

Geography of innovation in Europe and Finland: Empirical studies on innovation indicators and regional development

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ACADEMIC DISSERTATION

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Abstract

Innovation is commonly considered as the engine of economic growth. However, the role of education and training has been a recurrent subject raised as the actual driver of regional development. Accordingly, the role of universities has been highlighted as a significant contributor to local economies. The empirical literature remains inconsistent on the causal relationships between these phenomena. At the heart of this discussion is the on-going debate about which indicators should be used to measure innovation, as there seems to not be a single measure that could be claimed as clearly superior. This brings the question of the possible interconnections between innovation indicators and regional economic development to the fore on different scales: European Union, national, regional and local.

First, the sensitiveness of different innovation indicators and indexes is analysed. Second, the impacts of innovation indicators on regional and economic development are investigated. Third, the proposed role of education and training as the factors behind innovation and economic growth are put under scrutiny. Fourth, the role of universities in the local economy is studied.

The analyses are mainly carried out with standard statistical methods, including principal component analysis and Granger causality tests, but the picture is also deepened with a semi-structured thematic interview case study. The data for the statistical analysis are constructed from official statistical databases and from a unique innovation count database compiled by VTT Technical Research Centre of Finland.

The results show that great care is needed, when choosing the indicators to measure regional innovation with, as different measures produce highly divergent rankings. In worst cases this can lead to non-robust messages, if the shortcomings of the different indicators are not taken into account when drawing policy conclusions. The results also show that in a geographical context the innovative (European and Finnish) regions are among the most economically developed. The links between continuing vocational training, innovation and economic development are manifest in a similar fashion. Still, although innovation is clearly linked to regional development, other socio-economic variables, workforce characteristics, and education in particular, seem to offer higher explanatory power for the success of regions. In fact, educational attainment is shown to Granger cause economic development and innovative capacity, whereas the relationship between innovative capacity and economic development is bidirectional.

Finally, in peripheral settings, Joensuu in this case, the impact of university on to the local economy is not as straightforward as in the case of well-to-do regions and top universities: there are evident mismatches between the needs of local business life and the research, the teaching and entrepreneurial characteristics of the university and its staff and graduates. Still, when successful the university-industry collaboration has produced good experiences and beneficial cooperative projects in the locality.

In conclusion, since the link between innovative capacity and actual innovative outputs is not straightforward, policies simply relying on increasing regional research and development expenditures are not guaranteed to succeed. Therefore, although there is no universal 'one-size-fits-all policy', the strengthening of the educational base of the regions is highlighted here as a possible alternative to strive towards high levels of innovation and economic growth.

Acknowledgements

When I started pursuing this doctorate degree, in the summer of 2009, the words from a (loosely) biographical movie about the famous economist John Forbes Nash Jr. were lingering in my mind: "Find a truly original idea; it is the only way I will ever distinguish myself; it is the only way I will ever matter". Of course, things do not work out as they do in the movies. Still, I hope that this work would bear in it even a small original contribution to the distinguished field of economic geography. I tried to keep the facts straight. For example, "Aristotle was not Belgian, the central message of Buddhism is not 'every man for himself', and the London Underground is not a political movement. Those are all mistakes, I looked them up".

I am grateful for Professor (Emeritus) Juhani Hult for getting me interested in geography, to Dr. Jarkko Määttänen for refining this interest and to Dr. Timo J. Hokkanen for giving me the opportunity to gain a foothold in academic working life. Moreover I am indebted to Professor (Emeritus) Pentti Yli-Jokipii, who convinced me, via his lectures, to apply myself to the study of economic geography. This has proven to be sound advice, as "nobody is looking for a puppeteer in today's wintry economic climate".

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“Onpa mahtava innovaatio!”

-Juhani Tamminen-

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List of original publications

This thesis is based on the five (V) peer-reviewed articles listed below. The papers are referred to with their roman numerals in the text.

PAPER I: Makkonen, T. & R.P. van der Have (2012). Benchmarking regional innovation performance: Composite measures and direct innovation counts. *Scientometrics* DOI: 10.1007/s11192-012-0753-2.

PAPER II: Makkonen, T. & T. Inkinen. Geographical and temporal variation of regional development and innovation in Finland. *Manuscript submitted*.

PAPER III: Makkonen, T. & T. Inkinen (2012). Innovative capacity, educational attainment and economic development in the European Union: Causal relations and geographical variations. *European Planning Studies* DOI: 10.1080/09654313.2012.722968.

PAPER IV: Makkonen, T. & B. Lin (2012). Continuing vocational training and innovation in Europe. *International Journal of Innovation and Learning* 11, 325–338.

PAPER V: Makkonen, T. (2012). Peripheral university region and knowledge-based development: The case of Joensuu. *International Journal of Knowledge-based Development* 3, 216–233.

Author's contributions

In papers I–IV the first author is responsible for delineating the research questions and designing and conducting the analysis. Writing was co-authored.

Abbreviations

CVT	=Continuing Vocational Training
EU	=European Union
GDP	=Gross Domestic Product
ISO	=International Organization for Standardization
KMO	=Kaiser-Meyer-Olkin measure of sampling adequacy
LAU-1	=Local Administrative Unit
LLL	=Lifelong Learning
NIS	=National Innovation System
OECD	=Organisation for Economic Co-operation and Development
PCA	=Principal Component Analysis
R&D	=Research and Development
RIS	=Regional Innovation System
U-I	=University-Industry
USPTO	=United States Patent and Trademark Office
VTT	=Technical Research Centre of Finland

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1. Introduction

Innovations are topical in the literature on regional development. However, over recent decades at least, the volume of scientific books and articles discussing the issue has been inconsistent. For example, the problems related to measurement of innovations and the causal relations behind innovation and development are issues still deserving of systematic treatment. Also, the impacts of continuing vocational training (CVT) on innovation and economic development are an issue rarely discussed in the literature. The common view is that the relationship between regional development and innovation is self-reinforcing and bidirectional. However, although the causal links between economic variables and innovation have been raised to the fore of economic debate from time-to-time, there is no clear consensus on the direction of the causal relationship between innovation and regional development. Illustrative of this debate are the contrasting papers by Lach and Schankerman (1989) and Toivanen and Stoneman (1998), who with firm-level panel data from USA and UK, respectively, conclude with differing statements: whereas in the USA research and development (R&D) Granger causes (capital) investments this is not the case in the UK. Another prominent discussion has been that of the role of education, learning and training in the equation of economic growth. In this respect the role of universities has been highlighted as a driver of local economies. However, the research on universities has often been concentrated in well-off regions with successful universities, leaving aside the experiences from peripheral regions and lesser known universities.

This thesis makes a contribution to innovation studies, which is a fast growing segment of economic geography and closely related, theoretically and methodologically, to other branches of scientific thought, including economics, management and business disciplines (see Howells & Bessant 2012). The varied interests of scholars from those different fields has led to criticism; in particular (economic) geographers have criticized the works of (geographical) economists for containing "too little regions and too much mathematics" (e.g. Martin 1999). However, the complementarity between different approaches should not be viewed as a menace, but as a possibility (also Marchionni 2004). Whether we favour economics or geography to study innovation, it remains important to take the economics of location seriously (Brakman & Garretsen 2003) while not forgetting that economic life is conducted in and across space and determined by locally varying, scale-dependent social, cultural and institutional conditions (Martin 1999).

The specific question raised here is: how are different innovation indicators and economic regional development interconnected at different geographical scales? The individual original papers presented here are aimed at providing new knowledge on: 1) innovation measures; 2) geographical variations of innovation; 3) impacts of innovation, education and training on regional (economic) development and; 4) the role of universities in regional innovation systems (RISs), with data from diverse regional scales [European Union (EU), national, regional and local]. Paper I attempts to determine how well different proxy innovation measures and innovation indexes can predict actual innovation count data. In doing so it uses data from Finnish local administrative units (LAU-1) to discuss the methodological problems related to the measurement of innovation. With panel data from Finnish LAU-1s paper II sets out to explore the key variables of regional development *vis-à-vis* innovation. In paper III the causal relations between innovation, education and economic development are tested with data from selected European countries and regions. The links between CVT, innovation and economic development are illustrated in paper IV. Finally, using case study data from a peripheral university town of Joensuu, paper V offers some guidelines for successful university-industry (U-I) cooperation.

First the issue of how to measure innovations is discussed followed by the introduction of a stylised timeline of the regional development literature and the rise of regional concepts driven by

innovation and knowledge. Next, the localized and persistent nature of innovation is delineated and the importance of learning, training and universities is brought to the fore. The theoretical summary part ends in a description of the previous literature mapping innovation at global, European and Finnish scales followed by a short introduction chapter to the data and methods used in the original papers. Summary of the results of the original papers and conclusions follow.

2. Innovation and regional development

2.1. Measuring innovation

To discuss innovation is also to define it. One of the key issues is the distinction, made by Schumpeter (1934), between invention and innovation: invention cannot be considered as innovation until it is carried out in practise, that is, into the market (Fagerberg 2005). However, innovation typologies carry a whole set of classifications according to their novelty; from incremental to radical innovations and type; product, process, service, marketing, organisational etc. innovations (e.g. OECD 2005; Amara et al. 2008; Lemola 2009). The weight of emphasis has traditionally been on the industrial and technological product innovation, since the rest of the different innovation types are more difficult to measure with proxy innovation measures (Hipp & Grupp 2005; Tura et al. 2008), though, these other types of innovation are equally important. What makes innovation hard to measure is the fact that it is not an exact place in time, but a timely on-going process with feedback loops between the supply and demand sides (Schmookler 1966; Kline & Rosenberg 1986; Mowery & Rosenberg 1989). These problems get repeated in the growing literature on innovation. One the one hand there are those who have faith in the reliability of certain measures, and on the other those who claim that in a statistical sense there is no difference between the most commonly used indicators of innovation (Hagedoorn & Cloudt 2003; Gössling & Rutten 2007). Thus, in the innovation literature there is a lively debate on which innovation indicators should be measured. This is important if innovation studies are to be used as a basis for policy making.

The most commonly used proxy indicators of innovation include R&D (spending and/or personnel) and patent (applications and/or granted) statistics. The basic argument behind the use of these statistics as innovation measures is the assumption, that investment in R&D will lead to higher patenting, which in turn leads to higher amount of innovations introduced into the markets. However, not all R&D efforts are related to successful innovation outputs and not all patents become innovations, as not every registered patent is actually applied for and used (Gu & Tang 2004; Ratanawaraha & Polenske 2007). Furthermore, R&D activities do not represent an important innovation source to all industries or firms (Archibugi et al. 1995; Patel & Pavitt 1995) as R&D is only one out of several innovation inputs, that include design, trial production, market analysis and training (Kleinknecht et al. 2002; Ratanawaraha & Polenske 2007). The concepts of "open innovation" (as opposed to "closed innovation") where organisations exploit the inputs of outsiders to improve internal innovation processes, or search for outside commercialisation opportunities for what has been developed internally (Chesbrough 2003; Huizingh 2011), and "living labs" where users are involved as co-creators (Følstad 2008), are further examples of the range of divergent strategies to promote innovation. In accordance with R&D statistics, certain sectors (services in particular) are poorly suited for patenting, as the range of patentable innovations constitutes only a sub-set of all research outcomes (Camacho & Rodríguez 2005; Hipp & Grupp 2005). Therefore, patents are better suited for manufacturing and industry related innovation studies as they cover mainly product innovations. Furthermore, as firms can use other means of appropriation including secrecy and lead time to protect their intellectual property, not all firms make the effort to claim patents (Arundel & Kabla 1998; Arundel 2001). In other words patents measure the result of invention rather than innovation.

In a regional context further difficulties are posed by multiplant firms and outsourcing of R&D. R&D and patenting activities can be attributed to locations (usually to firm headquarters) other than the place where the actual innovative functions are carried out. Thus, the 'real innovativeness' of regions can be in some cases over- or underestimated (Evangelista et al. 2001; Kleinknecht et al. 2002). The differences in the requirements of patentability on national and regional levels as well as the uncertainty where firm place their patents (domestically or abroad) can further confuse regional comparisons (Unger 2000; Michel & Bettels 2001). Despite their limitations, both of these measures are widely used and provide, at the minimum, a good proxy for innovation, containing useful information on the innovative activities of regions and, thus, offering good data availability and reliability (Ma & Lee 2008; Sterlacchini 2008; Hasan & Tucci 2010; Nagaoka et al. 2010). However, even the most commonly used innovation indicators are not necessarily well justified in every region. Hence regional guidelines for innovation measurement, in contrast to the OECD (2002; 2005) manuals that are more devoted to developed countries, are called upon if the aim is to conduct innovation studies on developing countries (Lugones 2006; Castellacci & Natera 2011).

Some inventions are extremely valuable, whereas others are of almost no commercial value (Kleinknecht et al. 2002; Beneito 2006). Patent citation analyses are used to indicate and add information about the quality and value of patents. However, patent citations are also a noisy measure of information flows, because many citations are in fact added by patent examiners (Duguet & MacGarvie 2005; Alcácer & Gittelman 2006; Criscuolo & Verspagen 2008). Thus, patent specialists are sceptical about the counting of patent citations without in-depth knowledge of citation reports (Michel & Bettels 2001). In addition, Hall et al. (2005) have pointed out that citation-based analysis will by no means be useful for evaluating current or very recent innovations, because substantial time is needed after a patent is granted to accumulate significant information about its citations. Other less frequently used proxies for innovation include e.g. licences and science publications (Nelson 2009; see also Katz & Shapiro 1985), service- and trademarks (Schmoch 2003; Mendonça et al. 2004; Schmoch & Gauch 2009), utility models or petty patents (Beneito 2006) and internet domains (Sternberg & Krymalowski 2002), that all share the most commonly stated weakness of proxy innovation measures; they are not necessarily related to successful innovation outputs (see also Table 1).

Information collected through questionnaires (e.g. the Community Innovation Survey) or by analysis of new product announcements in journals (literature-based innovation output), that is, direct innovation counts, ideally surpass the shortcomings of proxy indicators. However, direct innovation data is unfortunately limited in its coverage and there are still shortcomings with the way that the data are collected. The shortcomings of new product announcements are related to their heterogeneous technological level and economic value, problems of judgement involved in the selection of relevant journals and to the fact that not all new products are reported in trade journals (Coombs et al. 1996; Santarelli & Piergiovanni 1996). A 'new product' is not always new in all respects, but rather a variation on an existing product featuring only limited additional technical novelty (Rothwell & Gardiner 1988). The domestic innovation can be overestimated as in many cases the new-product-announcing firms merely serve as the local distributors not actually involved in the developing process (van der Panne 2007). Moreover, as in the case of R&D and patents, the innovation can be attributed to the headquarters of a multi-locational firm in a different region to the actual establishment responsible for the development of the innovation (Feldman 1994). Thus, innovation input and output measures do not necessarily coincide in regional terms. In the case of surveys, the burden is placed on responding firms to provide data. Thus, indicators based on surveys suffer from low response rates and are subject to subjectivity leading to overestimation of the true novelty of innovations (Danneels & Kleinschmidt 2001; Kleinknecht et al. 2002). Still, innovation counts measure directly the output side of innovation, which is something that cannot be so confidently said of the proxy indicators of innovation.

Composite innovation indexes have been introduced to provide a more comprehensive way to describe the phenomenon by combining the information offered by the individual indicators. As innovation is not a certain stage, but rather an on-going process, the simultaneous use of input and output factors of innovation offers a summarization of a complex and multi-dimensional issue into one measure (Saisana et al. 2005; Carayannis & Provan 2008). There are numerous examples from previous literature on methods employed to construct these indexes, including factor analysis (Pinto 2009; Pinto & Guerreiro 2010), principal component analysis (PCA) (Kaasa 2009), fuzzy set theory (Moon & Lee 2005) and data envelopment analysis (Zabala-Iturriagoitia et al. 2007). However, recent studies have shown that even well-accepted methods for constructing indexes can lead to significantly varying results, when innovation activity and performance are assessed (e.g. Grupp & Moge 2004; Grupp & Schubert 2010). This is because the construction of indexes involves assumptions and subjectivity: the variable and method selection is performed in an ad hoc manner (Saltelli 2007). In the worst cases, innovation indexes may produce misleading, non-robust and oversimplified policy messages and conclusions (Saisana et al. 2005). Table 1 summarises the shortcomings of different innovation indicators.

Table 1. Summary of the most common innovation indicators and their drawbacks.

R&D	Patents
one out of several inputs	not necessarily applied for and used
poorly suited for service industries	poorly suited for service industries
not necessarily related to successful output	other methods of appropriation
Other measures	
publications: ignores informal communications	
utility models: petty patentability requirements	
licenses: not all patents are licensed	
internet domains: domain grabbing	
service- and trademarks: data and cross-country comparability	
Innovation counts	Composite indexes
data collection	abundance of different methodologies
data availability	selection of the measures included
re-designs	cross-survey comparability

In conclusion, it can be stated that there is no single reliable indicator of innovation, which could be claimed to be superior when compared with others. The same kind of ambiguity of agreed convention on measurement also revolves around regional development. However, the key issue is to take the advantages and weaknesses of these indicators into account, when making deductions derived from them. At the very least, all of these indicators provide useful information about complementary innovation activities, and support the long held view that, there are advantages to using simultaneous utilisation of multiple measures in empirical innovation studies (see Damjanovic 1991).

2.2. Theories on regional development in economic geography

Regional development is a research tradition associated with economic geography and geographers, but also a policy concept (e.g. Jauhiainen 2008). It is associated with positive attributes or goals and it can be seen as a resource which does not automatically guarantee the well-being of residents, but offers a means to it. The availability, or scarcity, of these resources defines the stage of development of a region. Consequently, regional development is regarded as uneven at its very base, but it is also a scale issue: in a global context, Finland is a developed country, but, on the other hand, there are *inter-* and *intra-* regional differences within Finland dividing the territory as more developed or less developed. What then constitutes 'development' is geographically differentiated and changes over time (Pike et al. 2007). Thus the concept of

development is largely a covenanted issue: it must be agreed what (and to what extent) constitutes the concept of development. Traditionally, variables such as industrialisation, productivity and gross domestic product (GDP) have been used to describe the development stages of regions. Nowadays, more technologically and scientifically oriented factors (e.g. knowledge generation, learning and innovation) have replaced conventional variables as key elements of development. This shift is evident when theories are time-lined from the traditional standpoint towards the newer concepts of regional development. A (non-exhaustive) timeline of the evolution in regional development theories is presented in Figure 1 to outline the most relevant (in terms of this study) landmarks. Furthermore, the historically dominant focus on the economic factors of development has broadened to include social, ecological, political and cultural elements.

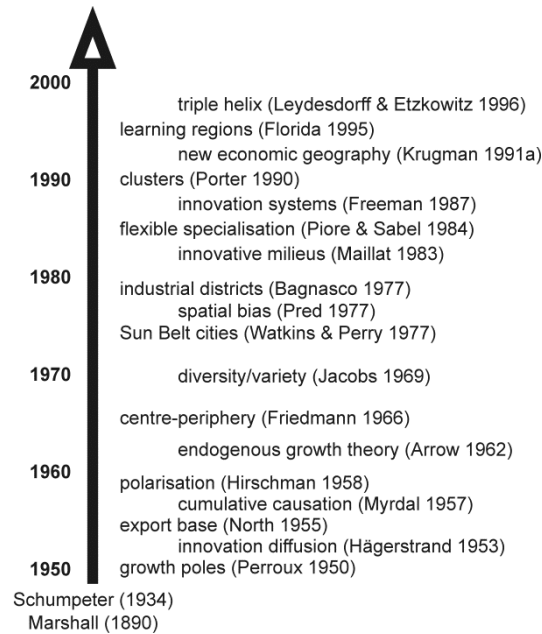


Figure 1. A timeline of the most relevant regional development and innovation theories and concepts (1950–2000).

The conceptual foundations of regional economic development theory are laid down in discussions of the theory of international trade (Ricardo 1817/1971; Heckscher 1919; Ohlin 1933/1957; Samuelson 1948), location theory (Weber 1909/1929; see also Isard 1956), “external economies” (Marshall 1890/1961; Hoover 1937), models of spatial competition (Hotelling 1929) and central place theory (Christaller 1933/1966; see also Lösch 1954). These theories have been revisited in more recent literature and associated concepts have been incorporated into more formal expressions of regional growth dynamics (Dawkins 2003). Traditionally regional development was explained using export base theory (North 1955), which emphasised the role of export activities as the determinant of a region’s position in the global economy and division of labour, and; exogenous growth theory (Harrod 1939), which models regional productive capacity (Dawkins 2003; Szajnowska-Wysocka 2009). Another approach from classical theories emphasises the importance of spatial distribution of economic activity in regional development: the seminal works by Perroux (1950), Myrdal (1957/1969) and Hirschman (1958) explicitly recognised and explained a clear tendency towards spatial concentration of economic activity as a source of regional disparities. Perroux (1950) introduced the concept of “growth poles”, as dominant centres with the highest levels of economic development. A polarised spatial system emerged in which the weaker centres and regions were dependent on the growth poles. The basic

idea behind Myrdal's (1957/1969) and Hirschman's (1958) thinking is basically the same. Myrdal (1957/1969) sees regional development as a non-uniform process of "cumulative causation", which is carried forward by fundamental innovations and has the tendency to start in a small group of cores. These cores develop as centres of high-tech goods and services, commerce, employment and finance. Accordingly, Hirschman (1958) described development as concentrated in geographic centres. Furthermore, he explained the reasons behind polarisation through backward (input provision) and forward linkages (output utilisation) in production.

Hirschman (1958) proposed that the development gradually trickles ("spread effect" by Myrdal) down to other regions. This (innovation) diffusion is directed from the cores to neighbouring regions and to secondary cores (Hägerstrand 1953/1967). Later, Pred (1977) bolstered the view of geographically concentrated development as a self-reinforcing process, but, however, argued against the likelihood of growth diffusion into lower-level centres [for diffusion of innovation see Rogers (1962)]. On the contrary, because of spatial bias ("backwash effect" by Myrdal) the regions outside these centres fall behind and are in many ways dependent on the cores and are rarely the producers of technologically advanced products or services. However, there are also hindering forces for the congestion to the cores, such as heightened living costs and crime rates. These relations were often described and discussed through the centre-periphery model (Friedmann 1966). Although, Myrdal (1970) held the view that the backwash effects overwhelm the spread effects, there is no clear consensus as to whether the positive effects actually surpass the negative effects of cumulative causation (cf. Hirschman 1958). The outcomes are dependent on numerous factors including national regional policy, developmental stage and position in global markets of a given region. Moreover, the situation between centres and peripheries is dynamic and may change. The centres may be downgraded to peripheries. By contrast, in favourable conditions a peripheral region may gradually take its place among the economic centres, as demonstrated by Watkins and Perry (1977) and Garreau (1991) with the rise of the Sun Belt cities and "edge cities", a complex polycentric pattern that cannot be explained by cumulative causation (also Szajnowska-Wysocka 2009).

The rise of radical geography throughout the 1970s (see esp. Peet 1977) and the dissatisfaction with the quantitative revolution of the 1950s and 1960s, were an earlier generation of location theories were brought together to construct models of agglomeration and spatial development (e.g. Isard 1956), and the incoherence between the growth pole theories and empirical reality (e.g. Watkins & Perry 1977) led to resistance against the assumptions of agglomerative regional development (MacKinnon et al. 2002). However, this did not altogether lead to the abandonment of cumulative causation theories. The tradition of modelling in regional development has continued through the literature on endogenous growth theory. The basic assumption behind this theory is that, instead of treating technological change and innovation as something exogenous to the model (a case in point for the classical economic growth theories), they are considered as endogenous variables of the region/model. This change can be traced back to the works of Schumpeter (1934), Arrow (1962) and Romer (1986). Schumpeter (1934) is also considered as the pioneer who linked economic development to innovation. Another far-reaching impact of the endogenous growth theory literature has been the highlighted importance of technology and knowledge in economic growth, an issue absorbed, modified and improved by many subsequent models and concepts (or theories) of regional development (e.g. Cohen & Levinthal 1989; Aghion & Howitt 1992; Grosman & Helpman 1994).

More recently, drawing from the ideas previously expressed by Marshall (1890/1961: p. 271) of "a thickly peopled industrial district", a refocus on the topical agglomerations, where the tendency towards co-locating is explained through the positive impacts of short proximities between actors and economies of scale, has emerged. Accordingly, the seminal work of Porter (1990) and Krugman (1991a; 1991b) introduced the concept of "clusters" that, are described as geographical

concentrations of interconnected firms and other institutions in the same or related industries (Porter 2000). In relation to regional development, these Porterian clusters are presumed to enhance national and regional competitiveness. However, Krugman (1996) is sceptical about the way that countries are assumed to compete like firms. Porter (1998) based the tendency towards clustering on the assumption that the enduring competitive advantages in a global economy lie increasingly in local assets that distant rivals cannot match, whereas Krugman's (1991a; 1991b) idea of clusters is more based on the accidental emergence of regional clustering sustained by economies of scale and transportation costs (see Gupta & Subramanian 2008). Krugman (1991a; 1991b) outlined his core-periphery model as a background for his new economic geography that combined together earlier regional growth theories; those highlighting the importance of export sector and cumulative causation (see Dawkins 2003).

As opposed to Marshall's (1890/1961) views on the importance of specialisation, the discussion on clusters has incorporated notions already made by Jacobs (1969) on the positive impacts of (related) diversity or variety (also Glaeser et al. 1992; Beaudry & Schiffauerova 2009). As summarised by Frenken et al. (2007) important innovations stem from the recombination of knowledge present in different industries and the way in which the locations' diverse industrial mixes improve these opportunities to interact across sectors. The emergence of a new cluster from the co-evolution of existing clusters is thus termed Jacobian cluster (see Cooke 2008). However, there is no clear consensus whether the specialisation or diversification externalities favour regional innovativeness (cf. Feldman & Audretsch 1999; Paci & Usai 1999; van Oort 2002; van der Panne & van Beers 2006). An alternative approach to spatial agglomerations was offered by the concept of "industrial district" that evolved from the works on the so-called Third Italy (Bagnasco 1977; also Moulaert & Sekia 2003) and evolved further during the 1980s and 1990s (e.g. Russo 1985; Bellandi 1989; Becattini 1990). These industrial districts and their competitive advantage are based upon, what was termed by Piore & Sabel (1984) as "flexible specialisation", (family-led) small and medium-sized enterprises with highly localized networks, and a long tradition of intraregional cooperation and a flexible labour force (see Szajnowska-Wysocka 2009).

The classical theories of regional development, as well as industrial districts and clusters literature have, however, encountered extensive criticism (e.g. Sunley 1992; Markusen 1996; Martin & Sunley 1996; 2003; Taylor 2010), as technological change, spatial clustering and economies of scale alone have turned out to be an insufficient explanation for economic growth (Szajnowska-Wysocka 2009; McCann & Acs 2011). Still, the resurgence of the importance of regions that started in the 1980s and 1990s (e.g. Bairoch 1988; Porter, 1990; Krugman 1991b; Cooke 1996; Saxenian 1996; Fujita et al. 1999) has persisted (MacKinnon et al. 2002; Scott & Storper 2003) alongside the heightened importance of globalisation and extra-local networking (Amin & Thrift 1992; Bathelt et al. 2004; Saxenian & Sabel 2008). There are examples of recent works that have attempted to combine different aspects of these theories to a more general model of technology-led regional economic development (e.g. Acs & Varga 2002). Moreover, a new set of concepts highlighting the importance of networks, regional social development, human capital and technical capacities have emerged. These partly overlapping concepts explain regional innovation performance including "innovation systems" (Cooke 1992; Lundvall 1992), "innovative milieus" (e.g. Maillat 1983; 1995; also Guillaume & Doloreux 2011) and "learning regions" (Florida 1995; Morgan 1997).

In view of this apparent shift towards a knowledge driven economy (MacKinnon et al. 2002), local assets including innovation, learning, knowledge, creativity and entrepreneurship are increasingly viewed as the engines of regional development and economic growth (e.g. Feldman 1994; Glaeser 2000; Acs 2002; Florida et al. 2008). Furthermore, empirical evidence points towards a conclusion that creativity, innovation and learning are geographically concentrated phenomena (e.g. Florida 2002). It is in this respect, the role of universities in regional development and innovation creation has received an increasing amount of attention.

2.3. Concepts of regional innovation performance

Although, the importance of innovation in the process of economic development was already noted by Schumpeter (1934) in the first half of the last century, it took considerable time for innovation studies to establish itself as a major subject of interest among economics, geography and other social sciences. The scholarly interest in innovation increased from the 1960s onwards, but the particularly rapid growth did not start until the late 1980s (Fagerberg 2003; Fagerberg & Verspagen 2009). Among the most influential contributions, impacting upon the rise of innovation studies, were Kline's and Rosenberg's (1986) argument that, instead of a linear model, innovation processes should be viewed as a web of feedbacks and loops and Dosi's (1988) notions concerning the cumulative and path-dependent character of innovation. Equally important were the claims, originally made in the field of economic sociology by Granovetter (1973; 1985), concerning "weak ties" and the "embeddedness" of economic actions that directed attention towards networks of localised learning and knowledge creation processes (see also Burt 1995). The subsequent rapid growth of innovation literature in the 1990s coincides with the revival of evolutionary economics, the development of a more systemic and holistic perspective on innovation and the inclusion of 'soft' factors (e.g. cultural characteristics and social interaction) as a background for explaining economic development. A case in point has been the emergence of several concepts concerning regional innovation performance. In this respect there is also an abundant amount of literature focused on innovation and geographical clusters, and clusters in heightening the innovativeness of firms (e.g. Baptista & Swann 1998), but here the emphasis is on concepts more directly leaning on the importance of institutions, networking, interaction and learning.

In the context of this work, it is relevant to start this discussion from the point of view of innovation systems, which have been adopted as an integral part of the science and technology policies in Finland (Miettinen 2002). Innovation systems literature emphasises the importance of the role of learning in (regional) economic development. The main argument is that a well-functioning innovation system will generate marked innovative outcomes, which in turn will lead to economic growth. Another key point of the innovation systems approach is the weight put on knowledge infrastructure and institutions. These innovation systems can be viewed from sectoral (Malerba 2002) and technological (Carlsson 1994) perspectives, but here the interest is on geographically delineated concepts; namely RISs and national innovation systems (NISs), which evolved more or less in parallel with the seminal works of Freeman (1987), Cooke (1992), Lundvall (1992), Nelson (1993) and Braczyk et al. (1998). Befittingly, several other geographically bounded concepts, including spatial (Oinas & Malecki 2002), local (Muscio 2006), scalar (Ahlqvist & Inkinen 2007) and cross-border (Trippi 2010) innovation systems, have been introduced to the innovation systems literature.

According to the literature, innovation systems are constructed from local firms, universities, research centres and other organisations, infrastructure, knowledge transfer mechanisms, innovation and development policies and from the local workforce. Thus, the innovation performance of a nation or a region is not only dependent on local firms, although they are still considered to play a crucial role in it. Despite similarities, there are also differences between RISs and NISs: in RISs the interactions between the institutions are more relevant when compared to NISs, where the central elements are those of knowledge, resource and human capital flows (Autio 1998). Therefore, the mere description of a RIS as a small-sized or scaled-down version of its national counterpart fails to take into account regional specificities (Pinto 2009). However, the ambiguity in defining an innovation system has led to an important question, as asked by Carlsson et al. (2002), that remains unanswered: how do we delineate and identify the key actors and relationships so that the important interaction takes place within the system rather than outside? Moreover, in Finland the existence of RISs has been questioned as regions do not have a direct say

in the formulation of science policies that fall under the remit of the central government (Sotarauta & Kautonen 2007).

The importance of knowledge and learning is embodied also in the concept of learning region, which emerged from the innovation systems literature. The learning region approach elevates collective regional learning processes to the fore of analysis and claims that the competitiveness of a region is directly influenced by its readiness to generate, access, understand and transform knowledge and information into innovation (Florida 1995; Morgan 1997; Keane & Allison 1999). Thus, the role of knowledge, trust, proximity and high levels of interaction are important in this relationship between learning economies and regional development (Howells 2002; MacKinnon et al. 2002; Hauser et al. 2007). This, however, has also invited critique against the learning region concept, namely its lack of novelty in relating innovation and knowledge creation to economic success (Hudson 1999). As a parallel notion, the concept of innovative milieu evolved in much the same direction as the works on industrial districts. In this context the local milieu is considered as an operator between markets and organisations which reduces the uncertainty of innovation activities by allowing local firms to benefit from synergies (Camagni 1991; see also Maillat 1995). The literature on innovative milieus, however, fails to formulate the economic logic behind the milieu's role in fostering innovation (Storper 1999; Simmie 2005), which has led to doubt and uncertainty on the veracity of such a concept. A summary of these three key concepts of regional innovation performance is presented in Table 2.

Table 2. Definitions and limitations of selected concepts of regional innovation performance.

	Innovation system	Learning region	Innovative milieu
Exemplifying definition	the institutional infrastructure supporting innovation within the production structure of a region (Asheim & Gertler 2005)	collector and repository of knowledge and ideas, and provider of an underlying environment or infrastructure which facilitate the flow of knowledge, ideas and learning (Florida 1995)	the set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal 'representation' and sense of belonging, which enhance the local innovative capability through synergetic and collective learning processes (Camagni 1991)
Main limitation	ambiguity in defining and delineating an innovation system (Doloreux & Parto 2005)	lack of novelty in the approach (Hudson 1999)	failure to formulate an economic logic of its contribution to innovation (Storper 1999)

Contra the "technopoles" literature, situating firms in close proximity to universities for the purposes of innovation is not a new idea (see Doloreux 2002). Enter the triple helix model of university-industry-government relations. As opposed to innovation systems where the firms are still considered to have the leading role in innovation, the triple helix thesis states that, universities can play an enhanced role in innovation in increasingly knowledge-based societies (Leydesdorff & Etzkowitz 1996; Etzkowitz & Leydesdorff 2000). This debate is closely associated with the observations on the new broader, trans-disciplinary, social and economic context of knowledge production (see Gibbons et al. 1994; cf. Weingart 1997): the role of the university has

changed from a mere knowledge producer to a more active agent in the local economy (the third mission of the university). However, although universities are increasingly seen as important economic agents, doubts about the potential conflicts within the triple helix model have arisen; for example, Lawton Smith (2007) for one has restated the concerns already expressed by Malecki (1997) about the overestimation of the universities' role in R&D and high-technology industry.

Other concepts used to discuss regional innovativeness include, regional innovation networks, innovation environments and knowledge laboratories. Regional innovation networks are loose multi-actor networks consisting of many different kinds of actors (Harmaakorpi & Melkas 2005). In parallel, Harmaakorpi (2004) has described innovation environments as systems of innovation networks and institutions located within regions with regular and strong internal interactions. Thus, regional innovation networks and innovation environments are conceptually bound to innovation systems, whereas knowledge laboratories are more related to the concepts of living labs and open innovation (see Sotarauta & Kosonen 2004).

The contemporary literature on regional development connects all of the above viewpoints by emphasising the importance given to knowledge, learning, innovation and institutions, especially universities. On the other hand, the collective shortcomings with all the concepts of regional innovation performance and economic development are related to conceptual fuzziness and the lack of analytical rigour (e.g. Markusen 1999; MacKinnon et al. 2002; Doloreux & Parto 2005). Similarly the resurgence of the region as the melting pot of economic development, labelled as the "new regionalism", in particular the role, importance and the definitions related to a region have been questioned (Lovering 1999; MacLeod 2001). Thus, in general, these concepts are still too vaguely-defined to allow systematic empirical work (see Fagerberg 2003). Still, these concepts can be viewed as helpful frameworks for comparative studies as they provide some meaningful insights into the processes that lie behind regional innovation performance.

2.4. Localization and persistence of innovation

Since knowledge is heralded as the most fundamental resource of the modern society (Lundvall 1992), it is necessary to relate it to the discussion on the localization of innovation. In that literature a fundamental division exists between two types of knowledge; codified (explicit) and tacit (Polanyi 1966; Nonaka & Takeuchi 1995). Tacit knowledge can be further divided into embodied and not yet embodied (self-transcending) knowledge, that is, the ability to sense potential (Scharmer 2001; Harmaakorpi & Melkas 2005). Whereas the sharing of tacit knowledge requires physical proximity (it is difficult to articulate or codify because practical skills embodying the tacit knowledge are impossible to express in numbers, text, formulas etc.), codified knowledge is information that can be expressed as messages and easily transferred with communications technologies (Rallet & Torre 1999; Asheim et al. 2007). Thus, for tacit knowledge to be effectively transmitted, geographical proximity is needed. Drawing on the notion of "industrial atmosphere" originally coined by Marshall (1919), the discussion has been further elaborated in the literature on the geography of innovative activity, especially through the concepts of "face-to-face communications" and "local buzz" (non-deliberate knowledge and information sharing propensities), which both play a pivotal role in innovation creation (see Storper & Venables 2004; Asheim et al. 2007). In light of the above, cities are traditionally seen as the centres for innovation as they contain a larger amount of inventors and, thus, provide the means and opportunities for face-to-face contacts and local buzz (see also Feldman 2002; Storper & Venables 2004; Bettencourt et al. 2007).

The traditional view on the importance of local buzz and face-to-face contacts has, however, been questioned. It has been argued that both tacit and codified knowledge can be exchanged both locally (buzz) and globally (pipelines) (Bathelt et al. 2004). The weight given to tacit knowledge,

face-to-face communication and local buzz have arguably led to an exaggeration of the importance of cities in innovation creation. Notably, Asheim et al. (2007) have proposed that cities are important units for innovation creation, but only for creative industries (industries that rely on symbolic knowledge base), as they rely heavily on tacit knowledge, face-to-face communications and local buzz (see Table 3). The same cannot be said for engineering (synthetic knowledge base) and the scientific industries (analytical knowledge base). Because of the strong codified means for communication (e.g. scientific publications and patents) in the science industries, the importance of face-to-face communications and local buzz should not be overestimated. Still, these industries tend to locate in close proximity to universities (e.g. Cooke 2002; Niosi & Banik 2005). Industries relying on synthetic knowledge bases tend to agglomerate together in a traditional Porterian sense, so that they can draw advantages from being located close to their suppliers and customers (Asheim et al. 2007).

Table 3. Typology of knowledge bases (Asheim 2007; Asheim et al. 2007; Asheim & Hansen 2009).

	Analytical (science industries)	Synthetic (engineering industries)	Symbolic (creative industries)
Innovation creation	By creation of new knowledge (know why)	By application of existing knowledge (know how)	By recombination of existing knowledge (know who)
Typical example industries	Biotechnology and nanotechnology	Plant engineering and shipbuilding	Cultural industries (media, fashion etc.)
Types of knowledge	Dominance of codified knowledge	Partially codified with tacit component	Reliance on tacit knowledge
The role of face-to-face	Minor	Major	Major
The role of buzz	Minor	Minor	Major

In sum then, industries building on synthetic or analytical knowledge bases do not favour urban regions per se, but are agglomerated irrespectively of the urban-rural dimensions near users and suppliers, and universities, respectively (Asheim et al. 2007). It should be noted that the threefold division presented in table 3 refers to ideal types: in the real world most industries are a mix of all three types of knowledge-creating activities (see Asheim 2007; Strambach 2008). Moreover, tacit and codified knowledge are always involved as they are the key to the process of knowledge creation and innovation, but the importance of these types differs between the knowledge bases (Asheim & Hansen 2009).

Localized knowledge spillovers are also a focus of the literature on the enhanced innovation capabilities of regions. There is little doubt about the positive impacts (actual and potential) of knowledge spillovers from university research, private R&D etc. on regional innovativeness, but there is a lively debate on whether spillovers need to be geographically (or spatially) localized. The importance of geographically localized knowledge spillovers may be, in some cases, overestimated, as there are many other types of proximity, including cultural, institutional, organizational and technological proximity, that are important to varying degrees of intensity for effective innovation cooperation and networking (e.g. Autant-Bernard 2001; Virkkala 2007; Tappeiner et al. 2008; Fitjar & Rodríguez-Pose 2011). Despite numerous empirical estimations and theoretical contributions, the results remain inconclusive; scholars continue to speak in favour of or against localized spillovers (see Breschi & Lissoni 2001; Maurseth & Verspagen 2002; Bottazzi & Peri 2003; Bode 2004; Torre & Rallet 2005; Rodríguez-Pose & Crescenzi 2008; Fischer et al.

2009; Ibrahim et al. 2009). Based on the results of previous studies it seems that knowledge spillovers are at least affected and restricted by national boundaries. Nevertheless, there are clear differences between different industries that exhibit complex patterns of global and local knowledge spillover patterns.

Innovation tends to have a persistent nature; current innovation is explained by past innovation through technological and knowledge accumulation (success breeds success), that is, innovations are path dependent (Alfranca et al. 2002; Roper & Hewitt-Dundas 2008; Colombelli & von Tunzelmann 2011). This is demonstrated by firm-level evidence which shows that a disproportionate share of innovations is generated by relatively few persistent innovators (Cefis & Orsenigo 2001). Moreover, firms that persistently innovate are also those most likely to survive (Cefis & Marsili 2006; Colombelli & von Tunzelmann 2011). In a larger context (the literature on agglomerations, clusters and localized knowledge spillovers are important reference points here), this means that, if a given region or nation gets ahead in the development process it tends to stay ahead. Still, drawing from Schumpeter's (1942) notion of "creative destruction", the creation of radical new knowledge with wide applicability allows the disruption of this leadership and enables new regions and nations to become leaders and push the technological frontier (Colombelli & von Tunzelmann 2011).

Empirical case-study evidence on the existence of persistent patterns of innovative activities is, however, inconsistent. In the case of high-tech industries, at least, studies have corroborated the persistence of the innovation hypothesis (Peters 2009; Raymond et al. 2010). Accordingly, Malerba et al. (1997) have stated that persistence is an important phenomenon that affects the pattern of innovative activities across countries and industrial sectors. Others including Geroski et al. (1997) have claimed that very few firms innovate persistently. As a type of compromise Cefis (2003) has suggested that in general there seems to be little persistence among innovating firms, but strong persistence among the 'great' innovators (firms with multiple patents). In conclusion, it is fair to say that the discussion on the persistence of innovation remains inconclusive, although, stronger support seems to be in favour of that hypothesis. The discussion has wider relevance, because if there is a true state dependence between past and current innovations, it would have significance in the geographical sense: it would make it more difficult for regions and nations to catch up with those who have initially gained a competitive advantage in innovation performance.

2.5. Impacts of education, training and universities

The increased importance laid to knowledge, learning and training as drivers of socio-economic development has brought forth different concepts of capital. Up until the 1950s the main factors of production consisted of physical capital, labour, land and management. However, a gap grew from the difficulties in explaining the growth of the more contemporary economy with these four traditional factors (e.g. Solow 1957). The concept of "human capital" was identified (see Nafukho et al. 2004) to fill in this gap – the "Solow residual" (see Grossman & Helpman 1991). The concept has its roots in much earlier literature (see Sweetland 1996), but it was through the works of Mincer (1958), Shultz (1961a; 1961b), Denison (1962a; 1962b) and Becker (1964) that the concept has grounded. Human capital was defined as the knowledge and skills that people acquire through education and on-the-job training (Shultz 1961a). It follows then that personal income dispersion and regional economic growth is driven by education, training and human capital. Although, the essential focus on competencies and knowledge and the positive impacts of education on economic growth have prevailed in the centre of the concept, the literature proceeding the early descriptions on human capital [notable contributions have come from the endogenous growth theory literature including the works of Lucas (1988), Romer (1990) and Stokey (1991)] have defined the concept in varying ways (Nafukho et al. 2004), and used divergent

modelling techniques (Engelbrecht 2003). This theoretical discussion also raises a pragmatic question; how do we best measure the concept of human capital?

According to critical voices, human capital, alas, is poorly measured by available proxy indicators (Temple 1999; 2002; Wößmann 2003). The main problems have to do with low data availability. Therefore, although on-the-job-training (or learning-by-doing) appears to be at least as important as schooling in the formation of human capital (Lucas 1988), and although human capital investments also include inputs in health and nutrition (Shultz 1961a), education has been the most consistent indicator in empirical analysis (Barro & Lee 1996; Sweetland 1996; Novak et al. 2011). To this day, as proposed by Teixeira and Fortuna (2010), data on formal education attainment levels still provides the best available proxy information on the human capital on national and regional scales. Thus, while human capital research is not restricted to formal modes of learning and empirical measures, the discussion is still often skewed towards education and training.

Education can be understood as the transmission and acquisition of new skills and knowledge, whereas training is most commonly understood as the teaching of vocational (or practical) skills. The main difference between education and training is that, while qualifications acquired through (higher) education are usually relatively general (formal scientific knowledge), the qualifications an employee acquires through training will be more specific (Lorenz 2006). The terms are complementary; a mix of scientific knowledge and employee skills gives rise to positive synergies (Herrmann & Peine 2011). Both learning and training should be viewed as lifelong processes where an individual continuously strives to enhance their skills and enlarge their knowledge base, a view that is encompassed in the goals of lifelong learning (LLL) and CVT. Using empirical data on EU countries, Lorenz (2011) has shown that the impact of LLL on innovative firms at the national scale is positive, but that the impact of CVT is more negative. However, the results related to CVT are tentative in that they show only very weak negative and non-statistically significant effects.

The broader concept of educated human capital encompasses terms including creative (Florida 2002), skilled (Leiponen 2005) and talented (Gössling & Rutten 2007) workers. Of these, Florida's concept of "creative workers" or "creative class" has gained the most attention in recent discussions on urban and regional development by advocating cities to compete for the "3 T's": technology, talent and tolerance. The basic argument behind the emphasis on creativity is that, when human capital measures are typically based on formal education statistics, Florida (2002) argues instead that an occupational division of people into what is described as creative class outperforms the traditional indicators of human capital in explaining economic development. Empirical validations of this superiority are, however, at best, inconclusive (cf. Rausch & Negrey 2006; McGranahan & Wojan 2007; Boschma & Fritsch 2009; Hoyman & Faricy 2009). Furthermore, the occupational composition definition of the creative class is debatable. Florida's thesis has been met with an increasing amount of criticism both from empirical and conceptual perspectives; notably, Glaeser (2005) stated that creative class is only another name given to what is still essentially human capital (see also Peck 2005).

Despite competing concepts and problems with the measurement of human capital, there is little doubt about the positive impacts of its most common proxies, education and training, on economic growth; authors have observed that a direct link exists between education and training and economic development (Engelbrecht 1997; Gyimah-Brempong et al. 2006; Tsai et al. 2010) and underlined their potential as a target of development policy in the EU (de Bruijn & Lagendijk 2005). A parallel proposition, supported by remarks highlighting the importance of education and training in the innovation performance of regions (Varsakelis 2006; Gössling & Rutten 2007), suggests that, although, economic growth is explained through innovation it is still ultimately driven by human capital accumulation (see Strulik 2005). However, the logic behind the causal

relationships between human capital and economic development has been criticized for being fuzzy and undefined (Krueger & Lindahl 2001; Markusen 2006). Moreover, developed societies, such as Finland, are already witnessing problems (e.g. academic employment) related to over-education (see Jauhiainen 2011).

Human capital is not the only concept which allegedly results in positive economic outcomes. Other examples include intellectual (Bontis, 1998; Nahapiet & Ghoshal 1998) and economic and cultural capital, but arguably the most widely used, among human capital, is the concept of "social capital" (see Bourdieu 1986). Despite differences in the definitions of social capital, it is generally accepted to mean the ability of actors to secure benefits by virtue of membership in social networks or other beneficial social structures. The birth of the concept itself can be traced back to criticism towards economic studies that focused exclusively on individual human capital. These early notions paved the way for Coleman (1988) to refine and introduce the concept of social capital, which he saw in an aiding role in the formation of human capital [for a review on the origin and applications of social capital see Portes (1998)]. Putnam (1995; 2000), another notable advocate of the concept, stresses the importance of social capital *qua* the well-being of a society and refers to it as the features of social organization, such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit. However, the problems identified with human capital, namely the lack of consensus on the definition and problems in measuring it, have hampered also the application of social capital in economic studies (e.g. Tura & Harmaakorpi 2005; Lillbacka 2006).

In light of the emphasis laid on knowledge, learning and innovation in regional development, universities have gained an increasing amount of attention as producers of knowledge (and knowledge workers) and as important economic agents. Traditionally the role of the universities was viewed as the source of scientific knowledge which would gradually spillover, for the benefit of private sector via science publications, conferences and patents, but even more importantly through informal conversations and interaction (tacit knowledge). Based on the early work by Griliches' (1979) and his knowledge production function, several authors have explored and refined the benefits of university research through impacts of these knowledge spillovers (Jaffe 1989; Acs et al. 1994; Jaffe & Trajtenberg 1996). However, the role of the universities has evolved to a point where this linear view of them only as a source of knowledge to be commercialised by the private sector (Mansfield 1991; Lee 1996) has become outdated (see e.g. Youtie & Shapira 2008). In addition, the mere presence of a university is not enough to guarantee a good regional innovation or economic performance. Therefore, the focus of studies on the impacts of universities has shifted from the warranting of university research's value to the economy towards exploring the most effective implements of U-I collaboration. In other words successful knowledge transfer mechanisms from the university to industry are complex case- and region-specific processes (Bramwell & Wolfe 2008; Uyerra 2010; Hidalgo & Albors 2011). Evidently, the educating and training function of the university has been brought forth as the most important channel for knowledge transfer to industry and for its potential to have a major impact on the local economy (Schartinger et al. 2001).

The interest in various forms of knowledge transfer from the university has included, among others, spin-off or start-up companies, joint R&D projects and research collaboration. The common denominator has been the normative position that universities should (must) have an impact on the local industry and economy. In this respect, growing attention has been placed on what have been termed "entrepreneurial universities" (Clark 1998; Etzkowitz 1998). In entrepreneurial universities economic development has been integrated into the university as a central academic function. However, the discussion on entrepreneurial universities has usually been concentrated on few successful examples from the United States and Canada (see Bramwell & Wolfe 2008; Bathelt & Spigel 2011). Thus, the generalisations drawn from these examples are not likely to

apply in every region. Despite the critical statements questioning the scope of the impact universities can have on the local economy (cf. Uyarra 2010), and negative attitudes of faculty to participate in U-I collaboration (Martinelli et al. 2008), the role of the university in regional development has generally been seen as significant and positive. Numerous conceptual and empirical studies support this notion. In short: when the local engagement is successful, universities are key actors for regional innovation performance and development (e.g. Coenen 2007; Benneworth et al. 2009). Furthermore, universities carry out a whole set of other important functions (including generation of new knowledge, acting as bridgeheads to leading knowledge centres of the world and provision of research-based education and well-qualified graduates) besides strict U-I cooperation (also Arbo & Eskelinen 2006).

2.6. Geography of innovation

Drawing from the literature on regional development and innovation performance it can be argued that innovation is geographically concentrated. Despite the critical voices towards the importance of spatial proximity, the same forces that are at work in agglomeration – cooperation, informal interaction and tacit knowledge – seem to affect innovation processes. Therefore, urban centres and developed nations and regions emerge as the most innovative in global, European and Finnish perspective (Figures 2–3; Table 4). This is confirmed by studies elaborating the innovative and technological capacities of individual regions and countries, as well as comparative research between them. According to the latter studies innovation activity is concentrated in developed countries. In a global context countries such as Sweden, Switzerland, Finland, USA and Japan traditionally rank high (also Furman et al. 2002), as expected, when national innovative or technological capacities are compared (Table 4). Keeping in mind the drawbacks related to the comparison of rankings with different methodologies in measuring innovation, Table 4 should be viewed only as a suggestive example (also Archibugi & Coco 2005; Archibugi et al. 2009).

On the European scale, innovation activities have been concentrated in (urban) regions in Northern Europe and in Central European countries like Germany and Austria (Figure 2) that are also more economically developed in terms of GDP, than the disadvantaged regions of Southern Europe (Paci & Usai 2000; Moreno et al. 2005a; 2005b; Hollanders et al. 2009; Pinto 2009). Moreover, regional innovative activity is highly influenced by a region's accessibility to central markets and knowledge (Andersson & Karlsson 2004; Copus & Skuras 2006; Massard & Mesier 2009). In this respect peripheral and rural areas in Europe are at a technological disadvantage where the geography of innovation is concerned (Copus et al. 2008; Coronado et al. 2008). Accordingly, the differences in the educational attainment across European regions are shaped by three factors: North-South and urban-rural divides and proximity (Rodríguez-Pose & Tselios 2011).

Despite the obvious innovation divide and bleak predictions of growing disparities between nations, some authors maintain a more positive standpoint and claim that there is an evident 'catching up' in progress. Moreno et al. (2005a; 2005b) state that the concentration of innovation activities has tended to decrease in Europe in favour of regions in the south of Europe. Furthermore, Furman and Hayes (2004) observed two 'striking' facts. First, although the absolute gap in innovation between successful and less-successful countries remains, this gap is still relatively smaller than it was two decades ago. Second, the set of countries introducing numerous new-to-the-world innovations has broadened to encompass a number of formerly less-innovative nations and regions. This is due to the higher growth rate of innovation inputs. However, there is a contradiction between the comparatively greater need to spend on innovation in lagging regions and their relatively lower capacity to absorb funds for the promotion of innovation, when compared with more advanced regions (Oughton et al. 2002). Thus, increasing knowledge investments alone are not enough to drive regional economic growth (also Audretsch 2007;

Table 4. Selected country rankings on national technological and innovation capabilities with comparable data (arranged in order of average standings).

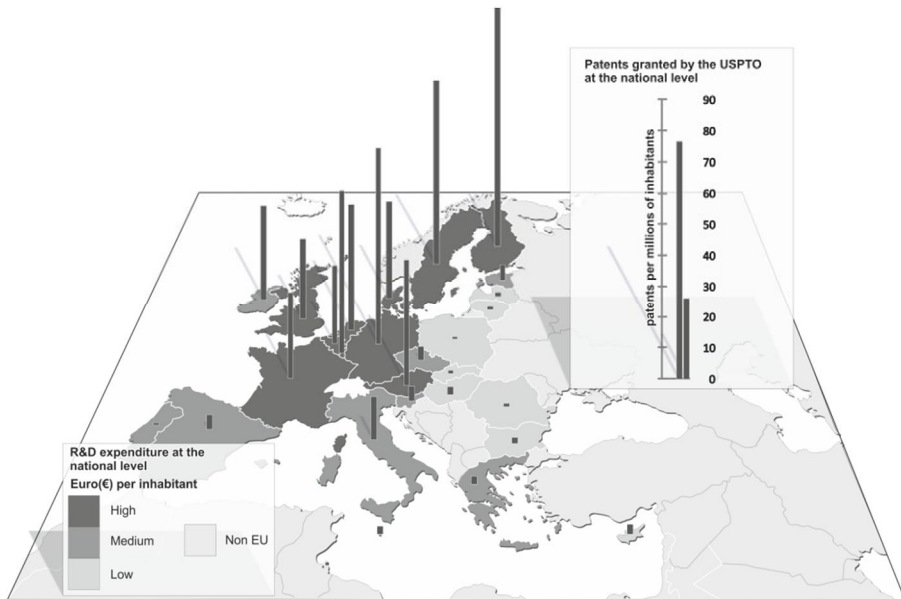
	Porter & Stern (2002)	Archibugi & Coco (2004)	Fagerberg & Srholec (2008)	Nasir et al. (2009)	Schwab (2011)
Sweden	8	1	2	3	2
Switzerland	5	3	7	N/A	1
Finland	2	2	13	2	3
USA	1	5	8	8	5
Japan	12	8	11	5	4
United Kingdom	4	13	5	9	13
Netherlands	6	11	10	6	12
Denmark	19	9	3	N/A	10
Germany	3	12	16	15	7
Australia	7	10	1	14	22
Israel	11	4	9	26	6
Canada	10	6	22	10	11
Norway	18	7	4	11	20
Taiwan	14	15	19	N/A	9
Singapore	13	21	26	4	8
Belgium	15	17	12	21	15
France	9	20	20	16	17
Korea	23	19	25	1	14
Iceland	20	14	N/A	17	19
Austria	17	18	18	24	16
Luxembourg	N/A	28	N/A	7	21
New Zealand	24	16	17	12	27
Ireland	16	23	24	13	23

Indicators used: Porter & Stern (2002) patents as a baseline, the proportion of scientists and engineers in the workforce and 24 survey measures; Archibugi & Coco (2004) patents, scientific articles, Internet penetration, telephone penetration, electricity consumption, tertiary science and engineering enrolment, mean years of schooling and literacy rate; Fagerberg & Srholec (2008) factor analysis with highest loadings for patents, science and engineering articles, ISO 9000 certifications, fixed line and mobile phone subscribers, Internet users, personal computers, primary school teacher-pupil ratio and secondary school enrolment; Nasir et al. (2009) patents, receipts of royalties and license fees, Internet users, high-technology exports, electric power consumption, telephone mainlines and cellular subscribers, gross enrolment ratio and gross enrolment ratio in science, engineering manufacturing and construction; Schwab (2011) patents and six survey measures.

Audretsch & Keilbach 2008): development of the capacities and infrastructure capable of turning the innovation inputs into outputs in the region is also required. Human capital investments and innovation incentives are important factors in this promotion (e.g. Furman et al. 2002). National culture and the successfulness of regional innovation policies in creating innovation responsive environments explain part of the differences in national and regional performances (see also Jones & Davis 2000; Rutten & Boekema 2005; Prange 2008). However, there is no universal policy tool that would enable lagging regions to catch-up to leading innovators.

The state of the national economy is an important factor affecting the innovation capabilities of countries (Faber & Heslen 2004). However, as proposed by Hinloopen (2003) innovation inputs do not always lead to heightened innovation outputs: due to differences in other factors (infrastructural, political, educational, cultural etc.) some regions are more successful (innovation prone regions) in transforming innovation into economic growth than others (innovation averse regions) (Rodríguez-Pose 1999; Bilbao-Osorio & Rodríguez-Pose 2004). Therefore, country and region-specific differences have emerged despite seemingly similar economic conditions. This discussion is also related to the observed innovation paradox. There are varying ways to formulate the paradox. For example, the European paradox refers to the assumption that EU countries play a leading role in terms of top-level scientific research but lack the ability to effectively transform this strength into innovations and economic growth (Dosi et al. 2006). Accordingly, although not

Figure 2. Patent and R&D statistics from EU in 2006 (source: Eurostat; cartogram: Arttu Paarlahti).



unambiguous to measure, Peterson and Valliere (2008) have stated that the reason behind relatively 'low' economic growth in Europe is actually caused by what can be termed an "European entrepreneurial deficit"; low levels of entrepreneurship in Europe are not enough to effectively commercialise the considerable knowledge and technology available in Europe. In the Swedish version, the paradox is described through the high and growing levels of business R&D connected with comparatively low GDP growth rates (Ejeremo et al. 2011; see also Bakucs & Fertő 2011). The discussion of a Swedish paradox might sound inconsistent with its high standings in a number of innovation rankings. However, as shown (Table 4), most of the rankings are constructed from combinations of both innovation inputs and outputs that rarely take the economic impacts into account (also Bitard et al. 2008). According to the regional innovation paradox, most of the lagging regions lack the necessary absorptive capacity to gain from increasing R&D expenditure (Oughton et al. 2002; see also Braunerhjelm 2007).

In a global context, the European paradox seems to be more a conjecture than reality, as European weaknesses are shot through with problems from both scientific research and industry side (Dosi et al. 2006). In line, Ejeremo et al. (2011) claim that the Swedish type of paradox applies only in the case of fast-growing sectors, concluding that the paradox should therefore in fact be considered as a sign of success. The mismatch between growing R&D and economic growth is therefore, according to Ejeremo et al. (ibid.), simply the result for diminishing returns to R&D investments. However, Bitard et al. (2008) provide empirical evidence stating that in Sweden, at least, there is an evident mismatch between the very large investments on R&D and other innovation activities when compared with the more modest achievement in process and product innovation on the output side. Thus there is an on-going debate on the existence of innovation paradoxes and the possible reasons behind them.

In Finland regional policy has traditionally supported populating the entire country with the aim of alleviating socio-economic differences between the most and the least developed regions (Jauhiainen 2008). For example, the regionalisation of university education and the establishment of provincial universities, that took place between the late 1950s and early 1980s, were founded

on the idea of spreading development across the nation (Tervo 2005). Regardless, in Finland the regional variations in socio-economic development (or well-being) are best characterized by urban-rural and proximity-remoteness axes; remote and rural municipalities especially in northern and eastern Finland have clearly fallen behind urban centres in southern and western Finland, when measured by unemployment or educational levels etc. (Siirilä et al. 1990; 2002). In fact, Lehtonen and Tykkyläinen (2010) have demonstrated with data on migration that, despite various policy measures the self-reinforcing processes envisioned by classic cumulative causation theories still hold weight in a limited number of spatial clusters that have resulted in a socio-economically polarised regional system. The already more prosperous regions have also better conditions for creating new innovations (Makkonen 2011). In other words, regional success has been concentrated in a small number of growth centres (also Loikkanen & Susiluoto 2012). These centres are, with few exceptions, also the larger university regions in Finland (Antikainen & Vartiainen 2002; 2005).

When it comes to the geography of Finnish innovation, Piekkola (2006) divides Finland roughly into three parts according to innovation characteristics and competitiveness: western, eastern and southern Finland. The western areas rely on a high degree of innovative ability (including R&D expenditures and the share of innovative companies), southern Finland has a high agglomeration of human capital, whereas the eastern part of Finland relies on R&D investments. All the same, the Finnish regional system is characterized by a strong concentration of innovation activities in a few larger city cores (Inkinen 2005). In relative terms, when normalised according to the population, innovation is more evenly dispersed across the country (Figure 3), but the nature of innovation differs between Finnish regions; in larger university towns the innovations are more complex, combining a large set of local know-how and technological expertise, compared to industrial and rural regions (Valovirta et al. 2009). To sum up, in Finland the role of universities in local economic development and as a partner for innovation is seen as important and effective, not least

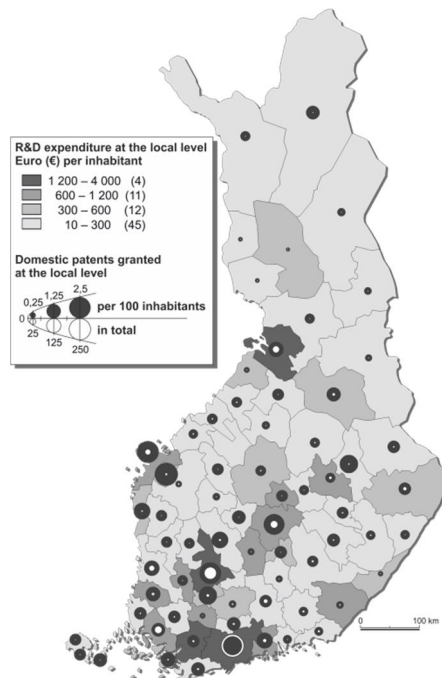


Figure 3. Patent and R&D statistics from Finland in 2006 (source: Statistics Finland; cartogram: Arttu Paarlahti).

for reasons observed by Husso (2001), Vartiainen and Viiri (2002) and Ebersberger (2005): the high standard of Finnish scientific research (measured by bibliometric indicators), the close cooperation of Finnish universities with business and industry sectors and the prominent roles of Finnish universities in local science parks.

Some stylized 'facts' can be drawn from the rich literature on innovation to explain the innovation capacity and performance of regions. It cannot, though, be stated that there is a 'one-size-fits-all' solution to explain the geography of innovation. According to the empirical evidence the different theoretical strands of literature work in one setting, but fall short of explaining the innovative activities in another.

3. Data and methods

In papers I to IV the data were compiled from the official Statistics Finland and Eurostat databases, because when working on a macro-level (EU, nations, regions) a self-conducted data gathering is rarely feasible. There are pros and cons related to precompiled statistics. The pros include the data availability and reliability, whereas the cons are mainly related to limitations with the qualitative and quantitative variables collected by the official authorities. This means that authors working with precompiled data are confined to a set of limited variables. Therefore, to widen the perspective of this work an innovation output database (SFINNO) compiled by the Technical Research Centre of Finland (VTT) was also utilized in paper I. Further to this, qualitative data were collected via specialist interviews in paper V. The data were gathered in correspondence with units of political and/or administrative control. The advantage of this approach is that these boundaries directly correspond to the boundaries by which development and innovation policies are usually implemented. However, these boundaries rarely conform to economic boundaries; although in the case of Finnish LAU-1s the selected spatial scale is relatively close to the ideal of functional economic areas (see Dawkins 2003).

For reasons of non-normal distribution of the samples the non-parametric Spearman correlation analysis, in papers I and IV, standard cross-tabulations and Cramer's V statistics, in paper I, were used to explore the possible interconnection of the dimensions under study. However, as such, correlation analysis does not say anything about the direction of the possible causality between the studied variables; rather it simply states that there is a positive or negative relationship between them. In order to tackle this question of causality, the Granger (1968) causality test was applied in paper III. The Granger causality test was founded upon the notion of time lags, as the dependence of variables is rarely simultaneous, but rather a variable responds to another after a lapse time (Gujarati 1978). Thurman and Fisher (1988), although at the same time criticising the ability of the test to imply true causality, have presented the rationale behind Granger causality test simply: "if lagged values of X help predict current values of Y in a forecast formed from lagged values of both X and Y, then X is said to Granger cause Y". Still, it has to be noted that, in addition to the concerns raised by Thurman and Fisher (*ibid.*), there are problems related to the validation of an appropriate lag structure (Graham et al. 2010; Mansson et al. 2011), that is, in choosing the right amount of lags, in this case years, to describe the probable time needed for a given variable to have an impact on another. Regardless, the method has proven to be useful, as it is frequently applied in economics related innovation literature [recent examples of the use of Granger causality test can be found for example in Rouvinen (2002), Schettino (2007), Battisti et al. (2010) and Lee et al. (2011)].

For the first two papers a decision was made to apply multivariate analyses to combine a set of variables incorporating the information of different aspects of the phenomenon under study into one composite index. The decision was made to coincide with the long tradition of regional studies

based on multivariate analysis in Finland (see Yli-Jokipii 2005). The birth of this tradition was influenced by Harman's (1960) classic text *Modern Factor Analysis* and a Finnish handbook by Vahervuo and Ahmavaara (1958). Multivariate analyses were introduced in the late 1960s, most notably by Riihinen (1965) and Hautamäki et al. (1969), in Finnish regional development studies. This rich tradition has all but faded, apart from a few recent examples, although the rationale for using multivariate analysis as the basis of regional development studies and policy remains meaningful, since multivariate analysis brings forth the most essential factors influencing regional development (Yli-Jokipii 2005).

PCA was applied in papers I and II. The methodological literature on PCA dates back to the seminal works of Pearson (1901) and Hotelling (1933), nowadays credited as first to describe the technique. More up-to-date methodological considerations and applications of the method can be found in the works of Jolliffe (2002) and Tabachnick and Fidell (2007). As a rule, PCA is commonly used to compress the information contained in several different variables into a small number of dimensions, based on principal components, in a way which ensures that as little of the original information as possible is lost. PCA was chosen because it is a relatively objective way of giving weight to the different variables that construct the index, that is, principal component scores. A further advantage of using PCA is that it does not presume that the variables follow a normal distribution, which is rarely the case with national and regional statistics. Calculation of the principal component scores is carried out in a way similar to that of the regression model by weighting the variables with coefficients produced by PCA. The most commonly used tests of PCA's suitability were also used here.

PCA presupposes and requires statistically significant correlations between the variables; over 50% of the correlations should be statistically significant. Small correlations between the variables, or small samples, complicate the analysis substantially. Selected variables can be excluded from the analysis if they show little variation in them or if they are not significantly correlated with other study variables. The Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were used as indicators of PCA suitability in this study. The Bartlett test of sphericity tests the hypothesis that the values of the correlation matrix equal zero (small significance levels support the hypotheses that there are real correlations between the variables) and the KMO measure of sampling adequacy tests whether the partial correlation among variables is sufficiently high. The KMO measure should be at least on the 0.6 level, for the correlation matrix to be suitable for PCA. The communality for a variable is the variance accounted for by the principal components found in the study. Normally, the acceptable limit of communality for a variable to be included in the analysis is 0.3. On the other hand, eigenvalues indicate how well the principal components are able to explain the deviation between all the observed variables, whereas the loadings of the principal component indicate how well the individual principal component considered explains the variation in observed single variables. Loadings can be either positive or negative, but it is customary that loadings under the absolute value of 0.3 are excluded. Principal components with eigenvalues less than 1.00 are also excluded from the analysis.

Moreover, PCA always requires meaningful interpretations for the principal components that are produced: otherwise another method should be applied. The designation of the principal component reflects the interpretation, because it requires consideration of what types of variables are loaded to the principal component. Therefore, it is important that the name given to the principal component describes the aggregate that it represents. However, there are limitations to the use of PCA. Most notably the observation by Tabachnick and Fidell (2007) that, there are no readily available criteria against which to test the solution. Thus, researchers have to rely on existing theories and their own good judgement, when considering the feasibility of the results. Furthermore, different decisions during the steps of multivariate analysis will lead to different results (see also Grupp & Schubert 2010).

Paper V takes the case of Joensuu and its local university to deepen the statistical data using semi-structured thematic interviews and analysis. The commonly voiced criticism towards the subjective bias of qualitative methods was taken into account by following Aronson's (1994) outlines for the procedure of performing a thematic analysis in the following way (expressed here in a simplified fashion): 1) data collection; 2) pattern identification; 3) sub-theme categorization and from these steps 4) argument building (also Crang 1997). A sample of specialist interviews (via telephone) was conducted. The interviews were transcribed to allow the identification of patterns and the categorisation of sub-themes and further the building of the arguments of the paper. The interviews were analysed using a conceptual framework, in which the main themes were based on existing theories and previous research. In particular a suggestive interview framework, underlining the importance of U-I linkages (sponsored and joint research, hiring of students and availability of skilled workers and spin-off and star-up firms) provided by Bercovich and Feldman (2006), was utilised, as the aim was to identify how well knowledge transfer mechanisms of the local university serve local business needs, that is, whether the local university is a significant element in local development or not.

4. Review of the study results

Paper I takes up the methodological issue of measuring innovation. This has specific relevance, if innovation studies are used as the basis for science-, technology- and innovation policies. Individual innovation indicators (R&D and patent data) and composite indexes derived from them were tested as regional benchmarking tools at the regional scale of Finnish LAU-1s. Direct innovation counts gathered from the SFINNO database of VTT act as the baseline to which the individual measures were compared. The study results show *inter alia* that:

- Since innovation is such a complex and challenging phenomenon, it is hard to measure with a single proxy measure of innovation.
- Composite indexes perform marginally better, but still the results are sensitive to changes inside the indexes.

This is a particular problem as innovation index construction is usually performed in an ad hoc manner, that is, the individual variables and the methods used to construct the index vary substantially (also Saisana et al. 2005), thus, creating a multitude of possibilities with different results. In sum, when benchmarking regions with different measures one comes up with divergent rankings. Most notably, a good innovative capacity does not automatically guarantee a high number of innovation outputs. Therefore, policies that rely simply on increasing innovative inputs (e.g. R&D) do not necessarily warrant successful results. On a practical note, caution is advised before making too far-reaching policy conclusions based on a single or relatively few innovation indicators or indexes. Thus, the shortcomings related to different innovation data have to be acknowledged and the selection of indicator(s) or index(es) to measure innovation should be done with care.

The interconnectedness of social, economic and innovation indicators reported in an earlier paper (Makkonen 2011) are taken into deeper consideration in paper II by probing their temporal and geographical variations. The analyses were conducted by using PCA with panel data collected on the scale of Finnish LAU-1s from the years 1995–2007. Income level of the population was the foremost explanatory variable for economic regional development at the start of the study's time period. However:

- Workforce and its educational characteristics are now the leading variables in explaining economic regional development in Finnish regions (LAU-1s).

Innovation indicators have a stable (but only) modest importance in explaining regional development and economic success. Still, innovation and development are closely connected; as a general rule, the most developed regions are also the most innovative. In geographical terms

regional development and innovation of Finnish regions follow a generally accepted (see Siirilä et al. 2002; Lehtonen & Tykkyläinen 2010) north (below average) – south (above average) trend with regional centres standing out as notable exceptions. The results indicate that the centre driven growth will continue in the future, since the larger urban cores are steadily among the most developed and innovative Finnish regions. However, some smaller centres have been able to rise among the most innovative regions, and consequently, the clustering of innovative activities towards the largest cores has decreased. Therefore, smaller towns and even non-urban regions have gained position in the ranking of innovative capacities. Thus, as stated by McCann and Acs (2011), the absolute size of the cities and the importance of economics of scale have lost some of their importance. Also, the earlier notions in literature (e.g. Bramwell & Wolfe 2008) about the enhancing role of universities in regional innovative capacities are supported; Finnish university cities are the cores of the most innovative regions.

Paper III addresses the discussion on the causality between innovation, economic development and education in the EU by using panel data and the Granger causality test. In this way the need of the use of time lags identified in Makkonen (2011) can be taken into account. The three dimensions are interconnected with interesting variations, in that they are intertwined and bidirectional:

- Educational attainment can be said to strongly Granger cause innovative capacity and economic development, whereas the link between innovative capacity and economic condition is bidirectional.

However, the causal link from economic indicators towards innovation indicators is stronger. Thus countries and territories with the best educational, innovative and economic conditions can be found in the core regions of Europe; Western and Northern Europe. There are, though, many exceptions to the hypothesised fit-lines between these dimensions; for example Åland is economically well equipped (due to its exceptional status as an autonomous part of Finland with a significant tourism sector), but performs low on innovation. The catching up of the Southern European countries, envisioned by Moreno et al. (2005a; 2005b), is evident only in a limited number of regions and indicators. Accordingly, the new EU states in Eastern Europe clearly lag behind in all of the examined indicators. The results back up the discussion on innovation paradoxes (see Oughton et al. 2002; Ejermeo et al. 2011): the ever increasing public and private investments on R&D are not enough to guarantee the economic success and growth of European regions, since on the other hand, in many (already established) high-tech societies the returns on R&D are diminishing, and on the other the absorptive capacity of many lagging regions is not enough to turn the increasing investments on innovative activities into significant economic gains. Thus, the strengthening of educational systems and endorsement of LLL are advised. The paper also highlights the need for smaller regional units of analysis to take into account the local particularities; the European territorial units for statistics work well in country- and region-wise comparisons, but undermine the true heterogeneity inside the EU (also Inkinen 2011).

In paper IV the links between innovation and CVT are brought forth to the centre of the analysis. In the European context:

- The nations where the commitment to CVT is the highest are also the most innovative.

CVT works as an important complementary resource in its capacity to produce innovations. Whereas higher education might be the most important factor impacting upon the innovativeness of nations, CVT can more directly influence the on-going innovation processes in firms. The qualifications acquired through higher education are targeted to meet more general goals. However, CVT and innovation have a significant, strong and positive relation with economic development; wealthier nations do well in innovation and CVT rankings. Thus, innovation and CVT are manifestations of economic conditions with complex strengthening interconnections; from wealth to investment on CVT to innovations and back to economic development. This is known as “vicious dynamics” and renders the situation challenging for less developed countries and regions

to catch-up with the more developed countries in the global market. The results indicate that investment and commitment to CVT (the same applies in the case of LLL, as paper III postulates), when properly planned and executed, have a positive effect on the innovativeness of firms and nations. However, problems might arise from an insufficient effort to identify the sectors in need of CVT provisions and innovation potential (e.g. Blažek & Uhliř 2007) as well as from the adoption of 'best practices' as such without sensitivity to the local conditions (e.g. Ertl 2000). For example, if the opinions of the participating firms are not taken into account, investments on CVT seldom yield desired results (MacDonald et al. 2007). Therefore, training policies should be carefully developed to meet the needs of the region in focus (see also Lorenzen 2001).

Finally, the results from paper V provide insights of U-I linkages from a peripheral region in Joensuu, Eastern Finland. Joensuu (University of Eastern Finland – Campus of Joensuu) was chosen as a case study location, due to its interesting R&D figures (high percentage of university R&D compared to the national average) and its peripheral location. Also, previous studies have tended to focus on examples of successful regions and well-known universities. Despite a number of positive examples of successful cooperation, the conducted interviews revealed that, there are several deficiencies in the local U-I collaboration:

- First, the lack of entrepreneurial spirit is a general challenge for the Finnish economy as a whole, but the non-zealous views on entrepreneurship among the university staff and graduates were considered particularly problematic in Joensuu.
- Second, the possibilities that the local science-based university could offer firms are not widely known.
- Third, a more active role from the private sector in seeking possibilities to cooperate was called for.
- Fourth, the lack of a technical faculty renders local U-I cooperation unfeasible for many companies seeking to collaborate.

To maximise its impact on the innovativeness of local firms and the local economy, the university should improve its service attitude and incorporate entrepreneurship more closely into its curriculum (cf. Kolvereid & Åmo 2007). Similarly, the private sector is encouraged to actively take part in finding common interfaces for collaboration. All in all, the role of the University of Eastern Finland – Campus of Joensuu – can be seen as a strengthening, but not the driving, factor in local knowledge-based development.

5. Concluding remarks

The connections between innovation and regional development in different spatial scales are bidirectional and cumulative. In particular, education and training play significant roles in this 'equation'. The most innovative nations and regions with highly educated workforces are also, in general terms, the most economically well-off, that is to say the larger core regions, but in innovation terms this exclusive division between urban and rural regions is diminishing. A methodological caveat: caution should be taken when making comparisons between regions based on different indicators or indexes of innovation, because even with well-established data and methods they produce highly divergent rankings. The link between innovation and regional development is not instantaneous, but a sufficient lag time is needed before innovation indicators manifest themselves as successful regional economic development. When taking into account this need for a lag structure, educational attainment Granger causes innovative capacity and economic development. The connection between innovation capacity and regional economic development works in both ways, but is stronger from GDP and income level to R&D and patents. Similarly, when measured with PCA the impact of workforce and its educational characteristics in particular are the foremost variables for explaining regional development.

When taking into account the results presented here, and as the identified innovation paradoxes undermine the possibilities increasing investment on innovation input activities to be a path that will automatically lead to economic success, the strengthening of the educational systems and promotion of LLL are highlighted as a (more) fruitful alternative for regions to make economic gains and to strengthen their absorptive capacity. The importance of universities and CVT in regional innovation and economic performance are thus also highlighted. Of course, the existence of a local university does not guarantee a successful U-I collaboration, but the incorporation of entrepreneurship into the curriculum and encouragement for the private sector to participate in finding common interfaces should alleviate the identified mismatches between the university and private sector. Still, there is no 'one-size-fits-all' solution in innovation promotion and economic growth (also Tödtling & Trippel 2005). Thus, careful consideration is needed to successfully implement the best practices that take into account the regional particularities, from elsewhere to national, regional and local levels.

In addition to the methodological limitations discussed in the methods section and original papers, the data used here does not cover the most recent years. Therefore the European-wide financial crises and the contemporary problems and layoffs faced by, for example, the Finnish forest and telecommunications industries are unobservable. However, in countries such as Finland where the levels of R&D remain relatively stable even when their GDP growth decreases, the impact on innovation is relatively less disturbing. By contrast, in some other European countries (including many South European countries), levels of R&D expenditures decrease more in line with their GDP (see Archibugi & Filippetti 2011; Filippetti & Archibugi 2011). In these countries the impacts of the financial crises on innovation will be steeper. Similarly, Finnish localities with high dependence on forest or telecommunications industries will face considerable limitations concerning their innovativeness and regional development potential. In fact, the downturn of just one company, Nokia, can have a decisive impact on the private R&D investments on a single region as well as in Finland as a whole (cf. Ali-Yrkkö & Hermans 2004; Sabel & Saxenian 2008; Ali-Yrkkö 2010).

As always, the results shown here are not exhaustive and much remains for further studies to elaborate on in greater detail. An obvious next step would be to repeat the analysis presented here in different countries and regions for the purpose of comparison. Moreover, the emergence of new innovation indicators, surveys and indexes, the application of more qualitative approaches and the triangulation of qualitative and quantitative data on smaller regional scales are bound to bring forth interesting new insights. The employment of direct innovation counts would allow a discussion on innovation performance in addition to the innovation capacity provided with the proxy indicators mainly used in this study. Similarly, the inclusion of different social factors would permit an investigation into the well-being of the population in a given region. In the case of U-I collaboration a more extensive survey data also taking into account the views of small- and medium-sized enterprises, would be a fruitful next step in the local context of Joensuu. Likewise, the role of serendipity in U-I collaboration is heralded here as an interesting 'black box' worth opening for the purposes of achieving successful innovation futures.

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