Catalogue no. 21-601-MIE — No. 076
ISSN: 1707-0368
ISBN: 0-662-42052-7

Research Paper

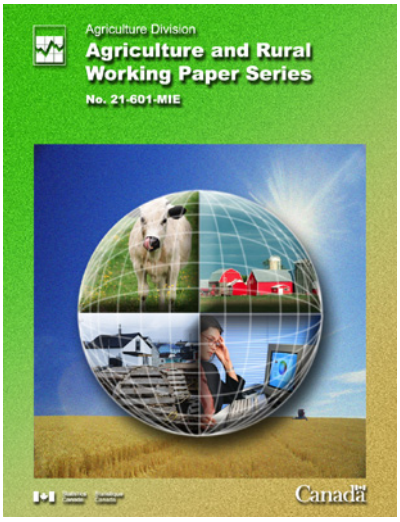
Skills, Innovation and Growth: Key Issues for Rural and Territorial Development - A Survey of the Literature

1980-2003

by Alessandro Alasia

Agriculture Division
Jean Talon Building, 12th floor, Ottawa, K1A 0T6

Telephone: 1 800-465-1991



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Agriculture Division

Agriculture and Rural Working Paper Series

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1980-2003

Published by authority of the Minister responsible for Statistics Canada

November 2005

Catalogue no. 21-601-MIE No. 076

ISSN: 1707-0368
ISBN: 0-662-42052-7

Frequency: Occasional

Ottawa

La version française de cette publication est disponible sur demande (no 21-601-MIF a u catalogue).

Note of appreciation

Canada owes the success of its statistical system to a long standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

Acknowledgments

This paper was prepared for the research project “An analysis of the spatial variation of skills and the implication for community innovation capacity”. The project was established as a research partnership funded by the Agriculture Division (Statistics Canada), Rural Secretariat (Agriculture and Agrifood Canada), Marketplace Innovation Directorate (Industry Canada), Atlantic Canada Opportunity Agency - ACOA, Human Resource Development Canada (Quebec), Western Economic Diversification Canada - WED, Federal Economic Development Initiative for Northern Ontario - FedNor. The report has also benefited from research collaboration with the Territorial Development Service/OECD, on a related subject.

Executive Summary

The relevance of human capital attributes in determining innovation and economic growth of localities has recently become a focus of interest for various regional and federal agencies. There is a large body of theoretical and empirical research that bears relevance on this policy issue. This paper surveys the literature related to the spatial variation of human capital and its implication for local innovation capacity and economic development. The paper is intended to be a roadmap through this literature and to provide a non-technical synthesis of it.

The survey develops around three major themes: 1) skills and human capital, 2) innovation and technological change, and 3) growth. These themes are brought together by a spatial perspective, meaning that the emphasis is on how they are related to the spatial (territorial and rural) dimension.

There appears to be two major ideas that lie beneath a large part of the literature that was surveyed in this paper. These ideas refer to the nature of *incentives* and *interactions* faced by various agents – individuals, households, firms, communities – in different territorial contexts. New growth theory shows that growth occurs because agents respond to endogenous incentives to invest in human capital and technology. The economy of some regions – typically rural regions – do not provide these type of incentives to individuals, firms or communities, primarily because of the low return or difficulty in capturing the return of the investment. Similarly, human capital attainments and the innovation levels of individuals and firms may affect the behaviour and opportunities of nearby agents through various forms of interactions – knowledge spillovers and various forms of externalities, role models, etc. These interactions, that is interdependence between individual decisions which are not mediated by the market (Brock and Durlauf, 2001), have relevant economic effects. As will be discussed throughout the paper, space helps to define the type of incentives and interactions which, in turn, affect human capital or technology investment decisions and technology diffusion.

Some of the key findings of this literature review are summarised below.

- Most of the available evidence indicates that geography matters in the new economy. New technologies have changed the spatial scale of the production processes but have not reduced the relevance of space. The declining cost of communication and transportation, combined with scale and agglomeration economies, have reinforced the process of geographic concentration of physical, technological and human resources mainly in favor of large agglomerations.
- The spatial variation of human capital attributes is a normal phenomenon, partly explained by the different industrial structure of each locality. Large disparities, however, have been a policy concern due to the possible effect on income disparities and the increasing demand for high-skill workers in all economic sectors. Moreover, recent developments in growth theory have emphasized the role of human capital in the growth process and suggested that market forces, left by themselves, can lead to a sub-optimal provision of human capital. This opened a new perspective on the potential role for government policy in reducing this gap, which also has implications for territorial and rural policies.

- The innovation process has both a sectoral as well as a spatial dimension. Spatial patterns of innovation differ systematically for industries with different technological intensity; part of these differences can be related to the concept of the industry life-cycle. Certain regions, however, have developed specific ways of producing and sharing innovation. This notion is at the core of the "regional innovation system" (RIS) concept. The main elements of the RIS concept are proximity, networks and institutions. However, the empirical evidence on a spatial hierarchical structure of innovation performance (urban vs. rural) appears inconclusive.
- The human capital attributes of a locality are an important component of the innovation process. This is particularly true for the relevance of "tacit knowledge" (i.e. not codified knowledge) in the innovation process. But, also in this case, the empirical literature does not appear to be conclusive regarding whether low levels of human capital necessarily represent an impediment to innovation.
- Instead, what most of the literature suggests is that rural and remote regions may face specific problems in their attempt to increase the level of their human capital as well as in supporting innovation at the local level. These are related to the nature of incentives and interactions that these communities face. The lack of incentives to invest in education (both in an individual and community perspective) combined with the mobility of high-skill workers represent a major challenge in enhancing the local level of human capital. Investment decisions in human capital or technology adoption made by individuals and firms affect the decision of others in the community through economic and non-economic interactions (role models, lowering costs of adoptions, etc). At the same time, the low density of economic activities and lack of institutions may reduce the opportunities for interactions among economic actors (networking and various other spillover effects) that support innovation. Finally, the lack of human capital has an effect on the capacity to access technology and public programs, which makes smaller communities potentially more vulnerable. The initial disadvantage of a locality may lead to what has been named in the literature as spatial poverty trap, i.e. a persistent condition of disadvantage.
- There are two main reasons that suggest some caution in generalizing the results of the empirical research. First, operational definitions of "skills", "innovation" and "regions" are far from being consistent across studies. There is an ongoing debate about what should be a proper measure of innovation or human capital attributes; the weaknesses of some of the prevailing operational measures, such as R&D spending, patenting, and years of formal educations are increasingly recognized. Different operational definitions may explain part of the conflicting results recorded by the literature. Second, a limitation of the current research on innovation is the focus on success stories, particularly high-tech clusters and major urban agglomerations. In contrast, relatively little research has been carried out on the innovation process in small areas and non-metropolitan regions.

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1. Introduction

Focus of the report

This report reviews the literature related to the spatial variation of skills and human capital and its implication for local innovation capacity and economic development. The report develops around three major themes 1) skills and human capital; 2) innovation and technological change; and 3) growth. The three themes are linked together by a spatial perspective, meaning that the emphasis is on the interaction between skills, innovation, growth and the spatial (territorial and rural) dimension.

Map a large body of literature

The report draws on an articulated body of theoretical and empirical literature, rather than on a single disciplinary perspective. In so doing, it identifies common themes and points of agreement and disagreement between perspectives. This literature ranges from economics and economic geography, to regional science, to managerial studies and educational sciences. In each of these fields, there exists authoritative surveys of the literature and this report relies often on these reviews in an attempt to integrate various perspectives. Given the breadth of the studies involved, this report is intended to be primarily a road map across this literature. The report highlights the main concepts, results and implications for policy (as opposed to methodological and technical aspects of the research).

Four elements of the rationale

There are four intertwined sets of motivations that justify an integrated survey of the literature related to skill, innovation and growth in a spatial perspective. First, the rapid and profound technological and policy changes that occurred over the past two decades have produced a new economic environment often referred to with the catchwords “new economy” and “globalisation”. Second, the rising importance of knowledge and the “knowledge sector” in the economy and the emphasis that the current policy debate has placed on skills and innovation as an engine for growth in the emerging economic environment. Third, the increasingly perceived notion that regions, i.e. sub-national territorial units, have acquired a new and more prominent role in the global economy. Fourth, the growing debate surrounding the nature of territorial development policies, such as rural policies, which has called for a rethinking of current policy and a search for new policy trajectories that fit the new economic environment. The following paragraphs elaborate further on these four points.

The literature reviewed in this report reflects the new economic challenges that have emerged over the 1980s and 1990s. During these two decades, employment in the primary sectors (agriculture, forestry, fishing and mining) has continued to decline and to erode the economic base of rural regions. By the beginning of the 1980s the structural transformation associated with the agricultural exodus had largely occurred in most of the OECD economies. However, since the early 1980s, and more intensively in the 1990s, a major wave of technological change has profoundly affected all economic sectors. These changes are associated in particular with the introduction of new information and telecommunication (ITC) technologies. Among the major consequences of new ITC has been a shift in the scale of production system towards global networks of production (Best, 2001; Cooke, 2001), paralleled by a growth of a "knowledge sector" with its own peculiar characteristics (Beckstead and Vinodrai, 2003). The "new economy" has developed in a renewed macroeconomic context, which has been strongly oriented towards market liberalisation and integration. This has further exposed the local economies to international economic trends. Finally, the new policy package has usually included some form of government downsizing and decentralization. This has placed an increasing burden on local decision-making and has required the development of new competencies and skills at the local level.

Knowledge is a determinant of growth

The diffusion of new ITC technologies is evidence of the fact that knowledge, and more generally human capital attributes, have achieved new relevance in all sectors of the economy. Knowledge has been long regarded as a key ingredient in the innovation process and a major determinant of economic growth. The growing knowledge intensity of the economy has further shifted the attention away from physical to human capital as a determinant of economic prosperity. Recent theoretical approaches to growth, such as the new growth theory (NGT), have formalised these ideas. NGT abandoned the simplistic view of "exogenous" technological change and started to investigate the endogenous process of investment in human capital, and consequently technological change, where growth is an endogenous function of policy and individual behaviour. At the policy level, this trend has led to a growing attention towards skills and innovation as an engine for growth; an example is the various knowledge and innovation strategies adopted at the national or regional level (for instance GoC, 2002; EC, 1995).

The emerging economic environment has also renewed attention towards the spatial dimension of growth (OECD, 2001b and 2002) and stimulated the debate on the spatial effects of economic policy changes. In an integrated economy, communities and regional systems have acquired new relevance as their prosperity is increasingly determined by their capacity to compete at the global level. Parallel to that, the regional effects of trade liberalization, as well as downsizing and downloading of government responsibilities, have been a subject of debate and concern for rural regions. Some scholars have pointed to the risks of increasing regional inequalities. The new knowledge economy has also brought new hopes and challenges for rural regions. There has been debate about whether the new technologies have lessened the importance of agglomeration and distance, thus opening new opportunities for rural and remote areas, or would have further marginalized peripheral areas with their low-skill labour force.

Impact of development policy in the periphery

Finally, the trends outlined above, combined with a long term decline of rural and peripheral regions, have called for a reconsideration of territorial policies and what these policies can do to enhance economic prosperity in disadvantaged areas (Bryden, 2003). Some scholars have pointed to the widespread failures of regional development policies in the past (Shankar and Shah, 2001). Others have questioned the capacity of public policies to counteract what appear to be inescapable and pervasive market forces that act to the disadvantage of the periphery (Polèse and Champagne, 1999). These concerns have given rise to questions about the feasibility of appropriate rural development programs and how, if ever, these policies could support human capital development and innovation at the local level.

This paper is organized in four sections. Section 2 presents a brief review of concepts and operational definitions that have been used in applied research and issues concerning the geographic unit of analysis. Section 3 reviews some of the most recent literature that links skills, innovation, and growth, without a specific spatial perspective. The goal is to highlight the concepts and ideas that have then been integrated in spatial analysis, and that currently constitute the backbone of most research that takes a spatial perspective. Section 4 focuses on the relevance of space in shaping the relationship between skills, innovation and growth. Starting with a review of research that investigates the nature of the spatial variation of human capital, the chapter moves to the literature on the spatial dimension of innovation, and the geographic spillovers hypothesis. Then some of the challenges faced by small and remote areas are reviewed, including the effects of agglomeration and increasing returns, the variations in returns to education and its relationship to human capital mobility, and spatial poverty traps. Section 5 summarizes the main conclusions and the implications for policy that can be drawn from the current literature.

2. Concepts and operational definitions

Key issues

- Terms such as “regions”, “skills”, and “innovation” are difficult to operationalise and measure. Researchers have struggled to identify the best and most appropriate proxy and problems and concerns in definition and measurement remain pervasive.
- The geographic scale of the analysis has varied greatly in the literature concerning spatial variations. The geographic units used have extended from the municipality or urban agglomeration to county to the province and to the level of the nation. Research has shown that the use of different spatial scales may generate substantially different results in terms of observed variability and correlation between the variables.
- Educational attainment is the most common indicator of human capital and similarly of skill level. Another frequently used proxy for human capital is the occupational status, with a major distinction made between professional, technical and production occupations.
- Research and development spending and personnel is the most common indicator of innovation input while patenting and brevets, that are not patented, are the most common indicator of innovation output. Human capital indicators are often reported as indicators of capacity to generate innovation and capacity to absorb innovation.
- The limits of the prevailing measures of human capital and innovation have been recently discussed in the literature. Educational attainment does not capture the quality dimension of education, which is particular relevant to determine the actual skills of the work force. Similarly, R&D spending and patenting measure only a limited dimension of innovation and are often limited to large firms.
- Data availability for small geographic units is a major constraint in assessing spatial variation. While educational attainment data are relatively easy to access for small territorial units, other indicators, including innovation indicators, are more problematic and not always available at the sub-national level.

Conceptual vs. operational definitions

This section outlines some key issues related to conceptual and operational definitions of the geographical unit of analysis, skills, innovation, and growth. Terms such as “regions”, “skills”, and “innovation” are difficult to operationalize and measure. All of these terms have a commonly understood and intuitive meaning. A major challenge in applied research is the identification of measures that properly represent these concepts and theoretical constructs (see for instance Agrawal and Cockburn, 2003). The bottom line in these attempts has usually been determined by data availability. Data problems are even more severe when small geographic units are considered. Many of the data that are available at the national level are not generated, or are incomplete, for sub-national territorial units.

2.1. Space and geographic unit of analysis

Regions are more important in the global economy

There appears to be a broad and shared understanding that, in the emerging economic environment, regions have become increasingly more meaningful than countries as a geographic unit of economic analysis (Quah, 1996; Anselin et al., 2000; Krugman, 1991; Cooke, 2001). Globalisation and increasing economic integration, or the integration of trade and disintegration of production as put by Feenstra (1998), have implied that the importance of the nation-state in determining local economic outcome has tended to diminish in recent decades. Yet, the definition of the appropriate territorial unit for economic analysis is elusive.

The geographic scale of analysis has varied greatly

The geographic scale of the analysis has varied greatly in the literature concerning spatial variations. The geographic units used have spanned from the municipality or urban agglomeration to county to the province, to the national level, with some of the aggregations reflecting functional regions for the process under investigation, while others emphasise spatial hierarchies. From a policy perspective it would appear particularly relevant to use territorial units that correspond to an administrative jurisdiction that could develop and implement policies. But, in applied research the choice of the geographic scale and unit of analysis is often dictated by data availability. One of the major challenges in spatial data analysis is the availability of data for small geographic units. The challenge is particularly acute when the study considers historical trends because of administrative boundary changes over time.

Choice of geographic scale for the analysis is crucial

From a methodological point of view, however, the level of geography used appears critical. First, this is because the economic process under investigation may occur at a spatial scale that is not the same one for which data is available. Second, the analysis of spatial data has generated abundant literature on the statistical and methodological implications of using spatially aggregated data. A review of these issues is presented in Arbia (1989). Two of the common problems associated with the so-called “modifiable area unit problem” should be briefly recalled. The first problem is that of spatial scale. It is demonstrated that the use of different geographic scales (for instance: nation, province, county, district, and municipality) can generate different results in terms of the variability of a single indicator, as heterogeneity may be concealed by large geographic aggregates. Second is the problem of spatial aggregation -- in essence, different aggregations of geographic units may generate substantially different results in terms of observed variability and correlation between variables.

In practice, applied research has been plagued by the problems encountered when data are aggregated across space. Many of these issues have not yet been investigated and properly addressed (Anselin, 2001), but this generally implies that the possible consequences of the geographic unit of analysis on the results should be assessed carefully. These considerations would also suggest that analysis developed and conducted at the national level, or with a cross-nation sample, offers relevant insights but results and implications would not necessarily hold for sub-national aggregates. Similarly, these problems call for a better understanding of the geographic scale at which spatial interaction occurs, as well as for the implications of data aggregation across functional or administrative regions.

Rural is hetero-geneous

In this paper the terms “region”, “territorial”, “local”, and “community” are often used in a loose sense as synonymous. Both the terms territorial and rural are intended for use primarily in their spatial connotation. “Territorial development” is used by the OECD to draw attention to the fact that economic development has sub-national or local dimensions. Rural is generally defined as that part of the national territory characterised by small population size, low population density, and distance from major agglomerations (for a review of operational definitions, see du Plessis et al., 2002). However, it is well established that the rural space presents a remarkable variety of socio-economic conditions (Bollman, 2000). This implies that a clear-cut and dichotomous distinction between rural and urban is increasingly difficult to make. To obviate this problem, many studies concerning rural areas make a major distinction between metro-adjacent, and often prosperous, rural areas and remote or non-metro-adjacent rural areas.

2.2. Skills and human capital

Human capital is knowledge, skills and abilities

The concept of human capital was developed in the 1960s by a group of economists - in particular Schultz, Becker, and Kiker - and has since generated a flourishing literature. Human capital is a broad concept that includes education and training attributes, hence also the notion of “skills”. Thus, the operational definitions of “skills” can be regarded as a specific component of a measure of human capital.

The conceptual definitions of human capital have been numerous and sometimes different within the same organization. The OECD (1996, p. 22) defines human capital as "the knowledge that individuals acquire during their life and use to produce goods, services or ideas in market or non-market circumstances". In a later publication, the OECD (1998, p.9) redefines human capital as: "the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity". The emphasis has changed, but these two examples show the complexity and broad scope of the definition.

There have been various attempts to operationalise the concept and break it down into its various components. A major distinction is often introduced between outcome indicators, such as educational completion rates, and input indicators, such as educational infrastructures. For instance, a comprehensive attempt to classify and identify a human capital indicator was carried out by the National Round Table on the Environment and Economy - NRTEE (2001) project. The NRTEE (2001) defines human capital as "the capabilities or capacities, both innate and derived or accumulated, embodied in the working-age population that allow it to work productively with other forms of capital to sustain economic production." The NRTEE has proposed a framework for developing indicators for human capital, which includes two major areas: education and health. In the area of education, NRTEE suggests six sets of summary outcome indicators (average educational attainment, literacy rate, percentage of the population with some university or equivalent, primary, secondary and tertiary enrolment, people with university degrees as a proportion of the labour force, and educational attainment of the population aged 25-64), and three sets of specific indicators (adult participation in education and training, percentage of graduates with science degrees, and an indicator of child development at age 5).

Education is the main proxy for human capital

It is fair to say that the large majority of empirical studies have used some education-related indicator to proxy the stock or flow of human capital for individuals or regions. Compared to other types of indicators, educational attainment variables and the standard classification of occupation based on skill levels are relatively easy to obtain even for small geographic units. A variety of educational indicators have been widely applied in empirical research. Barro and Lee (1996 and 2000), for instance, develop a set of educational attainment indicators to measure the human capital at the country level for a large number of countries. According to these authors "the percentage of the population who have successfully completed a given level of schooling … is a straightforward way to show the population's attainment of skills and knowledge associated with a particular level of education." (Barro and Lee, 2000: 2). The authors, however, recognize that educational attainment remains at best a proxy of human capital which includes a multitude of human attributes. The use of an educational attainment indicator has been extensive in growth regression models. In a review of growth regression models Durlauf and Quah (1998) list seven types of educational attainment variables (various level, growth, and gender types) that were used in modeling growth determinants, which augmented cross-section regression at various geographic scales.

Occupational status may proxy human capital

Another frequently used proxy for human capital is occupational status, with a major distinction made between professional, technical and production occupations. Examples are the work by Berman et al. (1994), Wolff (1996), Lavoie et al. (2003) and Beckstead and Vinodrai (2003). In addition, the spatial distribution of universities and research centres also has attracted considerable attention (Globerman, 2001; Anselin et al., 2000). There is, however, little agreement about the composition of specific occupational groups. Specialized skills (higher education, research capacity) have often been proxied by the number of people employed in research and development or even the level of expenditure in R&D. But broader categories such as "knowledge workers" have been defined in substantially different way by different studies. For instance Beckstead and Vinodrai (2003) apply a comprehensive definition of knowledge sector, which includes technical workers. In contrast, Lavoie et al. (2003) limit this definition to occupations involving the production of new ideas, which require a greater level of creativity than most technical occupations.

Skills and quality of education

Compared to educational attainment, the concept of "skill" is more closely associated with a notion of "being capable to do". The collection of specific indicators of skills, such as test scores in mathematical and scientific literacy, have recently been undertaken by conducting large scale surveys (OECD and Statistics Canada, 1995). These indicators have been used in applied research. Hanushek and Kim (1995) and Hanushek and Kimko (2000) focus their analysis on the importance of labour force quality and measure it with the cognitive skills in mathematics and science. Lee and Lee (1995) use student achievement test scores rather than school enrollment rates and years of schooling to investigate the relationship between human capital and growth. They find that the test score is a key determinant for economic growth. Cartwright and Allen (2002) use test score data to assess differences between rural and urban Canada. The availability of test score data, however, remains limited to a small sample of countries (Barro and Lee, 2000), while the availability for small territorial units appears even more limited.

Wage levels provide additional information

Finally, alternative and more sophisticated attempts have focused on labour income and wages to derive measures of human capital, with the assumption that the quality of a worker would be related to the wage that this individual receives. Instead, Mulligan and Sala-i-Martin (1995) developed a set of human capital indexes for the U.S. The results suggest that the use of average years of schooling, as a measure of human capital in empirical research may be misleading; the computations of the authors suggest that the stock of human capital in the U.S. between 1940 and 1990 grew twice as rapidly as the average years of schooling; similarly, the dispersion of the index increased during the 1980s, while the dispersion of the average years of schooling declined.

2.3. Innovation and technological change

Investment in innovation activities versus indicators of new innovation

Similar to human capital, the subject of innovation has become a major field of study, particularly in economics and managerial sciences. Innovation has generated its own sub-disciplinary area of research, namely Innovation Economics. There are several dimensions of innovation, including social and organizational innovation. In this review the emphasis is on technological innovation in the production and service sectors. Even within this restricted realm it is generally recognized that innovation, as a process of generating, introducing and extracting value from ideas, covers a broad range of activities for which a standard measurement is often lacking (Hanel and Niosi, 1998; Roger, 1998).

One indicator is a new product or a new process

An attempt to define internationally comparable measures of technological innovation was carried out through the *Oslo Manual* (OECD/Eurostat, 1997). The definition focuses on two main aspects of innovation: technological process and product innovation. Innovation is defined as a *new* or *significantly improved* process or product (good or service) introduced *in the firm*. This definition captures both the process of creation of new products or processes as well as that of diffusion. Since the unit of reference is the firm, if a firm introduced a technology that is already in use by other firms this would still be considered innovation by this definition. Moreover, a major distinction that is often made in conceptualizing technological change is that between embodied and disembodied change. While the former requires the acquisition of new equipment in order to be applied, the latter implies that existing machinery can be made more efficient by applying new ideas. To the extent that innovation takes the form of disembodied technological change, its measurement and quantification becomes increasingly difficult (Betts, 1998).

Although the OECD definition remains appealing in many respects, the data needed for applied research have often required the identification of best proxies for the process of creation and adoption of technological change. Comprehensive reviews of innovation measures used in the literature are presented, among others, by Roger (1998), Neely and Hii (1998) and Godin (1996). As with human capital indicators, in the measurement of innovation a major distinction is often made between innovation input and innovation output indicators. The main candidate for the former is research and development (R&D) spending or staffing; while innovation output is often quantified in terms of patented inventions.

Education enhances innovation

At a more general level, Godin (1996) presents an overview of science and technology indicators and attempts to develop a set of indicators of activity and a framework to tie them together into a coherent picture of science and technology. Godin (1996) developed statistical measurements in five key areas: innovation systems; innovation; government S&T activities; industry; and human resources, including employment and higher education. The argument of Godin is that indicators such as the investment of money and human resources in R&D are limited and potentially misleading indicators. It is generally accepted that not all R&D contributes to innovation. Likewise, not all innovation is the result of R&D, as there are many examples of low-tech innovation. The emphasis on R&D tends to ignore these two facts. Roger (1998), in reviewing innovation measurements at the firm level, suggests that given the broad range of activities covered by the innovation process, aggregate indices may represent a better measure of innovation.

Since the adoption of the OECD definition of innovation, several national statistical agencies have implemented the definition in national surveys (see for instance Anderson and Schaan, 2001) and in applied research. In several cases, various innovation indices derived from survey data have been used as an indication of innovativeness.

The relevance of human capital to the innovation process is evidenced by the common use of education related indicators as a measure for innovation potential. At the level of a single organization the link between innovation and skills is made by Grant (2002), who defines innovation as "a process through which value is extracted from skills and knowledge by generating, developing and implementing ideas to produce new or improved products, processes and services".

Measures of innovation have also been identified for various geographic aggregates. The innovativeness of a region is often referred to as the intensity of innovations developed by firms in that region (Frenkel, 2000). Besides the indicators of average educational attainment, the main indicators used for territorial units are R&D expenditure and personnel, patent data, trademarks, design or other forms of registered intellectual property recorded within that region (see for instance Lall, 2001; Hanel and Niosi, 1998; Fritsch, 2002).

Difficult to assess the value of an innovation

Despite the wide use of the measures of innovation mentioned above, several researchers have pointed to the potential problems related to their use. Indeed, some authors have shed light on the shortcoming of these indicators in capturing the innovation process (Hanel and Niosi, 1998). The main critique of these standard measures of innovation comes from the literature that stresses the learning dimension of the innovation process. Innovation is considered to be the outcome of a learning process in which knowledge is transferred and translated within and between organizations and other agents (Kirat and Lung, 1999). Within this process, tacit knowledge (as opposed to codified knowledge, such as patents) plays an important role, which is difficult to quantify and measure. The limit of measuring and equating innovation to R&D has been pointed out by Holbrook and Wolfe (2002). They argue that whereas some studies have regarded R&D as the primary factor driving innovation, the current literature supports the idea that innovation is the result of a complex social process with continuous feedback among actors and institutions, including markets.

In this context innovation is coming to be understood as a more complex process. R&D is clearly a subset of innovation and industries may innovate even if they do not perform R&D. But innovation and R&D are different. Holbrook and Wolfe (2002) maintain that many clusters within Canadian industry may enjoy competitive advantages based on factors other than the measurable performance of R&D. This view appears to be supported by the finding of research that indicates that small firms are engines of innovative activities in certain industries, even though they account only for a minor share of R&D, which is typically performed by large firms (Audretsch, 2003). These considerations appear particularly relevant for the understanding and "measurement" of innovation in rural areas.

2.4. Growth

It is beyond the scope of this report to review the literature concerning the concept and measurement of economic growth. In the literature surveyed by this report, growth is generally measured by income per capita or productivity changes, such as value added per worker. Growth is regarded primarily as a single outcome indicator and limited attention is paid to the nature and quality of this outcome. It is generally agreed that there exists a multidimensional nature of development and one point should be briefly mentioned.

Educational attainment is a measure of development

Educational attainment can be seen as an indicator of human capabilities and human development; therefore, human attributes like educational attainment can be considered to be both an instrument in development and an intrinsic value or outcome of development (Sen, 1999). If one subscribed to the view of development as a process of increasing human capabilities (Sen, 1999), then it might be argued that the enhancement of human capital can have a *direct* and intrinsic relevance to well-being and freedom, and *indirect* and instrumental relevance through influencing economic production *and* social change. Although this view may have a greater relevance for developing countries, it has also some relevance in developed countries, and for disadvantaged areas in developed countries. As a result, human capital measures are acquiring an intrinsic relevance on their own and are increasingly used in combination with GDP per capita as the socio-economic indicator of the progress of nations (see, for instance, Justus, 1995).

3. The broad framework

Key issues

- Knowledge is becoming more important for growth. There is a trend towards increasing knowledge intensity in each economic sector. This shift is driven by within-industry skill intensity growth, rather than between industry employment shift. Moreover the quality of knowledge required in the production process has changed. Research has also emphasized the distinction between codifiable and tacit knowledge.

- New growth theory emphasizes that economic growth results from the increasing returns associated with new knowledge. Human capital is associated with growth at the national level and human capital is a key determinant of innovation (the process of generation and adoption of new technology). Policies that affect human capital accumulation have an effect on the growth rate of the economy.

- Recent literature has also shifted the attention from the effect of the "quantity" of education on growth to the effects of the "quality" of education on growth, which has proved to have a strong explanatory power for growth.

- Innovation is a complex process and human capital constitutes a relevant component of this process. The capacity to innovate and absorptive capacity is related to the human capital dimension, even though there is unclear evidence whether human capital is an impediment to innovation. The relationship between human capital and innovation seems to have a twofold connotation: human capital can be relevant in producing innovation (technological change); and human capital can also be relevant in the process of diffusion and adoption of existing innovation.

- There is evidence of a relationship between educational attainment and income inequality. Technological change has increased the relative demand for more educated workers (skill bias). Technological change and globalization have placed a premium on highly educated workers. Thus growing education disparity may result in growing income disparity.

This section summarizes some of the literature that linked human capital, technological change and growth without making a specific reference to the spatial dimension. The intent of this report is to set these relationships in a spatial perspective. However, many of the theoretical frameworks used at the regional level draw on insights or methods developed for national level analysis or international comparisons. Thus, even though the research that has focused on the spatial dimension has introduced new elements in the analysis, the backbone of the conceptual frameworks often comes from non-spatial research.

Because of the relevance of these topics, there are several extensive surveys of this literature. Among the many are the works by OECD (2004), Temple (2001), Cortright (2001), Hanel and Niosi (1998) and Durlauf and Quah (1998), which are often referred to in this chapter. This section is far from being an exhaustive summary of this literature. Rather, the intent is to outline some key ideas which will be further discussed in the next section, when introducing a spatial perspective in the analysis.

3.1. Knowledge, skills and human capital

Knowledge intensity is increasing in all sectors

Knowledge has always been a central element in the process of innovation and economic growth. The evidence from the last two decades, however, suggests some further considerations about the relevance and nature of knowledge in the current economic context. First, there is a trend towards increasing knowledge intensity in each economic sector. Quah (1996) uses the term "dematerialization" to describe the fact that GDP is expected to become increasingly weightless as economies becomes increasingly knowledge and information-based. Related to this, organisational learning processes have become an increasingly central component in most production processes (De Bandt, 2001). In this context, the notion of disembodied technological change, recalled in the previous section, appears to apply (Betts, 1998). Finally, the difference between various forms of knowledge, specifically tacit and codified knowledge, have been emphasised in the recent literature because of their implications for innovation diffusion.

Since the 1980s, there is increasing evidence of a shift away from unskilled workers toward skilled workers in virtually all industries. This process has been generally referred to as the ongoing shift from a "resource-based" economy to a "knowledge-based" economy. Berman et al. (1994) investigate the changes in the demand for skilled labour within U.S. manufacturing during the 1980s. They find that labour-saving technological change was the key determinant of this shift. This implies an increased use of skilled workers in each manufacturing industry, and increasing use of non-production workers associated with investment in computers and R&D. Abowd et al. (2002) observe a similar shift toward skilled labour in the U.S. using data for the 1990s. Firms reduced the employment shares of low skill workers and increased the employment shares of high skill workers in every industry.

Similar trends are observed for the Canadian economy. Baldwin and Beckstead (2003), using census data from 1971 to 2001, find that the emergence of the knowledge economy has been more widespread and continuous than previously thought. Their main conclusion is that in spite of some differences among industries, the growth of skills, as proxied by type of occupation, occurred across most industries and was not restricted to a narrowly defined high-tech sector. Gera et al. (1999) also find that the growth in skill intensity is pervasive across Canadian industries; moreover, since the early 1980s, this shift is entirely driven by within-industry skill intensity growth, rather than between industry employment shifts.

Levy and Murnane (2000) investigate the skill content of recent technological change, specifically how computer technology has altered job skill demands. They argue that computerization is associated with declining relative industrial demand for routine manual cognitive tasks and increasing relative demand for non-routine cognitive tasks. De Bandt (2001) argues that the organisational learning processes appear to be increasingly relevant in most production processes. One explanation for this, according to De Bandt, is the growing complexity of production systems and increasing uncertainty that economic agents have to face. As a consequence an increasing share of decisions in the production sphere require the support of complex knowledge.

Tacit knowledge may be less geographi-cally mobile

Several researchers have shed light on the difference between codifiable and tacit knowledge. Codifiable knowledge is the type of knowledge that can be coded, such as R&D outputs or a scientific publication, and therefore it is relatively easy to measure and to disseminate. Tacit knowledge refers to the background, experience, motivation and behavior of individuals and is embodied in the skills and routines of individuals and organizations (Kaiser, 2002). Important parts of knowledge are tacit and this type of knowledge is considered less mobile and specific to locations (Fischer 2001). The emphasis on tacit knowledge also reflects the growing emphasis on non science-based knowledge for innovation. Since the difference between tacit and codified knowledge has helped to incorporate geography into the analysis of innovation (Audretsch, 2003), this issue is further discussed in the next section.

3.2. Human capital and growth

The analysis of the relationship between human capital and growth has been a primary undertaking in the economic literature. This section highlights the recent developments in growth theory, which have reshaped the debate on the role of human capital and of public policy. Then, this section considers some of the empirical evidence on the relevance of human capital to economic growth.

Over the last two decades, the developments in growth theory have renewed the attention on the role that human capital plays in the development process. The new theoretical approach, known as new growth theory, emphasizes the linkages between human capital investment, technological change and economic growth. In so doing, it has helped re-conceptualize the ongoing shift from a resource-based economy to a knowledge-based economy (Cortright, 2001).

Previous growth theories treated technology as a given, or a product of non-market forces. Solow's model, the prevailing theory before the development of the new growth theory, conceptualized technology as a continuous flow of knowledge that was just becoming evident over time. Technology was not something that was specifically created by economic forces; rather it was determined by forces which were not explained by the growth model itself. The model did not provide any insight into the causes of technological change over time. Thus, technology was "exogenous" to the model. Implying that technology "just happened" led to an emphasis on capital accumulation and labour force improvement as sources of growth. When testing his model, Solow discovered that most of the growth of the U.S. over the past one hundred years could not be explained by increased use of labour and capital. He attributed the unexplained "residual" to technological progress. In this perspective, technology appears like a free good; that is, something that is accessible to everybody free of charge. There is no attempt to explain where it comes from or what it costs (Hanel and Niosi, 1998). Yet knowledge and technology (concepts often used interchangeably) remained, in growth accounting models, the principal sources of economic growth.

Traditional growth models assume diminishing returns

A second major characteristic of the traditional growth models was the assumption of diminishing returns. This implies that beyond a certain level, the addition of more input (labour, capital, land) results in a progressively smaller amount of output. Diminishing returns and rising marginal costs were critical assumptions in order to get a solution, and a unique equilibrium, from the mathematical equations used to describe the economy. The assumption of diminishing returns allowed the traditional growth models to work, but at the cost of an over-simplification (Krugman, 1991).

The new growth theory overcomes the assumption of exogenous technological change and decreasing returns. The new theory views technological progress as a product of economic activity. Knowledge and technology are an output resulting from investments in human capital (education and training), employment of specialized labour (R&D personnel), equipment and material inputs. The new approach is called "endogenous" growth theory, because it internalizes technology change into a model of how markets function. As a result, growth is associated with the strength of the incentives to invest in physical and human capital. Therefore, policies that affect these incentives will also change the long-run rate of growth of the economy: changes in the savings rate will change the long-run *growth rate* (unlike in the Solow model where the savings rate determines only the *level* of income and not its long-run growth rate).

Economic growth is associated with increasing returns from new knowledge

The new growth theory also points to the limitation of assuming diminishing returns to capital. The attention of the first generation of these models focused on the mechanism that prevents the returns to capital from falling below a certain level, and in particular the effects of increasing returns associated with the accumulation of knowledge. This approach points to the fact that unlike physical objects, knowledge and technology are characterized by increasing returns, and these increasing returns drive the process of growth. Knowledge has different properties than other economic goods (being non-rival, and partly excludable). Because ideas can be infinitely shared and reused, they can be accumulated without limit. They are not subject to what economists call "diminishing returns." Furthermore, the accumulation of knowledge can facilitate the further generation and acquisition of new knowledge, also through various forms of interactions among agents. Hence, the aggregate output of an economy depends not only on the amount of knowledge investment effort of a single firm or individual (such as R&D spending), but also on the effort and activities undertaken by all firms and individual in the economy. These 'spillovers' of new knowledge and technology explain why the total output of the economy may grow faster than would be indicated by the efforts of single agents.

Consumer demand for knowledge increases knowledge intensity which increases the growth rate

The supply-side effect of human capital does not tell the full story on the potential effect of human capital on growth. An alternative perspective on the consequences of knowledge intensity for the economy is provided by Quah (1996). His analysis suggests a demand-side explanation of the growth impact of human capital. The knowledge-intensity of the economy is not only determined by the quantity of knowledge used in production, but also by the quantity of knowledge-products consumed. Knowledge-products, such as computer software, new media, electronic databases and libraries, and Internet services have physical properties that resemble those of knowledge and their demand depends on the education level of the population. Thus, training and education can have a double impact in strengthening both demand and supply sides of technical development. Using these insights, Quah (1996) constructs a model of knowledge-products and growth in which the structure of demand determines patterns of aggregate economic growth. Along similar lines, Temple and Voth (1998) present a model in which the pace of industrialization is determined by the accumulation of human capital. Higher levels of human capital lower the cost of adopting advanced technologies and increase their diffusion.

Human capital differences explain one-half of the differences across US states

The empirical literature that has tested the relationship between human capital and growth with cross-country data is vast. A comprehensive review of the growth effects of education in OECD countries is conducted by Temple (2001). Kodrzycki (2002) maintains that the most detailed accounting of the role of educational attainment in U.S. growth is found in a series of papers by Dale Jorgenson and various co-authors. These studies conclude that increases in labour quality via rising educational attainment have had a measurable effect on economic growth in recent decades. Temple (1999) argues that the findings of some recent papers, which have found insignificant or negative correlations between educational attainment and economic growth, can be explained by a number of unrepresentative observations. He maintains that a subset of countries exert considerable influence on the overall results and hide the positive correlation that can be detected in the majority of the sample. Accordingly, one should focus on characterizing the most coherent part of the dataset rather than the whole sample, omitting a few observations in order to discern the pattern present in the majority of the cross-country data.

Bhatta and Lobo (2000) analyze the extent to which human capital differences can explain the differences in gross state product (GSP) per capita levels between the richer and poorer states of the U.S. They use 1990 Census and Bureau of Economic Analysis data on educational attainment, wage levels of different segments of the labour force, and GSP to compare New York – chosen as the representative rich state – with the poorest third of the states. The findings indicate that human capital differences explain at least 49% of the observed difference in GSP per capita between New York and each of the poor states.

Recent literature has shifted the attention from the effect of "quantity" of education on growth to the effects of "quality" of education on growth. This literature provides evidence that quality of education may have an impact on economic growth independent of quantity of education. Dessus (1999) argues that the ambiguity in detecting the effects of education on economic growth can be partly explained by the fact that international differences in the quality of the educational system are not taken into account. The author estimates a neo-classical growth model on panel data in which the elasticity of human capital depends on different characteristics of the educational system. Several of these characteristics explain the quality differences, such as the educational infrastructures, the initial endowment of human capital and the ability to distribute educational services equally across the population.

Quality of schooling may be more important than years of schooling

Lee and Lee (1995) find that a higher initial stock of human capital leads to a higher growth rate of real GDP per worker. The main feature of this study is that the student achievement test score rather than school enrollment rates and years of schooling is a key determinant for economic growth. Such a finding implies the presence of non-economic factors in economic growth such as school curriculum teaching methods, student's aptitudes, and even the socio demographic and cultural environments in different countries. The authors argue that the key to economic growth may not simply be a matter of money. Similar findings are reached by Hanushek and Kimko (2000), who examine the relationship between cross-country growth rates from 1960 to 1990 and average scores on various international mathematics and science tests. They find that the quality of human capital as measured by comparative skill tests has a consistent and strong relationship with economic growth. Quality of the labour force is shown to have a much stronger effect than the average years of schooling (a more common standard quantitative measure of labour force skills). The authors conclude that the importance of quality implies a policy dilemma, because their analysis indicates that a simple resources approach to improve human capital might be ineffective.

Levels of educational attainment influence economic growth

To summarize, the new growth theory brought forward two main ideas which appears particularly relevant to the subject of this paper. First, growth is driven by human capital and technological change that arises from intentional investment decisions made by economic agents. These decisions are in response to endogenous incentives determined by polices and contexts. Second, the increasing returns to knowledge propel economic growth; part of the increasing returns are explained by various forms of interactions – i.e. interdependencies between individual behavior, such as externalities and knowledge spillovers – which had been neglected by mainstream growth models.

The cost of generating and adopting new technology may be lower in technology –intensive regions

New growth theory has provided new support for the role of public policy. One of the main implications of new growth theory is that human capital investments affect technological change and this, in turn, has an impact on economic growth rates. In this perspective, the *rate of growth* of an economy is determined by the decisions of economic agents, such as the accumulation of physical capital, human capital investments, or firms' R&D expenditures. In turn, these decisions can be affected by taxes and subsidies, that is, by public policies. Public policies that encourage investment in human capital can enhance efficiency and accelerate the economy's growth rate (Fortin and Helpman, 1995). In contrast, markets forces alone may not lead to optimal investment in human capital resources. New growth modeling shows that, partly because of the public good nature of knowledge and the associated externalities, market forces alone can lead to equilibrium conditions characterized by sub-optimal investment in human capital and research capacity (Romer, 1990). A second implication, and most important for the focus of our paper, a regional economic system may not converge toward a steady state; on the contrary, is that technological and regional development may exhibit path dependence. As pointed out by de la Fuente (2000), if the cost of additional innovation falls with scientific or production experience, the return on technological investment may not be a decreasing function of the stock of accumulated knowledge. Under these circumstances, the cross-regional differences in levels in technological capacity, and eventually economic well-being, could persist indefinitely.

3.3. Human capital and innovation

Skills training enhances innovative capacity of firms

Human capital factors are among the primary determinants of an environment conducive to innovation and technological change. This relationship is implied by most of the literature on human capital, innovation and growth. However, the relationship between human capital and innovation seems to have a twofold connotation: human capital can be relevant in producing innovation; and human capital can be relevant in the process of diffusion/adoption of existing innovation. Despite the generally acknowledged relevance of human capital to innovation, a question that has received particular attention is whether the lack of human capital may represent an *impediment* to innovation.

The concept of skills enhancement and innovations imply a process of knowledge generation, acquisition and sharing. These have been closely associated in the macroeconomic literature. For instance, OECD (2004:30) notes that "Expenditures on education and training could … have a more permanent impact on the growth process if high skills and training go hand-in-hand with the process of innovation, leading to a faster rate of technological progress, or if a highly skilled workforce eases the adoption of new technologies. Advances in technology indeed often have strong links with education, especially at the higher level. Thus, education may not only make a contribution to growth via improvements in the quality of the workforce but also a contribution via innovation."

At the micro-level, research on small and medium-sized business in Canada and the U.S. has demonstrated that the emphasis on human capital is an important part of an innovation strategy and that skilled workers are crucial to innovative firms (Baldwin and Johnson, 1996; Baldwin, 1999; Gale, 1997a and 1997b). Gellatly (1999) profiles the differences between innovator and non-innovator establishments in business services. The findings indicate that innovators place more emphasis on recruiting skilled labour. For these firms, financing and human resources play a crucial role in the innovation process and they are also more likely to report difficulties related to skills restrictions. In a study by Kangasharju and Nijkamp (1997), support measures for skills training are indicated by the interviewed firms as particularly important for innovations, among over 20 determinants. The results of a logit model indicate that skills training links with a local university, in particular, contribute significantly to the propensity to innovate.

R&D allows "catch-up" which is a social return for lagging regions

At the regional level, skills availability is also indicated as a relevant determinant of the capacity to adapt to the evolving needs of the labour market. Ceh (2001) argues that the southern and western parts of the U.S. are today important source points for industrial creativity that can rival the Northeast. In these areas, regional technology production, based on patent activity, is helped by the presence of professional skilled labour, rather than manufacturing and related activities.

The concept of absorptive capacity (or innovative ability, capability, or competencies), as applied to firms or regions, is particularly relevant in this regard (Neely and Hii, 1998). Authors such as Cohen and Levinthal (1989), and Griffith et al. (2001) have claimed that R&D has two faces. In addition to the conventional role of stimulating innovation, R&D enhances technology transfer by improving the ability of firms to learn about advances in the leading edge. Griffith et al. (2001) find evidence that R&D is important in this catch up process as well as stimulating innovation directly. Human capital also plays a major role in productivity growth, but they only find a small impact on trade.

R&D increases innovation and increases the capacity to absorb the innovations of others

Similarly, Kinoshita (2000) investigates the two faces of R&D: innovation and absorptive-learning capacity. The argument is that R&D has both a direct effect on innovation as well as indirect effect through enhancing a firm's capacity to identify and assimilate outside knowledge. Technology diffusion is not an automatic consequence from the presence of the knowledge stock of others. It also requires that the recipient possesses the ability to absorb and to adopt the technology. R&D activities can help to increase the incidence of technology spillovers by enhancing the firm's absorptive capacity. Consequently, R&D affects the productivity growth of firms via two channels. First, it directly increases the technology level by adding more new information (innovation). Second, R&D increases the absorptive capacity of the firm and induces a greater extent of technology spillovers. Kinoshita argues that the learning effect of R&D is far more important than the innovative effect in explaining firms' productivity growth.

A substantial body of research has investigated the factors which either impede or support innovation at both the firm and the regional level. Among these factors are the availability of the skilled workforce, the presence of regional technological infrastructure, strong public support for innovation and the existence of trade linkages (Neely and Hii, 1998). Other research has investigated the potential impediment to innovation posed by skills availability (Sabourin, 2001; Baldwin and Lin, 2001), or more generally, the identification of the barrier to innovation (Mohnen and Rosa, 1999). According to Morck (2001), one consistent finding of empirical research is that innovation, as measured by R&D, raises the demand for high-skill workers and drives up their wages. Nevertheless, whether or not the paucity of a skilled workforce represents an impediment to innovation at the firm level remains a controversial issue (see for instance Baldwin and Lin, 2001).

3.4. Innovation and growth

Higher educational levels imply higher earnings and lower inequalities

Technological change and innovation are one of the main drivers of economic growth. At the macro level, despite the concerns raised by Godin (1996) with regards to R&D as a comprehensive measures of innovation, R&D expenditures are strongly correlated with technological adoption and with economic growth (OECD, 2004). At the firm level, a strong emphasis on technology appears to be highly correlated with a firm's growth. For instance, Hanel and Niosi (1998) note that for both large and small or medium-sized enterprises, high growth rates are strongly correlated with R&D investment. Several other empirical studies support this claim (Baldwin, 1999).

Over the last decade, however, a question that has attracted considerable attention is the effect of technological change on income distribution. Research addressing this question has focused in particular on the effect of the new information and telecommunication technologies (ITC), whose rate of adoption surged over the 1990s. This debate appears also to have implications for the spatial dimension of growth.

Wages of skilled workers have increased, relatively

This stream of literature originates from an uncontested empirical observation: during the 1990s, wage inequality between high and low skill workers has widened in several OECD countries. Various studies report an increase in the university-high school wage premium. For instance, Bradbury (2002) assesses the relationship between education and wages in the 1980s and 1990s in the U.S. The author observes an increase in the "educational wage premium", defined as the degree to which highly educated workers are paid more than less-educated workers. The payoff to education has risen steeply in recent decades and this accounts for a significant fraction of the increase in overall wage inequality. Berman and Machin (2000) consider the shift in the skill structure of employment in the developed world, illustrating how demand has shifted in favour of skilled workers and how these relative demands shifts have been larger in technologically advanced industries.

The hypothesis that has been put forward to explain these inequality trends is that the recent wave of technological innovation is biased in favour of high skilled labour. The fact that technological change may have an effect on the use and remuneration of factors of production is well understood and accepted (Betts, 1998). The skill bias hypothesis implies that high skills employment is a complement to new ITC technology adoption. Investments in ITC have increased the demand for, and ultimately the wage of, high skilled workers relative to low skilled workers.

The literature on skill biased technological change is briefly summarized in Box 1. The hypothesis has not been unanimously accepted and further explanations have been proposed. Yet, this literature has pointed out that, to the extent that human capital attributes are not uniformly distributed across space, educational inequality may become a relevant explanatory factor of increasing territorial inequality.

Box 1. Skill biased technological change and income distribution

One of the widely investigated and best-documented empirical regularities is the positive relationship between education attainment and personal income earnings (Temple, 2001; Checchi, 2000; De Gregorio and Lee, 1999). The rising inequality trends recorded during the 1990s have provided a new stimulus to the literature that investigated this relationship.

The key hypothesis that has been put forward to explain growing wage inequality trends - often referred to in the literature as skill biased technological change - is that the current wave of technological change affected the distribution of income in favour of high skill occupations.

The insight underlying the skill bias process is that skilled and unskilled workers present different degrees of complementarity with new technologies (Eicher and García-Peñalosa, 2001; Murphy et al. 1998). Neo-classical growth models consider more educated workers as a perfect substitute for less educated workers, or technology as a complement with both types of workers. Under this assumption, technological change would not affect the relative wage of workers with different levels of education. The proponents of the hypothesis have argued that there is little support for this assumption; in contrast, more educated workers can be considered a stronger complement with new investment than less educated workers. Thus, despite a certain degree of substitutability, workers with different levels of education are not perfect substitutes. The new wave of technological change has generated a demand for new skills that outstrips its supply and so creates scarcity rents for skilled workers (Murphy et al., 1998).

There are clear policy implications that follow. Murphy et al. (1998) argue that government can affect the relative wage by controlling the supply of skilled workers through investing in education. Their results suggest that changes in the supply of skilled workers appear to be the most important force causing variations in trends in relative wages. Hence, policy makers who want to affect relative wages may want to adjust the relative supply of skilled workers, through policies that raise educational attainment such as educational subsidies, rather than the relative demand.

The hypothesis of skill-biased technological change has not been unanimously accepted as the primary explanation of the observed relative wage shifts. There is controversy and open debate on the actual causes of the observed disparity trends. Machin and Van Reenen (1998) compare seven OECD countries and show that there were dramatic changes in the wage structure of the UK and the US but relative stability elsewhere. The authors infer that there can be other factors in addition to technology that have contributed to the declining labour market position of unskilled workers and suggest that the declining role of labour market institutions may also explain the observed changes in factor remunerations. Along the same line, Card and Di Nardo (2002) argue that the evidence in favour of this hypothesis has weakened over the 1990s, as wages stabilized in spite of continuing technological advances. They conclude that the trends in the minimum wages, declining unionization and the re-allocation of labour caused by the 1982 recession should be further investigated as potential explanatory factors of relative wage shifts.

Other authors have emphasized the effect of the globalization process on income distribution. Shankar and Shah (2001) maintain that globalization places a premium on skills. With globalization, skills rather than the resource-base determine the competitiveness of a region, and in this process skilled workers gain at the expense of unskilled workers. Feenstra (1998) provides further support to this view in considering the process of international outsourcing of production that characterise globalization. Since outsourcing is likely to reduce the domestic demand for unskilled workers relative to skilled workers (in industrialised counties), this process has a qualitatively similar effect to skill-biased technological change. The distinction between “trade” and “technology” effects could be in fact blurred, as the position of low-skilled workers in the industrial countries is worsened by the complementary combination of globalization and new technology (Feenstra, 1998).

4. The relevance of space

Key issues

- The available evidence suggests that the relevance of space has not decreased in the new economy. Knowledge, and specifically tacit knowledge, is a location-specific attribute that does not move easily across space. New technologies have made location more important (rather than less important); agglomeration is persisting and increasing, indicating the pervasive effect of agglomeration economies and increasing returns.

- Spatial variation of human capital indicators is a normal phenomenon partly related to the different industrial structure of each region. Concerns about the large regional differential in human capital levels have been raised due to the increasing importance of knowledge in the production process. Moreover, a process of change that has attracted considerable attention is the spatial segmentation of the labour market: urban labour markets have increasingly attracted high-skill jobs, while rural labour markets have tended to attract low-skill labour.

- Space has relevant implications for the innovation process as well. The stage of maturity of the industry, specifically the industry life-cycle, has been used to explain industry location and innovation patterns. Specific local attributes also matter: particular regions have developed specific ways of producing and sharing innovation. The concept of a "regional system of innovation" has become prominent in the literature. This idea embodies the notion of proximity, networks, and a complex set of institutions and local relationships that support innovation.

- Local human capital influences the innovation potential in various ways. Local human capital resources are essential for local collective learning processes, because labour is more mobile within a region than between regions. Geographic proximity facilitates knowledge spillovers and accelerates the accumulation of human capital.

- Most of the empirical research that has explicitly compared urban and rural innovation performance assumed that resource-rich urban areas may be more conducive to product innovation while more rural areas are better suited to process change. The evidence on innovation propensity of areas with various degree of remoteness does not appear conclusive. However, substantial data and methodological problems are reported for this type of research.

- Rural regions, characterized by remoteness, low population density and small agglomerations, may face several problems when attempting to increase human capital and stimulate innovation. Under these conditions, disparities can persist or even increase, leading to a so-called "spatial poverty trap". Spatial poverty traps suggest both efficiency and equity arguments for investing in disadvantaged areas. The literature points to some of these intertwined problems.

- Individuals and communities in rural areas may under invest in education, because of the lack of incentives. The return to education tends to be lower for rural residents; and communities may face problems in capitalizing on their investments in education due to the high-mobility and out-migration of high-skilled workers.

- The lack of agglomeration economies has an effect on productivity and accumulation of human capital. Geographical proximity offers more innovation opportunities than scattered locations due to knowledge spillover and networking opportunities. Also, rural areas often have few institutions (such as universities and research facilities) that can support the innovation process.

Human capital is ultimately an individual attribute. Similarly, innovation is a process that can be ultimately measured at the firm level. Besides the more descriptive analysis of the nature and existence of spatial variation in human capital and innovation attributes, when space is introduced in the analysis of behavior of micro-units there appears to be two major sets of questions that have been tackled in the literature. First, researchers have investigated how spatial features such as distance, density, and agglomeration influence human capital and innovation outcomes. Second, researchers have attempted to disentangle compositional effects from context effects. For instance, does the geographic concentration of individuals with a certain level of human capital have a different effect on the behavior and outcome of a single individual in that area as compared to a similar individual located in an area with different characteristics? Ultimately, the rationale for, and the effectiveness of, rural, territorial and regional policy relies on the understanding of these issues.

The review of the literature suggests that there are two concepts that help with framing a response to these questions. These refer to the nature of *incentive* and *interaction* faced by various actors in each regional context. Investment decisions with respect to human capital are made in response to incentives. These incentives may vary systematically by type of region. Learning as well as innovation (in its broadest meaning of generation and acquisition of new ideas) implies interaction between individuals; this in turn results in various forms of interdependences between individual decisions which are not mediated by markets (Brock and Durlauf, 2001). Elements such as population density and regional socio-economic characteristics can substantially shape these interactions and eventually determine economic outcomes.

The issues discussed in this section are highly interconnected and often two faces of the same coin. In an attempt to organise the discussion, the chapter is divided into seven sections as follows. Section 4.1 reviews the evidence of spatial variation of human capital indicators and sub-national models. Section 4.2 presents the literature on the spatial dimension of innovation and technological change. Section 4.3 reviews the literature on spatial knowledge spillovers. Sections 4.4 to 4.7 discuss some of the challenges that small and remote communities can face in enhancing their level of human capital, including the relevance of agglomeration and density of socio-economic activities, returns to education investments and migration patterns, and spatial poverty traps.

4.1. Spatial variation of human capital and its contribution to local growth

Spatial patterns of skills persist

Spatial variation of skills and educational attainment is a normal phenomenon partly related to the different industrial structure of each region. Over the long run, the regional change in labour force composition, from unskilled agriculture to non-agricultural employment, along with technological adoption and diffusion, has been one of the major drivers toward regional economic convergence. The very essence of development is often described as the structural shift from a low-education rural labour force to a highly educated urban labour force. Caselli and Coleman (2001) model this idea for the U.S. economy over the last century in order to explain regional convergence. They suggest that a key determinant of the shift in the relative supply of unskilled farm workers has been the long run decline in the cost of acquiring non-agricultural skills, due to factors such as declining transportation costs, improved quality of education and increased life expectancy.

Empirical evidence on spatial variation for a multitude of human capital indicators is relatively abundant. Campbell et al. (2000) present an analysis of skills variation in the U.K. This analysis indicates systematic variations of skill levels between regional districts and shows, by using simple correlation analysis, an association between skill levels and various indicators of local economic performance. Kodrzycki (1999) investigates the geographic shifts in higher education across U.S. states, as related to demographic factors and persistent tuition differential across States. Cartwright and Allen (2002) investigate the rural-urban variation in reading skills of Canadian students, and find that urban students perform significantly better than rural students. Alasia (2003) presents trends in educational attainment across Canada from 1981 to 1996, showing a closing gap for primary education but a persistent gap in university educational attainment between urban and rural regional types. Beckstead et al. (2003) find that after controlling for industry and urban-rural structure there is no significant difference in knowledge intensity, as measured by occupational attainment, across Canadian provinces. This suggests that rural-urban differences prevail over the macro-regional differences.

Potential for regional disparities to persist

Large regional disparity in human capital indicators, however, remains a major policy concern. Some authors have indicated that these disparities represent a threat in federal states, as the inability of the state to deal with such inequities creates the potential for disunity and challenges social cohesion. Others have pointed to the potential problems associated with a persistent spatial division of labour, due to the rising inequality in wage remuneration in favour of skilled workers. In the remaining parts of this section, we review the theoretical models that link human capital and growth in a spatial framework. Second, we summarize the empirical evidence that relate to human capital attributes to local growth, as well as the spatial distribution of human capital and its changes over time.

At the sub-national level, the evidence about the contribution of human capital to local economic development is somewhat controversial. Bollman (1999a and 1999b) suggests that the human capital in Canadian communities did provide a positive but weak boost to job growth in the locality during the 1980s. Rappaport (1999) using a newly constructed data panel on U.S. locality attributes, sketches four sets of empirical facts on economic growth across U.S. counties. Controlling for local government size, local growth is positively correlated with expenditures on elementary and secondary school education. Regression analysis reveals a strong and positive correlation between high initial levels of human capital (as measured by the percentage of adults with four-years of college or higher) and growth (as measured by the rate of net migration, per capita income growth, and growth in housing median value). A five percent increase in a county's percentage of adults with college degrees would raise its net migration rate by one-half of a percent and both its per capita income growth rate and housing median value growth rate by more than one-quarter a percentage point. Coulombe (2003) notes that, at the regional level in Canada, human capital is a necessary but not sufficient condition for growth.

Box 2. Effect of spatial interdependence depends on how the model is constructed

New growth theory has shifted the focus to the relevance of human capital as a key input in the generation of new ideas, thus placing education as a central determinant of growth. In its original formulation this theory left out spatial considerations, assuming that the stock of knowledge was freely available to everyone (Acs and Varga, 2002). Attempts to extend the analytical framework to account for space interdependence have been conducted by Nijkamp and Poot (1998). According to these authors, spatial interdependence between regions can occur through factor mobility, the diffusion of innovations and trade and can eventually influence technological changes and growth. However, these authors show that the effect of spatial interdependence depends on the specification of the theoretical model. The results generated by these authors show that spatial convergence, a steady state with persisting spatial differences in growth rates and unstable growth are all theoretically possible.

A number of formalised models have been proposed to investigate the effect of alternative policy options, in particular alternative systems of education financing, on regional economic disparities. De la Croix and Monfort (2000) investigate the links between alternative types of education funding systems and regional convergence. They investigate the process of regional convergence within the framework of an overlapping generations model in which the determinant of growth is the accumulation of human capital. The model considers different education funding systems and compares the performance of two heterogeneous regions in terms of growth rates and pace of convergence. This model suggests that the choice of a particular education system (such as private versus publicly-funded schools) incorporates a possible trade-off between long-run growth rate and short-run convergence. In such choices, the initial capital stock and the extent of regional human capital discrepancy appear as central variables.

Palivos and Wang (1996) develop a dynamic general equilibrium model with spatial interaction (using a monocentric city set up). In their specification, human capital externalities are the centripetal force that leads to agglomeration, while the cost of transporting resources is the main centrifugal force opposing agglomeration. The model is used to investigate the socially optimal and decentralized growth rate. In the decentralized environment, the authors argue that individuals under invest in human capital, because they do not take into account the positive spillover effects that an increase in their human capital has on the community. The authors investigate how public policy can enable a decentralized city to attain the socially optimal allocation.

Bradley and Taylor (1996) examine the interaction between skills and educational attainment and the local economy using spatially disaggregated data. The evidence suggests a cumulative process which results in economic divergence. Economic performance affects the quality and the quantity of educational output. In turn, the quality and quantity of educational outputs affects economic performance (Bradley and Taylor, 1996). Mauro (2000) reports a positive and significant influence of schooling investment on the long-run growth of the Italian regions in the period 1963-1995. This finding is in contrast to those of previous studies. This result is obtained when the unemployment rate is added as an additional controlling dimension. Accumulation of human capital is a learning-by-doing process where scholastic knowledge must be combined with working experience. The dynamic steady state of the model implies a negative relationship between long-run growth and equilibrium unemployment rate. Evidence on the relationship between skill levels, growth and its spatial dynamic, even though restricted to urban areas, comes also from Glaeser and Shapiro (2001). The authors show that the 1990s have been a decade of rapid growth for the largest U.S. cities. But growth was higher in cities with a strong human capital base and with better climatic conditions (warm and dry places).

Urban appears high-skilled; rural appears low-skilled

A process of change that has attracted considerable research attention is the spatial segmentation of the labour markets. Although the macro-regional trends suggest a process of convergence of the human capital level (see for instance Coulombe, 2003), other evidence suggests that urban labour markets have increasingly attracted high-skill jobs, while rural labour markets have tended to attract low-skill labour to perform relatively routine and simple tasks. This spatial specialization, combined with relative wage shifts in favour of high-skill workers could reinforce territorial income disparities.

Rural-urban polarization may continue

Wojan (2000) analysed the changes in the spatial distribution of skilled labour in the U.S. The hypothesis that drives this research is that employment growth has been characterised by low-skill job concentration in rural areas and high-skill job concentration in urban areas. The results support this hypothesis for the U.S, particularly during the 1980s. According to Wojan, this trend raises concerns about the long-term sustainability of this process and the potential increasing vulnerability of rural areas. Barfield and Beaulieu (1999) observe a similar trend for the Southern US. The authors suggest that a polarization is emerging within tomorrow's workforce of the Southern U.S. Using industry and occupational projections from the Bureau of Economic Analysis and the Bureau of Labor Statistics, the authors observe that, on the one hand, the largest numbers of new jobs are expected to occur among occupations requiring no post-secondary degree. On the other hand, a significant portion of the fastest growing occupations are demanding post-secondary training or degrees. These trends have important implications on the anticipated earnings and employment experiences of Southerners; according to the authors the expected changes in the economy will exacerbate the gap between the educated and undereducated, the skilled and unskilled. This polarization is likely to effect rural areas.

But knowledge workers are increasing at a faster rate in rural areas

Recent research findings for the U.S., however, suggest that rural areas have also been affected by the long-term national movement toward a more skill-intensive economy (Gibbs and Kusmin, 2003). In fact, the evidence for the 1990s shows that the share of workers in low-skill jobs declined more in rural areas (2.2 percentage points) than in cities and suburbs (1.1 percentage point). According to this study, most of the decline in the low-skill share of U.S. rural employment is attributable to occupation shifts within industries. This study also indicates that educational attainment (which closely tracks skill measures) rose at the same rate for both the rural and urban population during the 1990s. Beckstead and Vinodrai (2003) found that although the probability of being a knowledge worker in rural areas was less than in urban areas in both 1971 and 1996, the probability of being a knowledge worker increased at a faster pace over the period in rural areas compared to large urban areas. It should be emphasized, however, that this research adopts a very inclusive definition of "knowledge workers" which extends to what are generally defined as technical occupations.

Büchel and van Ham (2002) analyse how macro-level opportunities (regional labour market characteristics) and micro-level restrictions (the extent to which job searchers are restricted to the regional labour market) can help to explain the phenomenon of over-education. Access to suitable employment is severely restricted by the fact people look for jobs in the regional labour market rather than the global one. The authors use a multilevel model, which links regional data to micro-data from the German Socio-Economic Panel (GSOEP), and a Heckman two-step procedure to control for selective access to employment. The results show that the size of the labour market is an important factor in avoiding over-education. Looking for a job on a large labour market increases the probability of finding a suitable job.

Box 3. Local labour market and skill matching

Some of the literature that explored the human capital characteristics of local labour markets has investigated the nature and effects of a mismatch between demand and supply of human capitals at the local level. Green et al. (1998) explore the notion of skills shortage and vacancies that are hard to fill from a firm perspective. According to this study there is a considerable overlap between the two concepts. However, there are also a substantial number of establishments which fit into one or the other category, but not both. While many employers see skill shortages as hard to fill vacancies, there are also some employers who see the problem in wider terms, perhaps taking a longer term view than just their recent recruitment activities.Green and Ashton (1992) argue that the emphasis on skill shortage misunderstands the real problem facing Britain and other nations in relation to their skills base. Skill shortage is defined as: 'when there are not enough people available with the skills needed to do the jobs which need to be done'. This divides into two subcategories: first, recruitment difficulties measure shortages in the external labour market; and second, a skill gap exists in the internal labour market when 'firms existing staff do not have the skills they need to do their job effectively'. The difference between the current and the optimal level of skills is defined as "skill deficiency". The demand for optimal level of skills is often wrongly equated with companies' actual demand of skilled labour.Green and Owen (2001 and 2003) look at the relationship between vacancies proving hard to fill for skill-related reasons, unemployment and employment growth. Results reveal that there is a weak negative relationship between the incidence of skill-shortage vacancies and the local unemployment rate (areas with low unemployment rates tend to have a high incidence of skill-shortage vacancies and vice versa). There is a weak positive relationship between the incidence of skill-shortage vacancies and recent employment growth (areas experiencing greater employment growth in recent years tend to display a higher incidence of skill-shortage vacancies). By disaggregating the UK data by region, the results show that most developed regions register a mismatch between skills demanded by employers and skills possessed by workers. In these regions, both the unemployment rate and skill-shortage vacancies are higher than expected.

A skills shortage means a lack of supply of skilled workers to hire and / or an existing workforce in need of skills enhan-cement

4.2. Spatial dimension of innovation, regional innovation systems and clusters

Innovation and spatial patterns of develop-ment are inter-twined

The literature indicates that the innovation process has both a sectoral as well as a spatial dimension (Fischer, 2001). These two dimensions are often intertwined and difficult to disentangle. We start this section by presenting some evidence on industrial location that has implications for the observed spatial patterns of innovation. Then, we shift the attention to the innovation literature that has emphasized the role of locality and space. Part of this literature has underlined the innovative capacity of cities, in which density of institutions and networks facilitate the generation and diffusion of knowledge. Another stream of research has placed greater emphasis on the region and the regional innovation system. Some of this literature has taken a case study approach (Isaksen and Smith, 1997; Isaksen, 1998; Koschatzky, 2000; Frenkel and Shefer 1996). In this section, a greater emphasis is given to the research that analysed cross-sections of territorial units.

With regard to the sectoral dimension of innovation, the technological intensity and the relevance of technological change clearly have an industry-related connotation. Industries differ in their use of technology. Hanel and Niosi (1998) distinguished between low, medium and high technology industries, with the latter being those that invest more in research and technology. In turn, the different technological intensity of industry is likely to have an effect on the spatial distribution of the industry. Research also indicates persistent industrial localization patterns. For instance, Polèse and Champagne (1999) show that industrial specialization varies systematically with city size and distance from urban agglomerates, and these spatial patterns are persistent through time.

Spatial patterns of innovation are consistent across countries

Breschi (2000) investigates the geographical distribution of innovative activities in relationship to sectoral differences due to the difference in the underlying technology (summarised by the concept of technological regime). The analysis uses patent data for a set of EU countries from 1978 to 1991. The results confirm the existence of differences across technological classes in the spatial patterns of innovation. Spatial patterns of innovation differ systematically across technological classes. These patterns are similar across countries for each technological class, therefore suggesting that industry-specific and technology-specific factors (i.e. technological regimes) have a bearing in shaping the spatial patterns of innovation across countries.

The incubation phase of innovation tends to be urban

The stage of maturity of the industry, specifically the industry life-cycle, has also been used to explain industry localization and innovation patterns. Kangasharju and Nijkamp (1997) argue that the phases of an industrial life-cycle tend to create spatially recognizable impacts on the innovativeness of firms. The authors use the three-phase technological trajectory suggested by Davelaar to represent the spatial-dynamic process of innovation. Following Krugman, the authors argue that the initial locations of new technological systems are often somewhat arbitrary. The initial stage of a technological trajectory (incubation) is concentrated in a very few locations; firms tend to agglomerate near innovating firms, mainly because of the need for skilled labour and information. During the incubation phase, when major product innovations are made, firms are usually concentrated in central (usually urban) areas because early innovations are more dependent on the urban 'milieu' than subsequent innovations. During the second phase (competition), product innovations become more marginal and process innovations prevail. The relevance of the urban milieu (such as research institutions) tends to diminish. Hence, innovativeness of entrepreneurs in intermediate and peripheral areas will then tend to rise. Finally, during the last phase (stagnation) of innovative behavior, peripheral (rural) areas may even be in a favourable position as compared to urban areas.

Some authors have emphasised the predominantly urban nature of the innovation process (Duranton and Puga, 2000; Florida, 2000). Davelaar (quoted in Kangasharju and Nijkamp, 1997) distinguishes four groups of factors affecting local innovativeness:

- agglomeration economies which include location economies accruing from the presence of the same industry and urban economies accruing from the presence of different industries;

- local resources of human capital, local customers and size of the local market area;

- the availability of specialized information and intensive communication networks including educational institutes; and

- social overhead capital which responds faster to a new demand for technological systems in central areas than in the periphery and which requires various local institutions and physical infrastructure.

Scale and diversity of cities matter

Frideman (quoted in McCann, 1987:36) argues that innovation (defined as the introduction of new ideas, or artefacts perceived as new, into a social system) is the key element that distinguishes core from peripheral areas. Core areas are those capable of innovating. Jane Jacobs has argued that cities play a decisive role in economic growth. Jacobs maintains that new knowledge created in cities drives human economies and progress. In two books, *The Economy of Cities* (1969) and *Cities and the Wealth of Nations* (1984), Jacobs describes the process by which cities generate new forms of work. In particular, the scale of cities and their diversity of inhabitants create the interactions that generate new ideas. More recently, other authors have evidenced the potential urban bias of the knowledge economy (Florida, 2000), arguing that innovative and creative energy is predominantly urban.

Different regions "socialize" innovation differently

A large body of research has emphasized the role of regions in the process of innovation. This literature hinges on similar concepts as outlined above for innovation in cities, but further concepts are introduced into the analysis. Although innovation can be ultimately seen as a firm attribute, this literature emphasizes that innovation is social in character and that some regions have developed specific ways of producing and sharing it. Several terms have been used to capture the notion of a regional innovation process. Among these are "learning region", "regional innovation system", "innovative milieu" (OECD 2001a; Wolfe, 2002b) and "innovation prone/adverse society" (Rodriguez-Pose, 1999). These terms primarily entail the capacity of a geographic area to foster and support technological change and innovation.

Innovation has a spatial component

Most of this work has developed around the idea of "systems of innovation". This refers to the sets of economic agents participating in the creation and development of new and improved products and processes, and the collection of flows that occur among these agents within a national or regional economy (Hanel and Niosi, 1998). The agents involved include primarily the innovative firms, public laboratories and universities. Within the system of innovation approach, a major distinction has been made between sectoral/technological systems and localized systems (Fischer, 2001). The latter, which imply some form of geographic proximity, have gained increasing attention in the literature. During the 1990s, the concept of national innovation system (see Hanel and Niosi, 1998) was gradually overshadowed by that of regional innovation systems (Cooke, 2001), territorial innovation systems (Morgan, 2001; Fischer, 2001), or spatial innovation systems (Oinas and Malecki, 2002).

Holbrook and Wolfe (2002) referred to a "regional system of innovation" as the complex set of institutions and relationships that sustain the capability of a firm to innovate. This system includes the regional communities of firms and supporting networks of institutions that share a common knowledge related to a shared access to unique skills and resources.

Innovation appears spatially specific or "clustered"

At the core of this shift (from national to regional systems) is the idea that geography is important in shaping these systems, as they are based in clusters or industrial districts. A substantial part of this literature is generated from the work of Porter, who showed that the U.S.'s competitive lead in innovation hinged on the existence of regional and local innovation systems based in spatially delimited clusters (Cooke, 2001). Globally competitive firms in any given industry are not only found in particular nations, but are frequently concentrated in particular regions, or even cities, within those nations. This has proved to be particularly true in new economy, high-tech sectors. Since its introduction in the early 1990s, the idea of "cluster" has become one of the most appealing models to enhance industrial performances for policy makers worldwide (Best, 2001; OECD, 1999; Isaksen, 1998). This literature has emphasized that the development of new innovative capabilities tends to be location-based, as it occurs in a specific area and displays a strong regional component (Wolfe, 2002a). Firms that are located in different regions, but have identical innovative inputs, may have different innovative outputs. The essential ingredients of this literature are the notions of proximity, networks and the emphasis on institutions. These three elements are further discussed below.

Proximity of producers and markets plays a limited role

The relevance of proximity, among actors involved in the innovation process, to the innovation process itself is investigated by Green and McNaughton (2000), Kirat and Lung (1999) and Morgan (2001). The most relevant dimension of proximity is geographic proximity, as measured by the physical distance between the actors involved in the innovation process. A specific dimension of proximity, which refers to the distance between producers and markets, is investigated by Cornish (1997). Information about markets (or market intelligence) is a critical input to product innovation. The conclusion of Cornish (1997) is that proximity between producers and markets plays a limited role in product innovation.

Buyer-supplier networks have a spatial character

Cooperation and networks are a second key ingredient in the functioning of regional systems of innovation. Proximity allows the development and strengthening of cooperative relationships and networks for innovation. Oerlemans et al. (2001) investigate why innovator firms engage in innovation networks and which factors explain the spatial dispersion of these networks. They used a modified production-function approach in which innovative output depends on the presence and volume of innovative resources and the utilisation of these internal and external resources in the innovation process. Spatial concentration of innovation networks of buyers and suppliers turned out to have a reciprocal positive relation to interaction intensity between firms. Interaction enhances spatial concentration of relations and vice versa, although the strength of the effect differs for ties with buyers and suppliers. The authors found that higher regional economic embeddedness increases spatial concentration of innovation networks, whereas R&D effort had no effect at all.

Institutions such as universities, think-tanks, vocational training providers and trade associations are also essential in shaping innovation dynamics within a region (Holbrook and Wolfe, 2002). These institutions offer specialized training, information, and technical support that are critical to the innovation process. Wolfe (2002a) suggests that a comprehensive framework of policies to support the innovation system must recognize the interactive and interdependent nature of the roles played by this array of actors. Local education and research facilities contribute to this local accumulation of skills and knowledge, because producers gain when at least part of the costs of job training as well as basic R&D are carried out by such institutions. Best (2001) develops the idea of "technology management" as the capacity of a region to absorb and develop technology. This capability is embodied in and amongst business enterprises and partner institutions. Advancing technological management capabilities are organizational accomplishments that underlie the industrial development process.

Tacit knowledge is geographically "sticky" – local institutions can augment this asset

Within the cluster/regional system of innovation framework, the role of human capital has been investigated by several authors. There are two main elements that define the conceptual nexus between local human capital and the innovation process. First, as put by Morgan (2001), knowledge tends to be spatially 'sticky'. Despite the diffusion of new ITC technologies that make diffusion of knowledge potentially easier, a relevant part of knowledge, namely tacit knowledge, is not easily communicated other than through personal interaction and physical proximity. Second, regional agglomeration and local labour market pools facilitate a collective learning process whereby information, knowledge and best practices are diffused rapidly throughout the local milieu, thus increasing the innovative capacities of firms (Neely and Hii, 1998). This idea is related to that of local knowledge spillovers, which is further discussed in the next section. These interactions between local human capital and innovation output have often been tested by using a "knowledge production function", which is in essence a functional specification that links innovation outputs measures with innovation inputs measures (see also Breschi and Lissoni, 2001). The following points further elaborate on these ideas.

Informal linkages among (local) firms provide collective learning

Advocates of the "innovative milieu" school argue that local human capital attributes are extremely important in the innovation process. These human capital attributes are also represented by informal linkages between firms in a region, and synergy effects from a common cultural, psychological and political background. The importance of local human capital resources results from the fact that they tend to stimulate local collective learning processes, because labour is more mobile within a region than between regions (Kangasharju and Nijkamp, 1997). One of the core ideas of a regional innovation system is that when looking at localized knowledge a major distinction should be made between codified and tacit knowledge (Fischer, 2001). According to Fischer (2001), since tacit knowledge is collective in nature and related to a socio-cultural context, it is territorially and place specific. Camagni and Cappello (1997) analyze the Italian regional industrial structure, in terms of performance and innovative behaviors. The evidence suggests the capacity of small firms to innovate is promoted only in certain spatial contexts, where dynamic spatial elements support this process. According to the authors, collective learning is one of these elements.

Similarly, Patrucco (2003) suggests that localization is conducive to a multilateral exchange of interdependent and external knowledge bases. The author presents the case of the Brianza technological district in Italy and shows that different and yet complementary knowledge bases are built upon the institutional variety characterizing the local economic system. The author concludes that the construction of an inter-organizational network of dissimilar but complementary cooperative relations - in contrast to a concentration on one dominant kind of interaction - is the key source of innovation and growth of local firms in the Brianza case.

Investments in knowledge generates a higher return in the core than in the periphery

The so-called knowledge production function has been a major empirical tool used to investigate the nature and determinants of innovation in a cross-section of regions. Generally, the function relates R&D expenditure or personnel (or other innovation input measures) to an innovation output measures, such as patents or innovation counts (Oerlemans et al., 2001). Using this approach, Fritsch (2002) investigates the interregional differences in the productivity of R&D activities in Europe. He finds that these differences are to some degree similar to a center-periphery paradigm, as suggested in the literature. Specifically, output elasticities of R&D inputs in manufacturing establishments tended to be relatively higher in the center as compared to the periphery. Rodriguez-Pose (1999) investigates the relationship between innovation (R&D spending) and growth indicators across European regions. The analysis suggests that the relationship is not achieved in all regions. Specific conditions of the regions play an important role in turning innovation activities into economic growth. The authors use the terms innovation-prone and innovation-adverse regions to distinguish between the two. The latter are characterized by rigid labour markets, shortage of skills and outward migration and aging of the labour force.

In Ireland, rural does not appear disadvantaged in terms of innovation

Most the empirical research that has explicitly compared urban and rural innovation performance has hinged on the hypothesis suggested by the urban hierarchy model. This hypothesis implies that resource-rich urban areas may be more conducive to product innovation while more rural areas are better suited to process change. The evidence on the innovation propensity of areas with various degree of remoteness does not appear conclusive, however. In a study concerning Ireland, Roper (2001) differentiates among four types of areas (urban, urban-periphery, rural, and second centre) and uses survey evidence to examine the impact of these different environments on plants' innovation activity. Two main empirical conclusions are drawn from the analysis. First, networks play an important part in determining the probability that plants will be innovative and, to a lesser extent, the success of that innovation. This provides some conditional support for recent calls for network-based regional development strategies. Secondly, there is no evidence of any urban hierarchy of innovation in Ireland. If we were to expect such a hierarchy, then this finding suggests that regional policy initiatives successfully dispersed economic activity throughout Ireland.

North and Smallbone (2000) investigate innovation in rural SMEs in England over the 1991–96 period, using a survey of over 300 firms. They compare similar SMEs in remote and accessible rural areas using a multi-dimensional index of innovation. The results show relatively little difference in the level of innovation between different areas. A remote rural location is shown to influence innovation in different aspects of the business in different ways. The most innovative firms are shown to be those that have achieved the fastest growth and best employment creation during the 1990s.

Rural may not be disadvantaged, but the types of innovation in rural appear different

Evidence of spatial variation in innovative potential is indicated by Frenkel (2000) using data from the northern region of Israel. The result of his analysis suggests that high-tech industries have a relative innovation advantage in urban areas, and intermediate zones, but not in peripheral zones. The author argues that, on the contrary, the innovation potential of peripheral zones is manifested by their ability to attract firms of the traditional industry type. These findings appear to reflect the industry life-cycle dynamics discussed above.

Therrien (2003) investigates innovation performances and strategies in a cross-section of Canadian cities of different size. He finds that the rate of innovation is not correlated with the size of the city when an inclusive definition of innovation is used. However, when using more specific measures of innovations (world-first, nation-first, and firm-first innovation) the results indicate that city-size is positively associated with world-first innovation performances. Moreover, the results also indicate that the industrial sector has a significant effect on innovation performances, as suggested by the literature.

City size influences the type of innovation

Frenkel (2000) investigates whether and how regional policy could affect the innovation potential of a region. Specifically, whether the effectiveness of these policies is related to the degree of regional innovation potential of innovativeness. One of the author's conclusions is that effort should be made to direct industries to different regions "based on natural trends proved to be effective in fitting industries to a spatial location" (urban versus peripheral). Innovation policies that affect location preferences may result in inefficiency due to the existing localized compatibility of industry/spatial innovation patterns. The effect of regional policy aimed at attracting innovative firms to less attractive regions may be extremely limited (Frenkel, 2000). In contrast, the author suggests that a regional policy for innovation should give priority to the internal characteristics of a firm that can have an influence on the innovativeness potential of the business. These policies may include training of the labour force, incentives for skilled labour to stay or facilitating migration to the peripheral zones, and support to internal R&D.

Regional innovation policy should invest in skill upgrades of existing firms

Michie and Oughton (2001) argue that programs supporting technological enhancement have not been targeted at the poorest regions in the way that specific regional funds have. There is a problem of accessibility for poorer regions, which results in a potential regional innovation paradox. The poorer regions that most need to innovate are the least able to access and use public support for innovation. The lack of specific skills, such as managerial skills, could further exacerbate this paradoxical situation.

Regions that are most in need of 'innovation' have the smallest base up which to build

According to Koschatzky (2003) current innovation policies indicate a shift from "hard" infrastructure promotion towards the development of "soft" intangible factors and human resources promotion, particularly in the European context. Holbrook and Wolfe (2002) argue that the problem faced by policy makers is how to develop, support and sustain regional systems of innovation that will be more effective in global competition than larger, more structured national systems.

Quality of local public institutions will be a competitive advantage

Several authors appear to place particular emphasis on the institutional building role of economic policy -- a crucial role for economic policy is to create an institutional environment that supports technological change (Cortright, 2001). As suggested by Romer (1992, p. 89), "As the world becomes more and more closely integrated, the feature that will increasingly differentiate one geographic area (city or country) from another will be the quality of public institutions. The most successful areas will be the ones with the most competent and effective mechanisms for supporting collective interests, especially in the production of new ideas." This idea parallels the argument of Florida (2000) with regard to the rising importance of the "creative class".

The capacity of local institutions to adapt to change is another critical issue. A determinant of a locality's economic trajectory is how far its social institutions, which reflect, at least in part, the legacy of past patterns of economic and social development, permit effective responses to the pressures generated in the new competitive environment (OECD 2001a). In this regard, Florida (2000) refers to "institutional sclerosis" as a major potential constraint on the capacity of institutions to perceive and adapt to ongoing socio-economic changes.

Finally, it should be mentioned that both the concepts of cluster and regional systems of innovation have been critically reviewed and "deconstructed". Oinas and Malecki (2002) argue in favour of a more comprehensive concept of Spatial System of Innovation, which combines the spatial dimension with its evolution in time. Martin and Sunley (2002) present a critical review of the concept of clusters and its use in policy making. In particular the authors argue that the observed association between some high-growth industries and some forms of geographical concentration does not necessarily mean that concentration is the main cause of their economic growth or success. According to these authors, the success of the "cluster concept" lies primarily in the way in which this concept has been "branded" and closely linked to a set of positive images and associations.

More interestingly, some of the literature has emphasized the limit of cluster research to date. According to Holbrook and Wolfe (2002), cluster research has been weak in generating a systematic comparison between more successful and less successful regions. This research has tended to focus on newer, more technology-intensive sectors. Innovation processes could help to rejuvenate "traditional" economic activities in sectors such as resource-based products and cultural industries. In contrast, the majority of cluster studies have focused on large metropolitan areas and emphasized knowledge-based clusters, to the neglect of those in non-metropolitan regions.

From a theoretical point of view, there has also been limited integration of the innovation literature with growth theory. The endogenous character of technological change and innovation, as postulated by the new growth theory, means that the innovation process is rooted within each country or region. From a theoretical perspective, a synthesis of recent contributions is attempted by Acs and Varga (2002). After reviewing the strengths and limits of new economic growth theory (Romer), new economic geography (Krugman) and new economics of innovation (Nelson), they sketch a possible synthesis that hinges on the concept of "regional knowledge production equation", but no attempt is made to develop this concept in detail.

4.3. Geographic spillovers and diffusion of knowledge

Local knowledge spills over

Local Knowledge Spillovers (LKS) have been defined as "knowledge externalities bounded in space" (Breschi and Lissoni, 2001). The connection between knowledge spillovers and local economic development is not new; it dates back to the work of Alfred Marshall in the early 1920s, who first studied the agglomerations and clustering of similar industries in particular locations. Marshall suggested that in addition to the advantages of labour force pooling and access to specialized suppliers, the geographic clustering of similar firms meant that knowledge could be easily shared.

The increasing knowledge intensity of the economy has led to new interest in these ideas. Knowledge spillovers have become one of the prominent factors in explaining the clustered nature of the innovation geography (Audretsch and Feldman, 2003). Local Knowledge Spillovers are due to the fact that knowledge flows more easily among agents located within the same area, thanks to social bonds, reciprocal trust, and frequent face-to-face contacts. Three major consequences have been highlighted in the literature (Audretsch and Feldman, 2003; Audretsch, 2003; Breschi and Lissoni, 2001). First, these spillovers allow companies operating near to key knowledge sources to introduce innovations at a faster rate than rival firms located further away. Second, as a generalization of the previous point, geographical proximity among actors involved in the innovation process offers more innovation opportunities than scattered locations. Third, LKS imply that an individual's or firm's productivity is influenced not only by their own investments, but also by spillovers from the investments of other individuals/firms.

The Internet has not erased the value of local knowledge spillovers

Rapid enhancements in communications technologies, particularly by the Internet, have led to the perception that information could be moved without cost from place to place. Some authors have conjectured that with the increasing dematerialization of the economy, and the shift toward a knowledge based economy, the traditional economic mechanisms of diffusion and spatial spillovers would become irrelevant. Some scholars have speculated on the "death of distance", predicting that geography would become less relevant to business and personal lives (Cairncross, 1997). The empirical evidence does not seem to support these claims. On the contrary, geography appears to matter more now than ever because knowledge, and particularly tacit knowledge, does not move without friction across space and among economic agents. Morgan (2001) argues that the "geography is dead" thesis over-estimates the distance-destroying capacity of ICT technologies. According to the author, this argument confuses spatial reach with social depth and wrongly assumes that because information may diffuse rapidly +across space, so can understanding.

The functioning of local labour markets and local human capital appear to be central elements in explaining knowledge spillovers. Although it is recognized that the literature on the mechanisms actually transmitting knowledge spillovers is still limited, skilled labor is important as a mechanism for knowledge transfer in technology based industrial clusters (Audretsch and Feldman, 2003).

A local pool of skills increases the productivity of local skill development

The effects of knowledge spillover have also been evidenced in a macroeconomic perspective. As recalled by Fortin and Helpman (1995), schooling and training can be useful to society beyond an individual's gains. This is because a society's stock of human capital can have an effect on the ease with which a single individual acquires skills. More human capital per capita raises the productivity of the system of human capital accumulation. In essence, this can be considered another form of knowledge spillover.

Spillovers of research activity are quite local

Using data for the world's seven major industrialised countries, Keller (2001) argues that convergence in per capita income depends on the nature of knowledge spillovers, specifically whether spillovers are global or local. Global (i.e. world wide) spillovers favour convergence, while local spillovers – meaning a spatially limited scope of knowledge diffusion – can lead to regional clusters of countries with persistently different levels of income per capita. His analysis also estimates the importance of geographic distance for technology diffusion and suggests that technology is severely limited by distance. The author argues that technological knowledge has become more global from the 1970s to the 1990s, meaning that the degree of localization of technology diffusion has substantially declined over the three decades considered in the analysis.

Empirical evidence of the existence of LKS comes from a variety of research. Jaffe (1989) and Jaffe et al. (1993) use patent citation to assess the geographic localization of knowledge spillovers. They find that citations to domestic patents are more likely to be domestic and more likely to come from the same state and metropolitan area. Their analysis suggests that localization fades over time but only very slowly. The results of Keller (2001), already mentioned above, provide a similar conclusion about the importance of geographic distance for technology diffusion. A study by Anselin et al. (2000) assessed the local geographic spillovers between university research and high technology innovation. The authors used sectorally disaggregated data for U.S. standard metropolitan statistical areas (SMSAs) and conclude that local university spillovers seem specific to certain industries. Specifically, no university spillover effects are recorded for the Drug and Chemical sector, while strong spatial spillovers of university research are recorded for the Electronics and Instrument industries.

Kelly and Hageman (1999) test for the existence of spatial spillovers (externalities). In the absence of spillovers, they hypothesize that the geographical distribution of research should be the same as that of production. This hypothesis is strongly rejected. Innovation in two-digit industries exhibits strong spatial clustering independent of the distribution of employment. They also find strong spillovers from aggregate innovative activity in a region to the research intensity of individual industries. The location of a sector's R&D activity is determined more by the location of other sectors' innovation than by the location of its own production.

A focus on LKS may obscure the crucial role of research facilities and univer-sities

Finally, Breschi and Lissoni (2001) present a critique of the LKS approach. Their argument appears directed, in particular, against the econometric focus, such as the knowledge production function approach, that may distort and restrict the research agenda. According to the authors, there are three elements of the research agenda that should received a greater attention in order to gain a better understanding of why geography really matters for innovation. First, research should understand the labour market, which represents the crucial mechanism through which innovation is diffused locally. Second, researchers should look at the firm's networks and in particular the geographic dimension of these networks. Third, one might hypothesize that research facilities and universities provide the "real" impact on a firm's innovation performance (according to the authors, the 'spillover' perspective has obscured the actual mechanisms through which universities contribute to the firm's innovation process).

4.4. Small and remote areas' challenges in enhancing educational attainments

Lower return to education in rural areas

Small and remote areas seem to face specific challenges in enhancing the level of their human capital. First, limited employment opportunities and low returns to education in the local labour market likely lead many rural families to place little value on the pursuit of higher education. Second, from the region's perspective, there appears to be an issue of appropriateness of the return to education. Mobility of skilled workers may reduce the incentives for regions to invest in education. This, in turn, causes some to suggest that rural areas do not have an incentive to invest in education, because the educated people move to the urban areas and the benefits occur in urban areas. Therefore rural areas would be expected to produce a lower than optimal level of education.

A less skilled workforce is less attractive to advanced technology manufac-turing firms

The fact that rural regions have generally lower educational attainment than urban regions is well documented, as discussed in section 4.1. This condition is indicated as a major challenge by several authors. McGranahan (2001) notes that in the "old economy", much of the manufacturing was attracted to the region by low-cost labour and low taxes. But in the current economic context, manufacturing is adopting new technologies and management practices and seeking more highly skilled labour. Rural manufacturers in Southern U.S. counties with a lot of manufacturing have few complaints about State and local taxes, but these counties also have low revenue per pupil in their school systems. The authors suggest that poor schools are likely to be a barrier to attracting advanced technology manufacturing. This in turn can limit the ability of these counties to participate in the New Economy.

Teixeira and Swaim (1991) point to a potential dilemma faced by small and remote communities. To make the people in rural places competitive, these people must have the skills to function productively in the new economy. But, new economy jobs are mostly urban. Thus, improving rural education might result in greater underemployment of rural workers or increased out-migration of relatively well educated youths.

A question that has received specific attention in applied research is that of the direction of causality between human capital and local growth. Does human capital follow the locational pattern of investments of business or do businesses locate where there is a consistent stock of human capital? The direction of causality between human capital and economic growth is fundamental because it affects the choices of a strategy aimed at rural economic development. Should we first invest in education in rural residents and subsequently attract new firms or should we first attract new firms? The direction of causality and the degree of simultaneity remain to a large extent to be determined empirically.

Freeman (2001) analyses the dynamic between job and locality using employment data. The question faced by this author is the following: Is the population moving to where the jobs are or are the jobs moving to where the population goes (attracted by amenities and recreational attractiveness)? A similar question can be posed for skilled labour. Both theories are plausible and consistent with anecdotal evidence, corresponding to a job demand versus job supply driven growth, but according to Freeman the data seems to support the "people follow jobs" explanation. In contrast, Morck (2001) suggest the existence of a positive feedback loop, where the concentration of skilled workers attracts the firms that need them, and with those firms attracting more skilled workers.

Jobs may follow where people choose to live

4.5. Agglomeration, increasing returns and knowledge

Over the last decade, there has been a growing literature on the nature and characteristics of the location of production in space, which has been labeled new economic geography. This literature originated in particular from the contributions of Krugman, Fujita and Venables (Ottaviano and Thisse 2004). The core of this approach is the recognition that one of the persistent features of the geography of economic activities has been agglomeration - that is the concentration of activities in a limited geographic area. This literature has also evidenced the fact that, once a process of agglomeration has started, there are self re-enforcing mechanisms that tend to sustain it. Hence, history and "historical accidents" generate spatial patterns of economic activities that tend to be persistent over time.

Geographic concentration of production is pervasive

Concentration and persistency of industrial location patterns are well documented in the literature. For instance, Polèse and Champagne (1999) compare industry location across the Canadian and Mexican urban systems and find that the basic assumptions of central place theory continue to hold in both nations. Clear hierarchical distributions were observed for most industries. In both urban systems, traditional manufacturing was found to be less sensitive to the proximity of a major metropolis than were high-tech industries. In both systems, producer services were concentrated in the largest urban centers, displaying hierarchical distributions. The shift of manufacturing out of major metropolitan areas indicated that relocation was primarily in favor of small and medium-sized urban centres within 100 kilometers of major metropolitan agglomerations.

This geographic concentration of production is considered the result of a pervasive influence of some kind of increasing returns, which had been ignored by traditional growth theory because they were difficult to model. The economic rationale for urban agglomeration cannot be explained using conventional production theory only. Land is always cheaper outside cities than inside; hence capital and people could move outside cities to cheap land and increase their profits. The existence and persistence of agglomerations must be explained by some form of externalities which increase productivity and which hold cities together.

Cities exist because of knowledge spillovers

The literature on agglomeration externalities, or localized increasing return, is abundant and human capital and knowledge factors play a relevant role in it. Localized knowledge spillovers, discussed in the previous section, are one side of this coin. The other side of this coin can be found in what the literature has defined as "learning agglomeration economies" (Duranton and Puga, 2003). An essential characteristic of learning is that it involves interactions with others. High population density, and greater diversity, allows for more and richer interactions. In turn, interactions facilitate knowledge generation, diffusion, and accumulation; in other words, agglomeration facilitates learning and innovation. As the economy shifts towards knowledge-based sectors the effect of these agglomeration economies may further reinforce the concentration of activities in urban areas.

The empirical research that focuses on the effect of agglomeration has consistently indicated that high density increases labour productivity. Ciccone and Hall (1996) estimate two models in which spatial employment density results in aggregate increasing returns. Using data on gross U.S. state output, the findings indicate that a doubling of employment density increases average labour productivity by around six percent. More than half of the variance of output per worker across U.S. states can be explained by differences in the density of economic activities. Hanson (1998) estimates the parameters of the Krugman model of economic geography and examines the relationship between increasing return to scale and the geographic concentration of economic activities. The analysis employs U.S. county data. The results provide support for the existence of small but significant scale economies.

Wages are higher in cities because cities are more productive

Glaeser and Mare (2001) analyze the nature of the wage premium in cities. This has been a persistent feature observed by many scholars. Part of this differential can be explained by the cost of living and urban dis-amenities, but this would not explain why many firms stay in cities. An explanation for this is that higher wages are compensated by higher productivity (including the reduction of transportation costs). Recent studies have argued that cities have information externalities that increase the productivity of firms. According to this approach, workers who move to cities will receive wage gains (i.e., a higher wage level), which would be lost when leaving the cities. Alternatively, the cities may benefit from human capital accumulation (wage growth). This approach suggests that the benefits of cities would accrue over time and would not be lost by the workers when leaving the cities. The findings of the authors indicate that a portion of the urban wage premium is a wage growth effect, suggesting that cities may speed the accumulation of human capital.

The potential role of agglomeration is also evidenced by research that stressed the importance of the cross-industry transfer of ideas (Jacobs, 1969; Duranton and Puga, 2000; Morck, 2001). This implies that mono-industry clusters like Silicon Valley are less stable than more diversified clusters and large agglomerations, like Boston, New York, or London. According to Morck (2001) this suggests that highly focused "centres of excellence" might produce only limited innovation.

4.6. Returns to education and human capital mobility

Rural and remote communities are often perceived as lacking in employment, education and social opportunities, which are of prime importance to youth. This circumstance is further aggravated by the differences in the return to education between rural and urban areas. Both conditions facilitate out-migration toward core urban regions, which in turns makes the accumulation of human capital in peripheral regions a difficult target to achieve.

Lower return to education in rural areas

Empirical evidence shows that human capital generates higher returns in urban areas than in rural areas, and the young working-age population is particularly sensitive to economic incentives to move (Huang et al. 2002; Greenberg et al. 1995; Kusmin 1994). According to human capital theory, the expectation of high returns - represented by good employment opportunities - creates the incentive for human capital investment. When the returns to the investment in education (i.e. the expected wage) are low or uncertain, individuals have no incentive to invest in education. Various authors have therefore suggested that educational outcomes observed in rural areas are the result of a rational under-investment in human capital, in communities that do not provide good employment opportunities (Smith 1989; Smith and DeYoung 1988; Stallmann et al. 1991; Broomhall and Johnson, 1994; Johnson and Stallmann, 1994).

Rural brain drain exacerbates the positive impact of knowledge spillovers

The persistence of a sizable differential in the return to education between rural and urban areas has been indicated as a major incentive to out-migrate. Those who out-migrate have generally higher educational levels; for this part of the labour force, the expected benefit from migration is the greatest. In Canada, research has indicated that individuals who move out of rural areas generally experience higher earnings growth than their counterparts who stay (Dupuy et al., 2000). These people take with them the locality's investment in their education. The rural brain drain was apparently a major reason for the decline in rural young adult education levels in the 1980s. With regard to spatial distribution of skills, for instance, the available evidence suggests a process of out-migration of the young and more educated labour force from rural to urban areas (Fellegi, 1996). This process suggests that rural localities have, for most of this century, subsidised urban economic growth.

Kodrzycki (2001) analyzes the location decisions of recent graduates, for the 1979 to 1996 period, to examine cross-state migration in the five-year period after the completion of schooling. The results indicate that college-educated individuals are more likely to migrate than those without a college education. In addition, the majority of individuals move to states with stronger economies or more attractive characteristics (as measured by factors such as higher employment growth, lower unemployment, higher pay, lower housing costs, or better amenities).

Migration of the better qualified ensures that the skill and ability gap between regions is more severe than the education gap. Martin (2000) observes that if the mobile agents are those with the highest human capital and if positive spillovers exist between workers due to localised social interactions, then as mobile agents move away from the poor region, immobile workers will also lose the benefits of these positive spillovers which may imply a decrease in their productivity and therefore in their equilibrium wage.

Regions with a higher average education level provide a skill premium that attracts more highly-skilled workers

Giannetti (2001) argues that regions with a high level of human capital are particularly attractive for skilled workers because they offer a high skill premium. The local externality deriving from the average level of human capital is weaker for less skilled workers, whose incentives are not strong enough to move. The analysis of this author offers an explanation of the high mobility of skill workers based on human capital complementarities. If the skill premium is increasing in the average level of human capital of a location (and there are fixed migration costs), the more skilled the workers, the stronger the incentive to migrate towards the richest regions. The model is tested using data from Italian regions. The results suggest that a high share of individuals with higher education seems to be a relevant pull factor for the most educated migrants.

The available evidence suggests that there are self-reinforcing mechanisms that can result, for certain regions, in a vicious circle or poverty trap (which will be discussed in the next section) or a virtuous circle, for other regions. In fact, evidence indicates that human capital moves to places where it is already abundant and where there is already a concentration of workers with similar skills. The spatial concentration of human capital further suggests that there is a productivity spillover from high average skills to new entrants, as discussed in the previous sections, which reinforces the evidence coming from the innovation literature on proximity and local systems.

Martin (2000) argues that some economic agents (workers and consumers) are not mobile and are stuck in declining regions that have been abandoned by more mobile factors, such as skilled workers and capital. A declining labour demand in these regions may result in downward real wage trends or, if real wages cannot adjust due to rigidities on the labour market, in rising unemployment. The residents of these regions may also see their welfare decrease as consumers. The production of some goods and services can move to core, richer regions. In this case, they may have to pay a higher price for those goods and services because of the transaction cost involved in importing them from the core region. In some cases, in particular for services, the transaction cost will become so high that they will become non-tradable so that the diversity of available services will decrease.

Policy should invest in inter-sectoral mobility of workers

The policy implications of these trends have been a subject of major debates. At the core of this debate is whether and at what cost policy can offset market forces that would affect the mobility of human capital. Some see human capital enhancing policies as a strategy to increase mobility, while in other instances human capital policies have focused on retaining people in regions and industries that offered limited development perspectives. Martin (2000) argues that from the policy point of view, housing and tax policies that facilitate the mobility of workers should be regarded as part of the regional toolkit. The fact that regions can be specialised in specific industries also suggests that low inter-sectoral mobility of workers adds to the welfare cost of spatial concentration. This means that policies that facilitate inter-sectoral mobility such as education and training policies in poor regions should be reinforced.

4.7. Neighborhood effects and spatial poverty traps

The effects of spatially bounded interactions among individual decisions have been recently investigated by a stream of literature that goes under the headings of neighborhood effects and spatial poverty traps (Durlauf, 1992). These ideas are not completely new. The concept of poverty trap, and the associated idea of a vicious circle of development (as opposed to a virtuous circle), originated and have long been used in the field of development economics. In recent development literature, Jalan and Ravallion (1997) use the term "geographic capital" to describe differences in physical, human and social capital endowment between regions. According to these authors, when one area is less well endowed with geographic capital than another, a spatial poverty trap can be said to exist if the household living in the better endowed area sees its standard of living rising over time, while the other does not.

A poverty trap implies that given an initial condition of disadvantage there would be self-reinforcing forces that result in a further deterioration of conditions or in a persistence of the disadvantage. For instance, in an area with initial low levels of education, there would be scarce incentives to invest in education and high incentives to out-migrate for the most educated labour force, so the level of the education remains persistently low.

Deprivation in communities may reinforce future deprivation

The notion of neighborhood effects is also common in sociological studies. Research focused on the problems of deprived neighborhoods and areas suggests that part of the disadvantage experience by individuals is a direct consequence of their residence in such deprived areas. Some research has used area level data to explore whether the form of the association between population characteristics and population outcomes indicates stronger effects in areas of concentrated disadvantage. The existence of non-linear relationships between population characteristics and outcomes would suggest that concentration influences socio-economic outcomes. Alternatively, individual level data (often longitudinal data) have been used in particular to investigate barriers to upward mobility in areas of concentrated deprivation (O'Regan and Quigley, 1996).

With reference to urban economics, it has been long noted that the conditions which most obviously produce poverty - the structure of the economy and the pattern of employment - have a strong spatial dimension. It has been observed that living near higher numbers of people who are unemployed affects job prospects in itself. The process is straightforward: where jobs become available which are accessible, there will be more competition at similar levels of skill. Residence in a particular area is likely, then, to be associated with employment prospects. Under these circumstances it is not surprising that certain areas of cities have tended to be associated with higher levels of employment than others.

Poorer regions are less able to keep or attract skills

From a theoretical perspective, Durlauf (1992) provides a modeling framework that explains persistent inequalities between neighbourhoods by relating human capital investment and neighbourhood choices of families (see Box 4). On the empirical side, various studies support this type of process. Bradley and Taylor (1996) argue that the accumulation of human capital is directly related to the initial stock of human capital. They argue that localities with a low initial stock will find it difficult to create additional human capital. These localities can be stuck in a low-skill poverty trap from which it might be extremely difficult to escape.

Napier and Camboni (1987) argue that the development of human resources in non-metropolitan areas is more difficult because training programs are less accessible. Furthermore, the content of the learning experiences may be less relevant to local employment needs because rural employment tends to require lower skill levels and to be labour intensive. This leads Napier and Camboni (1987) to suggest that people that live in less populous areas will not develop human resources to their maximum potential and that they will suffer from a comparative disadvantage, as compared to urban residents, in terms of competition for employment. Michie and Oughton (2001) indicate the existence of a potential regional innovation paradox. The poorer regions that most need to innovate are the least able to access and use public support for innovation. The lack of specific skills, such as managerial skills, could further exacerbate this paradox.

There is an argument for a focus on deprived areas rather than a focus on deprived individuals

There are clear policy implications that stem from the existence of spatial poverty traps. Although in many OECD countries only a minority of the disadvantaged people live in the most deprived areas, spatial policies rest on the assumption that the concentration of disadvantaged individuals creates additional negative consequences for the life chances of those individuals or for others in the areas where they live. Consequently, it has often been argued that it was more appropriate to focus policy on the most deprived areas, rather than to identify the most disadvantaged social groups, regardless of where they lived. Jalan and Ravallion (1997) argue that when supported by empirical evidence, spatial poverty traps suggest both efficiency and equity arguments for investing in disadvantaged areas, such as by developing local infrastructure or by assisting labour mobility to better endowed areas. Public policy could shift the economy from the vicious circle to a virtuous circle.

Box 4. Modeling persistent inequality

From a modeling perspective, attempts have been made to formalize the process of persistent spatial inequality. Durlauf (1992) presents a model that explains persistent poverty inequality between neighbourhoods by relating human capital investment and neighbourhood choices of families. In the model, families have an incentive to group themselves in homogeneous neighbourhoods in order to provide the highest level of education for their children at the lowest cost. Neighbourhood location affects children education through total income, as school funding is determined by majority voting, and through the effect of income distribution of a neighbourhood. Under these circumstances, the author shows that a process of endogenous stratification may occur which can result in permanent poverty among some families which are unable to generate sufficient human capital investment in their children.

5. Summary and conclusions

Few stylized facts

This paper has reviewed the literature related to the spatial variation of skills and human capital and its implication for local innovation capacity and economic development. The report developed around three major themes 1) skills and human capital; 2) innovation and technological change; and 3) growth. The three themes were linked together by a spatial perspective, meaning that the emphasis is on the interaction between skills, innovation, growth and the spatial (territorial and rural) dimension. The review of empirical works indicated that, in this broad area of research, there are few relationships that have achieved the status of stylized facts. In most cases, the nature of the relationship remains a matter of empirical investigation, which is specific to a given context. The main issues emerging from this large body of literature are summarized below.

There appears to be two key ideas that cut across a large part of the literature considered here: the nature of **incentives** that economic agents face and the way **interactions** among them are significantly affected by space. This in turn affects individual behaviour with regard to human capital and innovation performances and eventually the prospects for growth. Human capital investment and technological adoptions occur in response to specific incentives, which are endogenous to the system. Interactions, or interdependencies between individual behaviors, play a key role: externalities and spillover effects in firms and individual activities create complementarities whereby one action reinforces other actions, in a positive or negative spiral of effects. For instance, technology adoption and investment by one firm may reduce the costs of adoption for other firms and induce them to do the same.

What we know

The available evidence suggests that geography matters in the new economy. New technologies have changed the spatial scale of the production processes but have not reduced the relevance of space. Declining communication and transportation costs, combined with scale and agglomeration economies have reinforced the process of geographic concentration mainly in favour of large agglomerations.

Knowledge is becoming more important for growth. There is a trend towards increasing knowledge intensity in each economic sector. This shift is driven by within-industry skill intensity growth, rather than between industry employment shifts. Moreover the quality of knowledge required in the production process has changed. Research has also emphasized the distinction between codifiable and tacit knowledge. This distinction is relevant when space is included in the analysis, as tacit knowledge appears less mobile than codified knowledge.

Spatial variation of human capital attributes is a normal phenomenon. Large disparities, however, have been a policy concern due to the possible effect on income disparities and the increasing demand for high-skill workers in all economic sectors. Recent developments in growth theory have emphasized the role of human capital in the growth process, and opened a new perspective on the role for government policy in reducing regional disparities. The available evidence suggests that local human capital attributes have a positive effect on local economic development, although these findings and the direction of causality do not appear conclusive.

The innovation process has both a sectoral as well as a spatial dimension. Spatial patterns of innovation differ systematically for industries with different technological intensity; part of these differences can be related to the concept of industry life-cycle. Certain regions, however, have developed specific ways of producing and sharing innovation. This notion is at the core of the "regional innovation system" (RIS) concept. The main elements of the RIS concept are proximity, networks and institutions. The human capital attributes of a locality are an important component of the innovation process. This is particularly true for the relevance of "tacit knowledge" (i.e. not codified knowledge) in the innovation process. These characteristics make urban agglomerations the core areas for the innovation process.

Rural areas are characterised by a high heterogeneity of economic conditions. On the one hand, it can be argued that, to the extent that most innovation is not R&D-based, even small communities with relatively low-skilled workers can still be innovative. On the other hand, rural regions, characterized by remoteness, low population density and small agglomerations, may face several problems when attempting to increase human capital and stimulate innovation. The literature points to some of these intertwined problems:

- First, individuals and communities in rural areas may under invest in education, because of the lack of incentives. The return to education tends to be lower for rural residents; and communities may face problems in capitalizing on their investments in education due to the high-mobility and out-migration of high-skilled workers.

- Second, the lack of agglomeration economies has an effect on productivity and accumulation of human capital. Geographical proximity offers more innovation opportunities than scattered locations due to knowledge spillover and networking opportunities.

- Third, rural areas often have few institutions (such as universities and research facilities) that can support the innovation process, as well as human capital enhancements.

- Finally, the lack of human capital has an impact on the capacity to access and absorb technology and public programs, which makes smaller communities potentially more vulnerable. The initial disadvantage of a locality may lead to what has been named in the literature as a spatial poverty trap, i.e. a persistent condition of disadvantage.

With regard to the policy options, there is clearly a wide range of views that have been put forward. However, there appears to be some common elements that are shared by most policy thinking on human capital and innovation. First, there seems to be a general consensus that both human capital and innovation policies that are oriented against persistent and pervasive market forces have limited scope for success. For instance, policies that attempt to alter what appear to be pervasive industrial localization forces are likely to produce limited results at high costs.

Second, the fact that interactions, as well as incentives, are shaped by space and are geographically bounded has relevant implications. Interdependencies in individual behaviors may results in multiple growth equilibria, based on different expectations about the behavior of others. The concept of a spatial poverty trap has been used to describe this problem: a locality may find itself locked in a low level equilibrium trap because agents have mutually low expectations about the behavior of others. Spatial poverty traps suggest both efficiency and equity arguments for investing in disadvantaged areas. In particular, some form of coordination among actors may be necessary to escape the low level equilibrium and to shift to a higher income equilibrium. For instance, in rural development, the achievement of economies of scale is hampered by high fixed costs in setting up new institutions and reaching a critical mass that triggers self-sustained growth. Policies that will support these costs may be needed for disadvantaged regions.

These considerations remain difficult to generalize. Each context is different and may require different policies. There appears to be a widespread rejection of "one-size-fits-all" policy, both in the human capital as well as in the innovation policy realm. This implies that policies must account for territorial and regional differences in socio-economic and institutional conditions.

What we do not know

Finally, it should be emphasized that the innovation research on non-metro regions is still relatively weak. A limitation of the current research on innovation is the focus on successful cases, particularly high-tech clusters and major urban agglomerations. In contrast, relatively little research has been carried out on the innovation process in smaller communities and non-metropolitan regions.

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