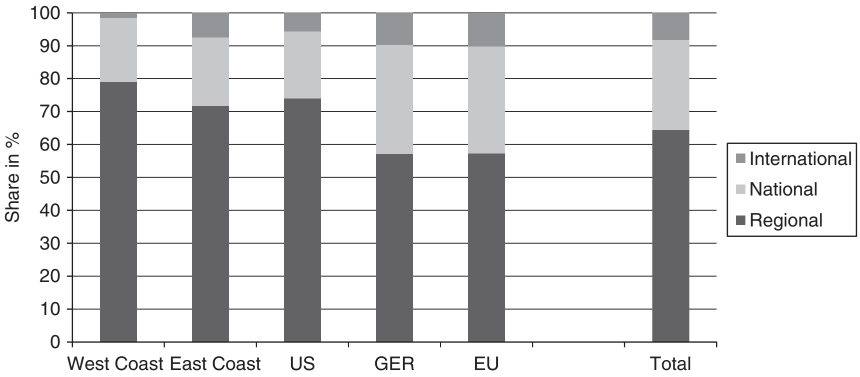

Figure 2.4 Recruitment of biotechnology firms at Islands of Innovation and research locations (N=598 firms from 20 locations in Europe and the US)

When enterprises at an Island of Innovation recruit personnel, they offer jobs within the region that frequently coincide with the university's or the university department's orientation in teaching. This situation and, in addition, the fact that there is a continuing relationship between university researchers and science-based enterprises in the region, helps to supply the enterprises' demand for creative and well educated personnel. Appropriate and attractive job opportunities then allow a selection from the best, who frequently want to stay in the area where they went to university (see Figure 2.4). Thus, about two-thirds of the personnel recruited by biotech firms is from the region where the firm is located. There is, of course, an important continuing relationship between firms and universities or institutes. But, maybe even more importantly, the firms have been founded on the basis of the scientific research carried out at the institutions based in the region. The institutions' research orientation and strategies are fundamental to both the spin-off firms and the education of university graduates, which makes both fit well and makes regional recruitment attractive.

There is, of course, an impressive variation that reflects divergent situations and their relationship to their national systems of science. While this relationship is particularly close at US Islands of Innovation, where not fewer than 70 per cent are recruited regionally[9] (including in-house recruitment), in Europe it varies between countries. Although Paris as an Island of Innovation in highly centralised France recruits 85 per cent from these sources, and the Öresund or the Randstad regions, which are located in the small countries of Denmark and the Netherlands, both compare with regions in other European countries, British and German Islands of Innovation show much lower regional recruitment. Here, an exchange of personnel between regions and a less intensive relationship between university education and new science-based enterprises is more identifiable than in the US. Thus, although there are close contacts and an important role for regional recruitment, such recruitments varies from between 50 and 70 per cent.

Of course, the size of the Island of Innovation with regard to a particular technology or area of research and the field of specialisation, has an impact on the closeness of these ties and how intensively the relationship develops. The more specialised the firms are, the more they may be related with particular fields of academic research carried out in the region, while a particularly strong and rich variety of academic research may provide for education that reaches further than the current orientations of enterprises in the region. Extraordinarily vital Islands of Innovation thus may have strong regional recruitment yet will also be attractive to job applicants from outside the region. It is interesting that at US Islands of Innovation this relationship is particularly strong and regional recruitment is particularly high – frequently, about 80 per cent and above of firms' personnel is recruited from inside the region.

While universities recruit labour intensively across each individual continent and country, enterprises are much more oriented towards regional innovative labour markets, which are fuelled by outstanding university education. At Islands of Innovation they can take advantage of the high quality of academic research, which is used when teaching students to prepare them appropriately for the demands of regional biotech enterprises. Thus such new biotech enterprises take advantage of both regional specialisation in research and teaching and synergy based on inter-regional collaboration and university recruitment. Since universities recruit across continents and countries, the region will continue to be related with the leading-edge research. Since university teaching is also based on this research, the regional labour market is supplied with labour related to the leading edge of research and which also meets the demands of the enterprises in the region. Enterprises at Islands of Innovation benefit from excellent university research through both highly educated labour and the competence that attracts collaboration with partners from other top locations.

When research-based enterprises recruit personnel from a regional catchment characterised by universities and public research institutes, they are, of course, in a most advantageous situation if there is world-class academic research and teaching. Since university graduates tend to stay in the area once they have finished their education, enterprises have access to top quality labour possessing leading-edge knowledge and a continuing relationship with leading academic research. However, further and even more so, when researchers from universities are recruited by enterprises there is also knowledge transferred that provides information about capable and attractive collaborators at other outstanding places of research in the world. The more deeply such researchers are involved in leading-edge academic research, the more such highly valuable knowledge they posses and make available for the purposes of individual enterprises. Thus a regional spin-off enterprise has several opportunities for participation in the dissemination of the most innovative knowledge from leading-edge research. Shortly after the spin-off enterprise has been established, the founding researchers bring their own knowledge and expertise of the area of research into play. Once they employ further personnel, these researchers also bring in their expertise. Finally, during collaboration based on this expertise within the firm, they will have access to the knowledge of collaborating partners outside it.

Nodal positions in academic research networks help to build a body of knowledge in the region and, in addition, make further knowledge from outside available through both collaboration and recruitment. Such processes are similar in general and divergent in detail; the processes follow a similar principle of synergy based on a variety of research competences, while individual Islands of Innovation have spin-offs from divergent research strategies and particular areas of research, which provide for highly divergent precise profiles of innovative capability at different Islands of Innovation. Thus bodies of knowledge and areas of innovation are complementary and vary between Islands of Innovation; recruited researchers make different contributions in divergent situations and when they move between Islands they are fundamental to new opportunities. An agglomeration of public research institutes, research-based enterprises and a central position in networks, related to a high reputation for creative and outstanding scientific research, are of great importance in attracting particularly innovative labour.

This situation is most frequently met at Islands of Innovation, where expertise, competence and leading-edge knowledge is heavily agglomerated. There the most appropriate access to knowledge dissemination is provided and expressed as a participation in networks of collaboration, which expresses the mutual exchange of knowledge while joint projects are realised. Through examination of the networks based on university recruitment in a region in fields that are important for biotechnology (for example, life sciences, medical research, biology, chemistry, pharmacology), and how this relates to the position of the Islands of Innovation in the network of collaboration between biotechnology enterprises, a rather close relationship can be identified. The networks formed through collaboration among enterprises in techno-scientific research are rather closely related to university recruitment (r=0.69) (see Figure 2.5), and networks of collaborative economic exploitation also show quite a close relationship to the network of university recruitment (r=0.47) (see Figure 2.6). Thus close collaboration with partners at outstanding Islands of Innovation, which exists during academic research, is continued when it comes to the activities of enterprises from the same locations; they address and inter-relate the knowledge of these outstanding locations for mutual benefits and dissemination.

Building centres of expertise, which become Islands of Innovation based on world-class academic research, provides the basis for both the agglomeration of knowledge and the exchange of innovative labour. Regional innovative labour markets that provide jobs for such highly prized labour are fundamental for such processes. This is clearly based on academic research and successful competition for research funds, and, in addition, newly founded science-based enterprises add to the number of research jobs and start to generate more from the dynamics of economic success based on the application of scientific findings. When enterprises merge their competences through collaborations with other enterprises and generate economically relevant knowledge, they still rely on the expertise of

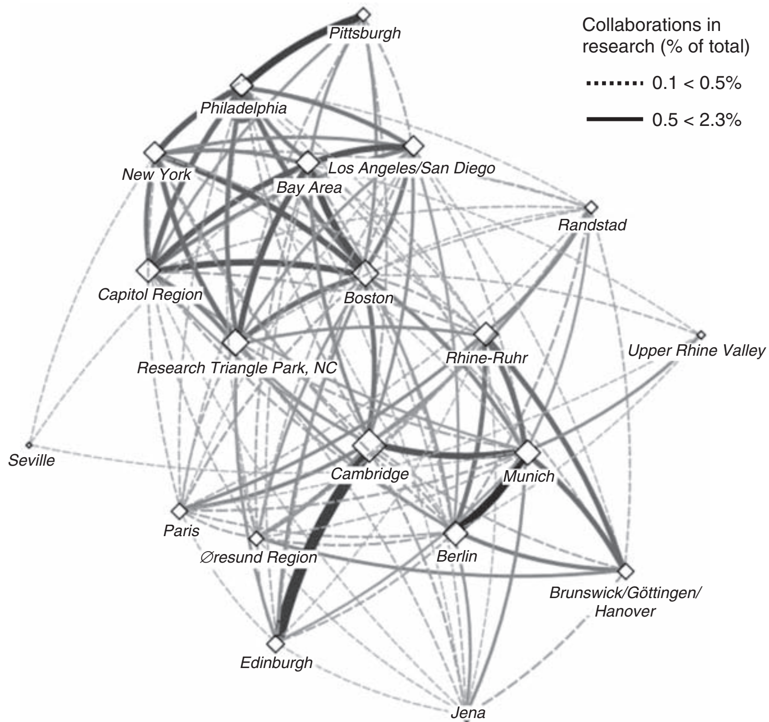

Figure 2.5 Networks of collaboration in research among enterprises (N=3,216), equal to 67.2 % of all collaborations in research (N=4,786)

academic research, and on the competences that graduates from university transfer from their education, but it becomes a divergent process from the knowledge transfer that existed when the enterprises started as spin-off firms.

Thus a strategy oriented towards leading-edge academic research can help to build a regional body of knowledge that allows for both dynamic and highly attractive innovative development, because it is based on the constant attraction of highly innovative researchers who constantly contribute the dissemination of their knowledge. The rich variety of opportunities, and the demand for divergent areas of research and competences, drive a constant attempt to attract innovative individuals from other outstanding locations to participate in the dissemination of knowledge and use their embodied knowledge for the generation of new and leading-edge knowledge. The networking of the regional innovative labour markets creates complementarity of development and the innovative potential that is associated with the agglomeration of innovative personnel and their creativity. The continuation of merging knowledge and competences is based on appropriate jobs and, therefore, can be realised only where these innovative individuals find jobs, either in academic research or in science-based enterprises.

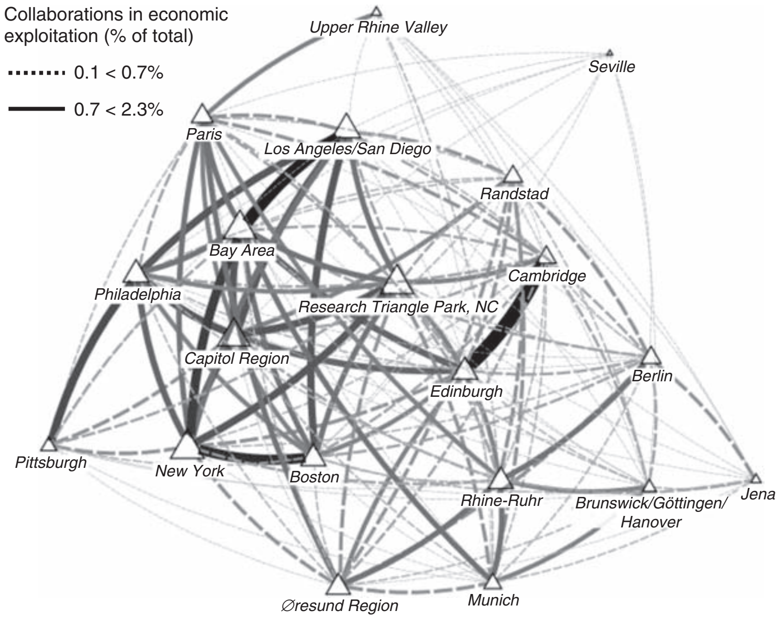

Figure 2.6 Networks of collaboration in economic exploitation among enterprises (N=1,213), equal to 63.5 % of all collaborations in economic exploitation (N=1,911)

Conclusions: Uneven regional participation in a global body of innovative knowledge

The network that is formed through recruitment of personnel and which clearly puts the Islands of Innovation into a dominant position relates to an interesting phenomenon of uneven participation in both the exchange and circulation of brains. While there is already a concentration of innovative development at such Islands and in a number of other regions which provide for strong fields of scientific research (which may be related to socio-economic development based on new technological opportunities), the agglomeration of innovative personnel and the exchange of such individuals, which widely concentrates on this small number of locations, has a fundamental impact on where future development may take place. Regional innovative labour markets provide the basis for attracting the most innovative personnel available. These knowledge-workers demand a creative situation in leading-edge science and research and they contribute their knowledge to such regional situations.

While innovative labour is often perceived in terms of the competition for such labour, in addition and in contrast, the emerging networks, the exchange of labour and the circulation of brains indicate that, in fact, the transfer of knowledge and competence among Islands of Innovation is similarly important to the processes of generating new and synergetic knowledge and technologies in these regions. Knowledge dissemination is realised through networked innovative labour markets. However, it is not just a redistribution of certain specialised knowledge and knowledge-workers; it is a process that provides the basis for new and innovative knowledge, which often emerges across scientific disciplines and different areas of research. The networking of innovative labour markets emerges through recruitment among Islands of Innovation, and thus is a necessary condition to further intensify the great number of regional innovative developments and allow for creative opportunities based on a variety of divergent competences.

Thus the networking of innovative labour markets is a necessary condition for future processes of leading-edge research and innovation. Simultaneously, this privileges Islands of Innovation because the knowledge and the personnel who possess such knowledge are predominantly agglomerated there, and the best opportunities to enter future innovative processes are to be found there. The more socio-economic development relates to scientific research and creative knowledge-workers, the stronger the outstanding position of Islands of Innovation

At the same time, the opportunities to participate in science-based innovation will become more uneven, and the differences between Islands of Innovation and non-Islands will intensify. The exchange of matching labour is a condition for attracting the best available labour and allowing such personnel to be creative when providing a positive impact on socio-economic development. Internationalisation, or globalisation, of the highly skilled workforce is a clear outcome of the networking of regional innovative labour markets and the regulations that allow for such processes of recruitment.

Innovative and creative labour becomes a basic resource for dynamic processes of socio-economic development during a period characterised by intense global economic competition. New products based on new technologies, or new scientific findings, allow for attractive positions in new global markets. Scientific research and creative personnel become the key issue for placing a region in a highly attractive position and contributing to national innovative development. The networks that can be identified in biotechnology recruitment indicate the role of labour in innovation; in addition, they highlight the diversity of regional opportunities and processes of development. Open innovative labour markets play a fundamental role in attracting the best available labour, which will further attract the attention of other innovative researchers. Regulations regarding the immigration of foreign researchers are important issues for participation in the network, and a culture of openness is necessary to take advantage of these opportunities.

Finally, the networks formed through processes of recruitment point to the fact that innovative regional development and processes, which take place predominantly at Islands of Innovation, cannot be understood without these opportunities for knowledge dissemination and synergy based on a frequent exchange of highly skilled labour and a circulation of brains. However, this again relates to the role of governmental policies, which are fundamental for funding academic research and building Islands of Innovation. Here, a recruitment of matching competences needs universities that produce the required graduates and allows them to be attracted from abroad. Thus, regional innovative labour markets can be integrated into networks only if policies allow and provide support for such processes and understand their role in bringing about the advantages of the exchange and circulation of brains.

Notes

1. In biotechnology one can identify a relationship between Nobel prizewinners and growing international interest in biotech firms in their location; this has even helped start-up firms at the location receive venture capital (Audretsch and Stephan 1996).
2. Such knowledge spillovers are frequent when it comes to an exchange of codified scientific knowledge and competences, but are still difficult to achieve when tacit knowledge is concerned (Criscuolo 2005), which might even play a role in everyday scientific research. Nevertheless, the internationalisation of technological and scientific education and of the workforce is not new. It was already noticed in 1990 when at Silicon Valley about one-quarter of science MAs working on a PhD came from India or China and accordingly about one-third of the scientists and engineers in the high-technology workforce were not from the US; 74 per cent of all Asian engineers come from India or China (Saxenian 2002). Similarly, about a decade later 41 per cent of UK doctorates were awarded to foreign-born students and 38 per cent of junior researcher in the UK were foreign-born (Ackers 2005). Again, almost 30 per cent of foreign-born workers in the UK were employed in professional occupations (Dickinson *et al.* 2008). The British demand for skilled labour continued and companies continued to hire skilled labour from abroad, in particular in information technologies (IT) and sectors that depend on IT. In manufacturing industries in 2005 the share among information and communication technologies (ICT) was 52.9 per cent, in extractive industries it was 67.8 per cent (Millar and Salt 2008). Britain was considered to be becoming uncompetitive without receiving additional knowledge-workers (Khadira 2001).
3. There is, of course, also an internal brain drain (Ackers 2005), which can be identified within countries in less innovative regions towards those where innovative labour markets provide appropriate jobs.
4. Similarly, in the 1990s approximately 70 per cent of collaborations in biotechnology companies and universities were not local (Audretsch and Stephan 1996; Hilpert 1992).
5. India, and more recently China, are important suppliers of innovative labour, which frequently concentrates at Islands of Innovation. There, they are often founders of high-technology enterprises (Saxenian 2002). Nevertheless, the number of Asian scientists (particular from China) who were schooled in the US and are returning home (Favell *et al.* 2006) is rather small.
6. Already in 1997, 17 per cent of the knowledge-workers in the US were foreign-born (compared to 12 per cent of the population), whereof 19 per cent were engaged in R&D and 20 per cent were engaged in basic research (Meyer *et al.* 2001). The 1990 US census indicates this even more strongly: 58 per cent of immigrants from India held a college degree; the number of foreign-born professionals was 461,000, most frequently from India (55,047) and less from Europe (for example, 6,665 from the UK). The median pay was clearly above the national average and the median age was very young (28 years) (Khadira 2001).
7. Nevertheless, one has to bear in mind that these losses may weaken the innovative capability of a country or region and may add to the human capital of innovative metropolitan areas or Islands of Innovation elsewhere, but they are not providing the basis for the innovative development of these locations because they widely reproduce their researchers and engineers (about two-thirds graduate from universities at their locations). Thus between 1992 and 1994, out of 764,000immigrants from Eastern Europe to Germany, there were about 82,000 highly qualified workers (Straubhaar 2000).

8. If the very early days of these programmes are taken into consideration, the situation is even more impressive. Between 1972 and 1975, US $21.9 million was spent, which makes an average annual funding of US $5.475 million in the early period of this research. This would indicate an increase by 3,973 times, but still showing the same distribution of Islands of Innovation.
9. There is only the Research Triangle Park (RTP) at North Carolina, where 50 per cent are from the region. The RTP is, of course, smaller and developed later as an Island of Innovation in biotechnology. Thus, there were fewer opportunities for regional recruitment based on the university education in the area and consequently a stronger demand for personnel from outside the region to fill the jobs.

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3 Star scientists, Islands of Innovation and internationally networked labour markets

Michaela Trippl

Introduction

New knowledge generated through cutting-edge scientific research is a vital input to technological progress and industrial innovation. Top researchers and elite scientists as possessors of cutting-edge scientific knowledge are therefore potentially a key source of regional competitiveness, spurring new forms of economic development in their location of choice. They might contribute to an increase of the regional stock of knowledge, promote the modernisation of existing industries located in the region and fuel the formation of new research-oriented companies. Moreover, they may play a key role in getting their locations of choice involved in international networks. Thus members of the scientific elite have the potential to contribute to the diffusion of knowledge and provide opportunities for the rise of new forms of regional development.

The overall aim of this chapter is to identify those regions that are involved in the processes outlined above. More precisely, the following three research questions will be addressed:

1. Which regions are characterised by innovative labour markets that empower them to succeed in providing employment opportunities for star scientists, and what is the role of Islands of Innovation and other regions in this context?
2. To what extent do mobile stars move between such places and generate knowledge spillovers between the labour markets of Islands of Innovation by means of their movements?
3. To what extent do elite researchers establish other kinds of international knowledge links and how do they contribute to the diffusion of knowledge at the regional level?

Examining these issues can provide insights for a new approach of regional policy, which focuses on the creation of labour markets for top researchers who contribute to scientific excellence and act as multipliers of innovation. Policy actions may centre on developing employment arrangements and labour markets, which constitute a basis for the attraction of talented people, the regionalisation of innovative potentials, and the participation of regions in international knowledge networks. Recruitment of top researchers and the creation of innovative labour markets can be regarded as appropriate instruments for regional policy to connect regions to the outside world and gain access to and capitalise on the global stock of knowledge.

This chapter will deal with the research questions raised above by focusing on so-called 'star scientists' who have made major contributions to the advancement of science and technology in recent decades. Stars can be identified by the number of citations they generate in the journals of the ISI (Institute for Scientific Information) database in the period 1981–2002. This chapter is partly based on recent analyses of:

1. the spatial concentration of star scientists in the US and European Islands of Innovation;
2. the geography of the international movements of those stars (Trippl 2011a).

It extends the analyses done by Trippl (2011a) by looking not only at Innovation Islands but also on so-called 'research cities'. Islands of Innovation constitute internationally renowned core centres of scientific and industrial competences (Hilpert 1992, 2011) and they are among the world's most important hot spots of science, research and innovation. Looking at a set of indicators such as public R&D expenditure, size of the research infrastructure, number of high-tech companies, etc., Hilpert (1992) demonstrated that only a few places in the US and Europe have the capacity to perform as Innovation Islands. There are strong reasons to assume that these regions and their innovative labour markets offer superior working conditions and opportunities for the further development and diffusion of knowledge and are, thus, highly attractive to star scientists. Furthermore, since star scientists are highly mobile on an international scale, one can expect that they move between such islands, thus contributing to the establishment of an international network between innovative labour markets. As noted above, this chapter does not only focus on Islands of Innovation but also on research cities to find out whether other places (i.e. regions that are not classified as Innovation Islands) are also successful in attracting and retaining stars and in participating in global networks formed by the mobility of stars. Research cities are defined here as regions that host at least one top university (that is, a member university of the Association of American Universities or the League of European Research Universities). Consequently, like Innovation Islands, research cities exhibit scientific competences. In contrast to the Islands of Innovation, however, they lack industrial expertise. A research city, as it has been defined here, can thus be interpreted as a reduced-form Island of Innovation.

The remainder of this chapter is structured in four sections. The first section establishes the conceptual background and provides a short literature review on elite researchers, their mobility patterns and their potentials effects on regional development. In the second section, I describe the data of the study and remark on some methodological notes. The third section presents the empirical results of the analyses of the location pattern, international movements and knowledge transmission activities of star scientists. Finally, the fourth section summarises the main results and draws some conclusions for policy.

Conceptual background and the view from the literature

In the emerging knowledge-driven economy, regional growth and technological change are seen to be intimately linked to the provision of employment opportunities for elite scientists (Zucker *et al.* 2002, Furukawa and Goto 2006, Baba *et al.* 2009). Star researchers are possessors of excellent scientific knowledge and they make outstanding contributions to scientific and technological progress. The creation of innovative labour markets for such stars, however, might have effects that go beyond a positive influence on the region's science base and its academic sector. Recent studies have shown that star scientists have the potential to perform as a key driving force of regional industrial development and innovation, contributing to the diffusion of advanced knowledge by creating knowledge links to regional actors (Schiller and Revilla-Diez 2010; Trippl and Maier 2011b), by combining distant and localised knowledge flows (Trippl 2011b) and by performing as a key source for the rise and transformation of regional high-tech sectors (Zucker *et al.* 1998, 2002).

Scientists in general and elite researchers in particular are highly mobile (see, for example, Skeldon 2009). The literature suggests that star scientists move to and concentrate geographically in only a few places worldwide (Mahroum 2003; Laudel 2005). Stars tend to move to global centres of excellence; they are attracted by those places where the best facilities are available and where their peers reside (Mahroum 2003; Zucker and Darby 2007). This implies that only a limited number of regions provide appropriate labour markets, empowering them to take advantage of the excellence and often scarce (and to some extent tacit) knowledge embodied in star scientists. In the following section, I will examine to what extent Islands of innovation and research cities represent the favourite working places of world-class scientists.

Migration and global mobility of researchers can be regarded as constituting key mechanisms for the international spillover and transfer of embodied scientific knowledge (OECD 2008). Star scientists act as 'knowledge spillover agents' (Trippl and Maier 2011a), transferring knowledge from one place to the other by means of their mobility. By moving between regions and their labour markets, they connect their sending and receiving areas. As a consequence, a system of internationally networked labour markets may be formed. The literature suggests that knowledge flows through mobile talent are not one-way flows but multidirectional ones. Indeed, several studies have shown that talented workers who relocate tend to maintain knowledge links to their previous location (Agrawal *et al.* 2006; Oettl and Agrawal 2008; Jöns 2009), stimulating development in both the sending and receiving regions of highly skilled mobile people.

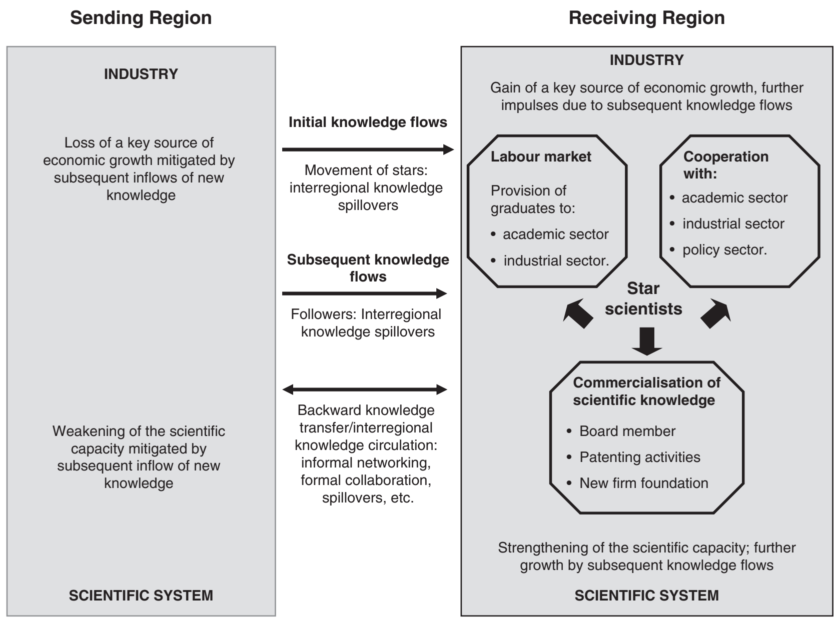

Figure 3.1 Conceptual model
Source: Adapted from Trippl (2011b) and Trippl and Maier (2011a)

Figure 3.1 brings together the issues raised above in a simple model (see also Trippl 2011b; Trippl and Maier 2011a) that constitutes the conceptual background for the empirical analyses in the following section. The model takes as a starting point the movement of a star scientist from Region 1 (sending region) to Region 2 (receiving region). Arguably, such a movement implies an interregional spilling over of knowledge ('initial knowledge flow') and constitutes a network relation between the sending and receiving areas and their labour markets. Provided that mobile stars maintain linkages to their prior location, a range of further knowledge flows between the sending and receiving regions might be observed ('subsequent knowledge flows'). Talented students or members of the former research team of the star may follow the top researcher from Region 1 to Region 2 ('follower phenomenon'), thus generating a further round of interregional knowledge spillovers from the sending to the receiving area. Moreover, if the star keeps close connections to the academic and industrial sector of the sending region, one might observe a circulation of knowledge between the sending and receiving regions and their innovative labour markets.

The model suggested here also takes into account the fact that stars may initiate manifold knowledge links at their current location of choice, thus contributing to the diffusion of advanced knowledge and to the development of regions and their innovative labour markets. One might identify three potential ways in this context. First, stars might have a positive effect on the development of regional labour markets. Elite scientists play a fundamentally important role in attracting the best young talent and they guide them into fruitful research areas (see, for example, Mahroum 2003; Laudel 2005). If these talents educated by star scientists do not relocate after having finished their studies but continue to stay in the region to work for other research organisations or companies, the regional scientific and industrial labour markets can be expected to be strengthened.

Second, stars might also be engaged in regional knowledge-transfer activities by establishing cooperative linkages to regional actors. Such links may include:

1. scientific partnerships with research organisations (academic collaborations);
2. joint R&D projects with regionally-based companies (industrial collaborations);
3. knowledge-sharing activities with policy actors by advising them with respect to innovation and technology programmes (policy collaborations).

Third, regions and their labour markets may also draw an advantage from the physical presence of stars if they engage in more direct forms of the commercialisation of scientific knowledge. This is the case if stars sell patents to regional firms, work part of their time for regional firms as member of the management or advisory board, or even found their own firm in the region.

The model presented in Figure 3.1 enables one to draw some conclusions about the potential effects that may result from the mobility of star scientists. There are good reasons to assume that the arrival of an elite researcher strengthens the labour market, the science base and the industry of the receiving region, while the sending region is likely to suffer from a weakening of its scientific and industrial capacities. The 'follower phenomenon' may reinforce this initial effect. Provided that mobile top scientists maintain linkages with their sending regions, one might observe an international circulation of knowledge that stimulates the development of both the sending and receiving regions. The latter may not only benefit from interregional knowledge exchange but also from a local diffusion of the incoming stars' know-how and expertise. This is the case if the stars engage in regional knowledge-sharing activities and act as a source of well-educated graduates to the regional labour market. The next section explores the extent to which elite scientists located in Islands of Innovation and research cities are involved in interregional and intraregional knowledge-transfer activities, thus potentially contributing to the development of innovative labour markets.

Data and methodology

The empirical part of this chapter is based on a web-based survey (conducted in August and September 2008) of top researchers. In order to identify these individuals, the database 'ISI Highly Cited' was used. This database includes 5,600 'star scientists' (defined as authors of highly cited research papers) who are among the world's top and most renowned researchers. The importance of the contribution made by these stars to the advancement of science and technology is measured by the number of citations they generated in journals in the ISI database. The information in ISI Highly Cited is based on the publications and citations from the period 1981–2002. The database includes the 250 most cited scientists in 21 different areas of research (such as clinical medicine, engineering, physics and social sciences).

To collect data on the location of star scientists, their movements between places and the knowledge connections they create, a web-based survey (conducted in August and September 2008) of star scientists was employed. All 3,274 star scientists who provided their contact information (email address) in the database were contacted and invited to participate in the study. A total of 433 stars were not reachable due to invalid email addresses. Out of the remaining 2,841 star scientists, 720 stars replied and filled in the questionnaire, yielding a response rate of 25 per cent.

Table 3.1 provides an overview of key characteristics of the overall sample. The overwhelming majority of responding star scientists was male (93 per cent) and more than 50 per cent were older than 60, signalling that they were at a relatively mature stage of their professional careers. Not less than 70 per cent of the sampled stars were employed by universities and another 18 per cent were working for non-university research institutions. The proportion of star scientists from the corporate sector was negligible (2 per cent). Looking at the subject areas,

Table 3.1 Sample characteristics (percentages of star scientists)

		Percentages
Gender (N=720)	Female	5.6
	Male	92.6
	Missing	1.8
Year of birth (N=720)	Mean: 1946.5	
Type of institution (N=720)	University	70.4
	Non-university research entity	18.3
	Corporate research unit	2.1
	Other	5.8
	Missing	3.3
Research discipline (N=720)	Natural Sciences	53.3
	Agriculture Science	3.1
	Engineering and Technology	10.1
	Medical and Health Sciences	23.3
	Social Sciences	7.6
	Missing	2.5
Mobility background (N=720)	Non-movers	47.9
	Expatriates	25.1
	Returnees	26.9
Expatriates: years already spent abroad	Mean (min. 0.7, max. 60): 29.5	
(N=181)	1–10 years	11.6
	11–20 years	8.8

(*Continued*)

Table 3.1 Cont'd

		Percentages
	21–30 years	29.8
	31–40 years	30.9
	More than 40 years	16.6
	Missing	2.2
Returnees: years spent abroad (N=194)	Mean (min. 0.5, max. 40): 5.9	
	Less than 1 year	1.6
	1–3 years	49.0
	4–10 years	32.5
	More than 10 years	12.9
	Missing	4.1

biology and biochemistry (8.8 per cent), chemistry (8.2 per cent) and ecology and environment (7.4 per cent) are found to represent the most important research disciplines. If the 21 subject categories are classified according to the Frascati Manual (OECD 2006) into broader fields of science and technology, it can be seen that more than 50 per cent of the respondents were working in the field of natural science, and another 23 per cent in medical and health sciences. Other categories (engineering, social science, agricultural science) play a minor role in comparison.[1]

Table 3.1 also provides information about the mobility background of the sampled stars. No fewer than 52 per cent of them were found to be internationally mobile. The sample included 181 expatriates (25 per cent of all surveyed stars), defined here as stars who left their home countries and now work in a foreign country. On average they had already spent 30 years abroad, reflecting a pattern of permanent migration. Another 27 per cent could be classified as returnees (194 stars), defined here as stars who relocated back home after working abroad for some time. Their movements pointed to temporary migration as they spent on average six years in a foreign location before moving back to their home countries. Almost 48 per cent of the surveyed stars were 'non-movers', i.e. scientists who had, so far, not relocated internationally for professional purposes, but had stayed in their home countries.[2]

The next section investigates whether the US and European Islands of Innovation as they have been identified by Hilpert (1992, 2011) are key locations of choice for the surveyed world-class researchers. In addition to applying Hilpert's list of Islands of Innovation, information from the Association of American Universities (AAU) and the League of European Research Universities (LERU) was used. AAU provides a list of 60 leading public and private research universities in the United States. No fewer than 39 out of the 60 AAU universities are located in the US Islands of Innovation. The remaining 21 universities point to the localisation of strong scientific capabilities outside the Innovation Islands. LERU comprises some of Europe's most renowned research universities.

Out of the 21 LERU universities, 13 are located in an European Island of Innovation and 8 are found outside this group of regions. The regions in the United States and Europe that are not classified as Islands of Innovation but host a top university (i.e. an AAU or a LERU member university) are here referred to as 'research cities'.

Empirical data

This section explores the role of US and European Islands of Innovation and research cities in attracting and retaining star scientists. Furthermore, it investigates whether movements of stars contribute to the formation of a system of internationally networked labour markets and to what extent such movements lead to subsequent global and regional knowledge flows.

Islands of Innovation, research cities and their labour markets: hot spots of star scientists?

The top researchers included in the sample are unevenly distributed across world regions. The United States provides employment opportunities for no fewer than 56 per cent of the surveyed stars and is thus clearly in the lead. Europe hosts 28 per cent of all star scientists, whereas Asia (7 per cent), Canada (4 per cent), Oceania (4 per cent) and other parts of the world (1 per cent) have been less successful so far in developing scientific labour markets for elite researchers. A more detailed analysis of the location of stars in the United States and in Europe reveals they are strongly concentrated in a few regions and highlights the crucial role played by Islands of Innovation and their labour markets in attracting and retaining top researchers.

The US Islands of Innovation and research cities host 80 per cent of the US-based stars (280 top researchers). Key centres include the New York region (made up of New York, Ithaca and places like Princeton, New Brunswick, Newark etc. in New Jersey), Los Angeles/San Diego, the San Francisco Bay Area (covering among others famous places such as Stanford, Berkeley, etc.), Washington/Baltimore, and Boston (Boston and Cambridge, MA). Together these top eight US Islands of Innovation and their labour markets host 55 per cent of all US-based stars.

The other US Islands of Innovation (comprising places like Ann Arbor, Philadelphia and Seattle) employ 39 stars (11 per cent of the US-based scientific elite). Furthermore, the group of major research cities with their excellent universities provides jobs for 50 star scientists, representing 14 per cent of all stars working in the United States.

Apart from one region (Dayton, OH) all US Islands of Innovation identified by Hilpert (1992, 2011) employ at least one of the surveyed stars. Regions that have not been categorised as Island of Innovations or as research cities do not provide significant employment opportunities for star scientists.[3] Only two exceptions are found (Orlando, FL, employing four stars and Millbrook, NY, employing three stars).

Table 3.2 Number of stars employed in US Islands of Innovation and research cities

United States	*Total*	*Natural Sciences*	*Medical and Health Sciences*	*Engineering*	*Social Sciences*	*Agriculture*	*Missing*
Top Islands of Innovation							
New York, NY	35	14	10	4	6	0	1
Los Angeles/San Diego, CA	32	13	8	7	2	1	1
San Francisco Bay Area, CA	29	17	4	6	1	1	0
Washington/Baltimore, MD	29	13	13	2	1	0	0
Boston, MA	21	10	4	1	5	0	1
Dallas/Houston/San Antonio, TX	19	10	4	2	3	0	0
Chicago, IL/Milwaukee, WI	14	7	3	2	2	0	0
Raleigh Durham (RTP), NC	12	7	2	2	1	0	0
Total for the top Islands	*191*	*91*	*48*	*26*	*21*	*2*	*3*
Other Islands of Innovation							
Ann Arbor, MI	8	6	0	1	1	0	0
Philadelphia, PA	8	1	3	1	3	0	0
Seattle, WA	8	3	4	0	0	0	1
New Haven/Hartford, CT	5	2	2	0	1	0	0
Columbus/Cincinnati, OH	3	2	1	0	0	0	0
NY-Upstate Network	3	1	1	1	0	0	0
Pittsburgh, PA	2	0	0	0	2	0	0
Minneapolis/St. Paul, MN	1	0	0	1	0	0	0
Urbana, IL/Lafayette, IN	1	1	0	0	0	0	0
Total for the other Islands	*39*	*16*	*11*	*4*	*7*	*0*	*1*
Research cities							
Boulder, CO	8	6	0	1	1	0	0
Atlanta, GA	7	3	4	0	0	0	0
Charlottesville, VA	6	4	1	1	0	0	0
Bloomington, IN	4	3	0	0	1	0	0
Madison, WI	4	3	0	1	0	0	0
Nashville, TN	4	1	2	1	0	0	0
Cleveland, OH	3	0	3	0	0	0	0
State College, PA	3	1	0	2	0	0	0
Tucson, AZ	3	3	0	0	0	0	0
Gainesville, FL	2	0	0	1	1	0	0
Providence, RI	2	1	0	0	1	0	0
St. Louis, MO	2	1	1	0	0	0	0
Ames, IA	1	1	0	0	0	0	0
Iowa City, IA	1	0	1	0	0	0	0
Total for the research cities	*50*	*27*	*12*	*7*	*4*	*0*	*0*
Total for all Islands of Innovation and research cities	*280*	*134*	*71*	*37*	*32*	*2*	*4*
*Total for the US**	*350*	*179*	*86*	*41*	*36*	*3*	

* Total for the US (including star scientists who provided information about their location at the national level but not at the regional level): 390

The European Islands of Innovation host around 55 per cent of all European-based top researchers included in the sample (103 stars). The regional labour markets of the top eight islands account for 40 per cent of all European-based stars, the other islands host 28 stars and research cities provide employment opportunities for 19 elite researchers. Key places in Europe include the London region (London and Oxford), East Anglia (Cambridge, Norwich), Munich, Copenhagen and Glasgow/Edinburgh. In Europe, one can identify several Islands of Innovation (Hamburg and Frankfurt in Germany, Toulouse in France, Rome and Livorno/Pisa in Italy) and research cities (Freiburg in Germany, Barcelona in Spain) that do not host any of the sampled elite researchers. Furthermore, there are a few hot spot locations of stars that are not classified as Islands of Innovation or research cities. These places include Leuven in Belgium (employment of four stars) and five regions each employing three stars (Aberdeen and Bristol in the UK, Florence in Italy, Lausanne in Switzerland and Würzburg in Germany).

The analysis of the location pattern of stars suggests that both in the United States and in Europe, Islands of Innovation and a few major research cities have been successful in developing highly innovative labour markets, offering significant employment opportunities for top scientists. The analysis has pointed to some differences between the US and Europe. In Europe, the spatial concentration of elite researchers in Islands of Innovation and research cities is weaker than in the United States.[4] As argued by Trippl (2011a), this pattern might be explained by referring to differences in the institutional framework conditions. While the United States benefits from a homogeneous institutional set-up and a common research area, the European countries differ substantially as regards science systems, language and culture. These variations might have a hampering impact on the intra-European movements of stars, leading to a less centralised distribution of stars in Europe.

Networking between innovative labour markets via movements of star scientists

The empirical findings on the location pattern of elite researchers have shown that they tend to concentrate in a few regional labour markets in the US and Europe. There are good reasons to assume that these places are among the most important nodes in the system of internationally networked labour markets that is formed by movements of the scientific elite. As noted in the conceptual section, mobile top researchers act as knowledge spillover agents, transferring know-how and expertise from their sending region to the receiving region by means of their mobility. By moving between places, they establish linkages between innovative labour markets.

This section investigates such movements of the surveyed star scientists. More precisely, it explores to what extent the mobility of stars generates a network between innovative labour markets and connects the Islands of Innovation and research cities to the rest of the world.

Table 3.3 Number of stars employed in European Islands of Innovation and research cities

Europe	*Total*	*Natual Sciences*	*Medical and Health Sciences*	*Engineering*	*Social Sciences*	*Agriculture*	*Missing*
Top Islands of Innovation							
London	26	13	9	1	1	2	0
East Anglia	12	9	2	0	0	1	0
Munich	8	5	3	0	0	0	0
Copenhagen	7	3	1	2	1	0	0
Glasgow/Edinburgh	7	3	3	0	0	1	0
Paris (Ile de France)	6	4	0	1	0	0	1
Amsterdam/Rotterdam	5	3	2	0	0	0	0
Milan/Torino	4	2	2	0	0	0	0
Total for top Islands	*75*	*42*	*22*	*4*	*2*	*4*	*1*
Other Islands of Innovation							
East Midlands	3	2	1	0	0	0	0
Heidelberg	3	0	1	2	0	0	0
Madrid	3	3	0	0	0	0	0
Rhein-Ruhr	3	1	0	0	0	2	0
Stuttgart	3	2	0	1	0	0	0
Bologna (Emilia Romagna)	2	2	0	0	0	0	0
Strasbourg (Alsace)	2	2	0	0	0	0	0
Wageningen (Oost-Nederland)	2	2	0	0	0	0	0
West Midlands	2	0	1	0	1	0	0
Berlin	1	1	0	0	0	0	0
Bordeaux (Aquitaine)	1	1	0	0	0	0	0
Kaiserslautern	1	0	0	1	0	0	0
Lyon-Grenoble (Rhone-Alpes)	1	1	0	0	0	0	0
Napoli (Campania)	1	0	0	1	0	0	0
Total for other Islands	*28*	*17*	*3*	*5*	*1*	*2*	*0*
Research Cities							
Zurich	6	3	1	2	0	0	0
Leuven	4	3	0	1	0	0	0
Helsinki	3	2	1	0	0	0	0
Lund	3	3	0	0	0	0	0
Geneva	2	2	0	0	0	0	0
Utrecht	1	0	0	1	0	0	0
Total for research cities	*19*	*13*	*2*	*4*	*0*	*0*	*0*
Total for all Islands and research cities	*103*	*59*	*25*	*9*	*3*	*6*	*1*
*Total for Europe**	*192*	*112*	*48*	*17*	*5*	*8*	

*Total for Europe (including star scientists who provided information about their location at the national level but not at the regional level): 197

As shown in the conceptual section, 181 stars (25 per cent of all sampled scientists) can be classified as expatriates. The US performs as a main receiving area, providing employment opportunities for no fewer than 110 expatriates, attracted particularly from Europe (61 expats), Asia (15 stars), Canada (11 stars and Oceania (10 stars). As revealed in Figure 3.2, within the US, Islands of Innovation and research cities act as magnetic centres for expatriates. Around 80 expatriates (73 per cent of all expatriates who are located in the US) work in an Island of Innovation or in a research city. One can find strong links between their labour markets and European ones via the mobility of expatriates. The US Islands of Innovation and research cities do not only benefit from an inflow of expatriates from European Islands of Innovation and research cities. Other European regions and other parts of the world seem to suffer from a loss of stars to top places in the United States. Arguably, the weaker labour markets of the sending regions and the superior working conditions in innovative labour markets in the US may be among the key factors driving the relocation of stars.

European labour markets have attracted 40 expatriates, many of them (26 stars) from European countries. There is therefore clear evidence for intra-European flows of expatriates. Europe, however, seems to be rather unsuccessful in attracting expatriates from non-European countries and regions.

Analysis of movements of returnees (197 star scientists, or 27 per cent of all surveyed stars) provides a different picture. Europe in general and European Islands of Innovation and research cities perform as core centres, showing a strong capacity to lure star scientists back home. Europe provides employment opportunities for no fewer than 88 returnees (45 per cent of all investigated

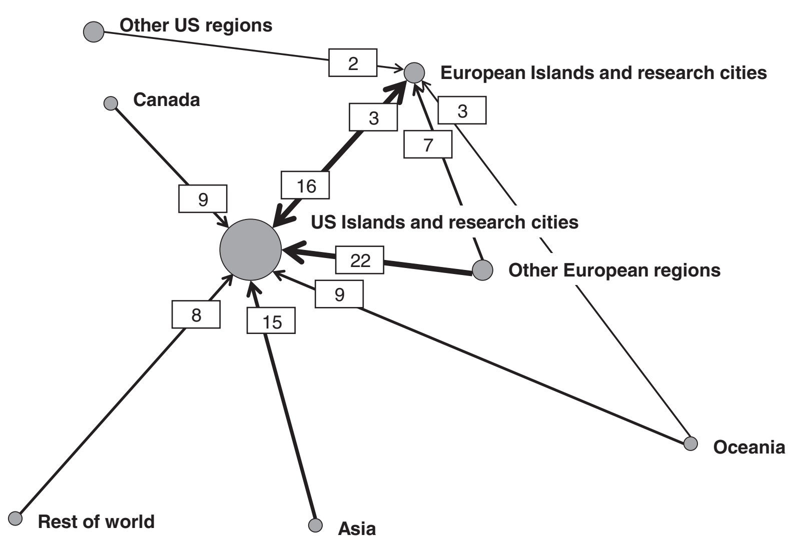

Figure 3.2 Movements of expatriates to US and European Islands of Innovation and research cities

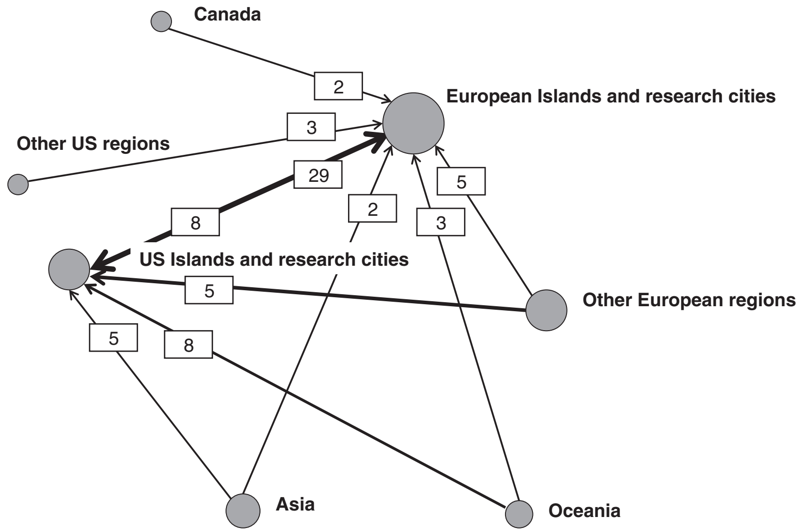

Figure 3.3 Movements of returnees to US and European Islands of Innovation and research cities

returnees included in the sample). The US, in contrast, hosts only 48 returnees. Movements of returnees generate strong links between the US and European labour markets. Europe benefits strongly from return flows of stars that have worked for some time in the US (54 stars) while flows in the opposite directions are less intense (21 stars). Furthermore, there is some evidence for flows of returnees between European places (18 stars).

US Islands of Innovation and research cities are the key sending regions of stars returning back home to Europe. One can identify strong linkages between these top places in the United States and European Islands of Innovation and research cities. More than 60 per cent (29 stars) of the stars that returned to European Islands of Innovation and research cities have temporarily worked in an US Island of Innovation or research city (Figure 3.2). These top places in the United States seem to be highly attractive for star scientists who move away on a temporary basis. This might reflect their innovative labour markets for mobile star scientists. Looking at stars that return to US Islands of Innovation and research cities, one can observe that they have many different sending regions.

Figure 3.4 illustrates the movements of mobile stars (i.e. both expatriates and returnees) between Islands of Innovation and research cities in the United States and in Europe and the resulting network between innovative labour markets.[5] Arguably, this network has a strong transcontinental character. Indeed, most links are between the top US and European labour markets. There is relatively little evidence for links among European labour markets. A few regions (in particular San Francisco, Boston, London, East Anglia, Copenhagen) perform as key sending and receiving areas of mobile stars, while others (for instance, Dallas, Raleigh

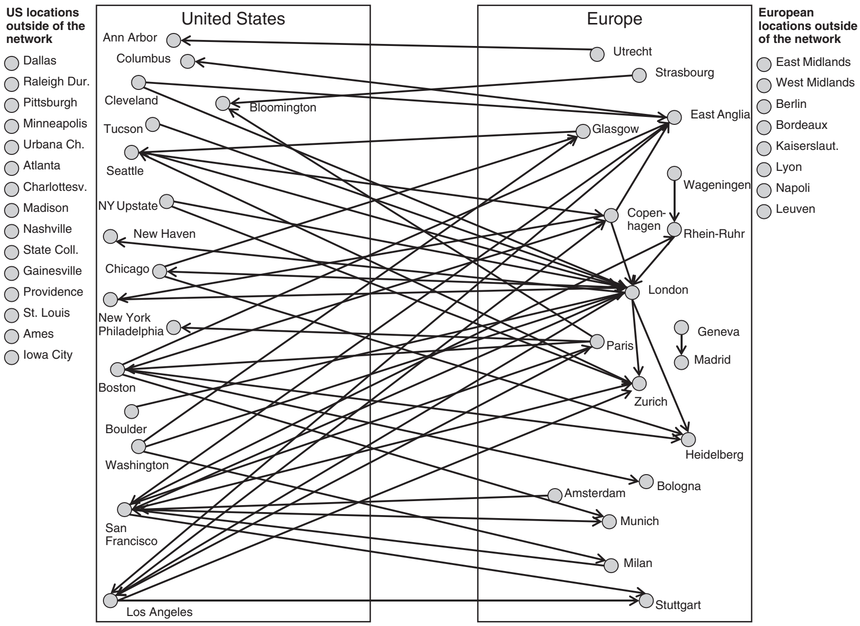

Figure 3.4 International networking between innovative regional labour markets (flows of both expatriates and returnees)

Durham, Berlin, Leuven) are not part of the network. Arguably, they have links to regions that are not classified as Innovation Islands and research cities.

To summarise, the surveyed star scientists tend to be highly mobile and concentrate geographically in a few areas. US and European Islands of Innovation and research cities play a key role in this regard, while other regions seem to be less capable of attracting and retaining the scientific elite, to capitalise on the exchange of stars or to benefit from related global flows of excellent scientific knowledge. In order to catch up with the leading Islands of Innovation and research cities, these areas face the challenge of investing massively in developing job opportunities for stars. Arguably, only a few wealthy regions that exhibit sufficient financial resources to adopt this policy strategy may achieve sustained success in attracting stars and in creating innovative labour markets similar to those prevailing in Islands of Innovation and research cities.

Moving beyond initial knowledge spillovers: subsequent knowledge flows triggered by star scientists

Mobile stars contribute in substantial ways to the international circulation of new knowledge. They act as 'knowledge spillover agents', transferring knowledge from the sending region to the receiving region by means of their mobility. The previous section has provided some insights into the respective geography of flows of stars and thus flows of knowledge embodied in these outstanding individuals. However, as noted in the conceptual section, it is too simple to consider only this initial effect. A range of subsequent knowledge flows might be observed, connecting the sending and receiving areas of the scientific elite. The analysis of the knowledge-sharing activities reported by the surveyed stars provides clear support for this view.

Stars located in US and European Islands of Innovation and research cities are strongly engaged in knowledge-transfer activities. More than one-third of the mobile stars included in the sample stated that their own movement abroad (expatriates) or back home (returnees) has led to further movements of followers (scientists or students) from their prior location. Thus there seem to be substantial knowledge spillovers from the sending regions to the receiving ones via the mobility of stars and the people following them. Furthermore, mobile stars keep close linkages to actors in the sending region. More than 80 per cent reported maintaining ties to the scientific community in their prior location and a considerable share seemed to exchange knowledge with firms in their sending regions.[6] Stars located in European Islands of Innovation and research cities, however, have more industry contacts than their counterparts in the US.

Star scientists are strongly engaged in creating knowledge links at the regional level, i.e. in their current location of choice. Almost 90 per cent of the stars who are located in US and European Islands of Innovation and research cities contribute to the diffusion of knowledge by providing skilled graduates to the scientific labour market. Another 70 per cent reported acting as a source of graduates who become employed by firms located in the region. By doing so, stars can be expected to strengthen the regional labour market. The mobility of skilled students educated by stars to research organisations or firms is a key mode of knowledge transmission, promoting the diffusion and commercial use of advanced scientific know-how. Stars also have manifold collaborative links with actors from the academic, industrial and policy sectors. Nearly 100 per cent of stars working in Innovation Islands and research cities of the US and Europe maintain regional academic collaborations. Around 70 per cent of them are engaged in R&D projects with companies while a similar share is stated to have policy collaborations by advising policy actors regarding innovation and technology programmes in the region. Finally, stars are also engaged in more direct forms of commercialising advanced scientific knowledge. More than one-third of the stars located in US and European Islands of Innovation and research cities sell patents to firms and more than one-quarter of them act as a member of the management or advisory board of regionally-based companies. Around 15 per cent of them reported having founded their own firm at their current location of choice.

The analysis of regional knowledge-transfer activities performed by the surveyed star scientists demonstrated that these outstanding individuals do indeed act as multipliers of innovation. They attract other highly skilled researchers to the region, strengthen the regional labour market by providing well-educated graduates and engage in various forms of knowledge transmission to the regional

Table 3.4 Subsequent knowledge flows established by star scientists (percentages of stars)

	United States			*Europe*		
	Islands of Innovation	*Research cities*	*Total US*	*Islands of Innovation*	*Research cities*	*Total Europe*
International links (only expats and returnees)						
Scientific contacts*	82	95	85	93	80	89
Contacts to industry*	20	5	15	38	80	41
Follower phenomenon	36	40	37	37	30	42
Regional links (mobile and non-mobile stars)						
Regional labour market						
Provision of graduates to the scientific labour market*	86	82	84	87	94	90
Provision of graduates to firms*	70	70	69	72	88	78
Collaborations						
Academic collaboration*	99	98	99	97	100	98
R&D projects with firms*	76	64	75	77	72	80
Advise policy actors*	70	72	69	76	72	75
Direct forms of commercialising knowledge						
Selling patents to firms	38	36	34	31	44	32
Member of firm board	32	25	27	25	28	25
New firm foundation	16	10	14	13	22	15

*Activities performed at least occasionally by the surveyed star scientists

industrial world. These findings provide support for the view that the recruitment of star scientists and the active promotion and support for multiplier effects to set in could be key elements of the repertoire of regional policy makers.

Interestingly, there are only a few differences between stars in US Islands of Innovation and research cities and those working in European Islands of Innovation and research cities. Furthermore, stars located in Islands of Innovation and research cities hardly differ in their knowledge-transfer and diffusion activities from the total US and European samples. Consequently, one might argue that stars – due to their embodied knowledge and energy – act rather independently from the specific conditions at their current location of choice. The regional effects of their activities, however, can be expected to differ enormously among regions, relying strongly on their absorptive capacity. One might expect that Islands of Innovation and research cities are better equipped with such capacities than other places. However, it is beyond the scope of this chapter to provide empirical support for this hypothesis. To measure the regional effects of stars' activities and their variation across regions should be a key issue for further analyses in the future.

Summary and conclusions

New knowledge produced through cutting-edge scientific research is a crucial input to regional innovation and technological progress. Star scientists as possessors of advanced scientific knowledge are increasingly recognised as an essential source of the competitive strength of their location of choice. They contribute to the growth of the regional stock of knowledge, promote the formation of science-based industries and the modernisation of ancestral branches, and they link their home regions to international networks by means of their mobility and global knowledge-sharing activities.

In this chapter an attempt was made to identify the regions that are involved in such processes, focusing in particular on the role of Islands of Innovation and major research cities in the United States and Europe in proving innovative labour markets for world-class scientists and taking part in the exchange of these stars.

Drawing on a survey of 720 highly cited star scientists it was found that they concentrate geographically in a few regions. Analysis of their location pattern revealed that US and European Islands of Innovation and research cities have a very strong capacity to attract and retain stars, performing as mega-centres of elite researchers. It can be assumed that these regions have succeeded in creating dynamic labour markets and providing favourable conditions for scientific breakthroughs and the commercialisation of research. In the United States, the spatial concentration of top researchers in a few Innovation Islands and research cities was found to be stronger than in Europe. As argued by Trippl (2011a), this might have to do with the fact that the US benefits from a common research area and homogeneous institutional framework conditions. Europe, in contrast, lacks such institutional advantages. Strong differences between European countries as regards language, education and science systems, research and culture might lead to lower mobility and a less intensive clustering of stars in space.

World-class scientists tend to be highly mobile and they have the potential to act as 'knowledge spillover agents', transmitting embodied expertise and know-how from one place to another by means of their spatial movements. Analysis of the geography of movements of the surveyed stars has pointed to an interesting pattern of connections between regional labour markets. The US and European Islands of Innovation and research cities are linked to each other via the movements of expatriates. These movements, however, reflect one-way flows from Europe to the US. Furthermore, it was found that US Islands of Innovation and research cities benefit from an inflow of world-class researchers from other parts of the world. Geographical movements of returnees were found to generate strong links between US and European Islands of Innovation and research cities. With regard to returnees, the net flow is biased in one direction, clearly favouring the top places in Europe. The innovative labour markets of the regions under consideration here constitute an international network via the exchange of expatriates and returnees. However, not all Islands of Innovation and research cities take part in this network. The network that is formed by mobile stars is transcontinental. Ties between US and European top regions dominate, while only a few links between European Islands of Innovation and research cities were found.

Finally, it was also shown that the surveyed top researchers do not only connect their sending and receiving regions by means of their mobility but also by setting in motion a range of subsequent knowledge flows between these places. This chapter provided evidence that mobile star scientists who are located in US and European Islands of Innovation and research cities tend to keep close connections to their sending areas and exchange knowledge with researchers and to a lesser extent companies. Furthermore, it was shown that the 'follower phenomenon' (i.e. students and researchers following the star to his or her new location) is rather common, leading to international knowledge spillovers. Finally, it was demonstrated that the surveyed stars are strongly integrated in their current location of choice. They contribute to a further strengthening of the labour markets of Islands of Innovation and research cities by acting as a source of graduates to regional firms and research organisations. Stars were also found to establish manifold cooperative activities with the research community, firms and policy actors located in the region, and sometimes they found their own companies and engaged in other more direct forms of the commercialisation of scientific knowledge. Consequently, stars residing in Islands of Innovation and research cities contribute in multiple ways to the diffusion of cutting-edge scientific results at the regional level. Interestingly, it was also shown that stars located in the top places (i.e. in US and European Islands of Innovation and research cities) hardly differ in their international and regional knowledge-sharing activities from stars located elsewhere.

The arguments raised in this chapter allow for some concrete policy considerations. Arguably, creating and further developing an attractive labour market for star scientists appears to be one key ingredient (among others) to future processes of science-based innovation. Those regions that have the capacity to develop such labour markets can participate in international world-class research by attracting and retaining top researchers, who further attract outstanding scientists and young research talent. Consequently, to actively recruit star scientists, provide international mobility schemes for top researchers, establish and keep at the forefront internationally renowned universities and prestigious research facilities, secure the availability of the best and latest scientific equipment, and provide excellent educational opportunities for young talent and high-quality living conditions might be crucial policy actions. The creation of innovative labour markets empowers regions to be among the leading centres of scientific research, participate in the international exchange of outstanding researchers and potentially become core centres of the commercialisation of the knowledge embodied in these individuals.

Notes

1. Looking at the year of birth, research disciplines and current location (world region) of (a) the total population of stars included in the database, (b) those who provided a valid email address (that is, those who have been reached), and (c) the responding stars, Trippl (2011a) has shown that the first two groups are very similar. No age, discipline or regional bias was found when it came to the accessibility of stars by email addresses. A comparison of the responding stars with the total population, however, has shown that the sample is not fully representative. First, the responding stars were found to be slightly younger than the total population. Second, social sciences and agricultural sciences were found to be under-represented in the sample, while natural sciences and engineering and technology were somewhat over-represented. Third, and most important, it was found that stars located in the United States were under-represented; those working in other parts of the world were over-represented in the sample. The results given in the next section may, thus, underestimate the role of the United States and its Islands of Innovation and research cities in providing employment opportunities for stars.
2. Chi-square tests have shown (see Trippl 2011b) that there are no statistically significant differences between expatriates, returnees and non-movers in terms of key sample characteristics such as age, gender or type of institution. Only the hypothesis that the distribution of the three groups of stars across research disciplines is the same could be rejected (at the 5 per cent level of significance). Compared to mobile stars, the proportion of non-movers doing research in the field of natural sciences was found to be lower, while the share of non-movers working in medical and health sciences was found to be higher (particularly when compared with expatriates).
3. Table 3.2 also reveals that the role of Islands of Innovation and research cities as main working places of star scientists is not confined to specific scientific disciplines.
4. The hypothesis that the distribution of elite researchers across top islands, other islands, research cities and other regions in the US and Europe is the same was tested by a Chi-square test and rejected at the 1 per cent level of significance.
5. The construction of this network is based on a rather low number of observations. The interpretation of key features of the network should, thus, be understood as tentative remarks.
6. For further analyses of the nature of these international linkages and the relative importance of different types of knowledge transmission (research cooperation, contract research, joint publications, etc.) see Trippl (2011b).

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4 Metropolitan area migration patterns of the scientific and engineering workforce within the United States

Vijai Singh and Christopher Briem

Introduction

Human creativity is at the heart of economic and social dynamism in societies. Even within the same nation, various regions differ in their quest for scientific research and development. In a sense, there is a culture of scientific discovery and innovation that often has historical roots which go back more than a generation. Such regions exist in advanced as well as emerging economies. Clearly, there are several factors that must be present to enable such developments, but it is human capital that is most important. It is people with scientific curiosity and the ability to take risks that make scientific discoveries possible. Some local endowments are unique in creating economic opportunities and attracting people with skills and enterprise. This creates a movement of people between regions so that there is an adequate match between available opportunities and people who are willing to take advantage of them. It is this type of environment that encourages migration between nations, regions, and often within a local community itself.

The availability of knowledge-workers in a region or nation reflects its scientific capabilities for creating new innovations, and engaging in scientific discoveries that are tailored to address important societal needs. Scientific personnel are trained in particular locations but their work is rarely geographically confined. Geographic mobility enables them to locate in places that provide greater opportunities for collaboration and further enhancement of their scientific pursuits. This process forms the basis of regional scientific innovation and competencies. Regional specialization is not a random event; it is based on locational endowments in the form of the available agglomeration of similar scientific and technological pursuits. Inter-institutional collaborations become common in order to maximize regional competence and, in some instances, regional dominance in certain scientific fields. Migration becomes a normal process of bringing like-minded scientific personnel together.

Knowledge and knowledge-workers are mobile. Knowledge is shared instantaneously by various means among scientists located in different regions. In spite of this fluidity, knowledge production still occurs in particular locations based on the availability of research infrastructure and scientific personnel. However, there is a sharing of knowledge among scientific personnel between different locations both domestically as well as internationally. In fact, in recent years some governments have instituted flexible visa policies to facilitate the geographic mobility of scientists and engineers. However, there are still governmental regulations and institutional practices that influence these multi-faceted collaborative endeavors. Each side seeks collaboration for mutual benefit and the sharing of risk, which accelerates the process of scientific advancement. Ultimately, the concept of comparative advantage must guide this process. Local and regional scientific strengths should be understood by participating regions. It requires the involvement of relevant stakeholders and careful coordination of their activities to achieve tangible results. This happens when appropriate changes are made in organizational structure, the recruitment of personnel, and the processes of decision-making as more information and experiences are gained.

There are barriers to the mobility of people and access to knowledge. Knowledge production is not cheap and therefore the sharing of knowledge and information becomes commoditized, even though such approaches are not always successful. The ‘knowledge communities’ that include scientists and scientific institutions (both public and private) create their own culture for the production and dissemination of knowledge. This facilitates scientific discoveries and commercial applications. These endeavors bring improvements to human health and general human well-being.

Regions that have the presence of scientific institutions and expertise are interlinked with other regions that share similar interests and opportunities. As abovementioned, this enables them to enhance their own goals and seek new levels of scientific and technological entrepreneurship. It is also important to recognize the importance of local public support for such initiatives. Civic, political, and academic leadership must encourage efforts to attract capital investment for these ventures from within the region as well as nationally and internationally.

Many scholars have observed that the local environment must be conducive to attract business investments and a talented and trained workforce for economic growth and dynamism (Wolman *et al.* 2008). The availability of an educated workforce is at least partly contingent on whether there are higher educational institutions and research opportunities in the community itself or in close proximity. These conditions also promote collaboration among regional stakeholders, such as the private sector, government, and educational institutions. People from outside the region find opportunities to migrate to this type of region.

A skilled workforce has a tendency to congregate in areas that have opportunities for scientific research and innovation. Demand for skilled labor is created when new high-technology enterprises are established (Berry and Glaeser 2005). They are usually located in the midst of high-technology areas. In addition, there is a tendency for new high-technology organizations and skilled workers to locate in the same areas for mutual benefits.

Major centers for scientific research are usually located in or near major metropolitan regions. These are also the locations of major universities and research centers. It enables them to recruit scientists and engineers for a variety of positions with great flexibility. Winters (2008) has observed that since metropolitan areas have major educational institutions in their vicinity, it is easier for business enterprises and other organizations to recruit people with relevant skills. In many instances, graduates themselves prefer to start their careers in an environment most familiar to them. Opportunities for entrepreneurship are essential for accomplished scientists and engineers who are already there and also attract others from the outside (Trippl 2010).

The presence of research-intensive universities in a region creates opportunities for collaborations in research and scholarship. It enhances a dynamic that brings people together who have shared academic interests (Abel and Deitz 2009). Zucker *et al.* (1998) showed the importance of star scientists, who are often associated with research universities, to the commercialization of new technology and the formation of a new high-tech industry. The ethos of research and innovation is sustained with an infusion of new ideas, and as more knowledge and information is gained and new challenges emerge for researchers. There is constant circulation of the individuals who form research partnerships. Production of knowledge and its dissemination across regional and national boundaries must be encouraged. However, any meaningful collaboration is not a random event. It is very often based on the continuous exchange of research findings, new ideas, and applications. Publications in scientific journals and periodic meetings and conferences offer opportunities for mutual learning and collaborative opportunities that transcend regional and national boundaries.

The impact of economic globalization is not limited to large-scale economic shifts, especially in employment and wages between nations and regions. The metropolitan regions are the hubs of economic activity and population dynamics. The skilled and educated move to places that offer them better opportunities to utilize their talents and abilities (Favell *et al.* 2006). There are still professional and personal barriers to the unrestricted mobility of professionals, but such obstacles are far less important at the regional level. There is rapid mobility of both capital and labor within a region in response to changes in the local economic environment. This chapter highlights some of the major factors that contribute to labor migration. The impact of migration has both positive and negative consequences. The introduction of new technologies and management practices necessitate a new configuration of the workforce to enhance productivity and the quality of goods and services. Many workers acquire new skills and education to become more marketable. It should be pointed out that many businesses have their own internal education and training programs as they introduce new technology, products, and services. A great many opportunities are made available to workers to ensure that they are not lured away by the competition.

Workforce development as an economic development tool is not new in concept, theory or practice. Yet the emphasis on building human capital at a regional level has never had a higher priority in local economic development policy than it has now. The supply of high skilled technical workers has become an ever-larger policy concern at both national and regional levels. Investment in training, attracting and retaining these workers, especially those with skills in science and engineering occupations, has become a key part of economic development policy at the national level. The agglomeration of human capital in specific occupational skills sets is perceived to be a key factor of national competitiveness. An increasing policy focus is based on the realization that this same type of competition for workers exists at sub-national levels as well.

Migration is known to be a major factor impacting the supply of highly skilled workers. Much research has focused on the international migration of members of the highly skilled workforce. Perceived issues of 'brain drain' have long been seen as major concerns in developing nations, which see their best and brightest students depart for training and education in other countries, many of who do not return. These flows have historically been one-way migration with only minimal return of these workers to their country of origin.

Migration is selective, even when the pull and push factors are strong. Age, sex, economic, and personal preferences are involved in complex ways based on the context. The migration process of educated people is different from those who have low education or skills. There are those who move only short distances such as between communities or counties, but there are also migrants who travel long distances within a nation or between nations. Some factors, such as economic incentives, are common but there may be other factors, such as political, linguistic, or cultural, which play a dominant role in migration decisions. One must be careful to distinguish migration indicated by factors that are primarily individual and migration indicated by other factors that may be related to decisions at the group level.

The migration of groups is generally related to political, religious, cultural, and ethnic affiliations. However, in the contemporary United States, such events are rare. Even group migration is motivated by individual self-interest, even though in the end it may look like a group activity. People move in search of economic opportunities in the proximity of relatives and friends, climates, and cultural amenities. It should also be noted that migration patterns are closely related to lifecycle events as they are linked to education, marriage, family formation, and work. Some move to another location to find a more stable job or to achieve better wages. The changing employment environment necessitates labor migration. With a growing concentration of the American workforce in service jobs, the migration of workers has continued, often if only short distances.

There has been significantly less focus on studying the dynamics of the internal migration of workers in specific occupations within national borders. In the United States, the distribution of highly skilled workers across metropolitan regions should be analyzed in relation to economic activities. The availability of highly skilled workers is increasing in importance not only as a factor in national competitiveness, but also in local and metropolitan area competitiveness. While local workforce development efforts that are focused on training local workers are a nearly ubiquitous part of local economic development policy, migration flows within the United States are a key factor impacting changes in local labor forces. Migration is known to be highly selective and migration rates peak for those in their early workforce years, typically after completing their final education. The result of these general migration patterns means that migration has a differential impact on specific occupational workforces and an even greater impact on the workforces of specific regions within a nation.

The importance of migration in the growth role of workforce immigration has taken on heightened priorities in economic development literature at the regional level in the United States. High levels of mobility have always characterized the United States' workforce. Yet the paradigm of worker migration following job growth mitigated the role of human capital as a competitive advantage at the regional level. The evolution of competitive advantage has seen the diminished impacts of natural geographic factors that once defined the specialization and agglomeration of industries across regions. The ability to grow, attract, and retain a highly skilled labor force is seen as an ever-larger part of the overall competitive position of a region. The migration of workers has always been a factor impacting growth and change for regions. Historically, the implicit assumption has been that workers would follow job growth wherever it was occurring in the United States. The mobility of the US labor force may be one of the greatest factors fostering the sustained growth of the US economy through much of the twentieth century.

This chapter will focus on describing the regional migration patterns of a set of highly skilled workers within the United States. Microdata available from the US 2000 decennial census provides data on a large cross-section of all US workers and their recent migration behavior. The specific workers are defined by a set of scientific and engineering occupations for US resident workers. These workers are among the most mobile within the already highly mobile US labor force and are also the focus of inordinate policy efforts to attract and retain them. The impact of migration patterns for specific metropolitan statistical areas (MSAs) is studied because MSAs are defined to reflect integrated labor markets at the subnational level in the United States.[1] This makes MSAs the ideal geographical level at which to study workforce development and local economic development policy in the United States. The differential patterns of migration among large metropolitan regions is compiled along with the impact of international migration flows in specific technology occupations.

Literature review and motivations

The more fundamental research on the spatial impacts of human capital accumulation goes back to Lucas (1988) who showed that the accumulation of human capital can make local labor more productive. This work has been extended by a broad range of studies focusing on the importance of geography in R&D and innovation, and ultimately regional economic growth. A sample of studies looking at the importance of the geography of innovation includes Jaffe *et al.* (1993), Audretsch and Feldman (1996), and Anselin *et al.* (2000).

The state of regional labor markets often skips analysis of the means and methods by which localized workforces change. Specifically, inter-regional, or more specifically inter-metropolitan, migration flows have not always been considered in an analysis of regional labor markets. Many models of local labor markets simply assume that labor supply is infinitely elastic for every occupation (Sweeney 2004). If that premise is not valid then the ability of regions to attract and retain workers is a crucial factor in growth and competitiveness. The failure of that assumption is likely to impact the more specialized or niche labor market made up of highly skilled workers.

There is a long history of factors that broadly impact inter-regional migration decisions. Migration is known to be highly selective by age, education, and other factors (Hoover and Giarratani 1999). Such heterogeneity in migration patterns implies migration research and policy is best focused on narrow groups of workers. Metropolitan characteristics along with personal situations are known to impact location decisions made when moving between metropolitan areas in the United States (Greenwood 1975). While highly skilled workers are known to have a higher propensity to migrate, their actual location decisions have not always been observed to be different from the location decisions made by other workers (Herzog *et al.* 1986). More recent work suggests that science and technology graduates choose to migrate to better educated regions (Gottlieb and Joseph 2006). If so, an open question remains as to why the focus is on policies aimed specifically at attracting and retaining technology workers. If high-tech workers behave no differently from other workers then there would be minimal policy implications based on the study of high-tech workers. Yet there has been growing interest, internationally and domestically, in the movement of highly skilled technical workers.

The focus on the workforce is not unique to technology workers, but one reason for program-based workforce programs is that technology-based industries are seen as much more dependent on their human capital assets than is typical in other industries (Malecki 1989). Workers in technology-based occupations, not unlike those in most specialized fields, are competing not just in regional labor markets, but in national and international labor markets (Ladinsky 1967). For the highest skilled occupations, regional labor markets are also directly impacted by international immigration. The interaction of internal and international labor markets has been a focus of a broad range of research and policy. Less is known about the occupation-specific, or region- and occupation-specific, differences of international immigration on local labor markets.

Technology-based industries have not only exhibited exceptional growth in recent decades, but technology employment differs in the observed rates of turnover and job tenure. Technology employment can be much shorter than is typical in other industries or occupations. Higher levels of turnover and shorter periods of employment with an employer have been shown to characterize high-technology labor markets (Angel 1989). If workers must plan on a sequence of short-term jobs versus long-tenure jobs, the agglomeration of available opportunities and labor force turnover could be amplified factors in migration decisions.

Recent focus on the migration of highly skilled technical workers extends to work by the National Science Foundation on the implications of skilled international worker migration (Regrets 2007). The agglomeration of highly skilled workers at a local level has been argued to have a disproportionate impact on regional economies (Saxenian 1985, 1994, 2002). Concentration of human capital is argued to be a key factor in explaining regional economic growth patterns in the United States (Glaeser 2000). As a result, local economic development policies have focused more and more on workforce development efforts.

Regional economic efforts have goals to both attract and retain highly skilled workers, but also work to avoid 'brain drain', characterized by the out-migration of skilled workers. The argument that the agglomeration of workers with specific skills is a key factor in regional economic growth is a central tenet of the 'Creative Class' policies popularized by Richard Florida (Florida 2002, 2004). It is a separate question as to which policies can achieve these goals of impacting professional workforce migration. Ó hUallacháin and Leslie (2005) look at high-technology agglomeration in the US and conclude that creative, skilled professionals seek to reside in states that offer both well-paying jobs in high-technology manufacturing and producer-services sectors and easy access to rural outdoor recreation and leisure amenities. Whether these workforce-based policies have been effective at promoting regional growth has yet to be shown and the efficacy of 'Creative Class'-focused efforts has been disputed (Hoyman and Faricy 2009). Nonetheless, the focus on workforce development as a causal factor promoting regional growth has only increased. It is even an open question as to whether public policy can substantially alter metropolitan area labor force trends in the long term.

There is a growing disconnect between past observations that highly skilled workers behave much as other workers and the growing policy focus on attracting and retaining these specific workers. Ongoing debates over the efficacy of these policies are unlikely to be resolved soon,; the same can be said for debates on the methods that would work best to attract highly skilled technical workers. In the future it is likely that trends in local economic development policies will only invest more in programs aimed at building local technology worker agglomerations. Extant research has some way to go in order to match the efforts and justify or critique the efficacy of these programs.

Here the use of large microdata files available from the US 2000 decennial census has been used to compile occupation-specific migration patterns impacting metropolitan region labor forces. The focus on technology-based, highly skilled occupations matches the growing emphasis local economic development policies place on attracting and retaining these workers. Whether there are substantial differences in the composition of regional labor forces and the role migration has in producing those differences is a crucial question in policy evaluations. Understanding the current state of workforce migration of the most sought-after workers will provide a basis for evaluating the potential impacts of migration-focused policies on metropolitan area growth and competitiveness.

Data and methodology

Individual-level data on migration is available in data distributed from the US 2000 Census 5 percent Public Use Microdata Sample (PUMS) files. The PUMS files contain person-level information from a 5 percent sample of housing units in the United States. A unique file exists for each state, and the entire PUMS dataset contains records for over 14 million people in over 5 million housing units. The PUMS data includes a broad set of variables collected from the long-form questionnaire used in the decennial census. The 2000 decennial census long-form questionnaire was provided to approximately one in six households.

The long form of the 2000 decennial census asks for each individual's place of residence in past years. The 2000 PUMS data releases data at the individual record level for each person's residence in 1995, five years prior to the date of the census. Within the 5 percent PUMS datasets, the past residence of individuals can be identified down to the PUMA area. PUMAs are a geographical level created for the reporting of PUMS data without violating confidentiality restrictions on the use of Census Bureau microdata. All PUMAs were indexed to MSAs as defined in 2000.[2] The resulting data allows for the characterization of migration flows in and out of a specified metropolitan area. The metropolitan areas used here are the MSAs or Combined Metropolitan Statistical Areas (CMSAs) defined as used for the 2000 census. Specific focus will be on the 25 largest MSAs or CMSAs as ranked by total population in 2000.

The 2000 census PUMS data also has information on each employed person's industry and occupation. The focus here on the scientific and technical workforce is defined by the occupational choice of individuals as self-identified on census questionnaires. The categorization of occupations comes from the US Standard Occupation and Classification (SOC) system. The SOC has 22 major and 517 detailed occupation codes. For the research here, the definition of the scientific and technical workforce is made up of workers in one of three major occupation categories: computer and mathematical occupations, architecture and engineering occupations, and life, physical, and social science occupations. Sixty-seven detailed occupation categories are defined within these three major occupation groups. The detailed occupations making up the science and engineering occupations and their associated major occupation groups are itemized in Table 4.1.

Results

The selected science and engineering occupations have the most mobile workers in the United States. Figure 4.1 shows the prevalence of recent migration among each of the 22 major occupation groups defined by the SOC system. Across these major occupation groups, recent migration is defined as the proportion of the employed workforce that resided outside their current MSA five years prior. This ranged from a low of 7.2 percent for workers in production occupations to a high of 17.8 percent for workers categorized as being in life, physical, and social science occupations. The three selected occupation groups are among the top four when ranked by the prevalence of recent movers by occupation.

The impact of migration is not uniform across metropolitan areas in the United States. Recent migrants are defined here as individuals who were located outside of their metropolitan area of residence in 1995, five years prior to 2000. Figure 4.2 ranks the prevalence of migrants within the total population

Table 4.1 Selected scientific and engineering occupations

Computer and mathematical occupations	*Architecture and engineering occupations*	*Life, physical, and social science occupations*
Computer Scientists and Systems Analysts		
	Architects, except naval surveyors, cartographers, and photogrammetrists	Agricultural and food scientists
	Aerospace engineers	
Computer programmers	Chemical engineers	Biological scientists
Computer software engineers	Civil engineers	Conservation scientists and foresters
Computer support specialists		Medical scientists
Database administrators		Astronomers and physicists
Network and computer systems		
Administrators	Computer hardware engineers	Atmospheric and space scientists
Network systems and data communications analysts	Electrical and electronics engineers	Chemists and materials scientists
Actuaries	Environmental engineers	Environmental scientists and geoscientists
	Industrial engineers, including health and safety	
		Physical scientists, all other
Operations research analysts		
Miscellaneous mathematical science occupations, including mathematicians and statisticians	Marine engineers and naval architects	Economists
	Materials engineers	Market and survey researchers
	Mechanical engineers	Psychologists
	Nuclear engineers	Urban and regional planners
	Petroleum, mining and geological engineers, including mining safety engineers	Miscellaneous social scientists, including sociologists
	Miscellaneous engineers, including agricultural and biomedical	Agricultural and food science technicians
	Drafters	Biological technicians
	Engineering technicians, except drafters	Chemical technicians
	Surveying and mapping technicians	Geological and petroleum technicians
		Miscellaneous life, physical, and social science technicians, including social science research assistants and nuclear technicians

Source: US Standard Occupation and Classification (SOC) system

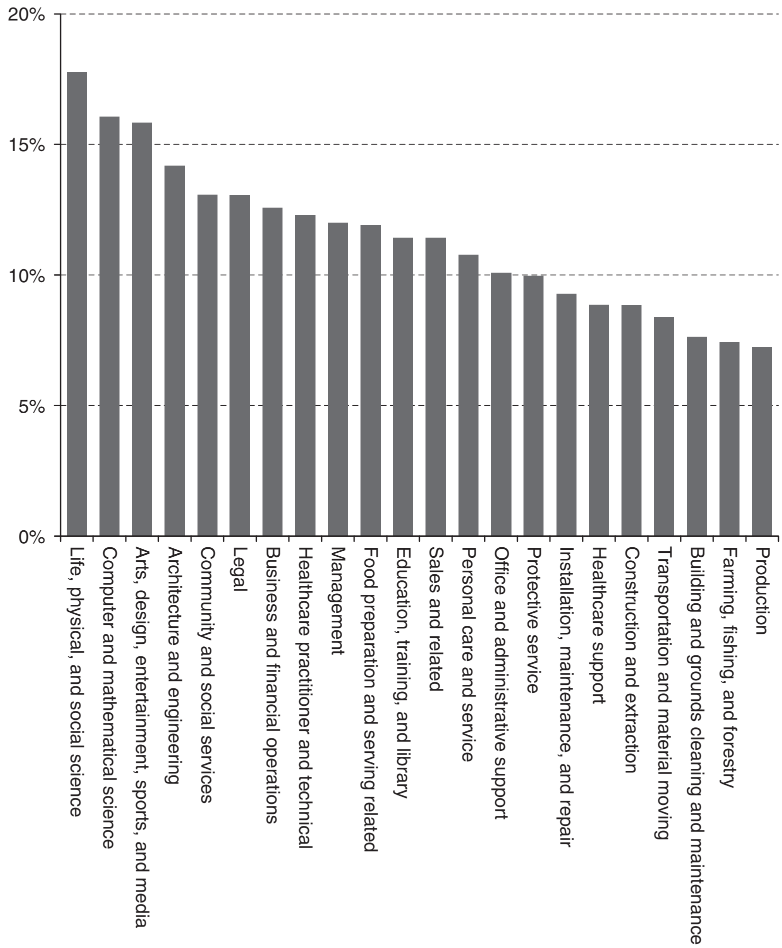

Figure 4.1 Prevalence of recent migrants by major occupation group, United States

for each of these metropolitan areas. Among the 25 largest MSAs, the concentration of recent migrants in the overall population ranged from a low of 3.2 percent to a high of 13.8 percent. Employed workers are more likely to be recent migrants than the population as a whole. Table 4.2 summarizes the impact of migration on the overall labor force and within the selected science and engineering occupations for each of the 25 largest MSAs in the United States in 2000. Figure 4.3 ranks the prevalence of recent migrants among employed workers for the 25 largest MSAs. Among employed workers, the concentration of recent migrants in the 25 largest MSAs ranged from a low of 4.2 percent to 16.4 percent.

Table 4.2 Recent movers in the workforce by metropolitan area

	Total employed				*Science and engineering occupations*						
MSA/CMSA	*Total employed*	*Total movers*	*Movers as % of total employed*	*% of all movers in US*	*Total employed*	*Movers*	*Movers as % of employed*	*% of all movers in US*	*Foreign*	*Movers*	*% of All movers in US*
Atlanta	2,028,307	312,417	15.4%	2.5%	136,295	28,878	21.2%	2.7%	6,144	4.5%	1.9%
Boston	2,655,334	195,500	7.4%	1.5%	233,642	30,272	13.0%	2.9%	14,896	6.4%	4.7%
Chicago	4,235,359	253,197	6.0%	2.0%	248,782	28,435	11.4%	2.7%	13,940	5.6%	4.4%
Cincinnati	880,792	72,720	8.3%	0.6%	56,908	8,963	15.7%	0.9%	1,768	3.1%	0.6%
Cleveland	1,400,273	88,574	6.3%	0.7%	71,217	7,332	10.3%	0.7%	1,976	2.8%	0.6%
Dallas	2,497,120	294,315	11.8%	2.3%	179,574	33,030	18.4%	3.1%	8,986	5.0%	2.8%
Denver	1,307,475	184,221	14.1%	1.5%	115,259	23,125	20.1%	2.2%	4,729	4.1%	1.5%
Detroit	2,387,326	139,322	5.8%	1.1%	171,573	16,678	9.7%	1.6%	9,070	5.3%	2.8%
Houston	2,116,670	184,894	8.7%	1.5%	148,082	22,244	15.0%	2.1%	9,356	6.3%	2.9%
Kansas City	852,566	74,998	8.8%	0.6%	52,343	6,254	11.9%	0.6%	1,567	3.0%	0.5%
Los Angeles	6,902,592	416,576	6.0%	3.3%	345,249	35,418	10.3%	3.4%	15,153	4.4%	4.8%
Miami	1,670,554	157,222	9.4%	1.2%	60,130	9,303	15.5%	0.9%	5,866	9.8%	1.8%
Minneapolis	1,556,071	120,787	7.8%	1.0%	116,848	12,029	10.3%	1.1%	3,796	3.2%	1.2%
New York	9,454,590	399,211	4.2%	3.1%	539,144	42,285	7.8%	4.0%	38,020	7.1%	11.9%
Philadelphia	2,818,596	190,938	6.8%	1.5%	174,036	21,539	12.4%	2.0%	7,636	4.4%	2.4%
Phoenix	1,431,576	234,511	16.4%	1.8%	89,914	19,426	21.6%	1.8%	3,650	4.1%	1.1%
Pittsburgh	1,037,912	57,706	5.6%	0.5%	58,233	6,520	11.2%	0.6%	2,274	3.9%	0.7%
Portland	1,099,023	125,776	11.4%	1.0%	70,445	12,409	17.6%	1.2%	2,946	4.2%	0.9%
Sacramento	817,309	119,422	14.6%	0.9%	61,415	11,162	18.2%	1.1%	2,236	3.6%	0.7%
St. Louis	1,251,949	75,493	6.0%	0.6%	74,074	8,013	10.8%	0.8%	2,598	3.5%	0.8%
San Diego	1,240,359	173,324	14.0%	1.4%	92,673	19,720	21.3%	1.9%	5,400	5.8%	1.7%
San Francisco	3,498,023	361,368	10.3%	2.8%	382,994	61,259	16.0%	5.8%	41,355	10.8%	13.0%
Seattle	1,742,819	195,275	11.2%	1.5%	147,300	23,773	16.1%	2.3%	8,534	5.8%	2.7%
Tampa	1,073,414	158,888	14.8%	1.3%	50,918	10,028	19.7%	1.0%	2,091	4.1%	0.7%
Washington	3,728,482	341,118	9.1%	2.7%	391,300	52,123	13.3%	4.9%	22,479	5.7%	7.1%
Other Metropolitan Areas	36,032,345	4,637,443	11.4%	36.6%	1,710,279	341,875	16.7%	32.5%	67,748	3.3%	21.3%

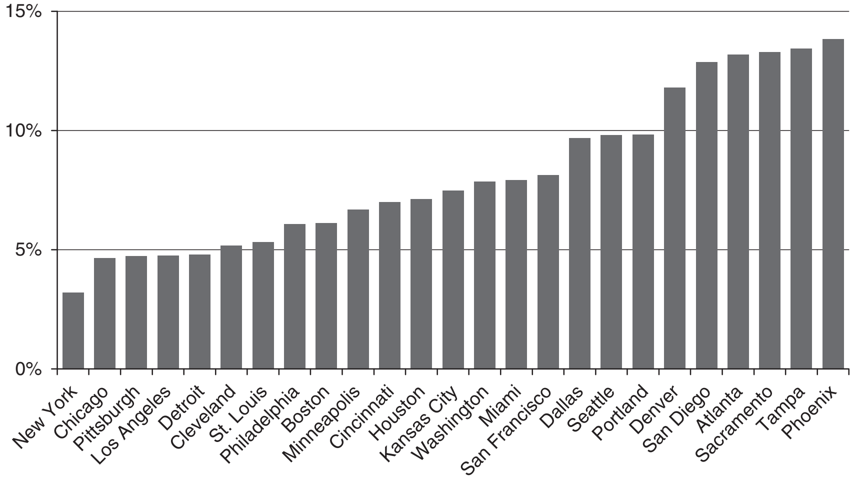

Figure 4.2 Percentage of population in 2000 residing outside current MSA in 1995

Focusing on the selected set of science and engineering workers, the concentration of recent migrants by MSA had a larger range, from a low of 7.8 percent to 21.6 percent. Figure 4.4 ranks these concentrations for each of the 25 largest metropolitan areas in 2000. The comparable proportion for all other metropolitan areas in the US in 2000 was 16.7 percent. There is a concentrated impact of international immigration within science and engineering occupations in the United States. These impacts are also not uniform across the nation and vary significantly across MSAs. Figure 4.5 shows the concentration of recent

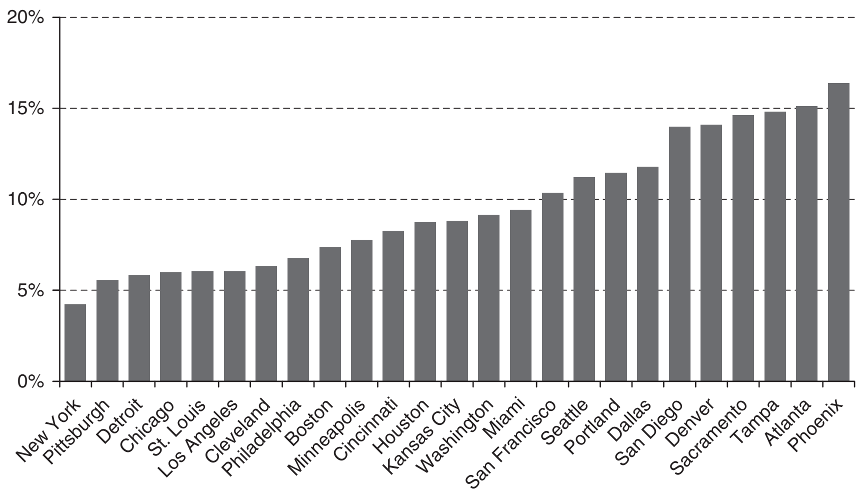

Figure 4.3 Percentage of employed population in 2000 residing outside current MSA in 1995

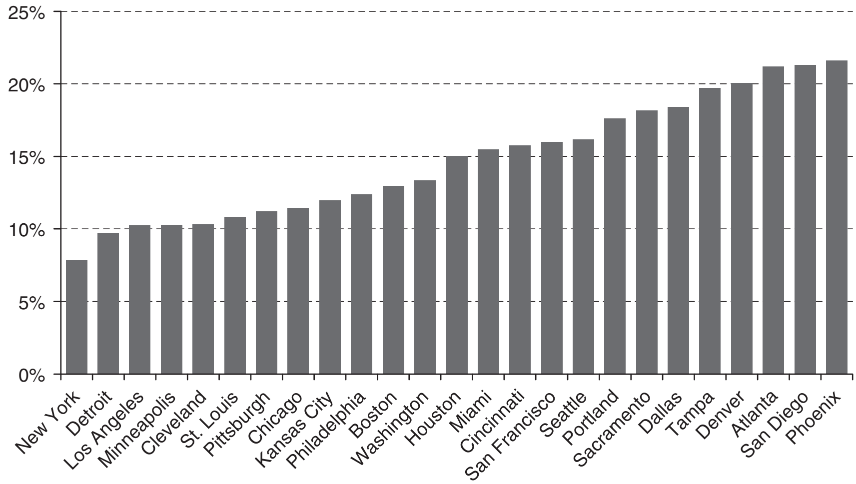

Figure 4.4 Percentage of employed population in science and engineering occupations residing outside metropolitan area in 1995

international immigrants in the selected science and engineering workforces for each of the largest MSAs.

What is not obvious from the national spatial pattern of migration is the concentration of migration within the largest MSAs. Figure 4.6 compares the distribution of employed recent migrants in three groups: those arriving in the 25 largest MSAs, those arriving in all other MSAs combined, and those arriving in non-metropolitan areas. While 38.9 percent of employed recent migrants were

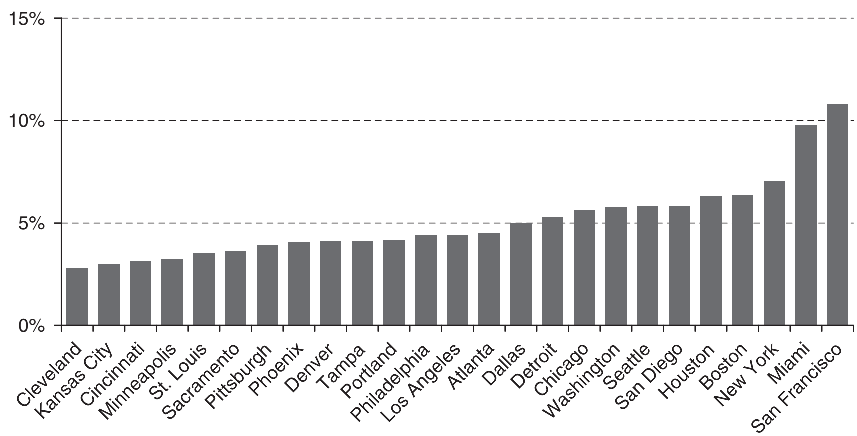

Figure 4.5 Percentage of employed population in science and engineering occupations residing outside US in 1995

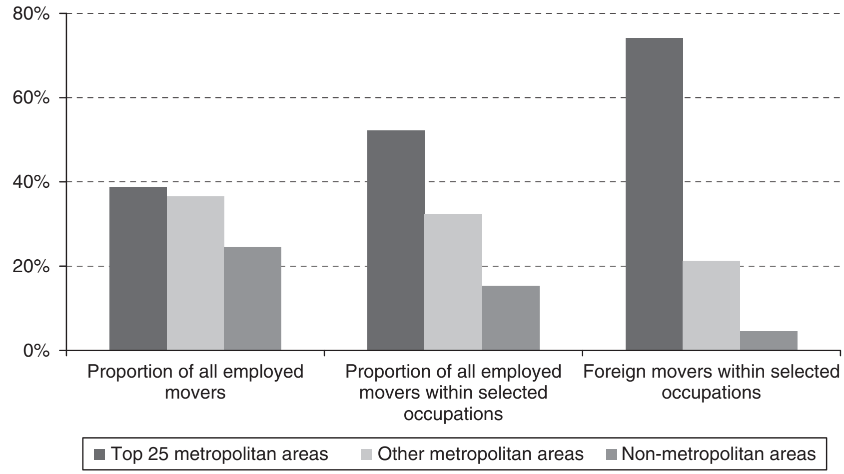

Figure 4.6 Distribution of movers, 1995–2000

concentrated in the 25 largest MSAs, 36.6 percent arrived in one of the smaller MSAs and 24.6 percent arrived in non-metropolitan areas.

When looking specifically at science and engineering occupations, the concentration arriving in the largest MSAs jumps to 52.2 percent, with a slightly smaller 32.5 percent arriving in one of the smaller MSAs and only 15.3 percent arriving in a non-metropolitan area. This disproportionate concentration of migration flows within the largest metropolitan areas exhibits a pattern of a closed network more so than the broader labor market. Figure 4.7 depicts the migration flows of the selected science and engineering workers among the 25 largest MSAs in the United States.

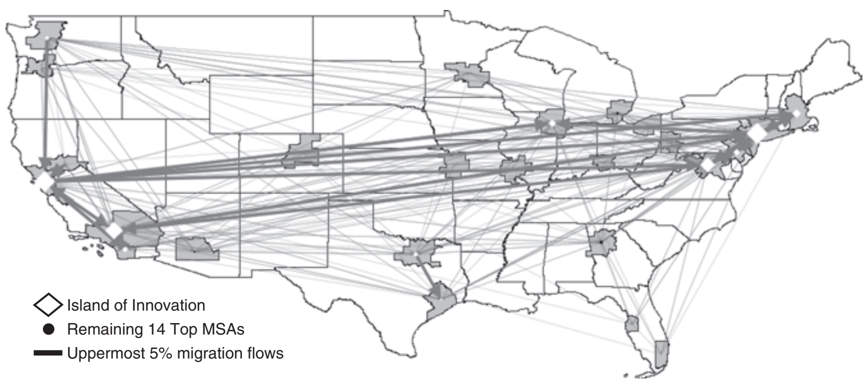

Figure 4.7 Flows of workers in science and engineering occupations – largest 25 MSAs in the United States, 1995–2000

The flow of science and engineering workers is further dominated by migration flows between a selected subset of the largest metropolitan areas in the United States. Table 4.3 shows the migration flows of selected science and engineering occupations among the 25 largest metropolitan areas. A significant proportion of the flows of these workers have originations or destinations in regions that are considered poles of innovation. For the United States, 11 of these 25 regions have also been identified as 'Islands of Innovation' (Hilpert 1992). Comparing the total flows, immigration and outmigration across the largest metropolitan areas, over 73 percent of those flows have originations or destinations among the 11 *Island* metropolitan areas.

Table 4.3 Distribution of migration flows among large metropolitan regions – selected science and engineering occupations, 1995–2000

	Share of migration		
*Metropoltian area**	*Immigration*	*Outmigration*	*Total flow*
Atlanta	3.2	4.1	3.6
Boston	*5.6*	*5.9*	*5.7*
Chicago	*6.3*	*4.2*	*5.2*
Cincinnati	1.2	0.9	1.1
Cleveland	1.9	1.0	1.5
Dallas	*3.8*	*4.3*	*4.1*
Denver	0.1	4.4	2.2
Detroit	4.3	2.4	3.3
Houston	*3.1*	*3.0*	*3.1*
Kansas City	1.2	0.9	1.0
Los Angeles	*11.7*	*7.7*	*9.7*
Miami	0.7	1.8	1.2
Minneapolis	2.1	1.7	1.9
New York	*13.9*	*8.6*	*11.2*
Philadelphia	*5.5*	*4.3*	*4.9*
Phoenix	2.3	3.6	3.0
Pittsburgh	2.0	1.1	1.5
Portland	2.0	2.3	2.2
Sacramento	2.4	2.6	2.5
San Die go	*4.2*	*4.8*	*4.5*
San Francisco	*8.1*	*14.1*	*11.1*
Seattle	*3.2*	*4.6*	*3.9*
St. Louis	1.9	1.2	1.6
Tampa	1.3	1.6	1.4
Washington	*7.8*	*9.1*	*8.5*
Total Islands of Innovation	73.3	70.5	71.9
Remaining top 14 MSAs	26.7	29.5	28.1
Mean Islands of Innovation	6.7	6.4	6.5
Mean remaining top 14 MSAs	1.9	2.1	2.0

* Islands of Innovation and parts of Islands of Innovation in italics

These specific labor markets, and their importance in attracting highly skilled workers, have shown consistency over time. Hilpert's taxonomy of US *Island* regions dates from patterns of research and development expenditures dating back to the 1970s. More recent work shows that 75 percent of star scientists are based in the same set of US *Island* regions (Trippl 2010). Ongoing patterns of migration show evidence that the cluster of regions fostering innovation and growth are sustaining. Migration flows among these regions may be an important part of the self-sustaining nature of these regions that separate them from other metropolitan regions.

Finally, there are linkages outside the United States that impact the supply of highly skilled workers in US labor markets. The flow of recent migrants with specific skills in science and technology occupations are even further concentrated in their arrival pattern across metropolitan regions. It is the concentration of foreign immigrants employed in science and engineering occupations that shows the largest concentration in the largest metropolitan areas. Over 72.4 percent of all recent immigrants from outside of the US employed in these selected occupations resided in one of the 25 largest MSAs in 2000 whereas 21.3 percent resided in one of the smaller MSAs and only 4.6 percent were residing in a non-metropolitan area.

Conclusions

The results show that there exists a large heterogeneity in the migration patterns of science and technology workers across metropolitan areas within the United States. The largest metropolitan areas attract a disproportionate share of science and engineering workers moving between metropolitan areas and virtually all recent international immigrants working in those specific occupations.

That metropolitan areas do not exhibit similar migration patterns for these most sought-after workers has ongoing implications for regional workforce development policies. Aggregate flows are not the best tools for understanding individual propensities to migrate, but these aggregate patterns do highlight the divergent success different regions have had at attracting these workers. Understanding the propensity to migrate and the interaction of migration-induced labor supply agglomerations remains a key factor in judging the efficacy of workforce-focused economic development programs.

The greater proportion of recent international immigrants arriving in just the largest metropolitan regions has additional implications for workforce development policies. Most significantly, it is clear that smaller- and medium-sized metropolitan areas are attracting minimal skilled technology workers.

The heterogeneity in migration extends the traditional research on the impact of localization in knowledge economies and the impacts of agglomeration in highly skilled workforces. The high mobility of skilled workers between selected metropolitan areas opens up the potential that highly skilled workforces are not necessarily a localized phenomenon, but form interconnected networks. The existence of labor-exchange networks alters the nature of competition for these workers and the efficacy of public policies aimed at attracting and retaining specific workers. If highly skilled labor markets are seen more as networks with continuous flows of workers between regions, then the evaluation of regional competitiveness extends to its ability to participation in these networks and not more traditional region-specific benchmarking.

Notes

1. In 2000, Metropolitan Statistical Areas (MSAs) in the United States were comprised of groups of counties or municipalities and were defined by commuting patterns of workers. MSA definitions used here are those in use with the 2000 decennial census.
2. A PUMA index was created by assigning each PUMA containing at least part of an area within an MSA. Some PUMAs are defined as multiple counties. Where a PUMA contains multiple counties it is possible that the resulting PUMA groups are not exact spatial matches to MSAs in a few cases.

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5 High-technology local economies

Geographical mobility of the highly skilled

Rupert Waters and Helen Lawton Smith

Introduction

When employees move within or between localities, knowledge sets are extended through exchanges of labour, and through a resulting creation and reinforcement of personal relationships (Criscuolo 2005). Mobility is thus an opportunity for the recruiting institution (firm, university or government organisation) to acquire skills, outlooks and networks that cannot necessarily be nurtured in-house. Skilled labour is a requisite for innovation-led economic development (Simmie *et al.* 2002; Florida 2002; Scott 2006) and is highly unevenly distributed, being disproportionately concentrated in persistent 'Islands of Innovation' (Hilpert 1992).

Labour markets for the highly skilled within these Islands of Innovation are not static. Rather they are characterised by mobility between organisations within and beyond the region, particularly with other Islands of Innovation (Faggian and McCann 2009), attracting scientists and engineers from around the world. In high-technology local economies, the labour market for the highly skilled is particularly important as a source of intellectual capital, expertise and the application of both for different employment segments. Three main inter-related segments of high-technology employment are the business sector, the academic sector and the publicly funded research sector. Beneficial spillovers result from mobility among the highly skilled (see Breschi and Lissoni 2009) and these transfers within and between Islands of Innovation contribute to the growth or reinforcement of them as 'learning regions'.

This chapter is about the extent of global circuits of labour in high-technology local economies, with a particular focus on scientific and technological skills using the exemplars of Oxfordshire and Cambridgeshire. These two locations are similar in many respects. We show, however, that even for people with similar academic qualifications and professional status, differences in career patterns and in international mobility are associated with segment, academic discipline and qualification, and that there are differences in patterns of mobility between the two places. For local policy-makers a challenge is to provide the right kind of social and economic infrastructure, which will underpin or reinforce the attraction and retention of talented people for the benefit of the local economy as a whole. Opportunities in the innovative regional labour market attract outstanding scientists and engineers, who may then help to further develop modern industries by making regions even more advantageous for enterprises.

Against this background, the chapter analyses the geographical mobility of nearly 1,000 highly skilled scientists and engineers into and out of the high-technology local economies of Oxfordshire and Cambridgeshire in the UK. These regions, like other Islands of Innovation such as the European high-tech region of Grenoble (Lawton Smith 2003) and New York and Los Angeles/San Diego in the US (Trippl 2011), are nodes in a system of Islands of Innovation at the heart of which is participation in inter-linked innovative labour markets of the very highly skilled, usually university-educated professionals.

The specific research questions addressed are:

1. To what extent are patterns of mobility in the three segments in the two locations similar and different?
2. How do we explain those differences?
3. What are the implications of those differences?

The data analysis identifies the country where people have previously worked, age, nationality, qualifications and segment. This chapter maps interconnections, and in so doing contributes to the understanding of geographies of innovation and the interpretation of the phenomenon of Islands of Innovation.

Career trajectories of the highly skilled: regional development

The literature on career paths in regional development has mainly focused on mobility or on the role of human capital in general. Less attention has been given to the differences within organisational segments in science and technology labour markets or the extent to which people move to, within and between Islands of Innovation. It is important to understand why workers from different segments follow different migration patterns. Moreover, the role of geography and physical distance and how it affects the decision to migrate in different segments are important aspects of understanding those patterns. Therefore, the analysis of the factors that influence mobility contributes to a wider understanding of both agglomerations of knowledge and geographical concentrations of innovative labour, as well as exchanges of knowledge through inter-regional mobility.

Conceptual and empirical problems exist, however, in estimating and analysing patterns of mobility of the highly skilled (Mahroum 1999). What constitutes a highly skilled person depends on the definition. The 1993 OECD *Proposed Standard Practice for Surveys on Research and Experimental Development* (the Frascati Manual) and the 1995 OECD *The Manual on the Measurement of Human Resources Devoted to Science and Technology* (the Canberra Manual) classify workers in four ways: (i) by qualification, (ii) by activity, iii) by sector and by iv) occupation. OECD (2002) later classified human resources in science and technology as people who have completed education at the third level in a science and technology field and people in those positions without qualifications but who have the necessary expertise.

Academic studies on mobility have tended to follow similar sorts of categories, examining international movements in general (brain circulation), by profession, by nationality, by impact on receiving countries and regions (brain gain) and on those that lose their talent (brain drain). Some studies have used occupational group to examine flows (for example, ONS 2006), while others have concentrated on particular disciplines (Almeida and Kogut 1999), or category of employee, e.g. researcher (Crisculo 2005; Herrera *et al.*, 2010) or sector (Breschi and Lissoni 2009). In effect, these are what Peck (1996) categorises as distinguishing features of the segmentation of labour demand (technical requirements of different labour processes etc.), segmentation of labour supply (e.g. occupational socialisation) and segmentation of the state (e.g. by the structure and emphases of the education and training system).

To understand which factors influence patterns of mobility among highly skilled workers in science and technology occupations in Islands of Innovation, a series of interdependent processes need to be explored. These relate to the segment of employment organisation, discipline and human capital intensity (qualifications), and why they are different. They are also associated with the characteristics of particular regions, particularly the reasons why they attract and retain the highly skilled. It also requires an understanding of the permeability of boundaries, segments and regions through permanent and temporary mobility in the context of global competition for highly skilled labour (Mahroum 2007). This is because it appears that different categories or segments within scientific labour markets respond to different career opportunities as well as to the particularities of individual academic institutions, firms and government institutions, while reflecting state investment in education and training. The category to which the employee belongs by position (manager and executive, engineer and technician, academic and scientist, entrepreneur or student [Mahroum 1999; Ackers and Gill 2008; Laudel 2005]) or by segment (business, academic or government research sector) has different push and pull factors which determine mobility and destination. Decisions to move permanently or temporarily are not necessarily subject to the same constraints of geography and distance.

We begin with the business segment. Mobility between places is associated with an individual's status within a company and with sector. For example, managers and executives may move because of a new merger or an expansion in the activity of the employing firm; engineers and technicians may move because of economic factors – responding to the best offer for where their skills are most needed and rewarded. Salt and Clarke (1998) found that in the late 1990s the highly skilled were more responsive to the state of the economy than other groups as increasing numbers were recruited due to increasing foreign investment in the British manufacturing industry. Companies came primarily from other EU countries and other highly industrialised countries such as the US and Japan.

Studies of career moves in the biotech sector suggest that there is a brain drain of the UK's top-level scientists to overseas posts (Williams 2001), suggesting a lack of ability to retain key workers and therefore capitalise on their knowledge and knowledge acquisition skills. However, a recent study suggested that as in Motorsport Valley, many return (Kelly 2010).

A rather different effect, i.e. indirect of geographical mobility, within this segment is that of migration on entrepreneurship. It appears that migration increases the odds of individuals engaging in new business activity (Levie 2007). Keeble (1989), for example, found that around 70 per cent of Cambridge-area high-tech entrepreneurs were in-migrants.

As well as intra- and inter-regional mobility, firms' internal labour markets also have a direct impact on the concentration and mobility of skills and on networks and their capacity to transfer information. The nature of employment relationships within the firm influence both the knowledge base and the learning capabilities of the firm (Lam 2000). They determine the extent to which expertise is developed outside or inside the firm and affect career mobility for the individual. Lam finds two different types of societal models of knowledge and learning and corresponding labour markets, only one of which is anchored to particular locations. The 'professional model' is defined as a narrow, elitist education based on a high degree of formalisation of knowledge and has no particular geographical connection. In contrast, the 'occupational community model' is rooted in a region-based occupational labour market surrounding a cluster of interdependent occupations and firms, which is what we suggest is the case in high-technology local economies.

Career paths have also been found to be affected by the decline of internal labour markets for scientists and engineers and consequently by the geographies of technology transfer through mobility (Mason and Nohara 2008). Instead of employees being recruited to entry jobs and internally promoted to senior positions, firms are increasingly reliant on the external labour market for recruitment at all levels of experience. This is because of their need to look outside the firm for new knowledge. Access to external knowledge sources is helped by recruiting experienced scientists and engineers from other employers, who have built up personal networks of external contacts.

The pull of regions to the highly skilled and the positive economic and technological outcomes of their success in doing so are also shown to have segmented characteristics relating to sector and qualification, with some places disproportionately attracting and retaining specialist skills, with the upshot that other places lose skills. For example, Silicon Valley acts as a magnet for IT specialists from all over the world (Saxenian 2006). In a similar vein, Henry and Pinch (2000) observed that the UK's Motorsport Valley is the world's leading motorsport cluster and that for engineers working beyond the cluster erodes the currency of their knowledge, so that 'few stay away from the Valley for long, returning once more to refigure their position within the community of knowledge' (2000: 128). In the case of Canada, the international migration of less qualified people to the country can have a detrimental effect as it tends to dilute skill intensity (Coulombe and Tremblay 2009), while internal migration between provinces usually takes the form of the highly skilled leaving poorer for richer provinces (brain drain).

A region's capacity to retain, recruit and absorb people's knowledge over time has been used as an indicator of a 'learning region'. Studies dating back to Keeble (1989), through to Bercovitz and Feldman (2006), have focused both on how the highly skilled are attracted to particular locations by the presence of other professionals and by other factors such as quality of life, and how the mobility of people between employers has been a crucial factor in transferring technology. Florida (2002), like Berry and Glaeser (2005), finds that a density of the highly skilled collectively raises the overall level of innovation in an area as individuals become more productive when they locate around others with high levels of human capital (see also Faggian and McCann 2009).

Academic and government research sectors have similarities in patterns of geographical mobility but workers in these sectors appear to be more mobile than scientists and engineers in the business sector (Meyer *et al.* 2001). Earlier research found that between 1994 and 1997, some 11,000 foreign academics, mostly from within the EU, were in the UK higher education system (Mahroum 1999), mainly in the top research universities such as Oxford and Cambridge, and in medical and biomedical sciences. Cambridge and Oxford universities attract more of Europe's foreign talent in biosciences and clinical medicine (Mahroum 1999) than other universities in Europe. This may also be a specific British situation, due to English being an international language, which means that there is a preference for Britain over continental European countries. Hilpert (2010), however, identified a variation on that pattern. His study of biosciences showed that in biotechnology research in 20 European and US locations, only 15 per cent of researchers were recruited internationally, whereas about 70 per cent were recruited regionally. University prestige also has an effect on students' mobility. Students are also a highly mobile component in a global scientific labour market with elite universities attracting the most students (Mahroum 1999).

In summary, on the basis of previous studies it would be expected that academics and research scientists would be shown to be more internationally mobile than those in the business sector, but that this might also be affected by discipline. It would also be anticipated that those in business sector would be more intra-regionally mobile.

We next turn to the case-study locations of Oxfordshire and Cambridgeshire. We begin by justifying why they can be categorised as Islands of Innovation and why they are characterised as nodes in global circuits of labour. We then identify the composition of the three segments in each location in order to frame the discussion of the empirical evidence and its implications.

Oxfordshire and Cambridgeshire as global centres of the highly skilled

Oxfordshire and Cambridgeshire are two of the most important centres of the knowledge economy in Britain and worldwide. As Islands of Innovation, the two counties, although not the largest concentrations of high-technology activity in the UK, are among the fastest growing centres and have high concentrations of research activity and highly skilled people (see Lawton Smith and Waters 2011). They are highly internationalised and attract scientists and engineers from around the world. Their importance as global centres of innovation has been widely acknowledged in public policy documents (see, for example, Sainsbury Report 1999; H.M. Treasury's Lambert Review 2003).

At the regional level, as nodes in global circuits of labour, figures suggest that Oxfordshire and Cambridgeshire are likely to benefit from the international mobility of tertiary-educated migrants. Such migrants come particularly from the EU and North America from where originate over 90 per cent of such people (Rüdiger 2008). The volatility of the Oxfordshire and Cambridgeshire labour markets is reflected by census data – Oxfordshire and Cambridgeshire had the least settled populations of any English county in 2001 and the cities of Oxford and Cambridge rank sixth and fourth respectively of all 380 local authority districts for having the most residents that had lived overseas one year previously (ONS 2006).

Next, we examine the composition of the highly skilled labour markets in each of the three segments. We show that the composition of the business segment differs from that of the university and research laboratory segments, which are very similar. Hence patterns of mobility would be expected to differ between industry and research segments. We begin with the business segment, followed by the universities and then public sector research laboratories.

The business segment

In both locations, the demand from industry for the highly skilled is strong, although variable over time, particularly in Cambridgeshire. Using Glasson *et al.*'s (2006) definition of high-technology industry, there were 37,300 employees in 3,600 high-technology firms in Cambridgeshire in 2007 compared to 35,500 in 3,800 firms in Oxfordshire (see Table 5.1). With 13.6 per cent of all employment being in high-technology industry, Cambridgeshire ranks first of all county council areas in England, with Oxfordshire ranking fifth. These are therefore innovative places that provide jobs which attract highly qualified individuals in all three segments.

Previous comparative studies of the two counties, which examined the recruitment of research staff, have shown high levels of intra-regional recruitment, but differences in the scope of international networks. Keeble *et al.* (1999) found that 35 per cent of firms had made at least one of their last three recruitments from other Cambridge firms or organisations, with the figures being 41 per cent for the rest of the UK and 8 per cent for the rest of the world, while for managerial staff the figures were 39 per cent, 58 per cent and 28 per cent respectively. This high degree of localised labour market movement can be seen to have encouraged inter-firm links, with 48 per cent of firms reporting links with other local firms due to staff movement, and 77 per cent of those regarding these links as important for their development (Keeble *et al.* 1999). However, the same survey revealed national and global research networks to be 'much more important' than local

Table 5.1 High-technology employment and firms, 2007

	Firms			*Employment*		
	No.	*%*	*Rank*	*No.*	*%*	*Rank*
Cambridgeshire	*3,700*	*13.6*	*3*	*37,300*	*13.6*	*1*
Cambridge	900	15.6	15	11,600	13.7	30
East Cambridgeshire	400	11.3	104	1,800	7.5	137
Fenland	300	7.5	308	1,100	3.4	350
Huntingdonshire	1,000	13.0	58	6,700	9.4	89
South Cambridgeshire	1,200	16.7	8	16,100	26.0	3
Oxfordshire	*3,900*	*12.3*	*6*	*35,500*	*11.2*	*5*
Cherwell	700	11.1	111	6,100	9.0	101
Oxford	600	11.1	112	8,100	7.9	124
South Oxfordshire	1,000	13.5	44	5,600	10.4	60
Vale of White Horse	800	14.8	23	11,400	21.1	7
West Oxfordshire	600	10.9	122	4,400	11.4	48
East	*27,100*	*11.2*	*2*	*194,100*	*8.2*	*2*
South East	*48,400*	*12.5*	*1*	*392,300*	*10.6*	*1*
Great Britain	*243,200*	*10.2*	—	*1,984,700*	*7.5*	—

Source: Annual Business Inquiry, Office of National statistics 2008

links, with Cambridge accounting for 14.4 per cent of collaborative research activity, and the rest of the UK and the rest of the world accounting for 48.0 per cent and 37.2 per cent respectively (1999: 327).

The number of private-sector research laboratories in each location varies considerably. Cambridgeshire has far more laboratories, which employ more people, than is the case in Oxfordshire. In Cambridge, laboratories include Toshiba Research Europe Limited and Microsoft Research Cambridge.[1] The NRC Cambridge UK laboratory develops nanotechnologies for mobile communication and ambient intelligence. Other laboratories include Philips Research Laboratory, Pfizer and Kodak Research. A notable closure was that of AT&T's European laboratory in April 2002. In contrast, in Oxfordshire the major research centres are confined to the Sharp European Laboratory (electronics) and Infineum (petrol additives). The latter is a 50-50 joint venture between Exxon Oil and Shell and is located on the former site of Esso Research. Because of these differences, it would be expected that there would be differences between the two locations in terms of both scale and discipline in patterns of geographically inter-linked innovative labour markets.

University segment

The university bases of the two counties are similar. Both have a premier university and both have a former polytechnic with similar student populations. The universities and their student populations in Oxfordshire are: the University of

Oxford (23,985) and Oxford Brookes University (18,035); and in Cambridgeshire the University of Cambridge (22,2745) and Anglia Ruskin University (19,000 students). Additionally, Oxfordshire has a third university: Cranfield University, at Shrivenham, which acquired the defence research academy that trains students for the military in the 1990s, and is now known as DCMT. It has around 1,000 students, mostly post-graduates. Unlike in the case of the public sector segment discussed below, it would be expected that on the whole there would be strong similarities in the migratory behaviour of the highly skilled in the university segment.

Oxford and Cambridge universities are particularly international both in their student bodies and academic staff. In 2011, international students comprised one-third of Oxford University's student body, including 15 per cent of full-time undergraduate (UG) students and 61 per cent of full-time postgraduates (PG).[2] Data from the Higher Education Statistics Agency (HESA) showed that in 2009/10, Oxford University had 16,080 UG students (of which 14,455 or 89 per cent are from the UK) and 8,390 PG students (of which 3,795 or 45 per cent were from the UK).[3] Cambridge had a slightly smaller student body and a slightly smaller international PG cohort than Oxford with 13,195 UG students (of which 11,070 or 89 per cent are from the UK) and 7,550 PG (of which 3,885 or 51 per cent were from the UK).[4] Most international students were from other European countries, followed by North America, East Asia (excluding China) and then China. At Oxford, students came from 140 countries and territories. The largest groups of international students were from the USA, followed by China and Hong Kong, Germany, Canada, India, Australia, Italy, Ireland, France and Greece. The problem here in assessing their impact on the local economy is a lack of evidence for the differences in the extent to which UG and PG students stay and work in occupations outside academia in a region after graduation.

Even between the two elite universities in this study there are differences in international recruitment. Oxford University's faculty is highly international. Some 40 per cent of academic staff are citizens of foreign countries. They come from almost 100 different countries and territories. The largest groups of international academic staff are from the USA, Germany, Italy, China, Australia, France, Ireland, India and Canada. In contrast, in Cambridge, the percentage is much smaller, with only 25 per cent non-UK nationals (personal communication, Cambridge University).

The public sector segment

Both counties are examples of places with concentrations of research that provide illustrations of participation in international networks and the attraction of innovative labour by supplying extraordinary jobs as well as opportunities for work and research. They are, however, markedly different in a key respect – the composition of the public research sector segment – and hence in the expected patterns of circuits of labour, but they are very similar in other respects. The main difference is that Oxfordshire has government-funded research laboratories, with a specialism in physics, which have no equivalents in Cambridgeshire. Both locations have a number of charity-supported research institutes, mainly in biomedical sciences, mostly attached to the Oxbridge universities (Oxford and Cambridge).

Oxfordshire's government research laboratories were established post-World War II, firstly to service the UK's nuclear energy programme (UK Atomic Energy Authority), and secondly to host the expansion of research council research into science and engineering. Oxfordshire's laboratories are primarily located in the south of the county on the Harwell site at Chilton: RAL (Rutherford Appleton Laboratory) owned by the Science and Technology Facilities Council, UKAEA laboratory, the National Radiological Protection Board (NRPB), the Medical Research Council (MRC) Radiation And Genome Stability Unit and the MRC Mammalian Genetics Unit. Nearby are the NERC (National Environment Research Council) Centre for Ecology and Hydrology, the UKAEA (United Kingdom Atomic Energy Authority) and JET (Joint European Torus) both in Culham.

Cambridge has a number of small research laboratories mainly specialising in biomedical science. These are not directly funded by government departments, but supported by charities and research councils, sometimes in association with Cambridge University. For example, Cambridge is home to the Strangeways Research Laboratory, which was originally a centre for research into rheumatoid arthritis and other connective tissue disorders. Since 1997 the building has been a centre for genetic epidemiology and hosts 12 research groups that collectively employ over 170 staff. These include the independent Foundation for Genomics and Population Health. Other research groups within the building are supported by the Medical Research Council and the European Commission.

Medical research is also conducted at the Institute of Public Health, a partnership between Cambridge University, the MRC and the NHS, created in 1993 (see www.bbsrc.ac.uk). The Babraham Institute, a registered charity, is sponsored by the Biotechnology and Biological Sciences Research Council to underpin its national responsibilities in healthcare and training, and supported by the Medical Research Council, many medical charities and other organisations. Similarly, Oxfordshire has a number of charity-supported research institutes including the Oxford Stem Cell Institute (Oxford University), Institute of Biomedical Engineering (Oxford University 2008), and the Oxford Biomedical Research Centre, a partnership between the University of Oxford and Oxford Radcliffe Hospitals, funded by the National Institute of Health Research. Other research laboratories include the Oxford Centre for Cancer Medicine, the Jenner Institute (vaccines, 2005) and the Wellcome Centre for Human Genetics.

Collectively, the highly skilled in the three segments enable the two counties to participate in the networks of Islands of Innovation. This is because they provide the type of jobs that attract people who are more likely to be internationally mobile. Moreover, having shown that the two counties have dense concentrations of research activity, next we support the assertion that they also have a high percentage of people who are likely to be mobile, thus increasing the likelihood that there will be relatively high levels of inter-regional mobility.

Highly-skilled labour markets

Although the counties are very different in the composition of the three segments, the stocks of human capital are very similar. Both Oxfordshire and Cambridgeshire have high proportions of well qualified residents compared to the rest of Great Britain. Table 5.2 shows that in 2010, 40.3 per cent of Oxfordshire residents and 36.2 per cent of Cambridgeshire residents are qualified to degree level (National Vocational Qualification (NVQ) level 4+) and rank as the 1st and 5th most qualified counties respectively in Great Britain. These figures mask the range of performance recorded for the local authorities that make up the counties. Oxford City is the strongest performer with 53.7 per cent of residents qualified to degree level to rank eighth of Great Britain's 380 local authority districts while in Cambridge City the proportion is 50.7 per cent to rank twelfth.

Outside the cities, South Cambridgeshire, which surrounds Cambridge City, also has a highly qualified workforce ranking 29th in Great Britain with 45.3 per cent of residents holding degree-level qualifications. East Cambridgeshire is the next strongest performer in the county with a national ranking of 95th. In Oxfordshire, the Vale of the White Horse district, in which the majority of the government laboratories are located, is ranked 34th and South Oxfordshire 61st. Although the proportions show a bias in favour of 'knowledge-workers', it is important to put these proportions into perspective. The actual numbers are less impressive than the proportions and are a truer reflection of scale. Other counties such as Berkshire, Hampshire and the London region have more highly skilled people.

Table 5.3 shows the occupational structure of the two counties based on Standard Occupational Classifications (SOC)[5] in 2010. Oxfordshire and Cambridgeshire rank first and second respectively of all county council areas for the proportion of residents employed in professional occupations (SOC2), while Oxford City (36.8 per cent) and Cambridge City (33.0 per cent) rank 1st and 2nd of all 380 local authority districts in Great Britain, ahead of the 14.0 per cent recorded across the country as a whole.

The counties' high percentage of people employed at SOCs 1–3 means that Oxfordshire is ranked 3rd and Cambridgeshire 5th of all 27 county council areas in Great Britain, while the cities of Oxford and Cambridge respectively rank 6th and 17th in Great Britain with 66.6 and 60.5 per cent of residents respectively employed in occupations in SOCs 1–3 compared to the national level of 44.4 per cent. Table 5.3 does, however, highlight the relative shortage of associate professional and technical workers in both counties.

In summary, the two counties have very high proportions of people with degree-level qualifications and those in professional occupations. While this makes the labour markets particularly strong at the highest skill levels, there is evidence of weaknesses in the depth of innovative labour markets.

Table 5.2 Educational attainment, 2010

	NVQ4+			*NVQ3*			*NVQ2*			*NVQ1*			*No qualifications*		
	No.	*%*	*Rank*	*No.*	*%*	*Rank*	*No.*	*%*	*Rank*	*No.*	*%*	*Rank*	*No.*	*%*	*Rank*
Cambridgeshire	*142,100*	*36.2*	*5*	*71,150*	*18.1*	*27*	*74,275*	*18.9*	*20*	*76,575*	*19.5*	*6*	*28,500*	*7.3*	*22*
Cambridge	44,100	50.7	12	12,650	14.6	362	13,025	15.0	339	14,325	16.5	228	2,700	3.1	376
East Cambridgeshire	18,300	35.8	95	8,590	16.7	335	10,115	19.7	196	10,395	20.3	85	3,900	7.6	288
Fenland	8,600	14.9	375	13,000	22.4	127	13,300	22.9	57	14,200	24.5	14	8,900	15.3	55
Huntingdonshire	30,100	28.4	222	21,400	20.2	238	23,350	22.0	92	23,450	22.1	44	7,900	7.4	295
South Cambridgeshire	40,900	45.3	29	15,620	17.3	325	14,420	16.0	321	14,360	15.9	253	5,100	5.6	346
Oxfordshire	*166,700*	*40.3*	*1*	*87,150*	*21.1*	*15*	*64,125*	*15.5*	*27*	*59,325*	*14.4*	*26*	*35,800*	*8.7*	*18*
Cherwell	26,900	30.4	173	20,360	23.0	97	15,760	17.8	268	13,980	15.8	257	11,400	12.9	114
Oxford	57,100	53.7	8	16,770	15.7	351	11,695	11.0	377	10,735	10.1	375	10,200	9.6	218
South Oxfordshire	30,300	38.1	61	20,410	25.7	27	10,285	13.0	364	12,905	16.3	239	5,500	6.9	308
Vale of White Horse	32,100	44.0	34	14,160	19.4	270	13,110	18.0	260	10,530	14.4	299	3,000	4.1	369
West Oxfordshire	20,300	30.8	163	15,440	23.4	80	13,240	20.1	177	11,120	16.9	213	5,800	8.8	242
Great Britain	*12,167,600*	*31.3*		*7,979,860*	*20.5*		*7,456,010*	*19.2*		*6,840,530*	*17.6*		*4,391,900*	*11.3*	

Source: Annual Population Survey, Office of National Statistics 2011

Table 5.3 Occupational profile, 2010

	SOCs 1–3			*SOC 1*			*SOC 2*			*SOC 3*		
	No.	*%*	*Rank*	*No.*	*%*	*Rank*	*No.*	*%*	*Rank*	*No.*	*%*	*Rank*
Cambridgeshire	*158,900*	*52.3*	*5*	*52,800*	*17.4*	*13*	*60,700*	*20.0*	*2*	*45,400*	*14.9*	*6*
Cambridge	39,600	60.5	17	6,700	10.2	354	21,600	33.0	2	11,300	17.3	56
East Cambridgeshire	23,000	54.7	53	5,300	12.6	289	10,100	24.0	11	7,600	18.1	41
Fenland	14,200	35.7	314	5,900	14.8	209	5,200	13.2	187	3,100	7.7	370
Huntingdonshire	40,300	48.9	98	19,600	23.8	25	9,100	11.0	260	11,600	14.1	192
South Cambridgeshire	41,900	56.6	39	15,400	20.8	55	14,700	19.9	30	11,800	15.9	91
Oxfordshire	*180,800*	*55.0*	*3*	*59,800*	*18.2*	*8*	*74,900*	*22.8*	*1*	*46,100*	*14.0*	*15*
Cherwell	34,800	49.2	95	13,700	19.3	77	11,600	16.5	84	9,500	13.4	226
Oxford	50,800	66.6	6	14,400	18.9	83	28,100	36.8	1	8,300	10.9	335
South Oxfordshire	38,400	57.7	28	13,300	19.9	70	15,200	22.9	16	9,900	14.9	149
Vale of White Horse	33,200	54.2	56	11,100	18.1	101	11,000	18.0	53	11,100	18.1	41
West Oxfordshire	23,500	43.7	164	7,300	13.6	252	8,900	16.5	84	7,300	13.6	215
Great Britain	*12,482,100*	*44.4*		*4,413,200*	*16*		*3,931,400*	*14.0*		*4,137,500*	*15*	

Source: Annual Population Survey, Office of National Statistics 2011

International mobility and career trajectories in Oxfordshire and Cambridgeshire

The study

In order to map career trajectories of the highly skilled in the two locations, data was obtained through a postal survey of members of three professional institutes working in Oxfordshire and Cambridgeshire. These were the Institute of Electrical Engineers, the Institute of Physics and the Royal Society of Chemistry. Membership of professional associations is based on a set of selection criteria relating to expertise even if potential members are lacking formal qualification. Therefore, by definition these people are highly skilled, consistent with the 2002 OECD definition.

A total of 6,099 questionnaires were sent. The 989 responses represent a response rate of 15.7 per cent. The response rate by institute is 7.0 per cent for IEE, 17.0 per cent for IOP and 17.1 per cent for RSC. The survey yielded 832 useable responses, plus 160 responses from people not working in the case-study area. This response rate is typical for this type of survey, providing sufficiently large samples for both case-study areas and institute membership to allow analysis by both place and branch of science, comparing favourably with previous studies of high-technology local economies.

The profile of respondents is shown in Table 5.4, which presents the educational attainment of the survey population. It shows that 90 per cent of Oxfordshire respondents and 86 per cent of Cambridgeshire respondents held degrees (48.5 per cent and 47.0 per cent respectively holding PhDs), demonstrating the highly skilled nature of the sample. A difference exists between the physicists and chemists, of whom over half have PhDs, and the engineers. Only 15 to 21 per cent of IEE members have PhDs, suggesting that the work of engineers is more applied than the theoretical work of physicists and chemists.

The differences in numbers of responses from each institute by county are shown in Table 5.5. The greatest number of replies is from the IOP in Oxfordshire, with IOP being the largest grouping, while more IEE and RSC members in Cambridgeshire replied.

Table 5.4 Educational attainment of respondents by location and discipline (%)

	IEE		*IOP*		*RSC*	
	Oxon	*Cambs*	*Oxon*	*Cambs*	*Oxon*	*Cambs*
Degree	56.7	43.9	17.4	9.9	15.8	19.1
Masters	20.0	26.2	15.3	23.8	7.9	13.9
PhD	15.0	20.6	59.8	49.7	61.8	57.4
Total	*91.7*	*90.7*	*92.5*	*83.4*	*85.5*	*90.4*

Source: Authors' survey

Table 5.5 Respondents by region and institute

	Cambridgeshire		*Oxfordshire*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
IEE	107	26.5	62	14.5	*169*	*20.3*
IOP	182	45.0	282	65.9	*464*	*55.8*
RSC	115	28.5	84	19.6	*199*	*23.9*
Total	*404*		*428*		*832*	

Source: Authors' survey

The breakdown of respondents by professional body and region by number and percentage are shown in Table 5.6. Overall, over 50 per cent of the respondents are in the private sector segment, with 20 per cent in universities and around 15 per cent in the public sector (including national laboratories). They also show regional differences. Not surprisingly, given the greater level of activity in Oxfordshire in national laboratories, particularly in physics and engineering disciplines, there were more replies from that segment.

International mobility by segment

We now examine patterns of international mobility by different elements of segmentation: academic attainment, discipline and sector by region. In both case studies, it was most common for those currently employed to have previously worked elsewhere and to have subsequently moved into the counties. This was true for all three of the institutes. Although no statistics exist for the population of the UK as a whole, this situation is not unexpected, but does have implications for organisational strategies, where decisions to expand or remain may be affected by the propensity of individuals to move into the locality and the career development of individuals (cf. Green and Canny 2003). We begin with mobility of employment and then examine factors that might be associated with those patterns.

The proportion of survey respondents to have worked abroad is presented in Table 5.7, which shows that over the course of their careers 18.5 per cent of

Table 5.6 Respondents by sector of employment

	Cambridgeshire			*Oxfordshire*			
	IEE	*IOP*	*RSC*	*IEE*	*IOP*	*RSC*	*Total*
Private sector	92.2	53.5	82.3	78.7	47.4	62.3	*65.2*
University sector	5.8	41.2	12.5	16.4	19.6	23.0	*20.2*
Public sector	1.9	5.3	5.2	4.9	33.0	14.8	*14.6*

Source: Authors' survey

Table 5.7 Respondents who have worked abroad

	Cambridgeshire		*Oxfordshire*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
IEE	15	14.3	5	8.5	*20*	*12.2*
IOP	29	16.1	65	25.4	*94*	*21.6*
RSC	17	15.0	14	20.0	*31*	*16.9*
Total	*61*	*15.3*	*84*	*21.8*	*145*	*18.5*

Source: Authors' survey

scientists and engineers in the case studies had previously worked abroad, ranging from 8 per cent of electrical engineers in Oxfordshire to 23 per cent for the same county's physicists. Thus one in five of the respondents had worked abroad at some stage in their careers, a considerable proportion of people whose international experience of research has added to the mix of knowledge and capacity to interpret and utilise that knowledge in these local economies.

Mobility, however, is more pronounced for physicists and less so for electrical engineers, who are also by and large far less well networked than physicists (Waters and Lawton Smith 2008). This finding shows that there are therefore distinctive patterns of mobility even within the labour market for the highly skilled, which has consequences for cluster development. On this evidence, physicists are more likely to reinforce and extend local specialisations through their networks than those in other disciplines, particularly electrical engineers.

The number of countries in which respondents had worked was remarkably similar: 24 countries in Oxfordshire and 23 in Cambridgeshire. The largest number in both counties had previously worked in the US. The number was higher for Oxfordshire than Cambridgeshire but percentages were similar. Overall, most mobility was within Europe, exactly one-third in the case of Cambridgeshire but higher in Oxfordshire at 45 per cent. In each case, France was the country most frequently cited. In general, mobility was within either Northern European countries with strong science bases, including Germany and Switzerland, or to North America, suggesting narrow patterns of inter-Island of Innovation mobility. Patterns of mobility, moreover, do not appear to be associated with attendance at an overseas university. Only a relatively small proportion of the sample (8 per cent of Cambridgeshire and 6 per cent of Oxfordshire respondents) had recently attended an overseas university (see Figure 5.1). Therefore, the pull of the regions is related to career mobility rather than inertia due to a desire to remain in the vicinity of the university post-graduation.

The likelihood of having worked abroad, however, increases markedly with educational attainment. When only those with PhDs are considered, the rates are higher for all groups, with the overall figure rising to 25.9 per cent. The full results are presented in Table 5.8.

This shows that it is the more highly qualified that are internationally mobile. This suggests that higher levels of knowledge are being produced as a consequence

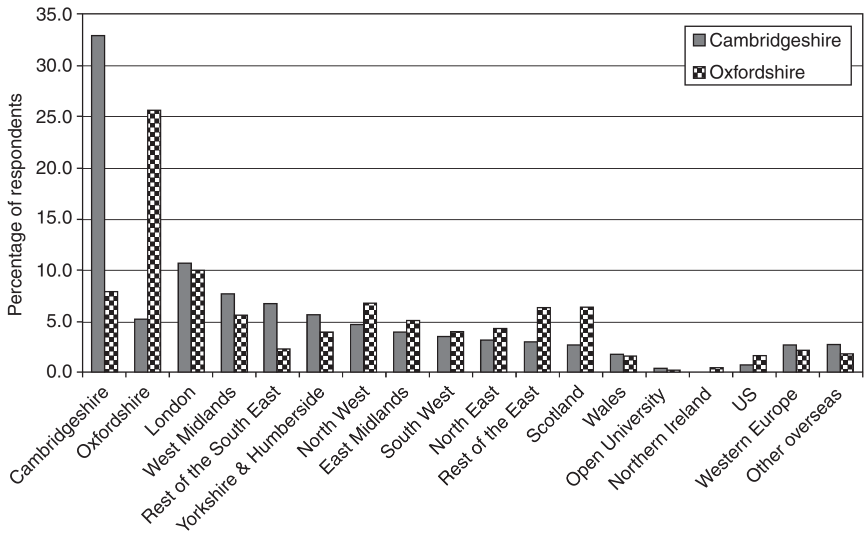

Figure 5.1 Location of universities attended by respondents (percentages)
Source: Authors' survey

of this mobility – leading-edge knowledge and its application. The findings show that in advance of new measures to increase rates of highly skilled in-migration to the UK, almost one-fifth of scientific professionals working in two of the country's most important centres of the knowledge economy already have experience of working abroad. The academic labour market provides considerable impetus to this, adding support to suggestions in the literature that such migration is driven by the status and performance of the local economy and individual institutions.

Mobility in the private sector

The evidence suggests that overseas recruitment for high-technology firms in Oxfordshire and Cambridgeshire is low at only 15 per cent. This percentage

Table 5.8 Respondents with PhDs who have worked abroad

	Cambridgeshire		*Oxfordshire*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
IEE	5	22.7	2	22.2	*7*	*22.6*
IOP	23	25.6	47	30.1	*70*	*28.5*
RSC	15	22.7	11	23.4	*26*	*23.0*
Total	*43*	*24.2*	*60*	*28.3*	*103*	*26.4*

Source: Authors' survey

disguises differences between academic disciplines and by location. For example, nearly one-quarter of chemists in Oxfordshire had worked abroad compared to only 4.3 per cent of engineers. In Cambridgeshire, only one-tenth of chemists had worked abroad. In both counties, one-fifth of physicists employed in the private sector had done so. This is consistent with the study by Hilpert (2010) of researchers in the biotech sector in Europe and the US mentioned earlier, which showed that even in that sector, international recruitment is low.

Universities

When employment in academic posts is examined, the results are markedly different. Across the sample, 26 per cent of academics had held posts abroad (21 per cent for Oxfordshire and 30 per cent for Cambridgeshire). Overseas positions were spread around the globe with 39 per cent in Western Europe, 29 per cent in the United States and 28 per cent in other locations.[6] The Cambridgeshire experience, in particular, demonstrates that an academic career can be a strong driver of migration among the highly skilled, but this varies by discipline. This time it is the academic physicists that are less mobile than the engineers and chemists. In Oxfordshire, it is only the physicists who are most likely to have worked abroad with the engineers not at all. The full proportions are shown in Table 5.9.

Government laboratories

International mobility in the government laboratory sector was almost entirely confined to physicists in Oxfordshire. Overall, very few respondents had previously worked abroad. Only one of the Cambridgeshire respondents had worked abroad and only one each of Oxfordshire's IEE and RSC members. Over 40 per cent of Oxfordshire physicists had worked abroad. This perhaps reflects the international nature of the work of physicists, who have been shown in previous research to engage in international collaborations and attend international conferences.

The extent to which international mobility is likely to increase is indicated by a question about future job-search locations. This showed that patterns of

Table 5.9 Respondents in academic positions we have worked abroad

	Cambridgeshire		*Oxfordshire*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
IEE	2	40.0	0	0.0	*2*	*20.0*
IOP	14	21.5	31	47.7	*45*	*34.6*
RSC	5	35.7	1	7.1	*6*	*21.4*
Total	*21*	*25.0*	*32*	*38.1*	*53*	*31.5*

Source: Authors' survey

mobility are stable. Respondents showed levels of interest in working abroad comparable with numbers to have employment histories that include overseas positions. The US was the most commonly cited possible overseas destination ahead of Western Europe in both case studies, with 31 per cent of Oxfordshire respondents highlighting the United States and 29 per cent highlighting Western Europe compared to 26 and 16 per cent respectively in Cambridgeshire.

In summary, nearly one in five of the very highly skilled in the two locations had worked abroad before locating in Oxfordshire and Cambridgeshire. It is the people with the highest qualifications who are more likely to be mobile (those with PhDs), particularly physicists (between one-fifth to one-quarter). Engineers are the least mobile. International mobility tends to be between the UK and the US, and within Northern Europe, the latter particularly so in the case of Oxfordshire, where the percentage of respondents who had worked abroad was higher than in Cambridgeshire. As expected, the business sector was the least internationally mobile with only a small proportion of respondents having worked abroad.

In general, these findings suggest that as personnel come from other highly innovative countries and regions, the regions receiving the incoming migration will be further advantaged over others that do not have access to the same kind of networks of knowledge, which develop through mobility of personnel, reinforcing their status as Islands of Innovation.

Conclusions

This research has provided detailed data on international mobility in three academic disciplines in three segments of highly skilled labour markets in Oxfordshire and Cambridgeshire. Analysing the work history and aspirations of the highly skilled provides vital insights and a valuable empirical source for understanding where particular regions and locations fit into global circuits of labour.

The chapter demonstrates that locations in Oxfordshire and Cambridgeshire are highly internationalised, attracting engineers, but more so scientists, from around the world, particularly in the academic and research segments, and this is consistent with other findings (Mahroum 1999; Ackers 2005; Laudel 2005). The caveat to this general finding is that engineers as a whole were least mobile. They could therefore be considered to represent an 'occupational community model' whereas there was strong evidence of physicists conforming more to the 'professional model' (Lam 2000), i.e. not anchored to a particular location. Alternatively, engineers could be seen as having rather different working patterns to other disciplines, being less internationally mobile as well as having fewer networks (see Waters and Lawton Smith 2008).

It is also shown those who left Oxfordshire and Cambridgeshire returned again later in their careers. Mobility was shown to be mainly within Europe and North America, suggesting that inter-Island of Innovation mobility is confined to countries with the strongest science bases (business as well as university and public sector laboratory sectors). The exchange of highly skilled labour is not just a present phenomenon but a process that has taken place for quite some time. Therefore, in certain segments and disciplines, both locations take mutual advantage from additional knowledge and synergies.

Moreover, these are also places where people from other countries come to study, particularly at post-graduate level, thus increasing the potential pool of knowledge and skills from other highly innovative regions, which promotes regional innovation. The converse is also true: the innovativeness of a region is one of the major factors that encourage university graduates to seek employment in a region (Faggian and McCann 2009). Oxfordshire and Cambridgeshire therefore score highly on both.

The policy implications of these findings are that in order to understand how the distinctive characteristics of Islands of Innovation develop and are reinforced, it is necessary to examine the components of the skill base. This allows an analysis of the specialisation by segment to see where drivers of change at the local level are coming from (discipline and international sources of new information carried by the process of mobility) and possible inter-segmental provision of resources (Mahroum 2007). In order for there to be 'learning-region' effects there would need to be inter-segment recruitment and spillovers, increasing the overall levels of innovation by co-location of the highly skilled. Linking Islands of Innovation through exchange of personnel (inward and outward) is a basis for development and helps to build a first-choice location for top knowledge-based entrepreneurship. Such processes fundamentally depend on public-funded world-class research and the development of infrastructures that support the exchange of knowledge based on leading-edge research.

Finally, while these findings are indicative of labour market behaviour within and between Islands of Innovation, more research is, however, needed on inter-segment mobility and on a comparison of recruitment patterns between undergraduates and postgraduates in order to understand how the process of spillover does in fact occur in Islands of Innovation.

Notes

1. See http://research.microsoft.com/en-us/labs/Cambridge (accessed 18 August 2009).
2. See www.ox.ac.uk/about_the_university/facts_and_figures/index.html (accessed 26 July 2011).
3. See www.hesa.ac.uk/dox/dataTables/studentsAndQualifiers/download/institution0910.xls (accessed 26 July 2011).
4. See www.admin.cam.ac.uk/reporter/2005-06/weekly/6037/3.html (accessed 26 July 2011).
5. For a full explanation see www.statistics.gov.uk/methods_quality/soc/structure.asp
6. With 4 per cent in multiple locations, including more than one of the locations used.

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Part III

How to connect with mobile innovative competences – the role of appropriate innovative labour markets

6 From Islands to Hubs of Innovation

Connecting innovative regions

Andrea Caragliu and Peter Nijkamp

Introduction and motivation

Recent figures on the spatial distribution of educated workers clearly show that three main trends are currently taking place in European regions. These are:

- a growing regional concentration of an educated labour force in a few hotspots (Islands) of innovation (Hilpert 1992; Zucker and Darby 2007);
- a growing probability for individuals within each region to meet people with different levels of education (Caragliu and Nijkamp 2012);
- a rising accessibility in terms of knowledge and information through virtual networks between geographically disjoint areas (Tranos *et al.* 2011).

Various data suggest an increase in both cross-regional and intraregional differentials in the human capital-rich labour force.[1] This stylized fact is in line with recent advanced literature on the increasing process of concentration of skilled labour in space. In fact, evidence-based research finds that if there are economies of scale, the major driver of such a concentration process is formed by more concentrated skilled labour, which tends to be simply more productive, thereby fostering the further attraction of skilled labour from outside (Acemoglu 1996; Rauch 1993). European cities offer a similar picture, with a few hotspots of innovation and creativity increasingly attracting knowledge-intensive labour (Caragliu *et al.* 2012; Nijkamp 2010). These findings are also in line with a rich literature on localised knowledge externalities typical of innovation clusters (Porter 1990, 1998, 2000; Saxenian 1994).

A convincing literature gives this process the name of Islands of Innovation (Hilpert 1992; Trippl forthcoming; Hilpert forthcoming). In the present paper we move a step further along the lines set by these studies and look for the conditions that allow the emergence of Hubs, and not Islands, of innovation. In fact, although pure concentration patterns are found to be optimal for the regions where educated labour migrates, no convincing explanation exists as to what happens to regions from which skilled outward migration originates. This issue reconnects to the literature on the brain drain (see, for example, Docquier *et al.* 2010; also Gibson and McKenzie 2011 for a recent overview of this topic), which usually finds that regions and countries that lose skilled labour face damage through several distinct channels (among others, the loss of human capital, a pattern of decreasing productivity, and the emergence of lower innovation rates in sending countries and regions; see, for example, Marchiori *et al.* 2009). The case for improving the connectivity (with the aim of avoiding 'splendid isolation') of Islands of Innovation is also made by Kourtit *et al.* (2011a, 2011b).

It therefore becomes fundamental to correctly assess the potential long-term effects of a human capital-rich labour force in space for sending regions. This chapter offers a new perspective on this point, on the basis of the empirical results shown in Caragliu and Nijkamp (2012). The chapter is structured as follows. In the first section, a set of stylized facts is presented, with the aim of framing the emergence of Islands of Innovation in the European regional context, while at the same time providing the rationale for this work. In the second section, the theoretical model employed in Caragliu and Nijkamp (2012) is briefly summarised. The results of the empirical validation of this model are presented in the third section on the data set and empirical estimates. The fourth section critically discusses the policy implications of such results. Finally, the fifth section concludes.

Stylized facts

Recent figures suggest that in most OECD countries education levels are, on average, increasing: more and more people are enrolling in higher education programmes. Nevertheless, this process is not always associated with an increase in per capita GDP, which is often taken as the main indicator of economic success. Figure 6.1, for example, exemplifies this process for the period 1985–2006, showing the percentage of students in total country populations and the per capita GDP level for five selected OECD countries (France, Italy, the Netherlands, the UK and the US).[2]

As can be seen from Figure 6.1, in some countries during the last decade the share of citizens actively employed in human capital accumulation actually decreased, mainly due to demographic reasons (i.e. the ageing population). However, in most OECD countries, wealth production increased. The question then would be: what prompted the increase in GDP not directly attributable to human capital accumulation? In other countries, GDP grew even without an increase in human capital (for example, in the US), raising the question: where do the necessary highly educated workers come from?

A partial explanation of this puzzling result lies in the process of concentration of the educated workforce, which has been described and explained by the literature on Islands of Innovation. Recent data sets allow the capture of part of these trends. In particular, the data set assembled by Docquier *et al.* (described in Defoort 2008) allows the breakdown of country populations into low, medium and high education, identifying for a subset of rich countries the determinants of human capital accumulation. Table 6.1 shows data for the same OECD countries shown in Figure 6.1, and in particular enables the identification of the determinants of all dynamics regarding the accumulation, or de-accumulation, of skilled

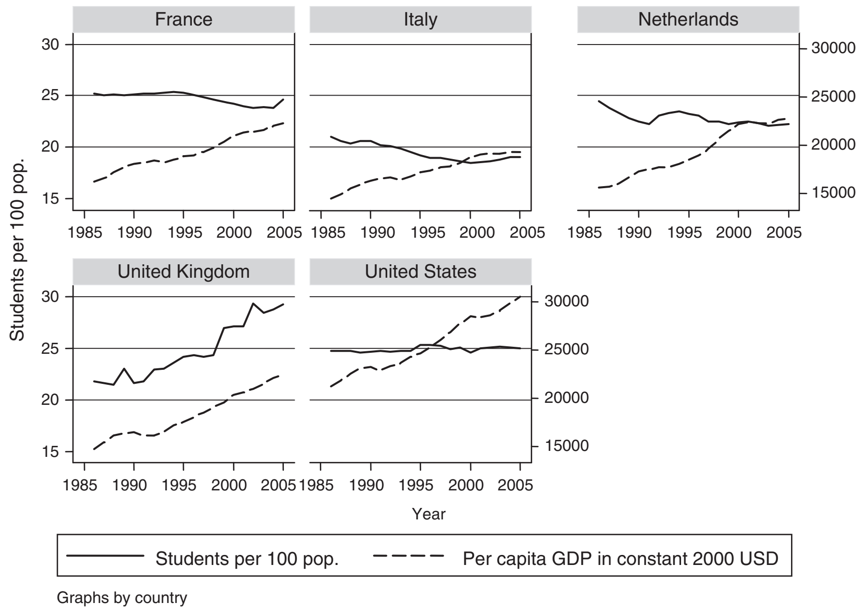

Figure 6.1 Human capital and per capita GDP in five OECD countries, 1985–2006
Source: Raw data from OECD; authors' calculations

labour. In fact, these dynamics could be best described with a simple differential equation as follows:

$$HC_t = (1-\delta)HC_{t-1} + (M_{HC,t} - X_{HC,t}), \quad (1)$$

where *HC* stands for the stock of human capital at time t; δ is the gross de-accumulation rate of human capital (i.e. the rate at which local students occupy skilled job posts left vacant by workers exiting the local labour market); and *(M-X)* represents the net import rate of skilled workers. Table 6.1 shows the values of *HC*, gross skilled emigration rates and the net human capital accumulation rate for five selected OECD countries. The results show that over the 25 years between 1975 and 2000, the US has been attracting a disproportionate share of the world's skilled labour force, with positive trends also to be found in France.

Not only do countries perform differently; also, within countries, regional education scores show increasing differentials. In order to illustrate possible time trends in the concentration of the skilled labour force in Europe, Figures 6.2 and 6.3 (first shown in Caragliu and Nijkamp 2012) indicate, respectively, a time series of the Krugman Specialization Index[3] and the Fractionalization Index.[4] The first index (Krugman 1981) measures the extent to which an area's specialisation pattern (in the original version of the index), or any space-varying characteristic, differs from those of a comparison group of areas. The second index (Alesina *et al.* 2003)

Table 6.1 Share of highly educated population, emigration of skilled workers, and net high education accumulation in five selected OECD countries, 1975–2000

Variable	*Country*	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*
Share of highly educated citizens (%)	United States	26.30	31.90	35.70	39.20	47.80	51.30
	United Kingdom	8.85	10.04	11.90	13.93	15.88	17.82
	Italy	4.05	4.73	5.44	6.30	7.80	8.66
	France	13.68	16.43	19.17	21.92	24.57	27.92
	Netherlands	8.22	10.70	13.18	15.66	19.38	21.86
High education emigration (%)	United States	0.4	0.4	0.4	0.4	0.3	0.3
	United Kingdom	19.9	17.9	16.3	15.7	12.6	14.3
	Italy	12.7	12.1	10.9	10.0	7.9	8.3
	France	1.6	1.7	1.7	1.8	1.6	1.7
	Netherlands	15.8	14.0	10.9	9.9	7.5	7.6
Net high education accumulation (%)	United States	–	5.49	3.67	3.35	8.46	3.33
	United Kingdom	–	–0.57	0.06	0.09	–0.24	–0.06
	Italy	–	0.16	0.14	0.27	0.87	0.24
	France	–	2.53	2.47	2.42	2.26	2.96
	Netherlands	–	1.18	0.98	1.04	2.17	1.03

Source: Defoort (2008); authors' calculations

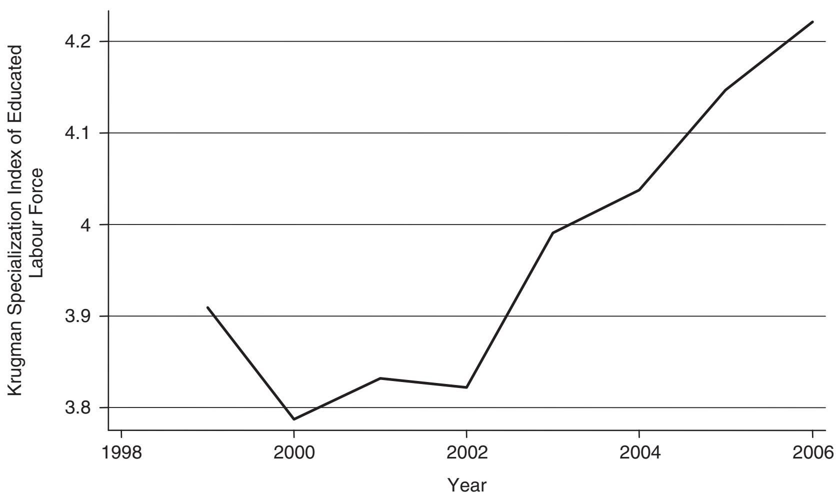

Figure 6.2 Krugman Specialization Index for the educated labour force, NUTS1 regions
Source: EUROSTAT, 1999–2006 data; own calculations

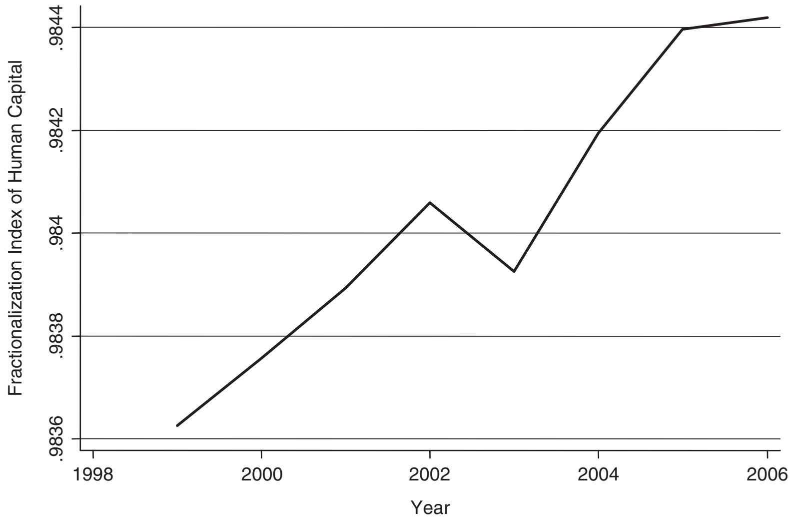

Figure 6.3 Fractionalization Index for the educated labour force, NUTS1 regions
Source: EUROSTAT, 1999–2006 data; own calculations

gauges the extent to which sub-areas within a larger space are heterogeneous across some dimensions. We measure regional human capital as the regional labour force (in European NUTS1 regions[5]) with ISCED 5 and 6 education.[6]

Results of these calculations clearly show an increasing trend in concentration using two indicators that are frequently adopted to capture within-country differences in regional endowments of human capital. In fact, they show that in the first years of the twenty-first century fewer regions attracted an increasingly larger share of skilled workers.

Figures 6.2 and 6.3 clearly suggest that some major trends are taking place in Europe:

- Western countries tend to attract an increasing share of the world's stock of skilled workers, with the traditional motivation of salary differentials as the main push factor.[7] Among rich countries, the United States tends to attract a larger share of skilled labour than most OECD competitors.
- Within rich countries, richer and more human capital-intensive regions tend to attract a disproportionate share of skilled labour, thereby further augmenting regional disparities, therefore creating potential threats to sending regions.

In Caragliu and Nijkamp (2012) we interpreted these stylized facts, clearly calling for sound empirical research, undertaken through the lens of the Lucas (1988) growth model. In this chapter we briefly review the way the Lucas model has been adapted to a regional setting, the results of that empirical analysis, and finally, we interpret those results in light of the ensuing policy implications.

The Lucas growth model from a regional perspective

The Lucas growth model was originally conceived more as a theoretical than an applied model. However, in Caragliu and Nijkamp (2009, 2012), we show that an endogenous growth model with a cognitive capital externality can generate increasing returns to physical production factors, even in a regional setting. In the original Lucas (1988) model, the mechanism driving the emergence of increasing returns to physical factors is the average human capital in a society or area: people enjoy positive spillovers from fellow members of the same social group, thus becoming more productive themselves. In our version of the model, the mechanism that produces increasing returns is the presence of higher cognitive capital.

In Caragliu and Nijkamp (2012: 10), we defined cognitive capital (in the spirit of Uphoff 1999) as 'the set of mental processes, reinforced by culture and ideology, in particular encompassing norms, values, attitudes, and beliefs that positively contribute to cooperative behavior and mutually beneficial collective action'. We therefore assume that people benefit from the positive externalities of cognitive capital. In an environment that is endowed with fluent interpersonal relationships and where people trust each other, tolerance for diversity enhances creativity, governance of cultural and natural institutions is able to properly manage public endowments and people are expected to gain more than proportionally in productivity. This is in line with the concept of Islands of Innovation.

The details of the model can be found in the cited works. For our analysis, it suffices to recall that the underlying preferences over consumption are described by a Constant Elasticity of Substitution (CES) function of the usual form:

$$U_0 = \int_0^{\infty} \frac{c_t^{1-\sigma} - 1}{1-\sigma} e^{-(\rho-\lambda)} dt, \tag{2}$$

Where σ-*1* measures the intertemporal elasticity of substitution, and ρ is a discount rate. In the Lucas model, labour productivity is raised not only by individual human capital but also as a result of the increase in the aggregate level of human capital. Analogously, when considering their time allocations, agents do not take into account the possible positive spillovers from their collective behaviour. Aggregate cognitive mechanisms, in the form of improved mutual understanding (e.g. district economies), thick and dense social networks (relational capital), wise management of collective goods that prevents spoiling natural resources, and the efficient transfer of R&D results, all combine as a cognitive catalyst that optimises the combination of physical factors and generates increasing returns Therefore, it is not just aggregate human capital that determines the generation of increasing returns to individual education, but also the regional endowment of cognitive capital.

The model for the individuals in this economy is:

$$y_{r,t} = Ak_{i,r,t}^{\alpha}(uh_{i,r,t})^{1-\alpha}, \tag{3}$$

where $y_{r,t}$ measures regional GDP; eq. (3) is therefore the production function for this model.

Our aggregate economy is described by the following equation:

$$y_{r,t} = Ak_{r,t}^{\alpha}(uh_{r,t})^{1-\alpha} cc_{r,t}^{\eta}, \tag{4}$$

where $0<\alpha<1$; and A, k, u and h are defined, respectively, as the technology parameter, the stock of capital (which we estimate with the perpetual inventory method[8]), the share of time devoted to working, and the stock of human capital (i.e. education) of an individual (or in a region); here cc is a measure of cognitive capital. Eq. (4) differs from eq. (3) in that in eq. (4) agents are averaged out at the regional level. The crucial assumption of the empirical component of our paper is that individuals create collective (i.e. regional) cognitive capital when investing in their own education.

Eq. (3) is the basis for our micro-regressions; eq. (4) is instead the baseline functional form for regional regressions. In this chapter we briefly review the results of this empirical exercise, which aims at assessing the relative importance of individual education decisions on regional performance, through the use of the Lucas (1988) growth model in a regional setting; region-specific characteristics (viz. cognitive capital) are demonstrated to affect the formation of Islands of Innovation, and policy implications are derived.

The data set and empirical estimates

To test the above model calls for extensive data. We built a comprehensive data set on European regions by combining EUROSTAT data for the quantitative variables in the Lucas model and European Values Study (henceforth, EVS[9]) data for the cognitive elements of regional knowledge systems. All data cover a cross-section of the year 2000: this choice is motivated by the availability of EVS data for that year.[10] Table 6.2 shows the main sources of our data set. The top section of the table shows the main variables used to test the Lucas model in an individual setting (eq. 3); the central part of the table shows data for the aggregate

Table 6.2 The data set

Data description	*Source*
Household real income	EVS
Household education level	EVS
Household stock of capital/savings	EVS
Share of time devoted to work activities	EVS
Regional GDP in constant 2000 prices	EUROSTAT
Regional investments (yielding the capital stock with the perpetual inventory method)	EUROSTAT
Regional human capital: share of human resources in Science and Technology	EUROSTAT
Cognitive capital elements (norms, values, attitudes and beliefs)*	EVS

* The choice of indicators is explained in detail in the cited work. The chosen EVS questions are reported as an Appendix.

Source: Caragliu and Nijkamp (2012).

setting test (eq. 4); and, finally, the bottom part of the table shows the cognitive capital measures.

The individual household test was carried out on 16,929 observations in the EVS data set, which are those in the EU27, for which we have answers to all four questions related to the Lucas model (Table 6.3).

The estimation of this model is carried out with a three-stage procedure. First, micro-regressions are run on a sample of 16,929 individual observations for which the EVS data set covers the whole spectrum of relevant variables. These observations are then aggregated to form a sample of 261 NUTS2 regions of the European Union. These regional data are used for standard OLS regressions, and – in the third stage – in a Spatial Durbin (henceforth, SDM) model, which generalises the spatial connectivity effects among spatial units. Estimates are based on Le Sage and Pace (2009),[11] which enables us to break down the general impacts of the model variables into direct, indirect and total effects.[12] The results of this third set of estimates are presented in Table 6.4.

The total impacts of the model variables show that the regional stock of cognitive capital is indeed positively associated with a higher per capita GDP. This result comes from a positive, but smaller, direct effect and a positive, but not fully significant, indirect effect. This implies that processes of spatial concentration of non-material growth-enhancing characteristics could indeed

Table 6.3 EVS questions chosen to test the Lucas model at the individual household level

Variable	*EVS Id*	*Question*
Household real income	Q110 (v320)	Here is a scale of incomes and we would like to know to what group your household belongs, counting all wages, salaries, pensions and other income that comes in. Just give the letter of the group your household falls into, after taxes and other deductions. (1 to 10 scale)
Household education level	Q94 (v304)	What is the highest level you have reached in your education? (1 to 8 scale)
Household stock of capital/ savings	Q110a (o49)	Socio-economic status of the respondent (1 to 4 scale)*
Share of time devoted to work (u)	Own calculation	Obtained as 1-Q93(v303)/80**
Units of effective labour	Own calculation	Obtained as u*Q94(v304)

* This is essentially a proxy for the extent of household savings, based on the assumption that the socio-economic status of the respondent crucially depends on his/her wealth.

** Question Q93 (v303) is: "At what age did you (or will you) complete your full-time education, either at school or at an institution of higher education? Please exclude apprenticeships"; 80 years is the assumed life expectancy at birth for all EU citizens.

Source: Caragliu and Nijkamp (2012)

Table 6.4 Estimation results for eq. (4), using a Spatial Durbin model, with country fixed effects

Dependent variable: log of per capita GDP	*Spatial Durbin estimates (1)*
Stock of capital	0.10***
	(0.000)
Units of effective labour	0.08
	(0.25)
Cognitive capital	0.04**
	(0.03)
Constant term	8.29***
	(0.000)
Spatial autocorrelation coefficients	
ρ	–0.05
	(0.47)
W*Stock of capital	0.05
	(0.23)
W*Units of effective labour	0.16
	(0.34)
W*Cognitive capital	0.07
	(0.18)
Direct effects	
Stock of capital	0.10***
	(0.000)
Units of effective labour	0.08
	(0.29)
Cognitive capital	0.04**
	(0.03)
Indirect effects	
Stock of capital	0.04
	(0.22)
Units of effective labour	0.15
	(0.37)
Cognitive capital	0.06
	(0.22)
Total effects	
Stock of capital	0.15***
	(0.001)
Units of effective labour	0.23
	(0.22)
Cognitive capital	0.11**
	(0.05)
Country dummies	Yes
R^2	*0.95*
Adjusted R^2	*0.94*
Log-likelihood	*167.97*
Number of observations	*261*

* Significant at the 90% confidence level.
** Significant at the 95% confidence level.
*** Significant at the 99% confidence level. P-values in parentheses.
Source: Caragliu and Nijkamp (2012)

foster the emergence of Islands of Innovation, where the returns to skilled labour are maximised not only by the local concentration of human capital, but also because of accessibility to neighbouring regions similarly endowed with skilled labour.

These estimates are based on a geographical connectivity matrix, where pure geographical distance drives the extent to which regions with a high density of highly-skilled labour benefit from being close to regions similarly rich with human capital. However, one major step forward in assessing whether real transfer of knowledge from these splendidly isolated regions to lagging areas takes place could be the use of non-geographical (e.g. relational, social, technological, and cognitive) forms for the connectivity matrix. Alternatively, the focus could be on selected sub-samples of star scientists, following their careers, and assessing their capability to bring in knowledge when moving across space (Trippl forthcoming).

Policy implications

In a previous study (Caragliu and Nijkamp 2012), the authors showed how encompassing spatial spillover effects in regional estimates of the Lucas growth model allows us to account for the potential access to external knowledge, even for regions that have low densities of their own skilled labour. In this section we analyse this result in the light of recent EU policies, and show that ignoring potential connectivity effects in shaping policies for human capital and innovation may be a cause of biased policy decisions.

The EU recently relaunched the Lisbon Agenda with the EU 2020 strategy, aiming at fostering the evolution of Europe towards becoming a ‘smart, sustainable and inclusive economy’.[13] This general objective is specified in five more detailed goals. By 2020:

- 75 per cent of 20–64 year-olds should be employed (employment target);
- 3 per cent of the EU’s GDP (public and private combined) should be invested in R&D (R&D target);
- greenhouse gas emissions should be decreased by 20–30 per cent with respect to the 1990 value, while at the same time obtaining 20 per cent of total energy consumption from renewables and obtaining a 20 per cent increase in overall energy efficiency (climate change/energy targets);
- school drop-out rates should be reduced below 10 per cent while at least 40 per cent of 30–34-year-old citizens should be completing tertiary-level education (education targets);
- finally, at least 20 million fewer people should be in, or at risk of, poverty and social exclusion (poverty/social exclusion targets).

Our work contributes to the debate on two of the abovementioned five targets, viz. the discussion on innovation/R&D and education. Our empirical results show in fact that ignoring spillover effects in the assessment of the impact of concentrating skilled labour may in fact blur our understanding of the likely spatial effects of policies which target education and R&D.

In order to gain a quantitative assessment of the likely distortion stemming from not using the appropriate techniques, we proceed as follows. First, we estimate the model explained in the previous section with OLS, calculating the predicted per capita GDP. Then, we repeat the exercise with the SDM, once again calculating the predicted values of regional per capita GDP. The two vectors of predicted GDPs are then compared region by region. Table 6.5 shows the top and bottom ten regions in terms of this discrepancy, and identifies a clear pattern: regions in the core of Europe enjoy potentially higher benefits just from being located in macro-areas with a high density of skilled labour, whereas regions in New Member States suffer from the opposite effect. Interestingly, geographically remote areas also seem to benefit from their potential accessibility to skilled labour of relatively close regions (this is, for example, the case of Valle d'Aosta, Corsica, Västsverige, and Notio and Voreio Aigaio). The poor performance of standard linear predictions for Eastern regions is particularly evident in Figure 6.4, where the whole set of regional discrepancies is mapped.

Table 6.5 The top and bottom regions by difference between per capita GDP predicted with OLS and SDM estimates

NUTS2 code	*NUTS2 name*	*Difference between SDM and OLS estimates (%)*
LU	Luxembourg (Grand-Duché)	15.93
IE01	Border, Midlands and Western	13.06
ES42	Castilla-la Mancha	12.08
ITC2	Valle d'Aosta/Vallée d'Aoste	11.73
NL42	Limburg (NL)	10.31
FR83	Corsica	9.98
SE07	Västsverige	7.94
GR42	Notio Aigaio	7.91
BE35	Namen/Namur	7.87
GR41	Voreio Aigaio	7.85
RO03	Nord-Est	−11.68
CZ08	Moravskoslezsko	−12.14
BG12	Severen tsentralen	−12.33
BG22	Yugozapaden	−12.91
LT	Lithuania	−13.10
RO01	Nord-Vest	−14.51
BG23	Yuzhen tsentralen	−14.65
LV	Latvia	−15.38
RO08	Vest	−18.68
BG21	Yugoiztochen	−18.96

Source: Authors' calculations

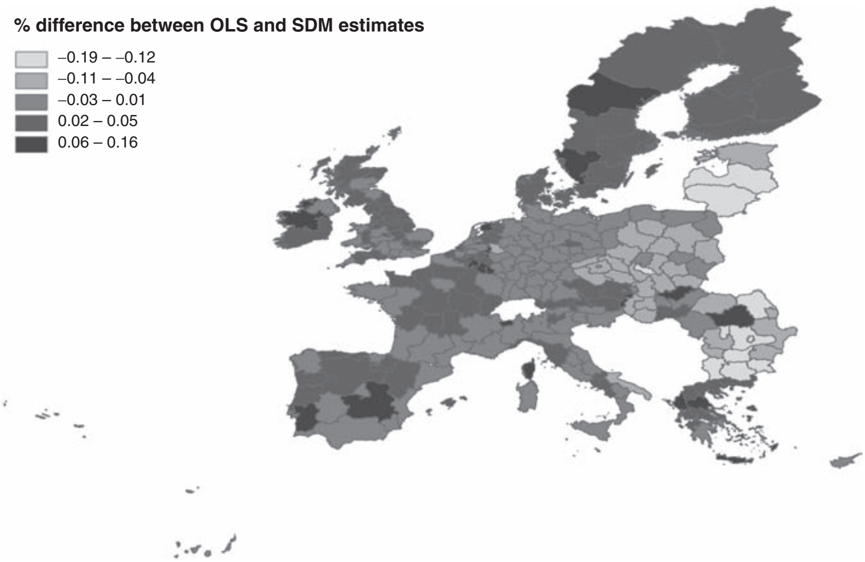

Figure 6.4 Percentage difference between OLS and SDM estimates of per capita GDP levels in 2000
Source: Authors' calculations

Dark grey colours indicate regions where GDP levels predicted with OLS estimates are higher than SDM predictions; light grey to white colours indicate the opposite case.

The appearance of the map in Figure 6.4 crucially depends on the adoption of a geographical connectivity matrix, which translates the effects of underlying real economic interactions (networks of relations and citations, and social, technological and cultural proximity) into tractable equations. Ertur and Koch (2011) state that:

> [the definition of] connectivity (…) is much broader and can be generalised to any network structure to reflect any kind of interactions between observations. (...) By analogy to Akerlof (1997), countries may be considered as located in some general socio-economic and institutional or political space, defined by a range of factors. Implementation of spatial methods thus requires accurate identification of their localisation in such a general space. Ideally, such a matrix should be theory-based, but this is beyond the scope of the present paper (2011: 236).

The need to consider other forms of proximity in regional studies has been advocated by a number of different theoretical perspectives using complementary (or alternative) specifications with respect to physical distance. These include relational proximity (Boschma 2005; Capello 2007, 2009), organisational proximity (Bellet *et al.* 1993), social proximity (Rallet and Torre 1995), institutional proximity (Lundvall and Johnson 1994), technological proximity (Canter and Meder 2007), and specialisation proximity (Ciccone 2002; Henderson 2003).

Recent empirical studies take this idea seriously (see, for example, Maggioni and Uberti 2009; Mora and Moreno 2010; Basile *et al.* 2012; Autant-Bernard and LeSage 2011; Frenken *et al.* 2010). Within the framework of the present analysis, examining the real mechanisms driving connectivity between regions in the transmission of knowledge spillover effects may be crucial in making a correct inference about the likely policy effects.

Conclusions

This chapter starts from the empirical findings in Caragliu and Nijkamp (2012) in order to review the concept of 'Island of Innovation' (a spatial singularity where highly skilled labour tends to concentrate over time). Indeed, current statistics demonstrate that because of higher returns to education and skills, which characterise these high-performance regions, skilled labour is increasingly concentrating, thereby posing major challenges for sending regions and countries.

In this chapter we reviewed this process through the lens of the Lucas (1988) growth model, which is adapted to a regional setting by introducing the concept of cognitive capital. The set of social capital skills needed to properly interpret, decode and fully understand reality is typical of local societies, which vary region by region, and cannot therefore freely move across space. This creates scope for local economies of scale in the formation of increasing returns to regional education, and fosters the emergence of Islands of Innovation. As sending regions may face several negative outcomes of such a concentration process, in this chapter we proposed the concept of 'Hub of Innovation'. To some extent, Hubs of Innovation may be compared to Islands of Innovation, but the main difference between these two concepts lies in the consistently higher degree of connectivity of the former vis-à-vis the latter.

In fact, our empirical estimates show that connectivity between regions matters in explaining the ease with which knowledge travels across space. One way to avoid the negative consequences from this process of increasing concentration of skilled labour is therefore to foster the creation of nodes of connection between Hubs of Innovation and sending regions. While in fact the case for concentrating where education is paid its highest return cannot be successfully opposed in a market economy, policies aiming at increasing the exchange of knowledge across space are much more feasible.

Any such policy should carefully consider the true channels through which knowledge travels. Although that type of analysis goes beyond the scope of this chapter, the authors would welcome the development of any step further in this direction.

Appendix

Selection of cognitive capital indicators from the EVS data set

Table 6.6 Selected questions in the EVS data set

Domain	*Question*	*Scale*
Community organisational life	How often is your time spent in clubs and voluntary associations?	1 Every week
		2 Once or twice a month
		3 A few times a year
		4 Not at all
Engagement in public affairs	Participation in any social activity	0–1
Community volunteerism	Voluntary work in any community activity	0–1
Informal sociability	Agree that "most people can be trusted"	1 Trust them completely
		2 Trust them a little
		3 Neither trust nor distrust them
		4 Do not trust them very much
		5 Do not trust them at all

Source: Caragliu and Nijkamp (2012)

Notes

1. These data are used to calculate the indicators shown in the 'Stylized facts' section of this chapter.
2. The selection of these five countries, maintained throughout this section, is motivated by the need to merge and analyse different data sets, with the aim of obtaining a homogeneous exemplifying data set with comparable data.
3. Here the Krugman Specialization Index is calculated as in Midelfart-Knarvik and Overman (2002). Our modified version does not capture sectoral issues, therefore it does not satisfy all properties of the original index, which include assuming a maximum value of 2.
4. *Atlas Narodov Mira* (1964); the index is calculated as the sum of the absolute differences in human capital intensity between each NUTS region and the average EU27 level, the latter being 1 minus the Herfindahl Index of educated labour force.
5. The sample comprises all EU27 NUTS1 regions, except the Bulgarian regions, for which data on human capital attainments prior to 2006 are not available. The NUTS1 level of aggregation is chosen, as Germany and the UK only release data at this level.
6. 'The International Standard Classification of Education (ISCED) was designed by UNESCO in the early 1970s to serve "as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries

and internationally". It was approved by the International Conference on Education (Geneva, 1975), and was subsequently endorsed by UNESCO's General Conference when it adopted the Revised Recommendation concerning the International Standardization of Educational Statistics at its twentieth session (Paris, 1978)' (www.unesco.org).

7. Gibson and McKenzie (2011) show that skilled workers from developing countries experience a net salary differential equal to about 40,000 to 60,000 USD.
8. The assumptions include a depreciation rate equal to 2.5 per cent, while the starting point of the capital stock time series is 1998.
9. EVS consists of a set of individual questionnaires administered to European citizens. Data were collected in four waves: this chapter uses the 1999–2000 wave, as it is the first to comprehensively cover the regional dimension of the analysis. Information on methods of data collection and on data stratification are available at www.europeanvaluesstudy.eu
10. A fourth wave of the EVS has recently become available. Individual interviews were administered in the 2008–2009 period. Therefore, the use of such data would induce a simultaneity issue with the dependent variables being explained with our model.
11. Recent empirical applications of this estimator include Fischer *et al.* (2009) and Del Bo and Florio (forthcoming).
12. 'Direct effects estimates measure the impact of changing an independent variable on the dependent variable of a spatial unit. This measure includes feedback effects, i.e., impacts passing through neighboring units and back to the unit that instigated the change. Indirect effects estimates measure the impact of changing an independent variable in a particular unit on the dependent variable of all other units' (Elhorst, 2010: 2).
13. The details of this strategy can be found at http://ec.europa.eu/europe2020/index_en.htm

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7 Islands of Innovation in the Czech Republic

The international labour market of highly skilled workers and brain gain policies

Josef Bernard, Věra Patočková and Tomáš Kostelecký

Introduction

Globalisation has changed industrial production networks. Manufacturing of mass production goods is being relocated to countries where acceptable quality of production can be assured while production costs are lower (Henderson *et al.* 2002). The competitiveness of the most developed nations can only be assured by specialisation in innovative products and services with a high value-added component. That is why innovation is a key source of economic sustainability for highly developed economies (Cooke 1996). Studies have suggested that innovations do not appear randomly in terms of location but their production is highly spatially concentrated in certain regions where conditions for the production of innovation are the best (Simmie 1998; Maskell and Malmberg 1999; Doloreux and Parto 2005; Kasabov and Delebridge 2008; Ibata-Arens 2008).

Such locations or regions are called 'Islands of Innovation' – regions where the most advanced industries, research and development facilities are located, advantageous kinds of participation in the international division of labour exist, and effective government policies support innovation processes (Hilpert 2003). Islands of Innovation are characterised by dense links among actors of innovative processes within the region as well as mutual interconnectedness with other similar regions around the world. Both formal and informal networks of actors within the innovative region facilitate the use of innovation in the actual production of new products or services by decreasing transaction costs and lowering the risks of doing innovative business (Sternberg 2000). The participation of an innovative region in a worldwide network of such Islands of Innovation provides actors in such a region access to state-of-the-art knowledge and know-how produced anywhere around the world.

The ability of a particular region to become a location of innovation-led economy requires (among other things) the presence of a critical mass of highly qualified labour force (Knudsen *et al.* 2008). Highly qualified workers are necessary in all steps of an innovation process – in the actual production of knowledge through research and development as well as in the assimilation and exploitation of novelty in economic and social spheres. The labour markets of Islands of

Innovation are therefore specific. Beside the internal resources of qualified labour, Islands of Innovation make use of qualified labour from other regions by attracting workers from them. In addition, the labour markets of Islands of Innovation are mutually interconnected. One can expect dense migration flows of highly qualified workers among them. These flows of labour contribute to the efficient distribution of the qualified labour force in the form of a relatively balanced 'brain exchange', and to information and knowledge diffusion.

Institutional environment and public policies to support innovations also have a great impact on the creation and development of Islands of Innovations (Hilpert 2003). Public support can take many forms, depending on the notion of major factors leading to innovations. The main factors include support for entrepreneurs, especially in the early phases of a company's development, support for networks and information exchange among innovation stakeholders in a region, and a quality infrastructure, especially infrastructure for information transfer and creation (Rhonda 2005). Public research institutions, engaged primarily in basic research, can play an important role in facilitating innovations. The significance of research institutions and universities is usually regarded as important due to the existence of spillover effects consisting in information transfer and human capital flows between public research laboratories and private companies, the formation of spin-offs and the education of the labour force (Diez 2000). Moreover, excellent and internationally competitive basic research institutions have the potential to attract a highly skilled labour force from other regions, which further contributes to the development of regional markets and can provide a positive incentive for innovation development. Appropriate funding of basic research is thus also related to an environment in which technological innovations can develop.

As yet, evidence on the development of Islands of Innovation in post-communist European countries whose labour markets were isolated during the communist regime is lacking. There is limited information about the opportunities for and limits to public support for innovations in the region as a whole. Partial analyses have been conducted regarding the development of selected branches of industry in post-communist Central and Eastern Europe (Radosevic 2002; McGowan *et al.* 2004) and the productivity of research and development organisations (Balázs 1995).

Full involvement of the most innovative regions in post-communist European countries in the network of mutually interconnected Islands of Innovation depends, among other things, on their ability to offer equally profitable work conditions to attract qualified labour and to build up networks of mutual migration with innovative regions in other countries. Post-communist countries face particular difficulties in attaining this goal. These include relatively low real wages in comparison to the most developed European countries, lower financial governmental support of research institutions (in absolute terms) and the lack of traditional, internationally competitive research centres. A potential brain drain to other countries rather than the attraction of a qualified workforce could have negative effects on their future innovative development. Their position in the international labour market for qualified labour is an important factor in their future development.

A case study of the most innovative regions in the Czech Republic, which is presented here, aims to show the position innovative regions in a post-communist country have in the international labour market for highly qualified labour. We shall concentrate especially on one feature of highly innovative regions – the flows of the qualified labour force between individual Islands of Innovation. Inclusion in mutually balanced exchanges of qualified labour is one of the comparative advantages of Islands of Innovation compared to other regions. Similar to the 'network cities' theory (Castells, 1996; Frenken and Hoekman 2006), the notion of Islands of Innovation presupposes that regions with concentrated innovative production participate, on the global level, with other similar regions in the exchange of information, services and labour, which in turn supports their growth, while regions outside such global networks are, to a large extent, excluded from those networks. As has been stated above, researchers involved primarily in basic but also applied research are an important segment of the qualified labour force. We will therefore analyse the position of innovative regions in the Czech Republic in terms of international flows of highly qualified labour and specifically researchers.

The characteristics of the relation of these regions to Islands of Innovation will be explored (exchanges of labour and information, or the unidirectional supply of labour from Czech regions to Islands of Innovation). Furthermore, consequences of the position of the analysed Czech regions for the further R&D development of the regions and for the development of Island(s) of Innovation in the country will be assessed, and existing policies will be examined which are aimed at researcher brain gain in the given regions as well as those aimed generally at the development of human capital in science and research.

The Czech Republic represents a medium-sized post-communist European country. During the authoritative communist regime, the interconnectedness of Czech research institutes and innovative firms with their counterparts in Western Europe and the USA could not develop and Czech research and development activities were relatively isolated. This situation gradually changed in the 1990s particularly after admission to the European Union (EU) in 2004 when the main institutional barriers to the migration of highly qualified workers to other European countries were removed. The performance of the Czech economy is below the EU average and financial conditions for highly qualified Czech workers are worse than in the most developed EU countries. One of the specific features of the Czech Republic is the heavy concentration of research and development in only a few regions, namely in the city of Prague and the surrounding Central Bohemian Region, and to a lesser extent in the South Moravian Region where R&D is concentrated in the regional capital Brno. On the regional level, only one NUTS2 region in post-communist countries – Prague – belongs to the top 20 most innovative EU regions (15th position) (Merit, JRC 2006). Prague, the capital of the Czech Republic, is thus one of the regions in the new EU member states that aspires to become a new Island of Innovation.

The regional pattern of research and development in the Czech Republic

As mentioned above, research and development in the Czech Republic is concentrated in only a few regions, namely in the city of Prague and the surrounding Central Bohemian Region, and to a lesser extent in the South Moravian Region (see Table 7.1).

The dominant position of the city of Prague in Czech R&D is indisputable. Prague itself is the workplace of 47 per cent of Czech researchers, and 42 per cent of R&D expenditure is spent in Prague. Both the number of employees in R&D and the number of researchers per 1,000 employees in Prague exceeds the Czech average by more than three times. Prague was classified by Muller *et al.* (2008) as the only Czech region able to be integrated into the European Research Area, although the South Moravian Region is considered as the Czech region with the best quality of 'institutions of innovation infrastructure' (Pokorný *et al.* 2008). The dominant position of Prague indicates that it has potential to develop as a nucleus of a Czech Island of Innovation, which would serve the interests of the country.

The exclusive position of Prague, and partly that of the Central Bohemian and South Moravian Regions, on the labour market of the highly skilled is well documented by data about the inter-regional migration of highly skilled workers within the Czech Republic (Table 7.2).

As the data in Table 7.2 suggests, the City of Prague and the adjacent Central Bohemian Region are clearly the most attractive Czech regions for highly skilled migrants. The only other region that had positive net migration of the highly skilled is the South Moravian Region. It is worth noticing that the majority of highly skilled immigrants to Central Bohemia were people who moved from Prague to its quickly developing suburbs (Kostelecký and Čermák 2004). While Central Bohemia was attractive for migrants of all educational categories, both Prague and the South Moravian Region were gaining migrants with tertiary education while losing population with lower levels of education (Polášek *et al.* 2007).

The position of Prague is also dominant as far as the output of research and development is concerned. The South Moravian Region is much weaker than Prague in this respect but still is the only Czech region besides Prague where the values of all key R&D performance indicators – patents, utility models and research publications per 100,000 inhabitants – exceed the Czech Republic average. Both Prague and the South Moravia Region are significantly more frequently involved in international R&D cooperation organised through the EU Framework Programmes than other regions. In fact, 75 per cent of the Czech institutions that participated in the activities financed by the Sixth Framework Programme were from one of the two regions (Albrecht and Vaněček 2008).

Methodology of the analysis

The analysis of the position of Czech innovative regions on the international labour market of researchers, and more generally other qualified workers, is

Table 7.1 Basic research and development indicators by Czech regions in 2007

	Prague	*Central Bohemia*	*South Bohemia*	*Pilsen*	*Karlovy Vary*	*Ústí nad Labem*	*Liberec*	*Hradec Králové*	*Pardubice*	*Vysočina*	*South Moravia*	*Olomouc*	*Zlin*	*Moravia-Silesia*	*Czech Republic*
Number of institutions performing R&D	*626*	*189*	91	84	22	82	74	111	111	66	*321*	107	131	189	2204
Share of region on total expenditure on R&D in CR in %	*42.2*	*19.5*	3.3	2.6	0.1	1.3	2.4	2.3	3.7	1.0	*10.5*	2.8	3.2	5.1	100
Share of region on total R&D personnel (FTE*) in CR in %	*43.0*	*10.3*	3.7	4.0	0.1	1.7	2.9	3.0	4.5	1.2	*12.6*	4.1	3.3	5.6	100
Share of region on researchers (FTE*) in CR in %	*47.1*	*9.9*	2.8	2.6	0.1	1.5	2.8	2.7	4.2	1.1	*13.4*	3.7	2.6	5.5	100
Employees in R&D (FTE*) per 1,000 employees in region	*33.5*	*8.7*	5.8	7.2	0.5	2.3	7.2	5.5	9.1	2.4	*11.7*	6.8	5.8	5.0	10
Researchers (FTE*) per 1,000 employees in region	*20.8*	*4.8*	2.5	2.7	0.3	1.1	3.9	2.8	4.8	1.2	*7.0*	3.5	2.6	2.8	5.7

Source: Authors' own calculations based on data from ČSÚ 2008 a, b
Note: * FTE = Full-time equivalent

Table 7.2 Patterns of internal migration of highly skilled workers by region in the Czech Republic, 1991–2004

NUTS3 region	*Total population (2004)*	*Percentage of labour force with tertiary education (2003–2005)*	*Internal migration – immigrants with tertiary education (1991–2004)*	*Internal migration – emigrants with tertiary education (1991–2004)*	*Internal migration – net migration of migrants with tertiary education (1991–2004)*
Prague	*1,165,617*	*27.3*	*30,116*	*22,288*	*7,828*
Central Bohemia	*1,137,748*	*9.9*	*22,358*	*12,177*	*10,181*
South Bohemia	625,421	11.2	5,883	6,538	–655
Pilsen	549,216	10.5	3,906	4,920	–1,014
Karlovy Vary	303,722	7.9	1,812	3,363	–1,551
Ústí nad Labem	820,619	6.7	4,513	7,550	–3,037
Liberec	427,395	9.0	4,070	4,250	–180
Hradec Králové	546,995	11.0	4,701	6,344	–1,643
Pardubice	505,193	10.1	4,689	5,889	–1,200
Vysočina	517,282	9.6	3,737	6,164	–2,397
South Moravia	*1,122,391*	*15.6*	*10,700*	*8,913*	*1,787*
Olomouc	635,449	11.1	5,907	6,969	–1,062
Zlín	591,287	11.2	4,388	6,193	–1,805
Moravia-Silesia	1,258,588	10.8	4,921	10,173	–5,252

Source: ČSÚ 2005, ČSÚ 2007b, ČSÚ 2007c

derived from a combination of several data sources. The basic analyses of the scope and patterns of the emigration of highly skilled Czech labour and of the immigration of qualified foreign workers to the Czech Republic are based on the OECD Database on Immigrants and Expatriates (OECD 2008) and on secondary analysis of different national statistical sources.

A deeper analysis of the migration patterns, motives and return migration of highly skilled Czechs is based on survey data about Czech researchers with experience of working abroad. The survey was conducted via a web-based questionnaire in 2008. Potential respondents were all researchers and scientists of Czech origin who had been working in a research position or studying for a PhD abroad for at least two academic semesters (nine months), regardless of whether or not they were actually abroad at the time of the survey. Due to the fact that at present there is neither a comprehensive database of Czech expatriate scientists nor a database of researchers and scientists with relevant international experience who work in the Czech Republic, the survey could not ensure that the respondents who participated in the survey were a representative sample of the target population. To decrease the probability of a biased sample we used various sources of information about Czech scientific expatriates to build our own database of potential respondents. Finally, we collected contact details of over 600 potential respondents who might be considered a target population and then collected 339 questionnaires that were usable for further analysis. We used 299 questionnaires for the purpose of this paper (40 questionnaires completed by researchers in medical sciences were excluded, because they form a specific sub-group with a very different migration behaviour to that of the rest of the respondents).

The analysis of the position of Czech R&D institutions on the international labour market is, in addition, based on unstructured interviews with representatives of Czech research institutions. We conducted a series of interviews with deans or vice-deans of individual faculties, with the heads of public research institutions both within and outside the Academy of Sciences of the Czech Republic, and with a managing director of one private share-holding research company. The institutions were intentionally selected to vary in terms of scientific disciplines; we approached both large and small institutions. All selected institutions had some experience with either the departure of their own employees to research institutions abroad or with employing Czech researchers who had relevant work experience abroad or foreign researchers in general. Altogether, we conducted ten in-depth interviews – five in Prague, three in Brno and two in other regions of the Czech Republic.

The scope and patterns of emigration of highly skilled Czech labour– is brain drain a danger for the most innovative Czech regions?

Czechs do not belong to a nation with a high rate of international migration. Obviously, the fact that the country was isolated from the West by the Iron Curtain for almost 40 years is a key reasons for this. However, recent migration studies prove that the rate of emigration has not increased to a high level, even after the breakdown of communist rule (Kultalahti *et al.* 1999; Drbohlav 2005, Drbohlav and Uherek 2007).

Bobeva (1997) studied the emigration potential of scientists and researchers from Central Europe using surveys. The authors somewhat surprisingly concluded that migration potential is not very high, particularly in the Czech case. In the Czech Republic, from those who left the science sector during the period 1989–1995, only 4 per cent emigrated while the majority joined another sector of the economy within the Czech Republic. This ‘internal brain drain’ not emigration, was considered the main problem for the R&D sector in the most turbulent years after the collapse of communism (Vavrečková 2005). Bernard (2008) clearly showed that although the emigration rate from the post-communist states of East-Central Europe to the USA increased noticeably immediately after the regime change, the rate of emigration subsequently decreased and from about the mid-1990s was lower than the emigration rate of highly skilled labour from Western Europe. The most recent studies by the Czech Research Institute for Labour and Social Affairs concluded that the risk of emigration of highly skilled labour from the Czech Republic is not high in either medical or IT sectors (Vavrečková *et al.* 2007) or among researchers and scientists (Vavrečková *et al.* 2008).

Taking into account the results of the migration studies, it is not surprising that the data from the OECD Database on Immigrants and Expatriates (OECD 2008) place the Czech Republic among countries with the lowest absolute numbers of tertiary-educated expatriates living in other OECD countries – altogether only 52,000 highly skilled Czechs lived in other OECD countries in 2001. That number represented the fourth lowest number from the whole data set (only highly skilled workers from small states – Luxembourg, Norway and Slovakia – were less numerous). The number of highly skilled Czech expatriates is also low in relative terms – they represent only about 6 per cent of Czechs with tertiary education, which is less than the analogous number in most of the middle-sized OECD countries (for example, 27 per cent in Ireland, 13 per cent in Portugal, 10 per cent in Austria or Hungary, 9 per cent in Switzerland, 8 per cent in Greece and the Netherlands) (OECD 2008).

To analyse the migration patterns of highly skilled migrants more deeply we conducted a survey among Czech researchers and scientists with relevant professional experience abroad. The analysis of the survey data confirmed the theoretical assumption that highly qualified Czech labour migrates to countries and regions with highly developed innovative economies and a high concentration of top-quality research institutions. It is also clear that the migration patterns of technical engineers and the other researchers and scientists are different.[1] The most important target countries for both groups are the same – the USA and the highly developed Western European countries, namely Germany, the United Kingdom, France and Switzerland. But while the position of the USA as the main target country is not as dominant in the case of technical engineers (less than 29 per cent of them chose the USA), the United States clearly represents the top destination for other highly skilled migrants, namely academic researchers (44 per cent of them chose the USA). Technical engineers prefer highly developed industrialised countries in close proximity to the Czech Republic (like Germany or Switzerland – see Table 7.3) relatively more often than academic researchers.

Differences between the two groups correspond with the theoretical assumptions that different groups of highly skilled migrants will have different migration preferences (Mahroum 2001; Straubhaar 2000). The higher percentage of migrants to the USA among academic researchers is probably caused by their

Table 7.3 Main target countries for international migration of highly skilled Czechs

Target country	*Technical engineers (%)*	*Other researchers (%)*
USA	28.6	44.3
Western Europe	63.1	50.9
Great Britain	11.9	9.9
Germany	15.5	10.8
France	7.1	9.4
Switzerland	10.7	3.8
Other European country	17.9	17.0
Other country	8.3	4.7

Source: Authors' own survey data, N=299

preferences to join the most prestigious research institutions, while the higher preference given to migration to Germany and Switzerland among technical engineers might simply reflect the attractiveness of conditions in these innovative labour markets (the number of jobs available, salaries) combined with their physical proximity to the Czech Republic, which decreases the costs of relocation and allows closer contact with the homeland. In any case, the information derived from the survey supports the idea that the labour market of the Czech regions with the highest innovative potential is connected to the labour market of developed regions abroad, but the actual number of migrants is small and therefore the connection is rather weak. This, however, does not inform us as to the form of the connection between these labour markets. Do Czech regions lose highly educated labour to the benefit of regions abroad (brain drain) or is migration balanced (brain exchange)? Neither do we know to what extent highly qualified Czechs return from abroad (brain circulation). It is necessary to use data sources on immigration and return migration to the Czech Republic to answer these questions.

Since there is little outward migration, there is little risk of losing technological competence or innovative human capital. This also reduces the opportunities for linkages to the home country (be it as collaborators or as commercial partners, as identified in the case of Chinese and Indian entrepreneurs in Silicon Valley; see also Saxenian *et al.* 2002; Mahroum 1999).

The immigration of highly skilled labour to the Czech Republic – does a potential for brain gain exist in the most innovative regions of the Czech Republic?

It is not easy to answer the above question as reliable data about international migration are scarce, particularly concerning the migration of the highly skilled. Moreover, practically all of the data refer to migration between states, not taking into account the position of particular regions in the international labour market of the highly skilled. In the Czech case, however, there is a good reason to believe that immigration of the most educated labour is highly concentrated to the most innovative regions (Prague and South Moravian Region). Data from the Czech Statistical Office show that the two most innovative regions in the Czech Republic (Prague and Central Bohemia, and South Moravia) capture over 50 per cent of the net gain from international migration in general (ČSÚ 2009). It is very probable that the spatial concentration of the immigration of highly skilled workers to the most innovative regions is even higher. Thus, in this specific case nationwide migration data can be used as a proxy for unavailable regional data concerning international migration of the highly skilled.

Data from the OECD Database on Immigrants and Expatriates suggests that the Czech Republic (and hence its most innovative regions) does attract migrants with tertiary education from abroad to the extent that the net balance is even slightly positive (OECD 2008). Statistical data about R&D personnel collected by the Czech Statistical Office (ČSÚ 2007a) show that from the total number of researchers and scientists 26,152 were working in the governmental and higher educational sector (as of 31 December 2006) and 1,091, that is 4.17 per cent,

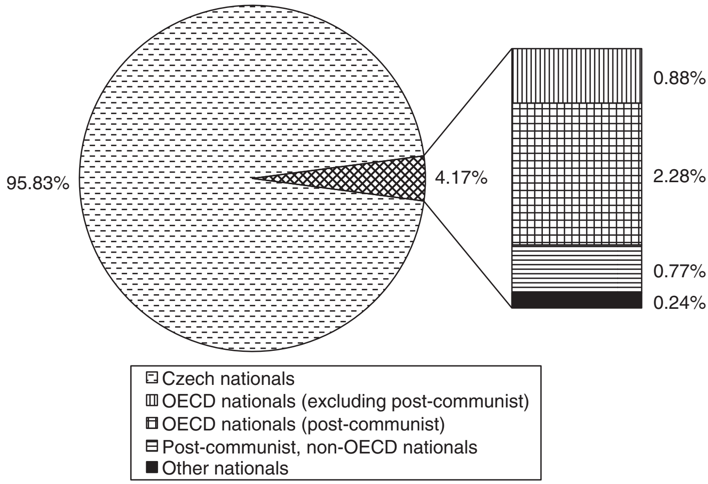

Figure 7.1 Researchers (HC) employed in the governmental and higher education sector in the Czech Republic in 2006 by nationality
Source: ČSÚ 2007a. Ukazatele výzkumu a vývoje za rok 2006, tab. 92, 93

were foreign nationals. The structure of highly skilled foreign nationals working in the R&D sector by nationality is displayed in Figure 7.1.

Figure 7.1 clearly illustrates that the bulk of foreign nationals working in the governmental and higher education R&D sectors in the Czech Republic came from other OECD countries, albeit mostly from the most developed former post-communist countries that became OECD members after 1989 (Slovakia, Hungary and Poland). Researchers and scientists from the 'old' OECD countries represent the second largest group, while skilled workers from the other post-communist countries that are not OECD members form the third. The percentage of foreigners from the 'Third World' is negligible. In terms of individual nationalities, the single most numerous foreign nationals are Slovaks who represent over one-half (555) of all foreigners in Czech R&D. Ukrainians (88), Russians (67) and Germans (67) are then the most numerous.[2]

Existing data show only the total numbers of Czech expatriates and foreigners in the Czech Republic, not the actual migration flows in individual years. Therefore we cannot conduct an exact analysis of the migration balance. However, it seems very plausible that the balance is strongly unbalanced in favour of the USA (there are more than 600 Czech national researchers in the USA while only 40 US nationals work in governmental or university research in the Czech Republic) and less unbalanced in favour of the most developed European countries (there are about 300 Czech national researchers in the UK, Germany, France and Switzerland, and more than 100 of their nationals in the Czech Republic). However, the Czech Republic has a positive balance vis-à-vis other countries, mainly other post-communist countries, with Slovakia being the main source of foreign R&D labour for the Czech Republic.

Thus there is no significant participation in the network of innovative labour markets: very little knowledge is made accessible via a transfer of personnel. Additional well-educated personnel come from places that are in general similar, and are apart from the Islands of Innovation system, which exchanges labour and competences by their incoporation in persons changing jobs and locations. While there is inward migration from other Eastern European countries, this is different from what is required to link up with the leading international processes of innovation.

Return migration of highly skilled Czechs – from brain drain to brain circulation?

The analysis of the return rate of highly qualified migrants is very important for the assessment of the position of Czech regions on the international labour market and for the further prospects of these regions, because long-term or permanent emigration has a very different impact on the situation in the regions of origin than short- or medium-term migration. Those who left the region and then return bring back not only acquired knowledge and know-how but also personal contacts and participation in social networks that can contribute to the building of links between the home region and Islands of Innovation networks.

To tackle the question of return migration we used the survey described above and started by examining the amount of time that Czech researchers and scientists spent abroad. The survey data showed that about one-half of the respondents stayed abroad less than three years and then returned to the Czech Republic. Two-thirds of respondents returned to their home country within ten years, and only about one-third of Czech researchers and scientists stayed longer (or permanently). Detailed information about the percentage of researchers and scientists who stayed abroad and the relation to length of the stay is provided in Figure 7.2. It is also clear from Figure 7.2 that there is no significant difference in the return rate between technical engineers and other researchers.

We also asked respondents who were abroad at the time of the survey whether they intended to return to the Czech Republic. About 70 per cent of them intended to return (answers 'yes definitely' or 'yes probably' combined); the remaining 30 per cent did not plan to return (answers 'probably not' and 'definitely not' combined). Again, there was no significant difference between the answers of technical engineers and other researchers. The observed return rate of Czech researchers and scientists is not unusual. The stay rate of researchers from the EU who obtained their PhD in the USA five years after graduation is about 40 per cent (Finn 2003); thus it is possible to assume that up to 60 per cent of them returned to their home country. The information on a limited number of Czech researchers leaving the country, combined with a fairly high return rate, strengthens the argument that there is hardly any risk of brain drain. Hence the overall low migration rate of Czech researchers and the low number of immigrants from the most developed countries show very limited possibilities for making use of experience from other locations and the diffusion of information and knowledge

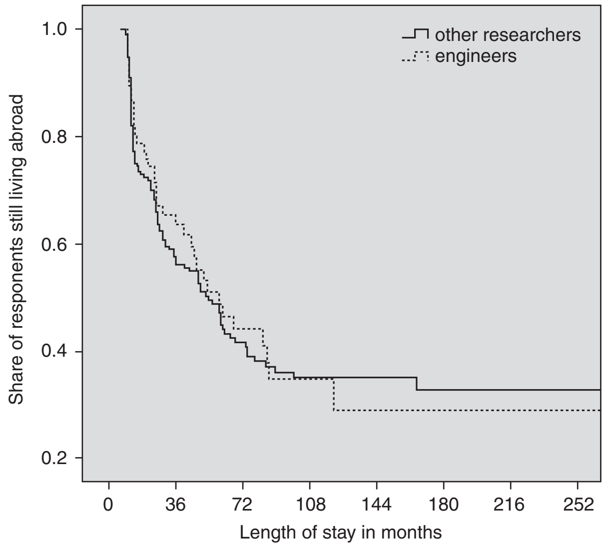

Figure 7.2 Cumulative survival plot showing the share of respondents abroad, depending on the length of their stay

via migration flows. Thus the Czech Republic faces little risk of negative impacts of migration because the share of migrating researchers is so low.

At the same time, the country has rather limited positive participation in the exchange of knowledge, access to new competences, creation of synergy and external innovative labour markets in general. Moreover, it is not only the total numbers that matter in the problem of brain drain and gain. Usually the best and brightest are attracted to highly prestigious foreign research institutes. This rather small group of people may be strategically important because they contribute to the innovative capacity of the region most. The productivity and creative capability of those who leave the Czech Republic is not easy to assess because we lack reliable indicators.

Motives for the migration of highly skilled Czech workers

When analysing the relationship between Czech innovative regions and Islands of Innovations abroad, it is useful to identify the key motives of the Czech researchers and scientists in migrating abroad or returning to their home country, because these motives help us to identify the main push and pull factors of these regions. There are several groups of possible motives that might contribute to the decision to leave the Czech Republic. The first group consists of factors such as the opportunity to increase qualification or personal development. Highly qualified workers need to constantly improve their professional qualifications in order to succeed in their professional lives. Improving qualifications is an important motive for career changes, including changes connected with international migration. The second group consists of motives connected with working conditions and incomes. It may be assumed that high salaries as well as good working conditions provided for researchers and scientists in some regions represent important factors increasing their attractiveness to highly skilled immigrants. The third group of factors is connected with the development of the labour market and the number and availability of specific types of research jobs. If a region does not offer an adequate number of jobs for researchers, or does not offer jobs in specific fields, it is plausible to expect high levels of out-migration to other regions. This may relate particularly to younger researchers at the beginning of their careers. Finally, the last group of motives consists of the personal motives for migration of researchers and scientists. It is necessary to take these motives into account as international migration deeply affects not only professional careers but also the personal lives of migrants. The importance of individual migration motives for highly skilled Czech migrants is illustrated in Table 7.4.

The results of the survey document the relevance of all four types of motive, but the motives connected with professional development and the effort to increase one's qualifications clearly dominate. Personal motives are of generally low importance. It is worth mentioning that the strongest motives for foreign migration – those linked to professional development – do not preclude

Table 7.4 Motives for emigration among Czech researchers and scientists (% of respondents who considered the motive as an important reason for migration)

Motives for migration abroad	*Technical engineers (%)*	*Other researchers and scientists (%)*
Professional development and qualification		
Interest in new professional experiences	86	83
Increase of qualifications	57	55
Obtain university degree abroad	19	23
Finances and work conditions		
Increase of income	47	30
Search for good working conditions	51	42
Effort to gain access to research equipment that is not available in the Czech Republic	25	22
Availability of specific types of research jobs		
Possibility to work on research in specific research areas that are not possible in the Czech Republic	38	39
Possibility to work in research discipline that does not exist in the Czech Republic	11	11
Personal and other reasons		
Personal and family reasons	15	19
Political reasons	4	4
Other reasons	6	4

Source: Authors' own survey data, N=299

researchers from eventual return to their home country after the achievement of their goals. Motives related to work conditions and the availability of specific types of research jobs indicate some deficiencies in conditions for research in Czech innovative regions. Almost one-half of respondents mentioned the search for good working conditions as a relevant motive for migration and over one-third of respondents claimed that the higher incomes available abroad were important to them. Both of the above mentioned factors are somewhat more important for technical engineers than for other researchers. The absence of specific types of jobs, or specific research topics that they wished to pursue, in the Czech Republic was mentioned by one-third of respondents.

The motives for return differ dramatically from motives for leaving the country.[3] Personal motives and other motives connected with non-professional life represent the dominant reasons for the return of Czech researchers and scientists from abroad. The existence of research job in the home country is of some relevance to respondents. On the contrary, motives connected with financial and working conditions in research in the Czech Republic are barely mentioned by returnees. This is a clear sign of the inability of the Czech innovative regions to be fully competitive on the international labour market vis-à-vis the most developed Islands of Innovation, and the limited possibility to build an Island of Innovation in the Czech Republic. There are basically no differences between technical engineers and other researchers in this respect.

When one evaluates the answers of respondents that did not want to return the picture is similar. The main barriers to return are the worse financial and working conditions and less developed specialised labour market for the highly skilled in the Czech Republic. It is worth noticing that technical engineers are significantly more critical in this respect, which probably reflects different conditions in the labour market for these two groups of highly skilled labour in the innovative regions in the Czech Republic. It is relatively easy to find a job in a research institution conducting basic research. Technical engineers, more often than others, mention difficulties in finding a job in a particular research field and worse career prospects in the Czech Republic as a barrier to their return. Moreover, a clear majority of them complained about the low salaries offered to them in their home country. Personal reasons represent a barrier to return for a noticeable share of respondents, but they are clearly a less prominent barrier compared to work-related factors.

The analysis of motives for and against return reveals that there are some deficiencies in the Czech innovative regions concerning the quantity and quality of research jobs offered to researchers and scientists on local labour markets. This finding seems to be supported by the answers of respondents to questions that asked them to directly compare working conditions in research in the Czech Republic with those abroad. In all aspects that were touched upon, respondents considered working conditions for researchers and scientists in the Czech Republic to be inferior to those they knew from their foreign stay. Generally, all respondents were most critical of salary levels and research budgets. Technical engineers more than other researchers specifically criticised the unavailability of specific research jobs and worse career prospects in the labour markets of the innovative regions in the Czech Republic. Although the survey revealed important deficiencies in the innovative labour markets in the Czech Republic, it should be noted that this represents only one group of factors that influence the migration decisions of highly skilled workers – personal motives for the decision to return and (to a lesser extent) the decision not to return are of high importance as well.

All the evidence suggests that there are serious difficulties in building a Czech Island of Innovation as long as there is such a strong motivation among creative personnel to leave the country and to work at more prestigious institutions abroad for higher incomes. Moreover, the orientation to remain abroad is serious since it often concerns the most creative and capable researchers who are in the early stages of their careers and may have long periods of creative contribution ahead of them.

What matters in the Czech case – barriers and opportunities in building an Island of Innovation

Czech R&D institutions and policies on the national level

We conducted several in-depth interviews with representatives of Czech R&D institutions. The majority of respondents considered the position of their institution on the international labour market to be weakened by the institution's inability to offer researchers and scientists a salary competitive to those in R&D institutions in Western Europe and the USA, as well as the impossibility of guaranteeing long-term funding for specific projects and research teams, the inability to offer enough job positions to post-docs, and sometimes insufficiently equipped laboratories.

Other types of problems mentioned were connected to the organisation of research in Czech R&D institutions: the administrative workload on researchers (connected to the management of research projects), the teaching load at universities (which is believed to be excessive), and unclear career prospects for young researchers working at Czech universities. Frequent changes to evaluation and performance measurement systems introduced by the numerous reforms to R&D policy by the Czech state are cited to be a factor that increases uncertainty about the 'rules of the game'. Some respondents stated that one of the factors that discouraged some scientists of Czech origin from returning to their home country was the fact that the working atmosphere in Czech institutions is not so stimulating in comparison to prestigious workplaces abroad. Institutions and institutional arrangements obviously matter. If young scholars from abroad are to be attracted to the Czech Republic, attractive opportunities and good research conditions must be established, which is a financial question among others.

As a special factor, the language barrier obviously decreases the interest of highly skilled potential immigrants who do not speak Czech. There are several research institutes where English can be used in working communication in the

Czech Republic, but general language competences are not so widespread that English could be used in everyday communication.

It is worth mentioning that representatives of some Prague R&D institutions consider the city of Prague to be an important point of attraction for foreign researchers. Although the high costs of housing in Prague represent a barrier to the migration of researchers from abroad to the city, many other features of Prague increase its attractiveness – the high concentration of research institutions, an internationalised social milieu, the availability of services for foreigners, and last but not least the cultural and historical heritage of the city. Interestingly, representatives of institutions located outside of Prague consider the attractiveness of the city of Prague as one of their additional disadvantages (if a foreign researcher decides to relocate to the Czech Republic, he/she surely opts for Prague).

Policies aimed at affecting the international flows of highly qualified labour are regularly used at the national as well as the regional level, and a fair amount of research attention has been dedicated to their scientific analysis (Kostelecká *et al.* 2008; Thorn and Holm-Nielsen, 2006; Salt and McLaughlan 2002; Giannoccolo 2006; Mahroum 2005; Mahroum 1999; Meyer *et al.* 1997). Several fairly similar classifications of these policies have been proposed. Three large groups of policies, which differ significantly in their focus, can be identified. The first type involves individual recruitment policies that focus on supporting and attracting individual researchers, whether through targeted financial support such as grants and fellowships, information campaigns, or restrictions on foreign stays and enforced return. The second concentrates on strengthening the efficiency and attractiveness of the home research environment and the entire national or regional innovation system on the assumption that systematic differences in quality are the main reason for imbalances in migration flows. The third aims to engage with the foreign diaspora and the internationalisation of home research institutions through development of contacts with researchers who have left, without necessarily expecting them to physically relocate to the country of origin. Thorn and Holm-Nielsen (2006), however, caution that the first type of policies are potentially risky and more likely to have low or even negative effects. There is the danger that less productive researchers who experience problems finding adequate positions abroad will take advantage of the opportunity to return or transfer to a country that offers such policies.

In the Czech republic, at the national level, the targeted recruitment policy of experts from abroad (foreigners as well as Czech nationals) is carried out particularly through the operational programmes of EU structural funds. In their frameworks, grants are called for to create jobs for foreign researchers, especially of Czech origin, which would offer internationally competitive conditions in terms of finance and the equipment of the institution. Their problem, however, is that the Prague region, as the most innovative region with a high concentration of science and research, whose institutions would be very likely to achieve a positive balance of foreign migration of highly skilled workers, does not meet the convergence criteria and is thus excluded from the structural funds support. In reaction to this disadvantage, a complementary recruitment programme funded from the stage budget has been launched in 2012 intended specifically for research institutions in Prague. Such programmes are, however, just starting and the recruitment policy has thus, so far, had effect primarily on the level of individual research institutions, which differ significantly in their effort to attract and keep foreign researchers.

Policies for the general strengthening of the efficiency and attractiveness of the home research environment concentrate primarily on funding and the allocation of public funds. The Czech Republic spends annually approximately 1.5 per cent of GDP on research and development (whereas the private sector contributes about 50 per cent), which is below the EU average but is above average among the new member states. Lower levels of research spending point to a risk that the gap between the Czech situation and that of leading European countries and Islands of Innovation in particular, could be widening year by year. A funding reform of public research institutions has been underway since 2009, based on using quantitative, especially bibliometric, indexes of productivity as a key factor in determining the amount of financial support for individual institutions. The reform has been criticised on account of the mechanical translation of performance indexes to funding (Schiermeier 2009). Hence its impact on the general productivity of Czech sciences cannot be anticipated. A very important financial stimulus for Czech research institutions is connected to the EU structural funds with their allocation of EUR 1.7 billion in the 2007–2013 budget period for R&D in the Operational Programme for Science and Research for Innovation. This amount is almost double the annual state expenditure for R&D and thus constitutes relatively very high financial support. As these funds cannot be spent in the capital Prague, they are therefore in some cases invested in the immediate vicinity of the city in locations that are part of another administrative region so that the newly established research centres can take advantage of the human potential in Prague. The general impact of this massive investment in research and its infrastructure on the migration of Czech and foreign researchers is as yet impossible to assess. It is assumed, however, that as a consequence dozens of new attractive positions in research will be established, which could considerably change the Czech labour market in research.

Regional policies aimed at brain gain and development of human capital in science and research – the example of the South Moravian Region

At a national level, new investments in research development are related significantly to the use of European funds. There are, however, also specific regional frameworks that aim to develop regional innovation systems and increase their competitiveness, both on the international and domestic labour market. One example of a developed innovation strategy can be found in the South Moravian Region which, after Prague, is the second centre in which research activities are concentrated, even if it lags significantly behind Prague in research concentration. This economic and innovative lag encouraged the regional government to introduce an ambitious, innovative strategy to establish good conditions for research, attractive opportunities for younger and creative scholars, and a dynamic academic and technological situation. A major step in the formulation of policies to support innovation in the South Moravian Region was taken in 2002 when the first Regional Innovation Strategy (RIS) was formulated whereby the regional public administration espoused support for innovation and research development and where the first objectives and tools for such support were formulated. Since 2002 the Regional Innovation Strategy has been reformulated twice, and its third version was drafted in 2008.

Four basic objectives are formulated in the strategy: the development of human capital for science and research; the creation and development of innovative firms; technology and knowledge transfer between research institutes and enterprises; and the formation of communication channels among major stakeholders. The first of these objectives directly aims to influence migration flows and will be discussed here. It focuses on the following areas:

- inflow of experienced researchers to the region;
- support for early-stage researchers in the South Moravian Region;
- support for the inflow of foreign students and early-stage researchers to the region;
- support of talented students at secondary and tertiary schools in the South Moravian Region.

To fulfil these goals the strategy formulates a number of concrete programmes. In terms of researcher mobility, the most important programme is focused, firstly, on attracting foreign researchers to the South Moravian Region and, secondly, on the reintegration of Czech scientists and researchers who have worked outside the EU for at least three years. The goal of the project is to provide for the long-term (one to three years) employment of these researchers in public science and research institutions in the South Moravian Region. The programme has been planned as a four-year pilot for the period 2009–2013. The total programme budget is EUR 3,887,158. According to the information available, 14 grants were funded in the first call for proposals (see the Zpravodaj JCMM 08/2010) and 13 researchers were supported in the second call for proposals (TZ JCMM 3 March 2011).

Another programme focuses on the internationalisation of higher education institutions in the South Moravian Region. With financial support from the South Moravian Region, stipends are provided to cover the first year of studies and administrative aid to people interested in doctoral or Masters programmes in technical or natural science disciplines at universities or higher education facilities in the region. In the 2006/2007 to 2009/2010 school years, 100 students were supported, mostly from the countries of South-East and East Europe.

The direct impact of the Regional Innovation Strategy on the inclusion of the South Moravian Region in international flows of highly qualified labour among Islands of Innovation cannot be, however, assessed with sufficient reliability. In an effort to quantify the results, we are faced with two obstacles. The first follows from the fact that the strategy is continually developing and most measures aimed directly at affecting migration have not yet been in force long enough to be able to judge their impact. The second obstacle is more general in nature. Individual indicators that could be used to assess the impact of policies built into the innovation strategy (in our case, for example, the number of jobs taken by foreigners in science and research or in innovative firms) are influenced by a whole range of factors, where the effect of the regional public sphere is only one. It is therefore not possible to evaluate the effect of individual factors separately. Interviews with major stakeholders in the innovation strategy make it clear that the offer of quality infrastructure and support for the development of small- and medium-sized innovative firms has the potential to attract entrepreneurs and highly skilled workers from other regions of the Czech Republic. The inflow of highly skilled labour from abroad is in this case significantly lower. However, in innovative firms in the region some demand for foreign workers is demonstrated, which relates to the relatively exhausted domestic labour market. It appears from these findings that the impact of the public sector in the South Moravian Region has had and will have a positive impact on the development of human capital, but it is not yet possible to assess its general impact.

Conclusions

Data on R&D activities show that the R&D is highly spatially concentrated in the Czech Republic. Prague (+ Central Bohemian) region is clearly dominating Czech R&D. The South Moravian Region lags behind Prague but is still well above the Czech average in terms of R&D activities. Both regions participate only weakly in the international labour market, with the South Moravian Region being particularly insufficiently involved in labour exchange with other innovative regions abroad. Nevertheless, both regions attract qualified labour from all other Czech regions and serve as primary centres of Czech innovative economy.

Despite their dominant position in the domestic labour market of the highly skilled the most innovative Czech regions are not equivalent partners with the most innovative regions on the international labour market. The working conditions in R&D in the Czech Republic were evaluated very critically in the survey in comparison to working conditions in most developed countries. The migration flows of highly skilled labour are not balanced – the most innovative Czech regions tend to lose highly skilled workers vis-à-vis the most innovative regions of the world, mainly to regions in the USA. The conducted analyses nevertheless suggest that Czech innovative regions do not primarily serve as mere suppliers of a qualified labour force for Islands of Innovations. The emigration rate of Czech researchers and scientists is relatively low and more than one-half of stays abroad are temporary. While there is no problem of a brain drain in terms of the quantity of highly skilled migrants, there might be a qualitative problem with the emigration of the 'best and brightest'.

The main reasons for that include the inability of Czech R&D institutions to offer fully competitive salaries and working conditions. To some extent, the low effort of Czech research institutes to recruit people from abroad, combined with their limited financial conditions, can be held responsible for the low numbers of foreigners from the most developed countries coming to the Czech Republic.

The surprisingly low migration rate of Czech researchers, which inhibits the brain drain problem, indicates the limited possibilities for the exchange of information and knowledge with the most developed Islands of Innovation. The Czech relationship with the most developed regions is thus rather weak. Mutual exchange of labour and networking activities are nevertheless very typical in Islands of Innovation and they present one of their main benefits. Migration from other post-communist countries to the Czech Republic, which can quantitatively compensate losses to Islands of Innovation, cannot make up for the missing links with the most developed regions. The weak interconnection with Islands of Innovation rather than constituting a quantitatively important labour loss represents a potential barrier for the future development of the innovation potential of the leading Czech regions and results in the partial isolation of these regions. The most innovative Czech regions are not able to fully utilise the advantages that follow from the mutual interconnectedness of the most innovative regions.

The research has detected potential in the high return rate of Czech researchers and scientists who left the Czech Republic. The process of economic convergence between the Czech Republic and the most developed countries in Europe surely makes the decision of highly skilled Czech expatriates to return to home easier, but the survey shows that the dominant reasons for return are actually personal ones. Regardless of the reasons for return, the high return rate of Czech R&D workers represents an important opportunity for the most innovative Czech regions to fully benefit from brain circulation. Returnees come back to their home country with improved qualifications, connections to formal and informal networks, and improved potential to participate in international R&D projects (Mahroum 2000). To convert the potential loss from brain drain into the benefits of brain circulation requires that policy makers support R&D institutions. The Czech Republic is in an initial phase to develop a systematic support policy for either the return migration of highly skilled Czech expatriates or for the immigration of R&D workers of foreign nationalities; unfortunately, some policies are focused on regions other than Prague. Major financial investments in research infrastructures, funded with the EU's structural funds, and recruitment programmes for Prague could bring an increased development of research in upcoming years, especially in some disciplines. It can be expected that this development will lead the heightened migration attractiveness of Czech Islands of Innovation. In some regions there are specific regional policies aimed at the development of highly qualified human resources and their employment. These policies are likely today to have the potential to influence the position of regions in the Czech Republic; however, it is uncertain to what degree they have an opportunity to influence the inclusion of regions in the international labour market.

If we use the metaphor of Archipelago Europe, the most innovative regions in the Czech Republic can be described as small islands on the edge of the archipelago from the point of view of labour force flows. Its labour markets are only weakly interconnected, and the Czech regions have a slightly subordinated position in the network. However, they can utilise a highly qualified workforce from other regions with less advantageous conditions. The internal labour market of the country and the attractiveness of these regions for researchers from post-communist states offer them advantageous conditions for the development of a strong research capacity. For further development in this direction, first the financial conditions of research institutes should be adapted to conditions that are standard in the most developed countries, and second their motivation for intensive international cooperation should be increased.

Notes

1. Due to a limited number of respondents, it was not possible to conduct a detailed analysis of migration patterns by individual scientific disciplines.
2. There are no data on foreign researchers working in the R&D business enterprise sector in the Czech Republic. The business enterprise sector researchers represent about one-third of all researchers in the Czech Republic. The absolute numbers of foreign nationals in Czech R&D are thus higher.
3. Only respondents who remained abroad at the time of survey and considered return were asked the question concerning motives for return. Only respondents who remained abroad while not considering return to the Czech Republic were asked the questions concerning the main motives against possible return. Owing to the fact that the number of respondents in both groups was small (97 and 43 respectively) the results should be interpreted with caution and we have not included tables with exact percentages.

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8 Embedding competencies

Human capital endowment and economic performance of Italian regions

Vincenzo Demetrio and Paolo Giaccaria

Introduction

The purpose of this chapter is to contribute to the understanding of the role of innovative labour markets in fostering regional development with reference to the Italian case. It does so by exploring some of the main beliefs concerning the relationship linking labour, competencies and innovation, from the perspective of the Islands of Innovation approach (Hilpert 1992, 2003). The debate in the early 1990s in the fields of economic geography and regional economics marked a clear divide in the understanding of the relationships between innovation and proximity by highlighting the role of both the national (Lundvall 1992) and regional/local scale (Cooke 1992; Hilpert 1992) in setting the conditions for innovation. Innovation is not, in fact, an aspatial phenomenon, since its production is highly spatially concentrated in specific geographical areas (see, for example, Cooke and Morgan 2000; Morgan 2004; Simmie 2005). More precisely, the public nature of knowledge (Arrow 1962), its localised spillovers (Jaffe 1989) and the relational proximity of firms (Capello and Faggian 2005) may favour the processes of 'collective learning' in the local system (Malmberg and Maskell 2006), so that over time agglomerations may develop specific conditions that facilitate the rapid dissemination of knowledge throughout the cluster and consequently increasing the innovative capacity of agglomerated firms (Pinch *et al.* 2003).

Therefore, on the one hand, local productive networks minimise the costs of innovations and changes (Piore and Sable 1984; Porter 1990) and those related to transactions (Scott 1988, 1989), but on the other hand the social networks favour collective learning, which is supposed to reduce the degree of uncertainty during changes in technological paradigms (Lawson 1997). Furthermore, regionally confined social networks help build locally differentiated cultures that reflect different collective socio-economic capacities and regional-specific innovation systems (Storper 1997; Simmie 2005).

Unsurprisingly, the presence of local productive and social networks alone might not be enough to explain how regions maintain their innovative economies over time. According to Simmie (2005), there are at least two other elements that are indispensable. The first refers to the participation of regional contexts in networks of the international division of labour. This is a key condition for the diffusion of the latest best practice or R&D results from other advanced economies, in order to prevent regional economies from being locked in path-dependent technological trajectories and, at the same time, to maintain continual waves of innovation. The second is related to the presence of a highly educated and trained labour force. This workforce is usually concentrated in a few areas of the world (Audretsch 1998) because of the stickiness of regional labour markets that force innovative activities to concentrate most of the phases of their life cycles in the region (Audretsch and Feldman 1996). Regions where innovative activities and R&D facilities networks are located and act as key knots in an international net of labour division, may be considered Islands of Innovation (Hilpert 1992). Being strictly interconnected with regions specialising in similar activities around the world, even through workforce mobility, these regions operate constantly at the technological frontiers, sustaining their innovative capabilities over time.

More importantly from our perspective, the Islands of Innovation approach entails fundamental relationships with the issue of regional and urban competitiveness (see, among others, Cheshire and Gordon 1995; and for a more critical appraisal, Bristow 2010). Adapting Budd's (1998) framework of competiveness, we can distinguish between 'direct' and 'indirect' regional competitiveness. First, we can define 'direct territorial competitiveness' as the degree of attractiveness of a certain region with reference to targeted subjects, which can be foreign direct investments, enterprises, residents, international organisations, workers, researchers, events etc. (Lever 1999: 1029). Second, we can define 'indirect territorial competitiveness' as the capability of a region to sustain the local firms involved in competition, through a set of place-specific assets that confer competitive advantages to firms. In this framework, the Islands of Innovation approach plays a key role in understanding the dialectics between direct and indirect regional competitiveness. Different Islands of Innovation, at the same time, compete with each other in order to attract skilled workers and, in doing so, contribute to producing the regional assets that foster firms' competitiveness. From this perspective, the exchange of skilled labour among Islands should be, in our opinion, assessed within the broader context of the regional learning and organisational processes that produce such assets.

Rodriguez-Pose and Vilalta-Bufi (2005: 546) explain that 'educational stock, as a measurement of the quantity, availability, and even quality of an area's human resources is […] one of the possible ways of assessing the impact of human capital on economic growth'. But:

> the number or percentage of primary, high school, or university graduates, different measurements of the educational attainment of the population, or even indicators of the quality of the education provided–while extremely informative about the quantity and quality of human resources–give precious little information about the use a society is making of its educational stock. A decent educational stock may have little impact on local economic performance and regional disparities if those human resources are left idle or not used to the best of their capacity in the workplace. Shortages or

> deficiencies in educational stock can also be tackled by the attraction of highly qualified or skilled labour from other areas of the country or other countries (2005: 546).

It follows therefore that indicators of the educational stock, the adjustment between educational supply and labour demand, the degree of employment of the best qualified individuals and the level of migration are key indexes of regional learning processes and of a society's capacity to transform human capital into economic growth.

In applying the framework of regional competiveness to the Italian Islands of Innovation, we must keep in mind some peculiarities of Italian national and regional contexts. As will be discussed in the next sections, while on the one hand the Italian labour market is characterised by both a lower level of technical education (Gros and Roth 2008) and a lack of attractiveness to skilled workers, acting as origin rather than destination for such flows (Avveduto and Brandi 2004; Becker *et al.* 2004; Censis 2002), on the other hand there seem to exist macroscopic differences in the economic performance of Italian regions, which are generally associated with difference in human capital endowment (Rodriguez-Pose and Vilalta-Bufi 2005). Hence the relationship between competencies and competitiveness becomes central: given the peculiar Italian situation, our question is whether and how firms compensate for this twofold failure of the labour market in order to secure the needed competencies and foster firms' competitiveness.

The first section of this chapter addresses the first of the two issues – the failure of Italian Islands of Innovation in both (re)producing skilled human capital and attracting skilled workers from other Islands of Innovation. The subsequent section of the chapter entitled 'The evolution of regional disparities in Italy' concentrates on the relationship between human capital endowment and regional competitiveness in order to gain some insights as to how the highly skilled influence the performance of firms within Italian regions. In doing so, we will use regional data (nationally standardised) concerning GDP per capita, stocks of human capital, levels of adjustment between labour demand and supply, and migration. It is worth noting while analysis at the regional level is useful in evaluating the role of aspects of the labour market mentioned above in fostering firms' performance, the micro level of analysis (Malmberg and Maskell 2006) is helpful in understanding how a specific Island of Innovation works in order to compensate structural labour market failure related to the lower level of technical education and the lack of attractiveness to the skilled workforce.

Italian innovative performance

Evidence of Italian structural weakness in innovation is broad and exhaustive (for a general historical assessment of the Italian national system of innovation, see Malerba 1993). More recent evidence comes from, for example, the European Innovation Scoreboard (EIS) where Italy is ranked 20th out of 29 European countries for the level of innovation, below Portugal and Greece (PRO INNO 2009a). According to another index, the Global Innovation Scoreboard (GIS), which includes some leading non-European countries, Italy is ranked 25th. Of particular note is that both indexes point to an Achilles' heel where training is concerned (PRO INNO 2009a).

Of course, the positions on both indexes do not mean that there are no innovation systems or Islands of Innovation in Italy. Indeed, national data are strongly influenced by regional economic, social and innovative disparities (Dunford and Greco 2006), specifically along the North–South divide. Furthermore, we must bear in mind that the innovation processes as defined and interpreted in the Lisbon process strongly rely on codified knowledge, so that most innovation performance indicators highlight the role played by research centres, human resources in science and technology, high-tech services and patents. These underplay the function of softer and more tacit factors, peculiar to many regional innovative productive systems that are based mainly on clusters and networks of SMEs. According to PRO INNO's work on design, creativity, and innovation (2009b), when we broaden our account of innovation, including these softer and tacit factors, Italy's ranking improves appreciably (12th instead of 20th). As we shall see, this is a key element in assessing the innovative Italian performance. Assuming that innovative firms and clusters do exist in Italy, we have to deepen our comprehension of the circumstances that allow innovation to take place, even in the absence of a skilled workforce circulation.

Moreover, if we take into consideration the performances of Italian regions in the Regional Innovation Scoreboard[1] (RIS) in 2006 (PRO INNO 2009a) we may notice that performance is strictly related to the regional dimension: the Centre and North-West are the best performing areas at national level, followed by the North-East and South, while the innovative performance of the two Islands is very poor (see also Evangelista *et al.* 2002). The splitting of the RIS index into its three component groups (seven indicators as a whole) offers a better insight into the main drivers of innovative behavior in Italian macro-regions (Table 8.1).

For instance, the Centre's performance depends mainly on *enablers* and *outputs*, being the Latium values of public R&D and high-tech services very close to those of European 'champions'.[2] The North-West figure is strongly influenced by *firms' activities* and *outputs*, given the high values of medium- and high-tech manufacturing (Piedmont and Lombardy), business R&D (Piedmont) and patents (Lombardy). The North-East differs from the North-West mainly for its poorer performance in *firms' activities* and *outputs* in terms of business R&D and high-tech services. The South seems to suffer from even lower outputs of firms' innovation activities, in particular those concerning patents and medium- and high-tech manufacturing.

Despite such intra-national disparities, all Italian regions seem to suffer from a relative weakness in European rankings. Even the regions hosting Islands of Innovation are quite low in the scoreboard: Piedmont and Lombardy are around the 70th position, Emilia Romagna is 81st, while the widely known Third Italy regions, such as Tuscany, Veneto and Friuli-Venezia Giulia, are not in the top 100. We are convinced that these poor performances are mainly related to *enablers* (drivers of innovation that are external to the firms) rather than to firms themselves or their innovation processes. In particular, the two variables

Table 8.1 Regional Innovation Scoreboard (RIS) in Italy, 2009

	Rank	*Rank (b)*	*RIS*	*RIS (b)*	*Knowledge-workers*	*Lifelong learning*	*Med-High-tech manufacturing*	*High-tech service*	*Public R&D*	*Business R&D*	*Patents*
North-West			*0.57*	*0.06*	*0.07*	*0.10*	*0.07*	*0.07*	*0.10*	*0.10*	
Piedmont	73	40	0.49	0.40	0.03	0.06	0.10	0.07	0.05	0.10	0.08
Valle d'Aosta	170	163	0.26	0.19	0.03	0.04	0.03	0.04	0.01	0.05	0.06
Liguria	94	90	0.44	0.31	0.06	0.07	0.06	0.07	0.07	0.05	0.06
Lombardy	71	54	0.49	0.38	0.05	0.06	0.10	0.07	0.05	0.07	0.10
North-East			*0.50*	*0.04*	*0.08*	*0.10*	*0.05*	*0.07*	*0.05*	*0.10*	
Veneto	122	104	0.40	0.3	0.03	0.06	0.10	0.05	0.04	0.03	0.08
Friuli	95	73	0.44	0.34	0.03	0.08	0.08	0.05	0.07	0.05	0.08
Emilia Romagna	81	63	0.47	0.36	0.04	0.07	0.10	0.05	0.06	0.05	0.10
Center			*0.59*		*0.06*	*0.08*	*0.07*	*0.12*	*0.13*	*0.06*	*0.07*
Tuscany	104	83	0.43	0.32	0.04	0.06	0.07	0.07	0.08	0.04	0.07
Umbria	107	113	0.42	0.29	0.06	0.07	0.06	0.07	0.09	0.02	0.05
Marche	132	129	0.35	0.25	0.04	0.06	0.07	0.04	0.05	0.02	0.06
Latium	44	34	0.57	0.42	0.06	0.08	0.06	0.12	0.13	0.06	0.06
South			*0.42*		*0.05*	*0.07*	*0.08*	*0.06*	*0.07*	*0.05*	*0.05*
Abruzzo	109	105	0.42	0.3	0.05	0.07	0.08	0.06	0.06	0.05	0.05
Molise	165	179	0.27	0.17	0.04	0.06	0.06	0.04	0.04	0.02	0.02
Campania	152	140	0.31	0.23	0.03	0.05	0.04	0.05	0.07	0.03	0.03
Puglia	185	182	0.22	0.16	0.02	0.04	0.03	0.04	0.05	0.02	0.03
Basilicata	159	150	0.29	0.22	0.02	0.05	0.06	0.04	0.06	0.02	0.03
Calabria	188	191	0.20	0.12	0.03	0.05	0.02	0.04	0.03	0.00	0.02
Islands			*0.26*		*0.03*	*0.05*	*0.03*	*0.04*	*0.06*	*0.02*	*0.03*
Sicily	177	172	0.25	0.18	0.03	0.05	0.03	0.04	0.06	0.02	0.03
Sardinia	184	184	0.23	0.16	0.02	0.05	0.03	0.04	0.06	0.01	0.03
Best European performance (excluding Stockholm)			0.90	0.62	0.14	0.16	0.15	0.15	0.15	0.18	0.16
			Västsverige	Braunschweig	Utrecht	Västsverige	Stuttgard	Praha	Berlin	Västsverige	Noord-Brabant

Source: Elaboration on PRO INNO Europe (2009) data associated with the Lisbon process (share of knowledge-workers and lifelong learning) are heavily influencing the outcome.

Hence, if we calculate a new RIS index excluding in the weighted sum these two *enablers* while maintaining all the *firms' activities* and *outputs* of innovation process indicators, we notice that the performance of many Italian regions – in particular, Northern and Central ones – improves noticeably. For example, Piedmont moves from 73rd to 40th position, Lombardy from 71st to 54th and Emilia Romagna from 81st to 63rd. The same applies to the Third Italy. In the case of the Southern region, the ranking stays stable or even deteriorates (as in the case of Calabria). In other terms, if we focus on the daily activities related to innovation, we register a reduction in the gap between Europe and Northern Italy and, at the same time, an increase in regional disparities between North and South.

According to Istat (2010), innovation *enablers* flaws can be explained with reference to three structural aspects of the Italian national system. The first is the weaknesses of the educational system, which is unable both to supply regions with the abilities needed to carry out the activities demanded by the knowledge society and to reduce social disparities. The second is related to the presence of two million young people who do not study or work (the discouraged),[3] with a youth unemployment rate close to 25 per cent. The third refers to the positioning and dimensional characteristics of the industrial and services sectors (for a general overview, see Rabellotti *et al.* 2009). Many Italian regions are dominated by mature industrial sectors that normally shackle the development of an innovation-oriented labour market, lowering qualified workforce turnover and pushing an increasing share of graduates towards more dynamic job markets. In other words, the absence or insufficient presence of science-based firms could be one of the reasons for the low demand for skilled workers. Even firm size plays a key role in explaining the demand for competencies. Normally, large companies demand a more skilled labour force than SMEs. As the Italian productive system is basically based on SMEs, we may deduce that, within the same industry, the demand for skilled labour is lower than in productive systems characterised by the presence of large companies (Camuffo and Comacchio 2004). The emergence of a dynamic and innovative set of medium-sized enterprises across the Po Valley, highlighted by Mediobanca (2010), is not enough to reverse the fragmentation of Italy's production fabric. In addition to the inadequate educational system and a lower demand for skilled workers when compared to the best performing European regions with similar productive structures, the most innovative Italian regions seem to be characterised by a lower level of human resources in science and technology (HRST) and of the job-to-job mobility of this kind of skilled workforce.

Concerning the gap in terms of HRST, we are convinced that it largely depends on cultural trends in tertiary education, as Italy has a strong tradition of social studies (comprising law and economics) and humanities which makes the ratio of HRST lower in terms of graduates. In fact, when we consider the HRST incidence in terms of occupation we notice that the gap with the rest of Europe is dramatically reduced, although it still exists. According to Eurostat data, in 2007 job-to-job mobility in Italian services was equal to 2.98 per cent, much lower than the peaks of Northern European countries such as Norway (7.87 per cent), Denmark (7.86 per cent), Finland (5.21 per cent) and the Netherlands (5.20 per cent), but also less than in other Mediterranean European countries, such as Cyprus (4.95 per cent), Spain (4.38 per cent) and Portugal (3.15 per cent).

Nevertheless, data in Table 8.2 clearly confirm the role that regional differences still play in explaining Italian innovative performance. From our

Table 8.2 Regional differences in the Italian innovation system, 2005

	R&D personnel (% of employees)		*R&D expenditure (% of GDP)*			*HRST*	
	Total	*BES*	*Total*	*BES*	*Patents (per million labour force)*	*% graduates*	*% occupation*
Oberbayern	3.76	2.34	4.71	3.68	751,988	50,71	41,52
Utrecht	1.94	0.78	0.53	0.53	192,709	53,31	41,69
Cataluna	1.66	0.05	0.86	0.86	93,373	35,49	20,69
Italy	*1.13*	*0.35*	*1.09*	*0.55*	*147,738*	*34,01*	*30*
North West	*1.21*	*0.61*	*1.27*	*0.93*	*225,389*	*36,8*	*32,96*
Piedmont	1.31	0.78	1.72	1.37	236,736	34,98	31,76
Valle d'Aosta	0.65	0.33	0.34	0.23	56,537	29,53	26,2
Liguria	1.13	0.45	1.23	0.67	83,901	38,01	33,87
Lombardy	1.18	0.56	1.11	0.8	243,887	37,5	33,43
North East	*1.13*	*0.43*	*0.88*	*0.47*	*248,26*	*34,43*	*30,57*
Bolzano	0.39	0.23	0.34	0.21	120,723	33,29	31,33
Trento	1.32	0.21	1.11	0.23	102,76	36,42	32,97
Veneto	0.79	0.3	0.57	0.29	230,179	32,95	29,22
Friuli	1.54	0.41	1.16	0.53	203,465	35,51	31,79
Emilia-Romagna	1.46	0.64	1.17	0.71	312,196	35,66	31,35
Center	*1.5*	*0.26*	*1.37*	*0.41*	*94,502*	*36,73*	*31,85*
Tuscany	1.2	0.24	1.09	0.35	126,148	34,46	30,15
Umbria	1.18	0.18	0.78	0.19	99,674	32,36	27,39
Marche	0.73	0.21	0.57	0.25	113,788	31,59	27,24
Latium	1.99	0.31	1.81	0.51	65,658	40,47	35,07
South	*0.81*	*0.14*	*0.84*	*0.28*	*30,047*	*29,09*	*25,1*
Abruzzo	0.99	0.32	1.03	0.49	64,426	31,6	27,15
Molise	0.72	0.05	0.48	0.04	23,782	30,34	25,59
Campania	0.99	0.18	1.13	0.42	30,065	28,27	24,62
Apulia	0.72	0.08	0.67	0.16	27,833	27,7	23,62
Basilicata	0.55	0.11	0.53	0.2	17,668	30,27	26,67
Calabria	0.46	0.03	0.38	0.03	13,337	31,83	27,44
Islands	*0.86*	*0.09*	*0.74*	*0.16*	*32,26*	*29,2*	*26,51*
Sicily	0.9	0.11	0.8	0.21	37,785	29,4	26,29
Sardinia	0.75	0.04	0.58	0.04	18,089	28,69	25,61

Source: Eurostat, 2005

perspective, it is fundamental to stress the position of Piedmont in this classification. This region is without doubt at the leading edge of R&D facilities in Italy, with regard to both share of R&D personnel and expenditure. It is worth noticing that the role of Piedmont is outstanding, mainly with reference to the business enterprise sector (BES), excluding universities and public research facilities: 0.78 per cent of employees in the private sector are R&D personnel (the national average value is 0.35 per cent; 0.56 per cent in Lombardy) and private investment in research is equal to 1.37 per cent of regional GDP (the Italian average value is 0.55 per cent). Moreover, Piedmont owns 25 per cent of Italian investment in R&D so that it is placed first in the national panorama for the amount of invested capital and the number of private R&D centres (220 in total). The most well known R&D centres in the region are those related to automotive and information and communication technologies, but there are less famous but equally important centres that operate in chemical/plastic, biotechnologies and complex systems fields. Furthermore, there are also different forms of interaction/cooperation between both Italian and foreign companies and polytechnics. The research labs of key multinational companies such as GM, Microsoft and Jac (an automotive company from China) that we find in the polytechnic structure are examples of these collaborations. Just to take some benchmarks, we can observe that the share of R&D personnel in the business enterprise sector (BES) is equal to 0.83 per cent in Germany, 0.74 per cent in France and 0.86 per cent in South-East England. The same applies to regional benchmarks; despite Piedmont's figures being far from those of Europe's leading regions – for example, Oberbayern – we note that its BES performs better than emerging innovative regions such as the Utrecht area or Cataluna.

In terms of patents (per million labour force), Piedmont is preceded in Italy only by Emilia Romagna and Lombardy, while the level of human resources in science and technology, both in terms of graduates and employed people, is only a little higher than the national average.

Hence we can draw some initial evidence relevant to the purpose of this chapter. First, the poor performance of Italian regions in innovation scoreboards does not imply the absolute inability of firms to innovate, but rather it can be explained with reference to the difficulties of the national system to 'produce' specific key labour inputs, such as skilled labour and continuous training. Second, clear regional differences exist with reference to innovative performance. Those differences are mainly related to innovation drivers (e.g. public or business R&D), prevailing productive structures (industrial districts, clusters etc.), forms of knowledge diffusion and firms' activities (engineering, biotech, ICT, traditional sectors etc.).

In this framework it is crucial for us to recognise other innovative areas in addition to the Islands of Innovation identified by literature (Hilpert 1992, 2010) and illustrate their specificities in terms of productive activities and networks on both the Italian and European scale. Particular attention will be paid to the behaviour of skilled workers and, in particular, to the exchange movement between innovative areas. In fact, labour exchange is a crucial factor not only in terms of compensating for local weaknesses in the skilled workforce but also in establishing national and supra-national connections enabling the circulation of information and knowledge, both explicit and tacit.

Innovation and skilled workforce movements in Italian Islands of Innovation

In order to identify the most innovative regions in Italy, we have focused our attention on the incidence of innovative networks operating on the national and international scale. The choice to use the presence of such networks as a proxy for regional innovative activity is strictly related to the conviction that this kind of network is functional to the maintenance of local innovative strength and competitive advantages over time.

With regards to such networks, our source of information has been a recent publication of the Italian Production Association (AIP 2008), which contains an extensive catalogue and a complete description of each network. Even though this book does not offer an exhaustive description of all national experience, it certainly includes the most important cases. Drawing on AIP data, we have divided Italian regions into four groups (see Table 8.3). The first includes two North-West regions, namely Piedmont and Lombardy, which are characterised by strong international innovative activity in mechanical engineering, ICT,

Table 8.3 International innovation networks in Italian regions

	Strength of international networking	*Main innovative activities*	*Area involved in innovative networks*
Italy			
North-West			
Piedmont	***	Aerospace, Biotech, Design, Mechanical engineering, ICT, Textiles	Turin, Biella, Alessandria
Lombardy	***	Design, Energy, Furniture, Mechanical engineering, ICT, Textiles	Milan, Brescia, Bergamo, Como
North-East			
Veneto	*	High-tech services, Leather	Verona
Friuli	*	Agri-food	Trieste
Emilia Romagna	**	Mechanical engineering, ICT	Bologna, Reggio Emilia
Centre			
Tuscany	*	Leather, Textiles	Florence, Prato
Latium	*	ICT	Rome
South			
Campania	**	Energy, ICT	Naples, Caserta
Apulia	*	Mechanical engineering	Bari

Source: Elaboration on AIP (2008) data
*** ≥ 7 international innovative networks
** ≥ 3 international innovative networks
* < 3 international innovative networks

design and textiles. The second is made up of Emilia Romagna and Campania, which appear to be characterised by a lower number of international innovative networks in mechanical engineering, ICT and green energy. The third incorporates Veneto, Friuli, Tuscany, Latium and Apulia, regions that have very limited innovative networks operating internationally. The fourth contains all the regions with no innovative networks. Consistent with Hilpert's (1992) findings, the areas of Turin and Milan continue to represent the most outstanding Islands of Innovation in Italy, followed by Bologna, Reggio Emilia and Naples-Caserta, and further by Verona, Trieste, Florence-Prato, Rome and Bari.

Given the lack of information on skilled workforce exchanges in Italian regions, we have adopted data concerning the registration and cancellation of graduate residence (Table 8.4) as a proxy of those fluxes.[4] The first piece of evidence here is that the presence of high regional inequality is fully confirmed:

Table 8.4 Skilled workforce exchange in Italian regions

	Strength of international networking	*Graduates from other regions or from abroad registered/ 100 graduates cancelled*	*Graduates from other regions or from abroad registered/100 graduates cancelled (0–29 years old)*	*Graduates cancelled going abroad/100 graduates cancelled*
Italy		*119.77*	*127.03*	*7.66*
North-West		*139.23*	*160.21*	*9.42*
Piedmont	***	91.04	89.82	6.19
Valle d'Aosta		90.83	118.18	7.34
Lombardy	***	160.46	196.12	10.43
Liguria		126.92	120.94	10.64
North-East		*141.31*	*164.98*	*9.61*
Bolzano		122.14	163.46	35.00
Trento		163.29	200.00	12.60
Veneto	*	127.19	141.87	7.74
Friuli	*	137.91	166.34	18.16
Emilia Romagna	**	155.96	184.70	6.62
Centre		*150.59*	*158.87*	*9.61*
Tuscany	*	137.07	152.11	4.46
Umbria		153.63	161.83	6.15
Marche		128.32	140.12	6.33
Latium	*	161.69	166.09	13.31
South		*73.55*	*76.04*	*3.13*
Abruzzo		104.67	105.61	4.95
Molise		102.30	105.38	2.99
Campania	**	61.85	55.94	1.64
Apulia	*	58.74	48.39	4.17
Basilicata		72.39	84.57	4.15
Calabria		90.35	122.62	3.29
Islands		*79.24*	*60.70*	*7.45*
Sicily		69.91	54.15	7.74
Sardinia		112.49	86.26	6.40

Source: Elaboration on ISTAT data

regions in Northern and Central Italy show a better capability of compensating for skilled workers' outward flows by the attraction of graduates from other regions or from abroad, in particular when considering recent graduates (under 29 years old). For example, we can see that innovative regions such as Lombardy and Emilia Romagna have almost a 1:2 ratio between cancelled[5] and registered young graduates. On the contrary, Southern regions show a negative trend: in Campania, Apulia and Sicily, for example, the ratio is 2:1.

From the Islands of Innovation standpoint, we may observe that those located in the North and Centre of Italy, namely in Lombardy, Emilia Romagna and Latium seem to be characterised by more dynamic job markets than those in the South (Campania), since they are able to offer more satisfactory employment opportunities and working conditions to young graduates and therefore to fuel the migration processes of tertiary-educated labour.

In this framework the most interesting exception concerns Piedmont. Despite being, as we mentioned above, one of the most innovative areas in Italy and the top scoring in terms of private R&D investment, Piedmont seems to be unsuccessful in offering attractive jobs to the skilled workforce from outside and, in particular, to younger workers. Piedmont is, in fact, the only wealthy Italian region with a negative balance of skilled labour exchange: only 91 graduates registered for 100 cancelled, a balance that becomes worse when we refer only to young graduates (90 graduates registered for 100 cancelled).

As far as foreign migration is concerned, we considered the presence of foreign citizens in European NUTS3 areas. In particular, we focused on foreign residents from prosperous and innovative countries such as Germany, the UK, France and the US (GUFU) and from Central and Eastern Europe (CEE).[6] Data in Table 8.5 reinforce previous results about the relative closure of Italian Islands of Innovation. Immigration from GUFU countries is mainly by wealthy, retired people, seeking natural beauty and the Italian lifestyle (see the outstanding performance of provinces such as Imperia's *Riviera* and Varese's lake district). The most cosmopolitan cities, Milan and Rome, have 5.79 and 2.26 GUFU citizens respectively out of 1,000 residents, far less than cities such as London (50.5), Amsterdam (18.05) and Paris (10.35). The same applies to Islands of Innovation, such as Turin (1.23), Bologna (1.36), Napoli (0.67), Verona (1.61), Prato (0.85) and Bari (1.04) when compared with Cambridgeshire (25.05) or Oxfordshire (20.95).

However, if we consider emigration from CEE countries the situation is reversed. In relative terms, the concentration of CEE citizens in the leading Islands of Innovation such as Milan, Turin and Bologna is the same or even higher as in Stockholm, while in Prato, Brescia and Verona (three leading Italian industrial districts) it is similar to that in West London. Immigration from Eastern Europe can be more easily explained in economic and demographic terms – as being due to differences in income and welfare – without evidence of the attractiveness of Italian Islands of Innovation on specific targets, with the exception of the design and fashion cluster in Milan. If we observe, for example, data from the

Table 8.5 GUFU and CEE migration in selected Italian provinces (NUTS3) and other European regions

	Ratio GUFU/ 1,000 inhabitants	*Rank*	*Ratio CEE/ 1,000 inhabitants*		*Ratio GUFU/ 1,000 inhabitants*	*Rank*	*Ratio CEE/ 1,000 inhabitants*
West London	50,50	1	13,47	Parma	1,46	358	7,48
Cambridgeshire	25,05	8	2,81	Biella	1,40	365	5,17
Oxfordshire	20,95	9	3,91	Trento	1,36	369	16,01
Groot-Amsterdam	18,05	11	2,15	Bologna	1,35	370	5,99
Oslo	11,77	30	5,12	Torino	1,23	381	6,92
Paris	10,35	40	4,00	Cuneo	1,13	395	12,35
Stockholms län	10,10	43	5,97	Modena	1,09	404	6,55
Hlavní Mesto Praha	3,19	233	7,05	Bari	1,04	421	9,70
Madrid	3,63	209	8,21	Brescia	0,92	429	11,12
Imperia	6,82	90	6,82	Reggio Emilia	0,91	430	7,11
Varese	3,22	229	6,20	Prato	0,85	443	12,98
Milano	2,33	282	5,79	Bergamo	0,74	464	7,81
Roma	2,26	286	8,90	Napoli	0,67	481	0,97
Verona	1,61	337	11,04	Palermo	0,54	509	0,68

Source: Elaboration on ISTAT data

Turin municipality (Table 8.6), comparing immigration from GUFU and CEE countries, we find that despite the overwhelming preponderance of CEE immigrants over GUFU ones, the latter are far more skilled and tertiary educated (53 per cent versus 7 per cent). Moreover, we observe that, according to ISTAT data referable to the year 2007, only 3.5 per cent of total foreigners worked in skilled jobs. This percentage rises to 7.2 per cent when technical professions and white collar jobs are considered. It follows therefore that tertiary education does not necessarily mean tertiary-skilled jobs, and furthermore that for a very much higher share of graduate migrants the university qualification is underused (Venturini and Villosio 2008).

In these two sections we have outlined some fundamental features of Italian Islands of Innovation, on both the national and regional scale, highlighting some preliminary findings. The first evidence is that innovation does take place mainly in Northern and Central regions, despite a structural weakness in the 'production' of the tertiary-skilled workforce, specifically in HRST and lifelong training. This indicator establishes a strong link with the Islands of Innovation approach, given its emphasis on the exchange of innovative personnel between Islands. At first sight, such an assumption collides with the well known discourse about the Italian labour market and academic/research system's lack of attractiveness to the highly skilled. Nevertheless, statistical data shows that Italian Islands of Innovation – in particular, Lombardy and Emilia Romagna – can compensate for the outflow of graduates by attracting tertiary-educated labour from other regions – mainly from the South – and from abroad. The most notable exception is Piedmont. On the one hand, Piedmont expresses the highest potential for BES research and innovation; on the other hand, it is the only wealthy Northern region with a negative balance in terms of both national migration flow and attraction of tertiary-educated workers from GUFU countries. This weakness is partially counterbalanced by a higher 'stickiness' in the local labour market: in fact,

Table 8.6 Tertiary-educated immigrants in Turin

	Tertiary-educated immigrants (2008)			*Enrolled in tertiary education (2009)*	
	Working-aged (tertiary)	*%*	*Working-aged (total)*	*University*	*Polytechnic*
GUFU	*1,110*	*52.95*	*2,096*	*208*	*144*
France	517	50.3	1,027	88	119
UK	254	57.5	442	20	2
Germany	197	46.7	422	78	19
US	142	69.3	205	22	4
CEE	*1,936*	*6.93*	*27,921*	*1,161*	*378*
Romania	1,184	5.5	21,367	488	145
Albania	275	7.2	3,836	580	179
Moldova	255	14.2	1,792	41	9
Poland	107	23.8	449	52	45

Source: Elaboration on Turin Statistical Office data

Piedmont is one of the Italian innovative regions with the lowest ratio of graduates leaving for a foreign country (6.19 per cent versus 6.62 per cent in Emilia Romagna and 10.43 per cent in Lombardy). This, however, is not necessarily a positive indicator from the perspective of the Islands of Innovation hypotheses, since we assume that the exchange of skilled workers among different Islands facilitates the spread of competencies and fosters indirect regional competitiveness. It rather suggests a lock-up strategy with a focus on stocking rather than exchanging competencies. Such an indicator is largely counter-intuitive. As Piedmont is the top-performing Italian region in terms of business R&D investment and medium- and high-tech manufacturing, we would expect that an Island of Innovation with such a strong private sector should be able to balance the failure in the regional labour market with a higher degree of direct regional competitiveness, attracting inflows from other Italian regions or from abroad.

The evolution of regional disparities in Italy

This section looks at the link between the availability of a highly skilled labour force and the performance of Italian regions, with the aim of gaining a deep understanding of how human capital and economic growth are related. In doing so, we adapted the interpretative model proposed by Rodriguez-Pose and Vilalta-Bufi (2005) in their work on the returns of human capital in the EU to the Italian case.

To evaluate the economic performances of Italian regions, data concerning GDP per capita from 2000–2009 at NUTS2 level were used (Table 8.7), while the supply of skilled labour was evaluated through three groups of variables, namely *stock of human capital*, *match between education and labour market*, and *migration*.

In order to minimise spatial autocorrelation, both economic performance and human capital data were standardised nationally, so that regional values were measured in terms of deviations from the national mean. Furthermore, in the reconstruction of the economic performances of Italian regions two periods of time were distinguished. The first is 2000–2007, while the second is 2007–2009. This choice was related to our desire to divide and evaluate separately the role of the highly skilled workforce during the expansion and contraction cycles of the world economy. In analysing the 2000–2007 period, the national average of GDP per capita in 2000 and its growth between 2000 and 2007 were used as the dividing criteria, bringing us to identify four different groups of regions:

1. *Catching-up regions*: characterised by an initial GDP per capita lower than the national mean and an economic performance above national average.
2. *Winning regions*: characterised by initial GDP per capita and economic growth rate higher than national average.
3. *Losing regions*: characterised by initial GDP per capita and economic growth rate lower than national average.
4. *Falling behind regions*: characterised by an initial GDP per capita higher than the national mean and an economic performance below national average.

Table 8.7 GDP per capita (€)

	Strength of international networking	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Piedmont	***	23,382	23,549	23,412	23,249	23,360	23,330	23,691	23,817	23,247	21,672
Valled'Aosta		26,734	27,425	27,695	28,060	28,153	27,539	27,797	28,207	28,241	26,756
Lombardy	***	27,488	27,929	28,067	27,779	27,668	27,555	27,836	27,994	27,233	25,251
Liguria		21,277	21,924	21,570	21,468	21,457	21,262	21,459	22,046	21,849	21,052
Bolzano		*27,800*	*27,808*	*27,323*	*27,401*	*27,861*	*27,681*	*28,298*	*28,207*	*28,195*	*27,169*
Trento		*25,830*	*25,840*	*25,586*	*25,331*	*25,008*	*25,063*	*25,196*	*25,564*	*25,340*	*24,294*
Veneto	*	24,843	24,914	24,486	24,503	24,833	24,775	25,177	25,369	24,877	23,187
Friuli	*	23,100	23,739	23,552	22,933	22,921	23,329	23,909	24,227	23,620	22,169
Emilia Romagna	**	26,870	27,090	26,761	26,316	26,196	26,147	26,824	27,022	26,261	24,396
Tuscany	*	22,847	23,303	23,379	23,254	23,268	23,189	23,565	23,643	23,239	22,066
Umbria		20,243	20,619	20,321	19,996	20,157	19,902	20,310	20,362	19,850	18,477
Marche		20,921	21,297	21,580	21,253	21,313	21,368	21,944	22,111	21,702	20,487
Latium	*	24,102	24,573	25,182	24,842	25,635	25,480	25,312	25,316	24,914	23,805
Abruzzi		18,022	18,353	18,271	17,846	17,298	17,507	17,878	17,992	17,634	16,311
Molise		15,237	15,586	15,675	15,390	15,618	15,698	16,244	16,614	16,547	15,948
Campania	**	13,202	13,612	13,865	13,717	13,696	13,625	13,789	13,908	13,511	12,776
Apulia	*	13,876	14,066	14,005	13,808	13,892	13,835	14,175	14,181	13,964	13,233
Basilicata		14,699	14,704	14,782	14,596	14,830	14,682	15,301	15,438	15,305	14,625
Calabria		12,922	13,438	13,442	13,598	13,914	13,689	13,947	13,971	13,510	13,179
Sicily		13,381	13,899	13,929	13,867	13,798	14,103	14,256	14,318	14,042	13,631
Sardinia		15,883	16,203	16,129	16,409	16,488	16,434	16,477	16,808	16,548	15,895

Source: ISTAT data

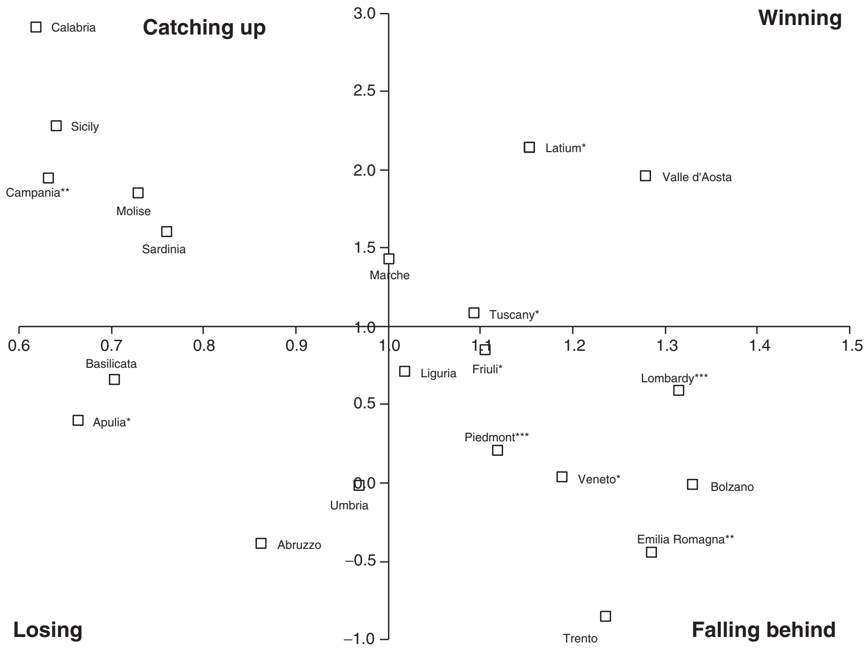

Figure 8.1 Growth performance of Italian regions, 2000–2007

As Rodriguez-Pose and Vilalta-Bufi (2005: 550) stated, 'the first two groups can be jointly defined as dynamic, while losing and falling behind categories can be defined as less dynamic'. Looking at the subdivision of the Italian regions into these four groups, we notice that only three regions containing Islands of Innovation (namely Latium, Tuscany and Campania) belong to the most dynamic groups, while the great majority clearly underperform in terms of growth rates, joining the *falling behind* group.

These results differ slightly from those of Rodriguez-Pose and Vilalta-Bufi (2005) referring to the period 1994–2000, since Lombardy and Emilia Romagna no longer belong to the *winning* group but are found instead in the *falling behind* one.[7] Latium seems to win instead of falling behind, while Campania, Sicily, Molise and Sardinia do not lose but catch up.[8] Our results, instead, support the evidence that the North-West and the North-East fall behind, as the NUTS2 regions in which the two areas may be divided (namely Lombardy, Liguria and Piedmont for the North-West; Veneto, Friuli, Trento and Bolzano for the North-East) seem to be characterised by falling behind patches, too.

From an Islands of Innovation standpoint we may notice that the regions characterised by higher attractive forces for tertiary-educated labour, both from other regions or from abroad, generally fail in maintaining growth rates higher than the national average. Therefore, a very counter-intuitive conclusion may be drawn here: the more innovative labour markets exist in certain regions, the more satisfactory employment opportunities and working conditions for skilled people are offered and the more innovative networks are participated in, the lower growth rates are reached.

The analysis of Italian regions' economic performances during the period 2007–2009 shows even stronger evidence of the failure of Italy's most innovative regions in maintaining stable growth or at least lower decline rates than the national average. Here the national average of GDP per capita in 2007 and its decline rate between 2007 and 2009 were used as the dividing criteria. Once again four groups of regions were identified, but they differ significantly from the previous ones:

1. *Stable regions*: characterised by an initial GDP per capita lower than the national mean and an economic performance less negative than the national average.
2. *Declining regions*: characterised by an initial GDP per capita and economic decline rate higher than the national average.
3. *Diverging regions*: characterised by an initial GDP per capita lower than national average and a decline rate higher.
4. *Resilient regions*: characterised by an initial GDP per capita higher than the national mean and an economic performance less negative than the national average.

None of the four groups identified may really be defined as dynamic, since the discriminating factor here is related to the ability to control losses. In this framework, *stable* and *resilient* regions perform better or at least less worse than those *declining* or *diverging*. Examining Figure 8.2 we may notice that almost all the regions characterised by the presence of high- and medium-high numbers of international innovative networks, particularly in mechanical engineering and ICT sectors, belong to the *declining* or *diverging* groups. Even Campania and Latium, the only two regions containing Islands of Innovation characterised by GDP growth rates significantly higher than the national average during the period 2000–2007, decline quicker than the national mean. Once again, regions containing Islands of Innovation seem to perform worse than those that don't. Since this conclusion seems to be rather counter-intuitive in respect to the literature on this topic, we need to clarify whether in Italy there is a link between the economic performance of regions and their human capital endowment.

The role of human capital endowment in the economic performance of Italian regions

In order to offer an accurate picture of the quantity, quality, use and mobility of human capital across Italian regions, we used a set of 14 indicators from different sources grouped into three categories: *stock of human capital* (six variables), *match between education and labour market* (four variables) and migration (four

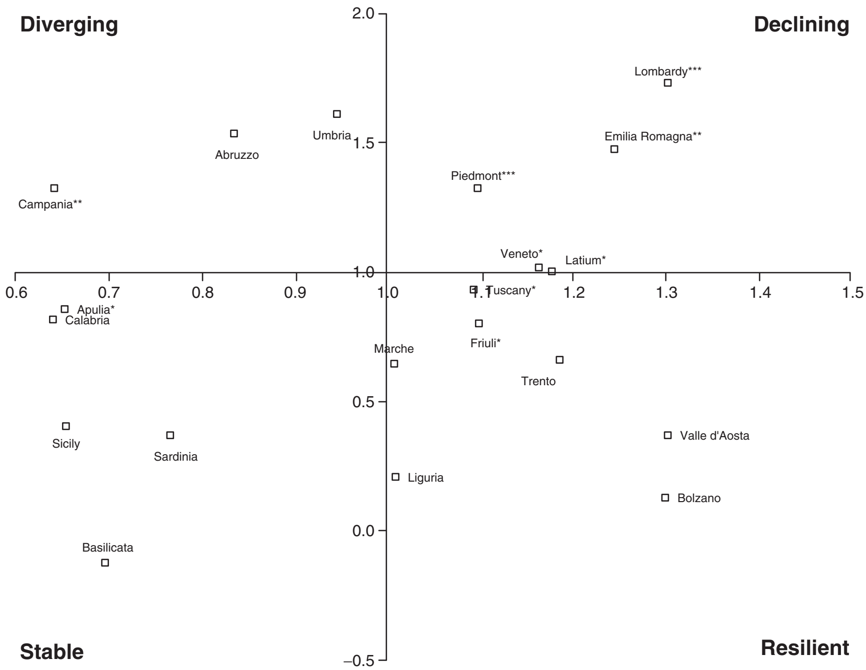

Figure 8.2 Decline patches of Italian regions, 2007–2009

variables). As before, in order to minimise problems of spatial autocorrelation each variable has been standardised nationally.

The variables estimating the stock of human capital offer a proxy for the stock of skilled workforce available in each region. They include: information concerning the average years of education of the resident population, the percentage of people who completed secondary or tertiary education, the share of resources in science and technologies, and the share of people enrolled in lifelong learning programmes. The match of educational skills to labour demand instead aims to describe the capability of Italian regions to offer adequate skills that suit the job market, in particular in the research and development sector. To reach this goal, the employment rate of tertiary-educated people and the percentage of workers in R&D (both public and private) were considered. In our view, this matching is very important since we are convinced that the capacity of markets to absorb the labour force and, in particular, the better trained is likely to have significant impacts on the economic dynamism of regions.

Finally, migration variables offer proxies both of the attractiveness of Italian regions for migrants with a university degree from other Italian regions or from abroad, and of the strength of links with other innovative regions via human capital movements. In particular, the variables examined are: the ratio of

Table 8.8 Human capital variables

Stock of human capital	Average years of education in resident population (1996–2002)
	Share of population with at least secondary education completed (2004–2008)Share of human resources in science and technologies (2001–2005)
	Share of human resources in science and technologies (2005–2007)
	Share of people enrolled in lifelong learning programmes (2001–2004)
	Share of people enrolled in lifelong learning programmes (2004–2008)
Matching education to labour market	Employment rate of tertiary-educated people (2007)
	Share of workers in R&D (2001–2004)
	Share of workers in R&D (2005–2006)
	Share of workers in R&D of private firms (2005–2006)
Migration	Ratio of immigrants' competencies and those of emigrants, in average years of education (1996–2002)
	Share of graduates from other regions or from abroad (2007)
	Share of graduates from other regions or from abroad, 0–29 years old (2007)
	Share of graduates going abroad (2007)

Source: Elaboration on ISTAT data

immigrants' to emigrants' competencies, both measured in terms of average years of education; the share of tertiary-educated migrants – people who moved from other regions or countries in search of new job opportunities; and the share of international graduate migrants – those who chose to move to other countries in order to exploit better job opportunities.

Being nationally standardised, the selected variables become indices of how well a region is doing with respect to the national average in terms of human capital. It follows therefore that the correlation of these variables with those regarding economic performances should suggest what aspects of human capital make regions successful or unsuccessful in respect to the national figure.

Examining Table 8.9, we notice that indicators of educational stock, adjustment between educational supply and labour demand and migration have a strong link with the economic performance and growth of Italian regions. Among the variables of human capital stock, those referring to the average years of education of the population and to the share of human resources in science and technologies seem to have strong links with regional disparities in GDP per capita. The latter, in addition, represents a determent to reductions in GDP during declining cycles. It is worth noticing, instead, that two of the most commonly used educational stock variables, namely the percentage of people with secondary or higher education and the share of population enrolled in lifelong learning programmes do not reveal the existence of any connections with regional economic performance in

Table 8.9 Role of the highly skilled in the economic performance of Italian regions

	GDP per capita (2000)	*GDP per capita (2001–2007 average)*	*GDP per capita (2007–2009 average)*	*GDP growth (2000–2007)*	*GDPdecline (2007–2009)*
Stock of human capital					
Average years of education in resident population (1996–2002)	.754**	.764**	.754**	–.226	.399
Share of population with at least secondary education completed (2004–2008)	.223	.209	.191	–.320	.134
Share of human resources in science and technologies (2001–2005)	.552*	.533*	.497*	–.412	.597**
Share of human resources in science and technologies (2005–2007)	.518*	.501*	.459*	–.390	.653**
Share of people enrolled in lifelong learning programmes (2001–2004)	–.217	–.199	–.225	.221	.211
Share of people enrolled in lifelong learning programmes (2004–2008)	.279	.260	.265	–.382	–.047
Matching education – labour market					
Employment rate of tertiary-educated people (2007)	–.220	–.191	–.222	.357	.273
Share of workers in R&D (2001–2004)	.396	.414	.372	–.080	.537*
Share of workers in R&D (2005–2006)	.599**	.600**	.565**	–.360	.476*
Share of workers in R&D of private firms (2005–2006)	.669**	.659**	.631**	–.443*	.430
Migrations					
Ratio between the competencies of immigrants and those of emigrants, in average years of education (1996–2002)	–.154	–.111	–.096	.655**	–.154
Share of graduates from other regions or from abroad (2007)	.729**	.725**	.707**	–.398	.310
Share of graduates from other regions or from abroad, 0–29 years old (2007)	.798**	.793**	.781**	–.405	.274
Share of graduates going abroad (2007)	.565**	.561**	.589**	–.272	–.149

** $\alpha = 0.01$
* $\alpha = 0.05$

the Italian case. Among the education variables, we note that the share of workers in research and development matters for difference in GDP per capita and for lower decline rate, but we also identify a negative correlation between the share of workers in private firms and the growth rate, which is very unusual in the literature.

Plenty of explanations may be found to discuss this un-positive link, but the most likely refers to the insufficient support offered by basic research (which is usually of a public nature) to the applied research realised by private firms. An inadequate stock of basic research will bring about a lower productivity of R&D workers in private firms, so that an increase of this kind of research personnel may be characterised by economic returns lower than additional costs.

Finally, migration variables clearly show that the ability of a region to attract skilled labour from other regions or from abroad can be as important for GDP as a good educational endowment. Generally, the regions with higher abilities in attracting highly skilled labour perform better. And, as we have seen in the descriptive analysis (Tables 8.3 and 8.4), these regions are characterised by the specific aspects of the presence of innovative networks operating on a national and international scale and a stronger foothold in the knowledge economy, since the capacity to attract this kind of worker is strongly correlated to the share of human resources in science and technologies,[9] people enrolled in lifelong learning programmes[10] and employees in research and development.[11]

Furthermore, coherently with the Islands of Innovation literature, the ability to export skilled human capital has important effects on GDP disparities. Indeed, the circulation of highly skilled labour, and in particular circulation among different Islands of Innovation, facilitates the spread of competencies fostering regional competitiveness. However, one of the most important findings concerning migration variables refers to the positive correlation between the immigrants' to emigrants' competencies ratio (both measured in terms of average years of education) and the regional growth. In particular, a ratio higher than 1 matters for additional growth in respect to the national average.

The correlations observed confirm the key role of human capital endowment in regional economic development, both in terms of stock, quality of labour market (in terms of allocation of the stock of education) and migration. However, it is worth noting that while the stock of human capital and the match of educational supply and labour demand are extremely important in explaining GDP inequalities across Italian regions, migration variables seem to be the only ones able to influence growth rates.

From the Islands of Innovation standpoint, we can confirm the corrrectness of our choice of criteria, as the regions with the higher number of international innovative networks are also those with the most human resource in science and technologies[12] and the higher level of employment in R&D facilities.[13] But what is surprising here is the positive link between the presence of Islands of Innovation in the region and the higher decline rate of GDP per capita during negative economic cycles[14] and the absence of a positive correlation with higher growth rate during expansive cycles. This means, in other words, that over the last decade, Italian Islands of Innovation have not positively affected the performance of regions where they were located.

Conclusions

Our analysis has shown that the poor performance of Italian regions in terms of innovation does not imply an absolute failure in producing innovation but rather a breakdown in creating fundamental labour inputs, such as skilled labour and lifelong training. This gap in reproducing skilled human capital is generally mirrored and strengthened, in a vicious circle, by a lack of abilities in attracting highly skilled workers from abroad and, in particular, those from foreign Islands of Innovation. Nevertheless, we notice strong regional differences in terms of innovative performances and desirable job opportunities for the qualified workforce. In particular, regions characterised by a higher incidence of innovative networks operating both locally and on a national/international scale seem to perform better. The only exception in this context is Piedmont, which despite being one of the most innovative regions in Italy and host to one of the most renowned polytechnics along with many well known private-firm research centres, fails in attracting skilled workers from outside both in absolute terms and when compared to the performances of Lombardy or Emilia Romagna.

Furthermore, through the examination of regional data referring to the period 2000–2009, this study has identified a strong correlation between human capital endowments (to which innovation is strictly related) and the economic performances of regions. We believe therefore that regions characterised by the presence of Islands of Innovation would perform better than those which do not. Surprisingly, however, we found that regions containing Islands of Innovation seem to be unable to maintain stable growth rates and competitive advantages over time, even though they still have higher levels of GDP per capita in respect to the national average.

Our results indicate that human capital stocks, the balance between the skills on offer and those demanded, and the capacity to attract highly skilled migrants have similar effects on the wealth of Italian regions, but different returns on development. In particular, stock and balance variables are connected with lower decline rates during contraction cycles, while migration is closely related to economic growth. The key variable for migration is the ratio of immigrants' to emigrants' competencies. The acquisition of knowledge through migration (ratio>1) favours increases in GDP growth rate, while losses (ratio<1) may slow growth speed.

With respect to policy implications, these findings may offer a possible rationale for public intervention both at national and regional levels. The impact of migration on growth suggests that the effectiveness of development policies could be improved if they were considered as part of a package of integrated measures aiming at fostering the increase of human capital stock, its match to labour demand and the attractiveness of the Italian research system. Nationally, the public educational system should be reinforced and supported, in particular scientific and technological training needs to be encouraged and funded. Furthermore, a radical change in migration policies is required, as bureaucracy ('bureau-crazy') represents a strong obstacle to the permanence of talented people from outside the EU.[15] Regionally, training policies should be tailored to the needs of local labour markets while research and development structures need to be strengthened and embedded in international innovative networks.

Although data seem to validate the overall picture outlined in the first two sections, as innovative producers within the Islands of Innovation generally complain about the availability of skilled workers in the local labour market and confirm the image of Italian production systems as made of SMEs, largely relying on tacit knowledge and blue-collar competencies, there is significant room for improving our knowledge of Italian Islands of Innovation. In this framework the use of micro-level data is a key element in understanding the dynamics within the Islands.

The case study of the robotic cluster located in Turin province (Giaccaria 2010) moves in this direction and it is particularly interesting from the Island of Innovation standpoint as it shows that the exchange of skilled workforce between Islands is not a mere compensation for the failure of the regional labour market to produce a skilled workforce but rather a cumulative process that enhances disparities within the same Island. This is because Islands of Innovation are not monolithic and homogeneous entities (see also Boschma and Ter Wal 2007). The evolutionary trajectories of innovative clusters are usually influenced by multiple cores, which normally rely on different knowledge and skilled workforces. Usually, only the more technology-oriented subgroup behaves in a similar way to an Island of Innovation, establishing flows of skilled labor with other Islands, either national or international. What we perceive as an Island of Innovation is itself an archipelago, made of atolls following different innovative trajectories. What appears to be an Island of Innovation is the outcome of variety within the Island itself (Essletzbichler and Rigby 2007). Every Island of Innovation can probably be understood as a 'chain of related varieties', with indentifiable sub-islands that interact differently with other Islands at the regional, national and international level. Hence, adopting an evolutionary perspective might be helpful in refocusing the very concept of Island of Innovation and avoiding reification.

Notes

1. The Regional Innovation Scoreboard is made up by three groups of normalised indicators:
   a) the *enablers* who capture the main drivers of innovation that are external to the firms: tertiary education, lifelong learning, public R&D expenditure.
   b) the *firms' activities* that refer to the innovation efforts that firms undertake: business R&D expenditures, EPO patents.
   c) the *outputs* related to the outputs of firms' innovation activities: employment in medium-high and high-tech manufacturing and employment in knowledge-intensive services.

   The RIS index is the weighted sum of the three groups of indicators. The methodology used for the calculation of the Regional Innovation Scoreboard is fully described in a report available at www.proinno-europe.eu/page/regional-innovation-scoreboard

2. The position of Latium as a leading innovative region in Italy can be largely explained with reference to the presence of Rome and the consequent concentration of public research headquarters (such as the CNR – the National Research Centre) and ministerial bureaucracy. Despite recent efforts in attracting innovative firms, in fact, Latium is far behind Northern regions in terms of private investments in R&D.
3. According to ISTAT the *discouraged* are generally people able to work but who give up searching for an occupation since they are convinced they will not be able to find one.
4. This simple measure of skilled workforce movements represents, however, a crude simplification of exchange fluxes of qualified migrants from and towards Italian regions, since we do not know if those human resources are left idle or not used to the best of their capacity in the workplace.
5. Cancelled graduates are tertiary-educated people who move away from the region of origin and therefore are deleted from the registry office records.
6. CEE countries are Estonia, Latvia, Lithuania, Poland, Germany, Czech Republic, Slovakia, Hungary, Romania, Bulgaria, Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Kosovo, Albania, Montenegro and Macedonia.
7. We must notice however that the two authors use GDP per capita data at NUTS1 level; it follows therefore that the results are not perfectly comparable .
8. Those differences may be caused by the restriction of the period of analysis to only seven years. In such a timeframe, regional growth paths may be strongly influenced by contingent factors and may not reflect long-term growth trajectories.
9. corr. = 0.702; $\alpha = 0.01$
10. corr. = 0.689; $\alpha = 0.01$
11. corr. = 0.695; $\alpha = 0.01$
12. corr. = 0.516; $\alpha = 0.01$
13. corr. = 0.574; $\alpha = 0.01$
14. corr. = 0.619; $\alpha = 0.01$
15. Two non-European skilled graduates presented a recent analysis (2009) on ‘how Italy rejects talented people’ at the Rodolfo De Benedetti Foundation, which helps us to better understand the paradox of the Italian situation:
    ‘I am now doing an internship in Singapore. I got the stay permit within 3 hours of submission of my application. In Italy it took 22 months. […] I am too much desperate with Italian bureaucracy. After finishing my studies I will run away from Italy.’
16. ‘I have studied in 4 universities before coming to Italy and worked in different parts of the world. I found Italy one of the places where a foreigner does not feel comfortable. I found that Italy is losing capacity to integrate foreigners to its culture and this will have a strong impact on the quality of students it will be able to attract.’

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Part IV

Conclusions

9 Selected places for attracted labour

Islands of Innovation as carriers of knowledge for science-based development

Ulrich Hilpert and Helen Lawton Smith

Processes of innovation require creative and talented people. New technologies, their creative applications or synergy across different areas of scientific research or technology development necessarily create opportunities for the employment of the highly skilled. Nevertheless, such labour is unevenly distributed geographically – it is not generated everywhere and there is a severe competition for highly skilled and creative personnel. The fact that the highly skilled are concentrated in certain places indicates more than just that some locations attract such labour while others do not. It shows that certain institutions and structures need to exist to ensure that skills are both offered and employed.

This brief introduction highlights the central elements as to why selected places are the locations for attracted labour. The narrative is about the distinction between those regions that manage to become an Island of Innovation and continue to be one and those regions that do not. Becoming an Island of innovation means that scientific, technological and managerial elites are strongly attracted to such places, which further contributes to their development. However, the processes by which places become outstanding locations in a number of areas of research and technologies are complicated and they take time. Thus their number shows very little change over time. Moreover, as these are places where new scientific findings and technological opportunities frequently emerge, for example in universities, research institutes, research- and development-intensive firms and from entrepreneurial individuals, there is a high level of potential for creative synergy for yet further development. This is because of the concentration of highly skilled, gifted and often university-educated labour ready to transform this potential into innovation. Hence very often the next steps on the path to technological advance emerge at these same locations. In addition, people with similar skills attracted from other locations help to strengthen regional labour forces, thus further reinforcing that potential·

Although a concentration of highly innovative people at Islands of Innovation is clearly in the favour of regional development in these locations, there are also national effects. Strong Islands of Innovation and the attraction of innovative labour to certain regional labour markets support a country's overall innovative performance. Uneven regional development is a necessary, though often unintended, consequence of national policies designed to foster innovation and science-based economic development. Hence, this is not just a matter of regional development, but is an outcome that needs to be understood in the light of national strategies and their effects on the location of innovation, employment and economic development.

The resulting small number of places identified as outstanding and representing regional disparities is unavoidable, and may be a necessary condition for participation in international divisions of labour and in the globalisation of technological advance. The increasing knowledge intensity of high quality products gives particular importance to the access and dissemination of knowledge. The labour force of knowledge-workers becomes critical for such development. This is because the constant flow of new ideas and knowledge, the ongoing search for new findings and their applications, and the exchange of ideas that provides for a wide variety of applications in different fields, become fundamental to modern, highly innovative industries. Competition is first of all based on the quality of new knowledge-intensive products. A high quality labour force can generate the ideas that form the basis of competition.

While certain paths of development result in the formation of Islands of Innovation characterised by regional, highly skilled labour forces, a continuation that relies exclusively or predominately on local or regional competences would bypass possible fertilisation based on the exchange of ideas, labour and attitudes towards areas of research and application. Even national situations become less sufficient in providing the basis for new creative and innovative development. Cross-fertilisation that takes into account different approaches, backgrounds, disciplines, industries, markets and, last not least, different cultures is increasingly critical. Innovative labour becomes more innovative when it is brought into contact with different fields of application and areas of potential synergy. Thus, besides the fact that there is competition for highly skilled labour, particularly for the elite, there is a strong need for the exchange of ideas and collaboration in order to generate new knowledge, scientific progress and technological innovation.

Since cross-fertilisation provides the basis for future development, Islands of Innovation are places that provide attractive, innovative labour markets. Again, exchange will be concentrated in established Islands of Innovation and their innovative regional labour markets. An exchange of such labour complements divergent opportunities for development and is in Islands' mutual interests. Scientific progress and the associated technological advancement of enterprises and industries favour participating Islands of Innovation. In effect, their regional labour markets merge. Highly mobile innovative labour finds opportunities in these selected places, in what becomes a *global research village*. This village comprises a patchwork of regional innovative labour markets, which provides a network for knowledge dissemination and innovative development connected by individuals moving between Islands of Innovation attracted by the jobs and working conditions offered.

Nevertheless, there are unanswered questions.

- How do locations qualify to become involved as Islands of Innovation?
- Is there an opportunity to provide for such participation through public policies?
- What makes a location perform as a magnet for knowledge-workers?
- How can regions provide for a situation that allows for an attractive participation in a changing international division of labour?

These questions concern more than regional development or a global race in innovation. They are also about how places can build environments that provide a basis for specific and strong contributions to a global system of innovation, which have a clear basis in innovative labour.

When Islands of Innovation form networked innovative labour markets: matching competence and regional development

In a constantly globalising world, Islands of Innovation provide important opportunities for realising structural change based on new scientific findings and technological opportunities, plus they attract innovative personnel. Thus strong Islands and dynamic innovative locations are more than outcomes of regional processes of development. They also need to be considered in the light of both their contribution to national development and their role within a changing international division of labour.

The stronger those Islands of Innovation become, the more innovative capabilities are accumulated in particular countries and the more intensive is their participation in international collaboration and exchange of knowledge. National processes of innovation benefit from the concentration of knowledge and competence available at such locations, or which is made available from an international network of collaboration through such locations. From these, there is access to knowledge and the competences of enterprises and institutes located at other Islands of Innovation, or which can be obtained from enterprises located in other regions that may be even more peripherally located. A strong regionalisation of innovation may indicate inter-regional grading, but it may also contribute to industrial modernisation in general. This is because strong regions, like Islands of Innovation, are participants in leading-edge research and technologies. They are able to transfer these competences to medium-tech industries or to regions that are not Islands but demand innovative impacts.

Nevertheless, countries and regions that are outside of systems of migration, collaboration and knowledge flows between Islands of Innovation will benefit less from a global growth of knowledge or from the availability of new technologies. Countries that lack such opportunities for contributing to an international body of knowledge and have limited access to joint innovative projects will not gain access to leading-edge knowledge generated among the participants of the network. The lack of potential for building Islands of Innovation limits results in increasing negative differences compared to scientifically and technologically leading countries and regions. Thus, in leading countries, it is in the interests of a country for there to be a concentration of such development and resources in a few outstanding locations.

When providing national access to an international body of knowledge and technological development, these locations serve even the interests of regions that have less advanced industrial structures, and where enterprises apply technologies to modernise their products rather than generating new technological opportunities. This can be clearly seen in Germany in a number of industries such as mechanical engineering, medical instruments, rubber and artificial fibre industries. These are not science-based, but they can apply new technologies (biotechnologies, new materials, new electronic devices etc.). Frequently, these industries are located in more peripheral regions and enjoy a transfer of new technologies to keep their mature industries/competences/enterprises innovative. Hence, the phenomenon of Islands of Innovation and their trans-regional networking across borders and continents is an important contribution to the countries to which they belong.

Those countries that lack the potential to build Islands of Innovation will also face fundamental problems in providing attractive innovative labour markets. These locations will be less vital with regard to scientific research and technological development, hence are less attractive to highly innovative scientists and engineers. Thus locations that do not perform as Islands of Innovation are less able to provide the conditions under which knowledge-intensive and research-driven industries are established and flourish. In particular, they have less strong and dynamic innovative labour markets, which means that they have both a smaller number of innovative people and fewer opportunities for cross-sectoral collaboration.

It is obvious that locations without a strong structure in advanced technologies, such as micro-electronics or biotechnology, will not be among the most dynamic places of industrial development. Simultaneously, these regions neither form a strong innovative labour market in these fields nor attract the most innovative personnel in these fields of activity. Concentrations of competence, talent and knowledge occur in a few regions, and the dynamically growing demand for new knowledge and creative opportunities introduces a situation that is characterised by an exchange of ideas and collaboration where leading-edge institutions and enterprises search for partners on the same level of competence. These are predominantly found at other Islands of Innovation. Trans-regional networking in leading-edge areas of science and technologies includes regions that have managed to emerge as Islands of Innovation, enabling the next step to new and highly innovative knowledge. Proximity, however, matters less than excellence. Since mutual benefits and joint projects help to merge processes of knowledge transfer and competence building, space and distance between the locations of the collaborators becomes less relevant. With regard to collaboration, the exchange of ideas and interrelated development becomes increasingly virtual.

Consequently, new and highly innovative enterprises predominantly emerge at Islands of Innovation. They may be spin-off enterprises from research universities or scientific institutes or spin-out enterprises from other previously founded science-based enterprises. Both types of enterprises relate to a mutually strong relationship with universities and reference industries. In addition, a growing demand by both scientific institutions at Islands of Innovation and enterprises introduces a greatly increasing demand for innovative labour. A growing innovative labour market at Islands of Innovation will attract the attention of highly innovative personnel elsewhere and will further contribute to the ongoing accumulation of creativity, competence and knowledge. Thus, large metropolitan areas with strong innovative potential or large Islands of Innovation clearly have an advantage. This is not only because they attract large numbers of university-trained personnel but also because they attract particularly innovative and creative people with a wide variation of skills and research strategies. These people increase the potential for synergy and build on existing strengths.

Thus large Islands of Innovation can build huge bodies of particularly strong human capital and intra-regional as well as trans-regional exchanges of innovative labour. Attractive employment opportunities provided through regional innovative labour markets help to both recruit highly skilled labour from other Islands of Innovation and identify competences in potential partners for collaboration. Finally, attracting labour from other highly innovative locations creates mutual effects for receiving and sending locations. This is because it contributes additional competences and allows for further collaboration with locations with which relevant personnel have had previous close working contacts. Since innovative people have often been educated at Islands of Innovation, exchanges frequently take place between a small number of selected locations but complemented by a number of further locations and knowledge-workers from outside the system formed by the Islands.

Opportunities to take jobs at these locations and to move from one outstanding location to another enables the building of networks of innovative labour markets, which provide for knowledge dissemination through the exchange of labour. Although there are opportunities for new locations to join these networks, the overall effect is to strengthen existing Islands of Innovation.

When Islands of Innovation form networked innovative labour markets, this does not just refer to migration patterns or building regional human capital. In fact, recruitment of personnel from other Islands of Innovation or even from abroad will contribute to the regional stock of knowledge and create a potential for new competences. Networking innovative labour markets contributes to regional innovative development and consequently to a country's socio-economic development where the Island is located. Recruitment also gives access to knowledge and competences; new and embodied knowledge is brought to a location and merges with existing opportunities for synergy. Thus it is more than a joint labour market that is advantageous for both employers and employees; it is also the basis for innovation and advanced socio-economic development. This is clearly exclusive and can be shared almost entirely among those who mutually contribute to the common stock of knowledge. Matching competences among distant regions and locations therefore provides for strong regional development.

How Islands of Innovation share the knowledge for mutual benefits: highly skilled labour and participation in innovative networks

Although Islands of Innovation exchange innovative personnel, and although enterprises and scientific research institutions collaborate, a continued competitive relationship exists. This is a highly specific situation because knowledge, competence and the highly skilled are the conditions for participation in networks among Islands of Innovation. Simultaneously, participants are potentially both partners and competitors. In such an environment, the positions of leading-edge enterprises and research institutions within networks clearly depend on the ability to attract mobile scientists and engineers. Once the highly skilled, attracted for example by higher salaries or improved working conditions, take new jobs at different locations, knowledge is made available in different situations. Thus the sending and receiving locations involved share a knowledge-base and, due to knowledge-dissemination processes, can now mutually contribute to technological and socio-economic development.

An exchange of personnel among Islands of Innovation also intensifies differences compared to other locations that are not part of the network. Sending locations or countries can also benefit from this process as contact with mobile scientists and engineers and with those who have started enterprises is maintained. International divisions of labour can similarly provide benefits for labour exporting countries (for example, Taiwan, Singapore, India or China). Globalisation of development and manufacturing includes less innovative locations, which provide fundamental elements for both new products and competences in manufacturing advanced industrial products.

Since the building and continuation of an Island of Innovation is based on the high reputation of scientists and engineers, there is overall little identifiable underlying change although some new locations emerge and join networks. Some Islands of Innovation are involved in almost all new technologies (for example, Boston or the San Francisco Bay Area). Others do not have an industrial history in particular industries, but new technologies provides for opportunities to link up with innovation and certain industries. Thus a strength in biotechnology allowed Islands of Innovation based on scientific research new technologies and a strength in highly innovative industrial segments (for example, related to pharmaceutical industries or medical instruments). This was the case with Munich, the Research Triangle Park and Seattle.

In such Islands of Innovation, outstanding institutions provide for both attractive jobs and working conditions and help to continue their positions as global centres of collaboration. In these institutions, new areas of innovative research and new technologies allow for additional jobs and for the further strengthening of regional human capital. In contrast, other regions or locations will have to build a critical mass of creative scientists and engineers in order to become an outstanding innovative location. Where this happens, there is greater likelihood for new research-based firms to be established, which will contribute further to an increasing demand for the highly skilled.

In addition, the relationship between firms and research institutions is fundamental to building a body of knowledge and to gaining a recognised competence. This is important for participating in mutually beneficial exchange and collaboration with partners at other outstanding locations. Thus building an Island of Innovation still demands a large number of university-trained personnel, technicians and highly skilled workers. If this situation is not created, or the situation is insufficient with regard to creativity or numbers, Islands of Innovation may not emerge. This situation is illustrated in this book in Chapters 7 and 8, which deal with problems in the Czech Republic and Italy.

The polycentric system of Islands of Innovation provides for networking innovative regional labour markets as a condition for mutual benefits based on an exchange of personnel and knowledge. Individually, an Island of Innovation allows for both clustering of creative personnel and, based on a regional innovative labour market, for participation in the exchange of personnel. When new projects or new technologies are developed, it is important that at these locations, top personnel are mutually available and knowledge and competence are concentrated. Thus ideas can be exchanged and provide the basis for synergies: at larger Islands of Innovation, which possess a regional concentration of appropriate firms, highly skilled and innovative individuals are at an advantage. There, a greater exchange of personnel is possible, more creative individuals can take jobs in their innovative, regional labour markets and, based on this, their central position in particular technological networks can be identified. A larger innovative labour market attracts more innovative people from abroad and allows a location to be ready to match a rich variety of competences with those that exist elsewhere. Finally, it qualifies the location to be the home of potential collaborators with whom to share new knowledge.

Thus networks of regional innovative labour markets will increase competition for highly innovative personnel but will also provide the basis for a constant exchange of labour and embodied knowledge, which is gained from leading-edge research or new technologies. Participation in knowledge dissemination and the building of competences is clearly an advantage of Islands of Innovation. In addition, a competitive situation in a polycentric system, with regard to the human capital required, helps to build a global body of knowledge. It is the networking of innovative regional labour markets that provides for mutual benefits from this knowledge through mobile innovative labour. The extent to which islands of innovation participate by attracting such labour has an influence on the trajectory of highly attractive socio-economic development within their regions. The entire system formed out of these locations or regions generates benefits from the exchange of labour, even when individuals may leave a region.

Although individual places may regret it, when outstandingly innovative personnel change places and institutions or enterprises, there are still opportunities for collaboration in scientific research or in the development of new technologies. Hence a change of places spreads knowledge and competences, which helps to form appropriate situations for future collaborations. New and synergetic processes based on exchange of knowledge and personnel will on the one hand continue and broaden opportunities for collaboration, and on the other contribute additional competences to new and synergetic knowledge.

Such mergers of competences are much more frequent when new research plans and strategies are realised because innovative labour takes the opportunities offered elsewhere. In addition, such innovative knowledge emerges more frequently when a vital exchange of outstanding labour is realised. Its impact will be based on teaching, scientific research or the development of new technologies. Thus this knowledge is related to its divergent origins from different places, and from the research traditions associated with these locations, as well as to the creativity and novelty of the knowledge itself. As a consequence, such new knowledge is applied by those involved in the exchange and dissemination, thus allowing for new opportunities in scientific research and technological development.

Since the number and locations of Islands of Innovation hardly change, even over long periods of time, an exchange of innovative labour provides for mutual benefits among the participating locations. It is important to note that such beneficial processes can be realised only when there are innovative regional labour markets that form networks. When such jobs are provided, which offer both attractive working conditions and high incomes at highly reputable places, there are good opportunities to participate in the exchange of labour. Nevertheless, it demands innovative labour that is ready to change its places of work.

Once clusters of innovative firms emerge, this indicates both an innovative regional labour market and a strong concentration of innovative competence, knowledge and outstanding scientific research. Jobs, innovative labour and leading-edge research form regional situations that provide the basis for Islands of Innovation. Such clusters contribute to a disproportionately high growth of new jobs and innovation, which can be, and usually is, based on both intra-regional collaboration and trans-regional collaboration. Mutual benefits are also generated across distances because these places are perceived as both highly vital and innovative locations, which can provide partners with an attractive body of innovative knowledge.

In conjunction with government policies and strong funding of both scientific research and new technological opportunities, these locations can continue their position in international networks. New areas of research may enter the profile of a location and innovative labour continues to be attracted to the place as well as the exchange of personnel continuing to generate further knowledge, competence and innovation. Over time, such processes create an established situation among those regions that also participate in networked, regionalised, innovative labour markets. This indicates the difference with regions that do not perform as strong innovative locations, but also points to an internal and clearly diversified structure of the relationships among the participating Islands of Innovation.

Regional participation in global economic development: culture and innovation

Participation in the exchange of highly skilled labour becomes a condition for innovation and access to leading-edge knowledge. Thus it is crucial to keep such personnel in the region, to attract additional personnel from outside, and also to have a vital exchange of such labour among enterprises and between firms and scientific institutions within the region. Building regional human capital that is prepared to contribute new findings to the global body of knowledge and that attracts attention from other outstandingly innovative locations, will also have an impact on a region's socio-economic development. Spin-offs from research institutions provide for new and additional jobs and help in building specific situations that are characterised, in particular, by their innovative human capital.

The high reputation of a research university, or even of individual departments, which stand out because of their international recognition for leading-edge research, will raise the interest of external firms to collaborate with partners from such a location. In addition, new science-based enterprises will be attracted to the location and will more frequently locate there as a start-up firm. Again, this adds further jobs to the regional innovative labour market and contributes to the attraction of the location as an accumulation of talents, capabilities and excellence. A close relationship between leading-edge scientific research and the production of high quality university degrees, as well as vital knowledge dissemination and effective technology transfer within a region, identify a centre of innovation. This allows for an attractive exchange of personnel and creates a high level of regional human capital to form a basis for an Island of Innovation and extraordinarily strong socio-economic development.

Nevertheless, processes differ, and participation in networked regional innovative labour markets varies, even among internationally highly recognised Islands of Innovation. The USA, as a country and at its individual outstanding locations, attracts a high percentage of the outstanding scientists and researchers in the world. Moreover, young talented students from abroad tend to search for education at a top American university and may stay thereafter as gifted researchers. Nevertheless, other countries and institutions continue to provide similar strengths and to hold leading positions in science and technology. They enjoy high international recognition and reputations, and scientists based in the USA also collaborate with a large number of universities and research institutions in Europe and other continents. Clearly, it is more than just excellence and reputation that matters when Islands of Innovation have different opportunities in recruitment in the networked innovative labour markets.

Language also plays an important role. English as the *lingua franca* of modern science attracts innovative individuals to places where this language is the everyday working language. Non-English speaking countries and their Islands of Innovation confront potential employees with the disadvantage of learning an additional language to live and work there. While the innovative labour markets of the USA and the UK are clearly favoured over other strong European countries, these non-English speaking locations have to face the additional problem of their outstanding scientists being attracted by positions offered at Islands of Innovation in the USA. An academic culture characterised by a strong system of scientific merit searching for outstandingly creative scientists and engineers from abroad to work in the country, creates a dynamic and clearly multinational situation. Foreign-born scientists and engineers are also important because of their start-up enterprises, which further contribute to regional innovative labour markets.

The in-migration of overseas scholars and students allows the USA to take strong advantage of networked innovative labour markets by hiring personnel from abroad more easily than non-English speaking countries because of language, culture and regulations. The country thus has a strong advantage in knowledge dissemination and technology transfer based on embodied competence, excellence and creativity. In general, the more open an Island of Innovation is towards outstanding individuals from abroad, the easier it is to attract them and to benefit from networked innovative labour markets. Finally, such an interrelation among the labour markets of Islands of Innovation is fundamentally a cultural and social question. Individuals may take decisions according to their opportunities and expected difficulties. While all Islands of Innovation, and the countries where these are located, may benefit from networked innovative labour markets, some may attract such labour more easily and may benefit more strongly than others. Socio-economic development based on innovation, science and technology therefore relates to cultural and social situations that allow creativity with a low level of associated cultural problems to be solved.

Thus, the world changes through its regions. New scientific findings, new knowledge and new technologies are concentrated in a selected number of locations. In these places, innovation is predominantly generated and highly specific cultural and social structures can be identified. Since innovative labour drives the socio-economic process and such highly creative labour is hard to find, networked innovative labour markets allow for wider headhunting as well as the attraction of young talent from abroad. The more successful such attempts are, the more multicultural the labour force at an Island of Innovation will become. The more innovative locations become, the more scientists and engineers will be drawn from a wider variety of countries.

As can be identified, particularly from the American experience, there is a clear tendency towards denationalisation of the innovative labour force in the strongest Islands of Innovation. Once a national economy and more mature industries benefit from such development, a renationalisation of innovative capability through applications of technology and manufacturing is identifiable. An international or global orientation in Islands of innovation and a contribution to national development based on the advantages of selected regions, characterise the relationship between outstanding innovative regions and national development in general. These locations are predominantly oriented at the top of an international hierarchy of research, innovation and new technologies. Therefore, they use networked innovative labour markets for gaining access to knowledge and personnel. Other less innovative situations, however, can benefit from the applications of such technologies and thus have less demand for the international recruitment of creative personnel. Hence there is regional division of labour, which may be to the advantage of a great number of regions.

In summary, regions in general, and Islands of Innovation in particular, provide an expression of global change. In Islands of innovation, processes of change can be identified most clearly. This is because innovative regions respond quickly to both new opportunities and to a changing or expanding global body of scientific and technological knowledge. Thus Islands of Innovation are the national links to a *global research village*, which is formed out of, and is constantly reproduced by, individual Islands of Innovation. Since participation is realised via innovative and creative labour, which is attracted to particular cultural and social situations, regional innovative labour markets play an important role in socio-economic development. Thus the message for public policymakers is that they need to facilitate the provision of attractive jobs in order to attract human capital as a basis for innovation in particular environments. This makes the regionalised participation in global socio-economic development based on innovation a fundamental question of political decision-making and programmes, and highlights the basic role of culture and society for science-based development.

Index