Is innovation important for development? Does innovation have any contribution in changing the landscape of regional inequalities? And if so, how? One popular perception of innovation is that has to do with developing brand new, solutions for sophisticated customers, through exploitation of the most recent advances in knowledge. Such innovation is normally seen as carried out by highly educated labour in R&D intensive companies, with strong ties to leading centers of excellence in the scientific world. Hence innovation in this sense is a typical *"first world"* activity. There is, however, another way to look at innovation that goes significantly beyond the high-tech picture. In this broader perspective, innovation is an aspect of most if not all economic activities. It includes not only technologically new products and processes but also improvements in areas such as logistics, distribution and marketing. In this broader sense, innovation may be as relevant in the developing part of the world and the determination of regional inequalities as elsewhere.

"An increase in the pace of innovation can engender regional disparities; if, afterwards, the speed of diffusion also increases enough, these disparities can fade out."

Ugo Fratesi, 2003

The Contribution of Innovation in Regional Inequalities

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The Contribution of Innovation in Regional Inequalities

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to my Family

ABSTRACT

Does the new technological paradigm based on Information and Communication Technologies (ICTs) and generally on innovation create new windows of opportunity or further obstacles for catching up countries? This dissertation analyses the spatial patterns of innovation, its regional interdependencies and evolution, as well as its role in determining local innovation in regions. It extends the standard economic geography model by introducing regional differences in technology levels and by assuming that initial technological gaps may be closed only when the learning capabilities of the lagging region are sufficiently developed. Interregional knowledge spillovers take place only when the initial technological gap is not too wide, and when trade costs, taken as a proxy for the obstacles to interaction between firms of different regions, are sufficiently low. Moreover, a minimum level of regional development is required. Therefore, it is necessary for innovation policies to act in combination with other policies focused on the improvement of socio-economic and structural determinants of regional innovative performance. Innovation is leading to several new opportunities for developing economies in order to decrease regional inequalities. If public policies will actively foster the development process by rapidly investing in the new technologies and in the related infrastructures and skills, these new opportunities will indeed be successfully exploited.

Key Words: Innovation, Regional Inequalities, Learning Capabilities, Knowledge Spillovers.

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TABLE OF CONTENTS

3rd CHAPTER

MEASURING INNOVATION

4th CHAPTER

INNOVATION AND ECONOMIC DEVELOPMENT

5th CHAPTER

INNOVATION AND REGIONAL INEQUALITIES

6th CHAPTER

INNOVATION POLICIES TO DECREASE REGIONAL INEQUALITIES

7th CHAPTER

CONCLUSION

LIST OF TABLES

LISTS OF FIGURES

ACRONYMS

C.C.I.: Current Competitiveness Index

C.I.S.: Community Innovation Survey

D.I.S.T.: Department of Industry Science and Tourism

E.P.O.: European Patent Office

F.D.I.: Foreign Direct Investment

G.C.I.: Growth Competitiveness Index

G.D.P.: Gross Domestic Product

I.C.T.: Information and Communications Technologies

I.P.R.: Intellectual Property Rights

K.A.M.: Knowledge Assessment Methodology

M.N.Es: Multi-National Enterprises

M.V.A.: Manufactured Value Added

N.I.Cs: Newly Industrialized Countries

N.P.D.: New Product Development

O.E.C.D.: Organization for Economic Cooperation and Development

O.M.: Oslo Manual

R.&D.: Research and Development

R.AN.D.: Research ANd Development

S.M.Es: Small and Medium Enterprises

S.P.R.U.: Social Policy Research Unit

S.&T.: Science and Technology

S.T.C.I.: Science and Technology Capacity Index

S.T.I.: Science Technology and Innovation

T.A.I.: Technology Achievement Index

T.P.P.: Technological Product and Process

U.N.D.P.: United Nations Development Program

U.N.I.D.O.: United Nations Industrial Development Organization

W.E.F.: World Economic Forum

1st CHAPTER

INTRODUCTION

Science and Technology (S&T) influence society as never before and increasingly contribute to the technological progress that affects how we live and work. New technologies help to protect the environment, to build safer structures, to develop energy-saving transport systems and to make improvements in genetics in order to save lives. Production has been enhanced by Information and Communications Technologies (ICT) in the advanced economies and has made it possible for a greater number of individuals, firms and countries to take part in the knowledge-based economy and promise further improvements in living standards and economic performance. However, this increasing performance in science and technology is not without risks. The outcomes of technologies have twofold meaning because either can be used to save lives and create jobs or can potentially be used to harm populations and disrupt economies.

The potentials risks are minimized as far as it is ensured that science and technology continue to provide solutions to economic, health and environmental challenges. So governments need to improve the efficiency of public research and to facilitate the translation of research into commercial realities. If they want to continue to harvest the goods of technology and science they have to enhance incentives for business

Research and Development (R&D), foster closer interaction between universities, governments, and firms, encourage the development of human resources in science and technology and craft Intellectual Property Rights (IPR) regimes that reward investments in innovation while encouraging the dissemination of scientific and technological knowledge.

The proposals to these cases begin from what is meant by the term innovation. One popular perception of innovation has to do with developing brand new, advanced solutions for sophisticated, well-off customers, through exploitation of the most recent advances in knowledge (OECD, 2004). That kind of innovation is seen as a typical *"first world"* activity that is carried out by highly educated labour in R&D intensive companies with strong bonds to leading centers of excellence in the world of science.

The center of discussion to the present day, are issues such as the nature of technology, the conditions for technological catch up etc. In these studies we can distinct a very optimistic mood, which is also shared by neoclassical economists, about the possibilities for technological and economic catch-up by poorer economies. From this point of view technology was assumed to be a so-called *"public good"*, freely available for everyone everywhere. Hence, a common interpretation of neoclassical growth theory has been that catch up and convergence in the global economy will occur automatically (and quickly) as long as market forces are allowed to *"do their job"*.

However, from another visual angle, writers from several other strands, such as economic historians or economists (who follow the steps of Joseph Schumpeter) have been much less optimistic in this regard. According to these writers, it requires considerable effort and organizational and institutional change to succeed so there isn't anything automatic that will lead us to technological catch up. Furthermore firms, industries and countries, in order to escape the low development trap, ought to generate various *"capabilities"* that comprise one of the main subjects in this specific literature. Following this perspective, countries that do not succeed in developing appropriate technological capabilities and other complementary conditions should be expected to continue to lag behind. Concepts such as *"social capability"*, *"technological capability"*, *"absorptive capacity"* and *"innovation system"* have been suggested and a burgeoning empirical literature has emerged focusing on these aspects of development.

Along with the literature and in combination with a deal of empirical evidence the presence of wide economic and technological gaps between regions is revealed to us. Furthermore, the process of convergence in Gross Domestic Product (GDP) levels across the regions, which was observed during most of the post-war period up to the 1970s, has tended to slow down in the latter part of the 1980s (Evangelista et al., 2001). Differences in the regions' ability to compete, which increasingly depends upon the innovative capacity of firms and regional systems as a whole, are reflected obviously by the economic gap between regions. Particularly, technological variables are proving able to explain a good deal of the diverging trends in the economic growth across global regions.

Technological change is a driver of productivity growth so differences in productivity are a major source of cross country income variations. An important key element of industrialization and catch-up in developing countries is therefore technological innovation. The question whether the sources of technological change are a combination of indigenous and foreign innovation efforts or are only based on one of the two of them at the time, remains one of the controversies. On the one hand, there is the opinion that innovation is costly, risky, and path-dependent. That opinion claims that it is more efficient for developing countries just to acquire foreign technology created in developed countries. In principle, a technologically emerging country could catch up with high speed rates by absorbing the most advanced technologies if only innovations were easy to diffuse and adopt regardless of their nature and type.

But there is also a second position on the other hand, in the catching up literature that is less optimistic with respect to the current and future prospects for innovation- and imitation-based growth, where technology diffusion and adoption is costly and conditional and economic development is far from being an automatic and easy process. In this respect, the new paradigm based on ICTs is opening as many opportunities as new obstacles for development it creates. The modern ICT-based global competition requires greater requirement in terms of skills, competencies and capabilities and because of these new requirements makes the process of creation of new technologies and its international diffusion more difficult to exploit for catching up countries. In particular, the international diffusion of technologies seems to have become more *"difficult"* and demanding over time in contrast to the major factor of catching up that could be in previous decades. This may be a reflection of the radical technological change in the last decades, with ICT-based solutions substituting earlier mechanical and electromechanical ones, and the derived change in the demand for skills and infrastructures (Howells, 2005).

Another reason because that is happening, is that it depends on substantial and well-directed technological efforts and on absorptive capacity. Additionally, because technical change is often biased in a particular direction, difficulties are created for firms, industries and countries due to the fact that foreign technologies developed in industrialized countries may not be appropriate to the economic and social conditions of developing countries. The availability of empirical evidence on the effects of indigenous or foreign innovation is failed to provide absolutely convincing evidence indicating significant positive technological transfer and spillover effect of Foreign Direct Investment (FDI) on the local firms.

Impressively rapid economic growth in Brazil, India, and China in the past three decades is changing the landscape of the world economy. These countries are catching up fast with the leading industrial countries, and this process is becoming a remarkable economic force influencing the world economy (Fu et al., 2010). The emergence of these economies has important implications for the world, not only in terms of its economic impact, but also in terms of their experiences in guiding and promoting the growth process. These countries have opened up to international trade and investment though to different degrees and with different speed and strategies, while at the same time they all have put an increasing emphasis on indigenous knowledge creation and innovation, though again to different extents and with varying success. Experiences from these emerging economies may provide valuable lessons also for other developing countries with regard to industrial, technology, and trade policies.

These successful cases, however, contrast with the general pattern of increasing disparities in income and technology levels that the world economy has experienced in the last few decades. A large group of less-developed economies, mostly in Africa, Asia and Latin America, have in fact been growing at a rather slow pace, and the technology and income gap has therefore significantly widened for many of them. Several countries have very low levels of technological capabilities, infrastructures and education, and consequently find it hard to exploit their backwardness position by imitating ICT-related foreign advanced technologies.

Thus there is another controversial issue, namely the extent to which technological activities in developing countries depend mainly on *"spillovers"* from the outer world. Much economic theorizing and applied work suggest that for all but the largest countries of the world, foreign sources dominate and much policy advice to developing countries has been based on this presumption (Fagerberg et al., 2009). Critics contend that this is not only a question of access to technology but also about the ability to absorb it in a way conducive to development.

However, the role of innovation and its diffusion/spillover effect in the catching up process has not received the attention it deserves. Many relevant questions still remain unanswered. The purpose of this dissertation is to investigate the issue of innovation within a national and a regional context and what that implies about regional inequalities. Through the analysis will seek to show the often conflicting and divergent views of how innovation may, or may not be seen to relate to regional economic development, growth and disparities.

What are the drivers of technological change and catching up in developing countries, and in middle income countries? What are the roles of innovation and its diffusion? What does it happen to regional inequalities with the acquisition of innovation? This dissertation addresses these questions, based on a series of empirical studies on a vast literature that concerns innovation and regional inequalities in emerging economies and the developed ones and tries to shed a light in these questions.

The structure of it organized as follows: The second chapter is an extended literature review where it is explored a number of contrasting perspectives in relation to innovation and regions and seeks to highlight the implications of the development of our conceptual understanding about innovation and regional disparities. The third chapter expresses the literature of research in the field of innovation that attests the measurement of innovation or the innovation abilities evaluation and what the way is to achieve that. The fourth chapter extends the line of research attempting to link innovation to economic growth by addressing some unexplored questions and discusses and outlines a perspective on economic growth based on evolutionary theorizing and the neo-Schumpeterian long wave theory. Consistent with this perspective, capitalist development is shown to be a process of alternating periods of convergence and divergence, with some signs of a shift towards divergence recently. It is also shown that the importance of innovation for economic growth has increased lately, while at the same time imitation, (or diffusion) has become more demanding. Continuing, the fifth chapter investigates the effect that the interaction between the creation and the spatial diffusion of technology brings on regional disparities. An increase in the pace of innovation, as it has happened with the "technological revolution" can engender regional income disparities; but also if, afterwards, the speed of diffusion also increases enough, these disparities can fade out. The aim of the sixth chapter is to untangle some of the *"fuzzy notions"* that have arisen out of the debate surrounding innovation policy and the regional dimension, which can be seen in relation to regional policy more generally. Also it is explored a number of other contrasting issues in relation to innovation and spatial policy including: public versus private investment in research and innovation, *"best practice"* versus *"bespoke policies"*, short versus longer time perspectives and demand versus supply led innovation policies. Finally, the seventh chapter which is an overview of what has been seen in previous chapters plus the framing of the final conclusions of the dissertation.

2nd CHAPTER

INNOVATION, REGIONAL INEQUALITIES & CATCHING UP - TAKING STOCK OF THE LITERATURE

2.1. Introduction

The history of capitalism from the industrial revolution onwards is one of increasing differences in productivity and living conditions across different parts of the globe. In 1998, the difference in income or productivity per head between the richest and poorest countries in the world was approximately 400:1 (Landes, 1998). However, there are many examples of (initially) backward countries that – at different times – have managed to defy the trend by narrowing the gap in productivity and income between themselves and the frontier countries, that is, by *"catching up"* (Fagerberg and Godinho, 2003). How did they do it? What was the role of innovation and diffusion in the process?

The pertinence of all these questions to an understanding of modern economic growth demands their continued study. The *"catch-up"* question should be seen separately from the discussion of *"convergence"*, although the two issues partially overlap (Fagerberg and Godinho, 2003). *"Catch-up"* relates to the ability of a single country to narrow the gap in productivity and income vis-à-vis a leader country, while *"convergence"* refers to a trend towards a reduction of the overall differences in productivity and income in the world as a whole. Of course, if all countries below the frontier country catch up, then convergence will necessarily follow and inequalities among the regions of a country and in a larger scale between the countries will reduce. But if only some countries catch up (and perhaps forge ahead), while others fall behind, the outcome with respect to convergence and inequalities is far from clear (Abramovitz, 1986). Through thorough empirical analysis it is found that such convergence, at best, is confined to groups of countries – or *"convergence clubs"*– in specific time periods. Arguably, to explain such differences in the conditions for catch-up through time it is not enough to rely on general mechanisms and a historical perspective is required.

During most of the nineteenth century, the economic and technological leader of the capitalist world was the United Kingdom. However, during the second half of the century, United States and Germany started to catch up and substantially reduced the UK lead. They did not do so by merely imitating the more advanced technologies already in use in the leading country, the UK, but by developing new ways of organizing production and distribution, e.g., by innovating (Freeman and Soete, 1997; Freeman and Louçã, 2001; Fagerberg and Godinho, 2003).

In the case of the US this led to the development of a historically new and dynamic system, based on mass production and distribution and exploitation of economies of scale, and a change of leadership. Also Germany introduced new ways of organizing production, particularly with respect to R&D, as in the chemical and engineering industries, that in the long run should come to have a very important impact. Also during the first half of the Second World War Two period, the very rapid catch-up of Japan towards Western productivity levels was associated with a number of very important organizational innovations (such as the *"just in time system"* in car industry). These innovations did not only benefit Japan, but diffused (with a lag) to the established leader (the USA) and contributed to increased productivity there.

Successful catch-up has historically been associated not merely with the adoption of existing techniques in established industries but also with innovation, particularly of the organizational kind, and inroads into nascent industries (Fagerberg and Godinho, 2003). However, as is equally clear, this has been done in different ways and with different consequences. If we extend the perspective to the most recent decades, this diversity in strategies applied and performance becomes even more striking.

The immediate occasion for this chapter, however, is the explication of the terms of innovation and innovativeness and the analysis of the complicated term of regional inequalities or disparities. The middle part of the chapter refers to the historical retrospect of the relationship between innovation - catch-up and – regional inequalities. Finally, the chapter ends, by way of conclusion, raising the question of what present day developing countries can learn, from the literature on innovation and catching up.

2.2. Innovation, Innovativeness & Regional Inequalities Explicated

2.2.1. "Innovation" Defined

There are various definitions of *"innovation"* that appear in the literature. Engineering, marketing, management and even economics provide unique suggestions as to what is considered an innovation. The purpose of this section is to compare some of the major definitions. Joseph Schumpeter is often thought of as the first economist to draw attention to the importance of innovation. He defined, in the 1930s, five types of innovation (OECD, 1997):

- introduction of a new product or a qualitative change in an existing product
- process innovation new to an industry
- the opening of a new market
- development of new sources of supply for raw materials or other inputs
- changes in industrial organisation.

A review of this literature reveals that the study on technological innovations best captures the essence of innovations from an overall perspective:

> *"Innovation" is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention"* (OECD, 1991: 307).

The definition of Organization for Economic Cooperation and Development (OECD) (1991) comes up with two important distinctions: 1) the "innovation" process includes the technological development of an invention in combination with the market introduction of that invention and 2) the innovation process is iterative in nature and thus, automatically includes the first introduction of a new innovation and the reintroduction of an improved innovation. It is necessary to point out that the OECD definition also refers to *"technology-based inventions"* in order to give us understand that technological innovations are those innovations that embody inventions from the industrial arts, engineering, applied sciences and pure sciences.

It is important to elucidate that an invention does not become an innovation until it has processed through production and marketing tasks and is diffused into the marketplace (Rogers, 1998; Garcia and Calantone, 2002). The invention of a new *"product"* only in a laboratory setting makes no direct economic contribution. Innovation includes not only basic and applied research but also product development, manufacturing, marketing, distribution, servicing, and later product adaptation and upgrading. A discovery that goes no further than the laboratory remains an invention. A discovery that moves from the lab into production, and adds economic value to the firm (even if only cost savings) would be considered an innovation. Thus, an innovation differs from an invention in that it provides economic value and is diffused to other parties beyond the discoverers.

According to the definition included in the third edition of the Oslo Manual (OM) (OECD, 2005), innovation is the introduction into the market of a new or significantly improved product or process, or the development of new organisational and marketing techniques. In this new edition are omitted the distinctions which were made in previous editions of the Oslo Manual between technological and non-technological innovation. In this edition technological innovations mean product and process (TPP) innovations. Product innovations being understood as those designed to modify the characteristics and/or intended uses of goods and services, while process innovations are those affecting the form or methods of production. In this respect, the third edition of the OM defines as organisational innovation the application of new methods of organisation and changes in business practices, in workplace organisation and in the enterprise's external relations (Lugones, 2008).

The basic lesson from the extensive work in the OM is that *"innovation"* is problematic to define precisely. In practice, survey research must choose a relatively short definition for innovation and accept the fact that respondents will use varying interpretations (Rogers, 1998). The continual evolution of innovations is the iterative nature referenced in the OECD definition. This iterative nature results in a variety of different innovation types, typically called *"radical innovations"* for products at the early stages of diffusion and adoption and 'incremental innovations' at the advanced stages of the product life cycle (Garcia and Calantone, 2002). Innovations do not occur just during the production development phases but also may occur during the diffusion process in which a product or process may undergo continual improvements and upgrades.

Once the production process has become standardized for product innovations, process innovations will evolve to improve the output productivity. Classic examples of process innovations are the float glass process for flat-sheet glass manufacturing and the Bessemer process for converting iron to steel, which revolutionized the steel industry. The efficiency improvement of the production process for 'product innovations represents the primary focus of *"process innovations"*. However what is not evident is that process innovations can lead to new product innovations.

Additionally one must distinguish the difference between technological innovation and non-technological innovation (which includes novel marketing strategies and changes to management techniques or organisational structures). As far as these two kinds of innovation are concerned, a firm can be defined as technologically innovative if it introduced at least one new or substantially improved product or process in a three year period. Similarly, a non-technologically innovative firm was defined as having introduced one of the changes mentioned above (Rogers, 1998).

In 1996 the Department of Industry Science and Tourism (DIST) of Australia use a relatively broad definition of innovation, namely:

> *"Innovation, at the level of an individual firm, might be defined as the application of ideas that are new to the firm, whether the new ideas are embodied in products, processes, services, or in work organization, management or marketing systems"* (Rogers, 1998: 8).

Lastly, the Business Council of Australia in 1993 has used the following definition:

> *"In business, innovation is something that is new or significantly improved, done by an enterprise to create added value either directly for the enterprise or indirectly for its customers"* (Rogers, 1998: 9).

Note that the last one defines innovation as something that 'adds value'. In general, innovation is only regarded to have occurred if it has been implemented or commercialised in some way. The invention of new products or processes, is not normally considered innovation until it has been productively incorporated into the enterprise's activities. This means that innovative activity is not something that can occur separate from the firm's core activities; rather it must involve the coordination of various inventive, learning and implementation skills.

This last point highlights that innovative activity requires a substantial effort from all elements of a firm. Moreover, innovative firms are likely to have the characteristics that allow innovation to occur consistently through time. Rogers expressed this as follows:

> *"Effectively innovating firms are those with strategies, values, organisational forms and practices which are conducive to consistent innovation and continuous improvement"* (Rogers, 1998: 10).

2.2.2. "Innovativeness" Defined

"Innovativeness" is most frequently used as a measure of the degree of 'newness' of an innovation. *"Highly innovative"* products are seen as having a high degree of newness and 'low innovative' products sit at the opposite extreme of the continuum (Garcia and Calantone, 2002). However, regarding from whose perspective this degree of newness is viewed and what is new, there exists little continuity in the new product literature. This nature of defining innovativeness has contributed to the lack of

advancement in understanding the New Product Development (NPD) process as studies cannot be compared across different units of analysis.

However, a single consistency for *“innovativeness”* does exist despite the varying vision angles. *“Innovativeness”* is modeled as the degree of discontinuity in marketing and/or technological factors. Thus product innovativeness is a measure of the potential discontinuity which a product (process or service) can generate in the marketing and/or technological process. From a macro perspective, 'innovativeness' is the capacity of a new innovation to create a paradigm shift in the science and technology and/or market structure in an industry. From a micro perspective, 'innovativeness' is the capacity of a new innovation to influence the firm's existing marketing resources, technological resources, skills, knowledge, capabilities, or strategy.

Moreover it must be emphasized that product innovativeness does not equate to firm innovativeness. Firm or organizational innovativeness has been defined as the propensity for a firm to innovate or develop new products (Garcia and Calantone, 2002). It has also been defined as the propensity for a firm to adopt innovations. In either case, the innovativeness of a product that a firm markets or adopts is not a measure of organizational innovativeness. Many firms have taken an innovation strategy of imitating and improving upon existing products or technologies. This type of firm is very successful at improving upon existing product designs. Microsoft is a classic example of this type of strategy. Even successful analyzers, including Microsoft, are often viewed by their competitors as great imitators and not highly innovative. Thus, a highly innovative product does not automatically imply highly innovative firms.

2.2.3. “Regional Inequalities” Analyzed

International disparities in economic performance across countries are often smaller than those among regions within the same country. In almost one-third of OECD countries, the highest regional GDP per capita was more than four times larger than the lowest regional GDP per capita in the same country in 2005 (OECD, 2009). Regional inequalities persist over time, for even though disparities between countries have been diminishing in recent years those within countries have not declined. Moreover, the gap between GDP per capita in rural regions and in urban ones did not narrow over the past ten years (OECD, 2009). Most of these differences are explained by productivity differentials among regions. Improving regional living conditions through gains in labour productivity requires a better use of regional assets. Among these assets to be mobilised, human capital and innovation related activities. Industry specialisation and the supply and utilisation of the labour force including women and young people are identified as factors to increase regional competitiveness.

Economic geography seeks to explain the riddle of unequal spatial development. The most salient feature of the spatial economy is in effect the presence of a large variety of economic agglomerations. Although using *"economic agglomeration"* as a generic term is convenient at a certain level of abstraction, it must be kept in mind that this concept refers to very distinct real world situations (Fujita and Thisse, 2009). At one extreme of the spectrum lies the North–South divide. At the other extreme, agglomeration arises when restaurants, movie theaters, or shops selling similar products are clustered within the same neighborhood, not to say on the same street.

What distinguishes those various types of agglomeration is the spatial scale, or the spatial unit of reference, chosen in conducting one's research, very much as there are different levels of aggregation of economic agents (Fujita and Thisse, 2009). Whatever the scale of analysis retained, the emergence of economic agglomeration is naturally associated with the emergence of inequalities across locations, regions or nations. Such inequalities are often at the origin of strong tensions between different political bodies or jurisdictions, or even social, religious or ethnic groups when they are geographically concentrated. Understanding how spatial inequalities in living standards arise is thus a fundamental challenge for economists and regional scientists.

2.3. A Typology for Identifying Technological Innovations

As classification is a common process in the physical, life and social sciences; the result is a diverse range of interpretations and frequent misuse of classification terms, theories and methods. Recent new product development literature has elucidated the importance of categorizing innovations into radical and incremental. However, *"radical"* and *"incremental"* can be defined in numerous fashions and is dependent upon from whose perspective innovativeness is being evaluated. This section provides a typology for classifying innovations based upon the extant literature. It is important to emphasize that this typology is relative to the firm. What one firm identifies as a really new innovation, can be labeled as an incremental innovation by another firm. The important fact remains that the procedures for developing really new innovations are relevant to the one firm and incremental innovation development procedures are relevant to the other firm (Garcia and Calantone, 2002). Even though they are both developing the same innovation and the end results for the firms will be the same. The process of reaching this result will differ significantly.

The new product literature has mainly used a dichotomous classification for identifying innovation type which is from my point of view, a bit simplistic. Radical innovations are rare in occurrence. It has been suggested that only 10% of all new innovations fall into the category of radical innovations (Rothwell and Gardiner, 1988; Garcia and Calantone, 2002; Coccia, 2006). Moreover Rothwell and Gardiner (1988) have suggested that incremental innovations cover the 90% of the remaining cases. Furthermore a third category is necessary in classifying innovations, the term 'really new' is used to identify this third categorization.

Boolean logic provides unambiguous labels for *“radical”*, *“really new”*, and *“incremental innovations”* (Garcia and Calantone, 2002; Coccia, 2006). Radical innovations are innovations that cause marketing and technological discontinuities on both a macro and microlevel. Incremental innovations occur only at a microlevel and cause either a marketing or technological discontinuity but not both. Really new innovations cover the combinations in between these two extremes.

Based on this classification schema, there are eight combinations of innovation types possible. It is impossible to have an innovation that is discontinuous on a macro level and not on a microlevel, thus, several combinations are eliminated. Radical innovations represent 1/8 of these posibilities or 12.5% (Table 2.1). Really new innovations represent 4 of the 8 combinations or 50% of all types of innovations, and incremental innovations represent 37.5% of technological innovations. The important distinction is that in a random sample, radical innovations are rare and should be not account for more than 20% of the sample, likewise, incremental innovations should account for no less than 20% of the sample. In this section we describe the characteristics of each of these types of innovations.

Table 2.1.: Typology for Identifying Innovation

INNOVATION TYPE		**LEVEL**			
		Macro		***Micro***	
		Marketing Discontinuity	*Technology Discontinuity*	*Marketing Discontinuity*	*Technology Discontinuity*
Radical		√	√	√	√
Really New	*A*		√	√	√
	B	√		√	√
	C	√		√	
	D		√		√
Incremental	*A*			√	√
	B			√	
	C				√

Source: Own elaboration.

Using items that measure product innovativeness on a macro and microlevel and on marketing and technological discontinuity, it is easy to classify highly innovative products as radical innovations, moderately innovative products as really new innovations and low innovativeness products as incremental innovations. Other typologies have been utilized but they are recognized as just alternative variations of these three product types like the discontinuous and imitative innovations.

2.3.1. Radical Innovations

Radical innovations have been defined as innovations that embody a new technology that results in a new market infrastructure (Garcia and Calantone, 2002; Coccia, 2006). It has been also maintained that radical innovation introductions result in discontinuities on both a macro and micro level. An innovation that causes discontinuity on a world, industry or market level will automatically cause discontinuities on the firm and customer level. If a new industry results from a radical innovation (i.e., the World Wide Web), new firms and new customers also emerge for that innovation. Radical innovations often do not address a recognized demand but instead create a demand previously unrecognized by the consumer. This new demand cultivates new industries with new competitors, firms, distribution channels, and new marketing activities.

A tool that can aid in the identification of radical innovations is the technology S-curve. The S-curve has been used to describe the origin and evolution of technologically discontinuous/radical innovations. This theory suggests that technological product performance moves along an S-curve until technical limitations cause research effort, time, and/or resource inefficiencies to result in diminishing returns. New innovations replace the old technology and a new S-curve is initiated (see Fig. 1.1).

Figure 2.1.: Technology/Marketing S-Curve Phenomena

Source: Garcia and Calantone, 2002.

Moreover we can use the S-curve in market formation where knowledge bases need to be built, lines of inquiry must be drawn and tested, and market-related issues surface. Marketers need to investigate and discard unworkable approaches. New markets evolve that support the new technological innovation, new competitors enter the market, and new partners and distribution channels emerge to exploit the new technology. So, until this market know-how has been acquired, the pace of progress toward market limits may be slow and diminishing returns are experienced (Garcia and Calantone, 2002).

Thus, it is easy to see that *"planning"* for radical innovation requires understanding how to strategically plan for both the technological discontinuities and marketplace discontinuities for the global marketplace. Most firms are unable to alter the inertial forces driving the firm down a particular path, further, to plan for major strategic changes based on macrolevel changes is unlikely (Garcia and Calantone, 2002; Coccia, 2006). This does not mean that innovative and proactive companies cannot lead to radical innovations, but more to the point, by their nature, radical innovations are rare. A failure to find discontinuity in technology and marketing strategies within a firm, should automatically exclude the product from being considered radical. Finding a microlevel shift in the S-curves, is necessary but not sufficient criteria for radical innovativeness as it also is an indicator of really new innovations.

2.3.2. Really New Innovations

Continuing the classification, the really new innovations are defined as the moderately innovative products which are not new to the market (not as much innovative) with new items in existing product lines for the firm (Garcia and Calantone, 2002). On a macro level, a really new product will result in a market discontinuity or a technological discontinuity but will not incorporate both (If both do occur, it should be classified as a radical innovation, if no discontinuity occurs at the macro level, it should be classified as an incremental innovation). On a microlevel any combination of marketing and/or technological discontinuity can occur in the firm.

Really new innovations are easily identifiable by the criteria that a discontinuity must occur on either a marketing or technological macro basis in combination with a microlevel discontinuity. They can evolve into new product lines (e.g., Sony Walkman), product line extensions with new technology (e.g., Canon Laserjet), or new markets with existing technology (e.g., early fax machines). Frequently *"really new"* products are misclassified as *"radical innovations"* and *"radical innovations"* are misclassified as *"really new"* products. But evaluating the innovation's technology and market S-curves is an easy test to determine the appropriate classification.

2.3.3. Incremental Innovations

The last important category of innovations is the incremental innovations which can easily be defined as products that provide new features, benefits, or improvements to the existing technology in the existing market.

> *"An incremental new product involves the adaptation, refinement, and enhancement of existing products and/or production and delivery systems"* (Garcia and Calantone, 2002: 123).

Incremental innovations will occur only on a microperspective affecting either the marketing and/or technology S-curve(s). Incremental innovations will not result in macro discontinuities which are only seen in radical or really new innovations. Incremental innovations can be used as a competitive weapon in a technologically mature market; and can help alert a business in good times to threats and opportunities associated with the shift to a new technological plateau.

Incremental innovations evolve from the iterative nature of the process of innovation previously discussed and can occur at all stages of the new product development process. At the conceptualization stage, R&D may use existing technology to improve an existing product design. At the mature stage of a product's life, line extensions may result in incremental innovations. Rothwell and Gardiner point out that a *"borrowed"* technology from a different industry may be new to a different market. If it does not alter on a macrolevel either the technology or marketing S-curves or on a microlevel both curves, this borrowed technology would be considered an incremental innovation.

2.3.4. Discontinuous Innovations

As far as discontinuous innovations are concerned it is possible to define them as "game changers which has potential (1) for a 5-10 times improvement in performance compared to existing products; (2) to create the basis for a 30-50% reduction in costs; or (3) to have new-to-the world performance features" (Rice et al. 1998; Garcia and

Calantone, 2002; Sandström, 2009). A discontinuous innovation may be either a radical innovation or really new innovation depending upon which level (macro/micro) and which S-curve(s) (marketing/technology/both) is affected by the introduction of the invention to the marketplace. Discontinuous innovations demonstrate new technologies that did not lead to discontinuity in the existing market infrastructures such as the digital X-ray and the digital light projector that are product line extensions. The hybrid vehicle, the IBM semiconductor, and the bi-directional elevator are new product lines. Thus, it is contended that most examples of discontinuous innovations are really new innovations since only one of the S-curves is affected. However, a discontinuous innovation may indeed be a radical innovation if both S-curves are perturbed.

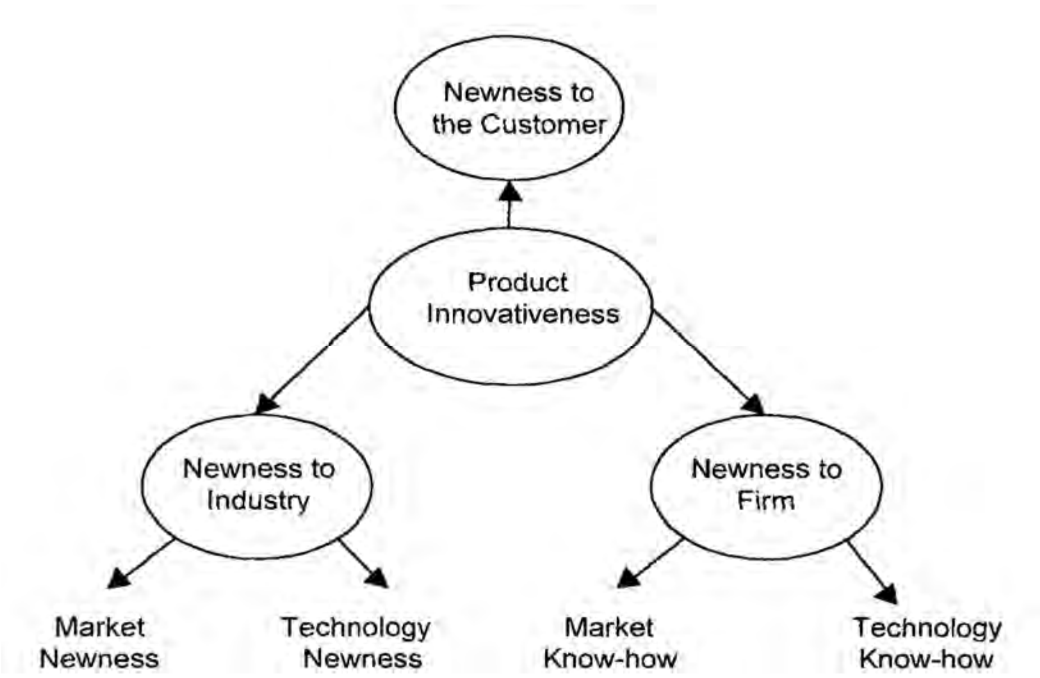
2.3.5. Imitative Innovations

Finally the definition of imitative innovation should be given in order for the difference between imitative and incremental innovation to be clarified. Garcia and Calantone (2002: 123) provide a very brief definition of imitative innovations.

> *"Innovation occurs only in the first company to complete industrial R&D which culminates in the launch of the first product on the markets. Rival innovations are designated imitations even if, in intracorporate term, very similar R&D processes are only a short distance from one another chronologically. The imitator need not necessarily be aware of or be able to benefit from the first innovator. Imitations can thus be just as resource-intensive, especially R&D intensive, as the first innovation"* (Garcia and Calantone, 2002: 123).

Because of their iterative nature, imitative products are frequently new to the firm, but not new to the market. Thus, imitative innovations usually have low technological innovativeness and low market innovativeness. Imitative innovations should not be underrated. Innovative imitators can significantly alter the market direction. The early imitators can play a major role in *"remaking"* or *"creatively destroying"* the market. Moreover, if they have more resources and already have a large market share, it is their imitative reactions that will have the most impact on changing the market, the rate of change and competitive dynamics in the market. Based on this typology, imitative innovations will most likely be incremental innovations, although on rare occasions they will be really new innovations.

Figure 2.2.: Operationalization of Innovativeness



Source: Garcia and Calantone, 2002.

2.4. The Main Strands of the Relevant Literature

The so-called *"old"* neoclassical growth theory of the 1950s provides a useful starting point. This theory was based on the idea of technology as a public good, freely available to everybody anywhere and hence a powerful equilibrating force in the global economy (Fagerberg et al., 2009). However, applied work based on this perspective soon confirmed that the optimistic scenario of this theory did not really fit the evidence, and this led to a search for alternative ways to understand the role of technology and innovation for economic development.

Another strand, which particularly gained currency during the 1980s and 1990s, although some contributions were older, was based on the work of several prominent historians (and other social scientists) who argued that in practice the successful exploitation of technology for development depends on the ability of a country to generate the necessary *"capabilities"* for doing so (Fagerberg et al., 2009). Some of the topics addressed in the *"capability"* literature, such as, for example, the role of institutions and policy for technological and economic development, are also central to the so-called "new growth theory" that developed from the mid 1980s onwards.

2.4.1. "Old "Neoclassical Growth Theory: An Optimistic Scenario

From the birth of the so-called *"classical political economy"* more than two hundred years ago, economists have focused on accumulated capital per worker when trying to explain differences in income or productivity. Similarly, differences in economic growth have been seen as reflecting different rates of capital accumulation.

Robert Solow adopted the important role played by *"mechanization"* as a mean for productivity advance in his so-called *"neoclassical growth theory"* (Solow, 1956). Solow's model was based on standard neoclassical assumptions, such as perfect competition (and information), maximizing behaviour, no externalities, positive and decreasing marginal products, absence of scale economies, etc. In this model, the capital-labour ratio approaches a constant, and productivity growth ceases. So, in this long-run equilibrium gross domestic product, capital stock and labour force grow at the same, exogenously determined rate.

However, Solow (1956) in his model added an exogenous term, labelled *"technological progress"* to explain the long-run growth in GDP per capita. In this interpretation, technology - or knowledge - is referred as a *"public"* good, meaning something that is accessible for everybody free of charge. Solow from his neoclassical perspective believed that if technology - or knowledge - is freely available in for example the USA, it will be so at the global level as well. On this assumption the neoclassical model of economic growth predicts that, in the long run, GDP per capita in all countries will grow at the same, exogenously determined rate of global technological progress.

Though, there is only one factor that could explain differences in per capita growth across countries and is so-called *"transitional dynamics"*: since initial conditions generally differ, countries may grow at different rates in the process towards long-run equilibrium (Fagerberg et al., 2009). An assumption can be made, then, for poor countries growing faster than the richer ones because countries where capital is scarce compared to labour it should be expected to have a higher rate of return on capital, a higher rate of capital accumulation and higher per capita growth. This tendency should be considerably strengthened to the extent that capital is internationally mobile and moves to the countries where the prospects for profits are highest. Hence, the gaps in income levels between rich and poor countries should be expected to narrow (so-called *"convergence"*) and - ultimately - disappear.

Still this could not be the whole story. From the late 1950s onwards empirical research on factors affecting long run-growth grew steadily. Abramovitz (1956) indicated that only a small part of a country's productivity growth could be explained by factor growth. Thus, the major part of a country's productivity growth remained unexplained (the *"residual"*) and had to be classified as so-called total factor productivity growth. Although several attempts have been made to *"squeeze down the residual"*, the result - that a theory that only focuses on factor growth is unlikely to explain long run growth very well - is now generally accepted.

Moreover, what came to be seen as the central prediction of theory - that convergence between rich and poor countries should be expected - was shown not to be consistent with the facts either (Islam, 2003). In fact, the long run trend since the Industrial Revolution has been towards divergence, not convergence in productivity and income. For example, according to the economic historian David Landes, the difference in income or productivity per head between the richest and poorest country in the world has substantially increased over the last 250 years (Landes 1998). Although different sources may give different estimates for this increase, the qualitative interpretation remains the same.

2.4.2. Knowledge & Development

"Knowledge" or *"Knowing Things"* may take many forms. It may be theoretical, based on an elaborate understanding of the phenomena under scrutiny. But it may also be practical, based on cause-effect relationships that have been shown to hold in practice. It may be created through search or learning but it may also be acquired through education or training or simply by observing what others do and trying to imitate it. The creation (or acquisition) of knowledge does not require an economic motive (or

effect), although this is quite common. The subset of knowledge that deals with how to produce and distribute goods and services, which is what interest economists most, is usually labeled as *"Technology"* (Fagerberg et al., 2009). An open question is whether the concept of technology only refers to knowledge about physical processes (*"hardware"*), or if it also includes knowledge about how to manage these (*"software"*).

As mentioned in the introduction the role of technology - and hence innovation - for catch-up processes has been a highly controversial topic for at least a century. Torstein Veblen (1915) put forward the argument that recent technological changes had altered the conditions for industrialization in latecomer economies. In earlier times, he argued, the diffusion of technology had been hampered by the fact that technology was mostly embodied in persons, so that migration of skilled workers was a necessary prerequisite for its spread across different locations. However, with the advent of *"machine technology"*, as he put it, this logic had changed. Veblen also argued, that this new type of knowledge *"can be held and transmitted in definite and unequivocal shape, and the acquisition of it by such transfer is no laborious or uncertain matter"*.

What Veblen (1915) was arguing is that while technology was previously *"tacit"* and embodied in persons, it later became more *"codified"* and easily transmittable. Hence, catch-up should be expected to be relatively easy, under *"suitable circumstances"*, since the latecomers could take over the new technology *"ready-made"*, without having to share the costs of its development. This might be expected to be a very profitable affair.

We have to mention that this perspective of technology was later wholeheartedly adopted by standard neoclassical economics. Following that approach, knowledge should be seen as a body of information, freely available to all interested, that could be used over and over again (without being depleted) (Fagerberg et al., 2009). Obviously, it should be expected knowledge benefit everybody all over the globe to the same extent, which means that cannot be used to explain differences in growth and development. Rather than, something that exists in the public domain and can be exploited by anybody everywhere free of charge, technological knowledge, whether created through learning or organized R&D, is in this tradition seen as deeply rooted in the specific capabilities of private firms and their networks/environments, and hence not easily transferable. According to this latter view there is nothing automatic about catch up. It requires a lot of effort and capability-building on the part of the backward country.

2.4.3. Social Capability & Absorptive Capacity

Another belief about the potential for catch-up by late-comers was placed by Abramovitz. He suggested that differences in countries' abilities to exploit this potential might be explained with the help of two concepts, technological congruence and social capability (Abramovitz, 1986). The first concept refers to the degree to which leader and follower country characteristics are congruent in areas such as market size, factor supply etc. The second concept points to the capabilities that developing countries have to develop in order to catch up, such as improving education (particularly technical) and the business infrastructure (including the financial system, how effective become when mobilize resources for change).

The concept *"social capability"* soon became very popular in applied work. These are some of the aspects that Abramovitz considered to be particularly relevant with the concept of social capability which he was intended to cover (Abramovitz, 1986):

- Technical competence (level of education).
- Experience in the organization and management of large scale enterprises.
- Financial institutions and markets capable of mobilizing capital on a large scale.
- Honesty and trust.
- The stability of government and its effectiveness in defining (enforcing) rules and supporting economic growth.

A related concept that has become popular concept in the applied literature on growth and development is *"absorptive capacity"*. The term itself is not new. In development economics it has been used for a long time, as the ability of a developing country to absorb new investments more generally (Adler, 1965; Eckaus, 1973). However, as the role of knowledge for growth and development became more widely recognized, it came to be associated with the ability to absorb knowledge. Rostow's (1980: 267-277) new perspective is concentrated as well in the following paragraph:

> *"Economic growth depends on the rate of absorption of the existing and unfolding stock of relevant knowledge; the rate of absorption depends on the availability of both trained men and capital; the reason for the accelerated growth among (...) middle-income countries is that they have built up the stock of trained man-power (including entrepreneurs) to a position where they can accelerate the rate of absorption of the existing stock of knowledge"* (Rostow, 1980: 267-277).

Cohen and Levinthal (1990) contributed to this new perspective with the application of this the concept to the firm level. They defined it as *"the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends"*. They saw absorptive capacity as dependent on the firm's prior related knowledge, which in turn was assumed to reflect its cumulative R&D. However, they also noted that the path dependent nature of cumulative learning might make it difficult for a firm to acquire new knowledge and retain linkages with holders of knowledge which were created outside its own organization and specialized field.

Although the focus of Cohen and Levinthal was on firms, many of the same considerations apply, as emphasized above, at more aggregate levels, such as regions or countries, and the term has been widely used. It should be noted, however, that the concept as used by Cohen and Levinthal combines three different processes into one, namely: (1) search, (2) assimilation (or absorption) of what is found and (3) its commercial application (Cohen and Levinthal, 1990). Hence, it refers not only to *"absorption"* in the received meaning of the term, but also on the ability to exploit and create knowledge more generally. Continuing the review of the literature, Zahra and George (2002) argue that the skills required for creating and managing knowledge differ from those related to its exploitation and therefore the two deserve to be treated and measured separately. They term the latter *"transformative capacity"*. In a similar vein Fagerberg et al. (2009) distinguish between a country's ability to compete on technology (what they term *"technology competitiveness"*) and its ability to exploit technology commercially independently of where it was first created (so-called *"capacity competitiveness"*).

2.4.5. Technological Capability

From the 1970s onwards several studies of catch-up (or lack of such) in other parts of the world emerged. One case which received much attention was the rise of Korea from being one of the poorest countries in the world to a first world technological powerhouse in just three decades. Linsu Kim, who made the study on the subject, used the concept *"technological capability"* as an analytical device to interpret the Korean evidence. He defined it as:

> *"The ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies. It also enables one to create new technologies and to develop new products and processes"* (Kim, 1997: 4).

The concept includes also other capabilities needed for the commercial exploitation of technology. Kim's notion of technological capability considers assimilation and adaptation of *"existing knowledge"* as key in the catching-up process. So it is expected the requirements to become more stringent, in particular with respect to innovation capabilities, as countries climb up the development ladder. Thus, for a firm or country in the process of catching up, the appropriate level of technological capability would be a moving target, in constant need of improvement (Fagerberg et al., 2009).

So far it has become common in the literature to consider three aspects of technological capability: production capability, investment capability and innovation capability (Fagerberg et al., 2009). Production capability is needed to operate productive facilities efficiently and to adapt production to changing market circumstances. Investment capability is needed to establish new productive facilities and adjust project designs to suit the circumstances of the investment. Finally, innovation capability is required to create new technology, e.g., develop new products or services.

Although initially developed for analysis of firms, the concept has also been applied to whole industries or countries. Sanjaya Lall emphasized three aspects of *"national technological capability"* as he phrased it: the ability to muster the necessary (financial) resources and use them efficiently; skills, including specialized managerial and technical competence; and what he called *"national technological effort"*, which he associated with measures such as R&D, patents and technical personnel (Lall, 1992). He noted also that national technological capability depends on foreign technology as well acquired through imports of machinery or foreign direct investments. Following this approach, catch-up or convergence is by no means guaranteed. It depends on the balance of innovation and imitation, how challenging these activities are and the extent to which countries are equipped with the necessary capabilities.

2.4.6. National Innovation Systems

The observation that technological and social factors interact in the process of economic development might also be taken as supporting the view that a broader, more systemic approach that take such interactions into account is required. Such concerns led during the 1980s and 1990s to the development of a new systemic approach to the study of countries' abilities to generate and profit from technology, the so-called *"national innovation system"* approach (Fagerberg et al., 2009). The concept, first used in public by Christopher Freeman (Freeman, 1987), but soon became a popular analytical tool for researchers who wanted to get a firmer grasp on the interaction processes underlying a country's technological and economic development.

However, the adoption of the innovation system approach to developing countries is a relatively recent phenomenon. Moreover, there is currently no agreement in the literature on how innovation systems should be defined and studied empirically. Some researchers in this area emphasise a need for developing a common methodology, based on the functions and activities of the system, to guide empirical work, while others advocate the advantage of keeping the approach open and flexible (Fagerberg et al., 2009).

2.4.7. New Growth Theory

During the 1980s and 1990s economists' interest in the possible role of knowledge (technology) for growth and development increased. An important development from the theoretical viewpoint was the emergence of the so-called *"new growth theory"*. According to this theory, differences in economic development across countries should be understood as the outcome of differences in endogenous knowledge accumulation within extended national borders. Although enough innovative technological knowledge may spread over from one country to another, according to this approach there are sufficient constrains to this process to secure that in most cases the lion's share of the benefits will be accumulated by the innovator.

Hence, long run economic growth should to be expected to depend on appropriateness conditions and the enforcement of intellectual property rights according to new growth theory. Moreover, the theory predicts that large countries should be expected to be more innovative, and benefit more from innovation, than small countries. However, the latter may to some extent overcome the disadvantages of scale by practicing free trade and exploiting international capital flows. Also it is obvious that openness to trade and foreign investment is essential for countries that wish to catch up (Fagerberg et al., 2009).

However, the evidence supporting this conclusion is quite weak and not sufficient enough. So it appears that the degree of openness to international transactions does not discriminate well between countries that manage to escape the low development trap and those that continue to be poor. Nevertheless, this does not mean knowledge flows across borders are not important for growth and development.

2.4.8. Forging Ahead & Falling Behind

2.4.8.1. The Catch-Up Hypothesis

The hypothesis asserts that being backward in level of productivity carries a potential for rapid advance. Stated more definitely, the proposition is that in comparisons across countries the growth rates of productivity in any long period tend to be inversely related to the initial levels of productivity (Abramovitz, 1986).

The central idea is simple enough. It has to do with the level of technology embodied in a country's capital stock. In a *"leading country"*, one may suppose that the technology embodied in each vintage of its stock was at the very frontier of technology at the time of investment. In a *"following country"* whose productivity level is lower, the technological age of the stock is obsolete even for its age.

When a leader discards old stock and replaces it, the accompanying productivity increase, is governed and limited by the advance of knowledge between the time when the old capital was installed and the time it is replaced. Those who are behind, however, have the potential to make a larger leap. New capital can embody the frontier of knowledge, but the capital it replaces was technologically superannuated.

So, the larger the technological and, therefore, the productivity gap between leader and follower, the stronger the follower's potential for growth in productivity; and, it is expected the follower's growth rate to be faster (Abramovitz, 1986). Viewed in the same simple way, the catch-up process would be self-limiting because as a follower catches up, the possibility of making large leaps by replacing superannuated with best-practice technology becomes smaller and smaller.

However, the follower's potential for growth weakens as its productivity level converges towards that of the leader. Moreover a country's potential for rapid growth is strong not when it is backward without any qualifications, but rather when it is technologically backward but socially advanced. In the first case, the evolution of social capability connected with catching up itself raises the possibility that followers may forge ahead of even progressive leaders. In the other, a leader may fall back or a follower's pursuit may be slowed.

The combination of technological gap and social capability defines a country's potentiality for productivity advance by way of catch-up. This, however, should be regarded as a potentiality in the long run. Having considered the technological catch-up idea, with its several extensions and qualifications, Abramovitz (1986: 390) summarizes by proposing a restatement of the hypothesis as follows:

> *"Countries that are technologically backward have a potentiality for generating growth more rapid than that of more advanced countries, provided their social capabilities are sufficiently developed to permit successful exploitation of technologies already employed by the technological leaders. The pace at which potential for catch-up is actually realized in a particular period depends on factors limiting the diffusion of knowledge, the rate of structural change, the accumulation of capital, and the expansion of demand. The process of catching up tends to be self-limiting, but the strength of the tendency may be weakened or overcome, at least for limited periods, by advantages connected with the convergence of production patterns as followers advance towards leaders or by an endogenous enlargement of social capabilities"* (Abramovitz, 1986: 390).

2.4.8.2. Interaction Between Followers & Leaders

The catch-up hypothesis in its simple form is concerned with only one aspect of the economic relations among countries: technological borrowing by followers. But a moment's reflection, however, exposes the inadequacy of that idea. The rise of British factory-made cotton textiles in the first industrial revolution ruined the Irish linen industry. The attractions of British and American jobs denuded the Irish population of its young men. These are examples of the negative effects of leadership on the economies of those who are behind. Besides technological borrowing, there are interactions by way of trade and its rivalries, capital flows, and population movements. Moreover, the knowledge flows are not solely from leader to followers. According to Abramovitz (1986) a satisfactory account of the catch-up process must take account of these multiple forms of interaction which are:

- *Trade and its Rivalries*
- *Interactions via Population Movements*
- *Interaction via Capital Flows*
- *Interactions via Flows of Applied Knowledge*

2.4.8.3. What it Takes to Catch up: The Need for *"New Institutional Instruments"*

Some countries are at the technological frontier while others lag behind. Although the technological gap between a frontier country and a laggard represents *"a great promise"* for the latter, a potential for high growth through imitating frontier technologies, there are also various problems that may prevent backward countries from reaping the potential benefits to the full extent.

Gerschenkron's work is often associated with his focus on investment banks, which he saw as critical in mobilizing resources for development (Gerschenkron, 1962). However, he made an attempt to arrive at a more general understanding of the conditions for catch-up, focusing on the instruments - or capabilities to use a more recent term - that need to be in place for successful catch-up to take place and the roles that public and private sector actors may play in generating these capabilities. He also emphasized the historically contingent nature of the capabilities needed for catch up. Hence, while the need for such capabilities may be a quite general phenomenon, their precise nature may well differ between historical time-periods, industries/sectors and levels of development.

2.5. Concluding Remarks

As revealed from the literature analysis above, few empirical studies have identified the idiosyncrasies of the development process for radical and really new innovations. It was found considerable evidence that radical innovations require unique and sophisticated development strategies, but little empirical evidence to support these theories. It has been shown empirically that radical products entail greater risk, product champions are more valuable in the radical development process, and radical innovation is best identified using both a technological and business perspective.

As far as concerns really new products, their successes are positively impacted by increasing the proficiency level of strategic planning activities, whereas, working to improve proficiency in business and market opportunity analysis is counterproductive. In the early development stages of really new innovations, customer research is critical in order to assess the types and degrees of discontinuities inherent in them. Additionally, managers are more likely to carry a risky NPD project through commercialization when the product is really new than when it is less innovative. It can be concluded that market learning for really new innovations differ drastically from those associated with conventional new product development processes.

Using a critical review of the new product development literature in the marketing, management and engineering disciplines, a typology for labeling innovation types and a method of operationalizing product innovativeness have been suggested. This propositional inventory and integrative framework represent efforts which were made to build a foundation for the systematic development of a theory-based definition of product innovativeness. Additional research is needed to empirically test this proposed operationalization.

How innovations are labeled is important if researchers want to increase their understanding of the development process of different types of innovations. Future research is needed to determine how really new product innovations differ from radical innovations in altering the new product development process. Because of the scarcity of radical innovations, this may be difficult to accomplishment without reaching back into history. The goal for future researchers should be to help practitioners identify how the characteristics of radical new products, compared to really new products, will alter the new product development process. Radical innovations can rarely be planned; it is through the creativity and genius of innovators and marketers that they evolve into commercialized products. Researchers can help this process by identifying how to take radical innovations and give them a distinct place in the abundance of innovations.

This chapter also shows us that differences among countries in productivity levels create a strong potentiality for subsequent convergence of levels, provided that countries have a *"social capability"* adequate to absorb more advanced technologies. It reminds us, however, that the institutional and human capital components of social capability develop slowly, as education and organization respond to the requirements of technological opportunity and to experience in exploiting it. Their degree of development acts to limit the strength of technological potentiality proper. Further, the pace of realization of a potential for catch-up depends on a number of other conditions that govern the diffusion of knowledge, the mobility of resources and the rate of investment.

The long-term convergence, to which these considerations point, however, is only a tendency that emerges in the average experience of a group of countries. The growth records of countries on their surface do not exhibit the uniformly self-limiting character that a simple statement of the catch-up hypothesis might suggest. Dramatic changes in productivity rankings mark the performance of a group's individual members. Some causes of these shifts in rank are exogenous to the convergence process.

The state of a country's capability to exploit emerging technological opportunity depends on a social history that is particular to itself and that may not be closely bound to its existing level of productivity. And there are changes in the character of technological advance that make it more congruent with the resources and institutional outfits of some countries but less congruent with those of others. Some shifts, however, are influenced by the catch-up process itself—for example, when the trade rivalry of advancing latecomers makes successful inroads on important industries of older leaders. There are also the social and political concomitants of rising wealth itself that may weaken the social capability for technological advance. There is the desire to avoid or mitigate the costs of growth, and there are the attractions of goals other than growth as wealth increases. A reasonably complete view of the catch-up process, therefore, does not lend itself to simple formulation. Its implications ramify and are hard to separate from the more general process of growth at large.

3rd CHAPTER

MEASURING INNOVATION

3.1. Introduction

It is an unquestionable fact that economic growth depends on the production of new ideas and innovation. Nevertheless, competitive markets do not provide appropriate incentives for such activities because if consumers were to pay only the transmission costs of new ideas, then the revenue obtained would be insufficient to cover the production costs (Jalles, 2010). Historically, societies have used a variety of mechanisms to foster the production of new ideas. Some of them, like copyrights and patents, ensure the innovator the monopoly in the production of the goods that uses those new ideas. Others may include direct subsidies to Research and Development (R&D). A large literature dealing with the correct measurement of the innovation process and technological diffusion, however, no consensus has yet been found. This chapter is expected to contribute with an additional approach to this ongoing literature and, therefore, help the decision making process.

Attention was formerly directed toward cost reduction, delivery time reduction and quality in order to become and remain competitive on the market. By extension, new criteria are emerging to successfully face competitors: among others innovators. The ability of companies to meet consumer expectations depends deeply on their ability to innovate and deliver new products at competitive prices. Innovation is a key driver to achieve sustainable competitive advantages and, more particularly, becomes one of the key challenges for small and medium enterprises (SMEs) (O'Regan et al., 2006).

Other authors outline the cognitive dimension of the innovation process, for instance the relationship between the short-term memory and the cognitive perception function (Rejeb et al., 2008). As a consequence, value creation through innovation is depending on the restructuring of the cognitive dimension of those involved in the process. Moreover, innovation relates to a learning process.

Furthermore, evidence of a necessary constructivist approach in innovation management was demonstrated, particularly within the SME's sector. Success of an innovation relies on the ability to identify and seize opportunities. Hence, top management has to: direct attention toward the definition of global development orientations, launch projects and organize an on-going improvement of innovative project management approaches (Rejeb et al., 2008). As a result evaluation of the innovation capacity becomes a major concern in order to ensure a continuous development of these management practices.

Many authors propose approaches to determine the balance between the outcomes and inputs of innovation. Generally, financial and commercial variables are taken into account. Financial evaluations are based on classical ratio including financial margins and returns on investment. Moreover, specific financial criteria dedicated to innovation resources are suggested: generally measurement of time and cost development. Marketing variables include qualitative and quantitative aspects, such as new market shares and customer satisfaction. Strategic considerations, such as competitive advantage, are integrated to evaluate the balance between outcomes and inputs.

Synthetic indicators can help in spite of all the limitations. This is certainly not the first time that aggregate indicators have been used for economic and social analysis. Take, for example, the most widely employed economic aggregate indicator, the GDP. Although GDP has the great advantage in converting each aspect of economic life into a monetary yardstick (an advantage that only very few technological indicators have), it is equally evident that it highlights some aspects of economic and social life (such as income) and obscures others (such as wellbeing) (Archibugi and Coco, 2005). Not surprisingly, other social indicators are becoming more frequently used to guide strategic decisions. Despite the limitations, and if taken with due caution, these indicators help to understand the reality of certain situations, and can assist in devising strategic decisions.

The general indications, drawn from the recent theoretical and empirical literature in this field, state that the process of technological accumulation takes place at local or regional level, even in the era of globalisation, and that technological spillovers tend to be highly concentrated at the geographical level (Evangelista et al., 2001). All this explains why regions have become fundamental units of analysis in the cost/benefit evaluation of the economic integration and in the studies which look at the process of economic convergence (or divergence).

Some significant attempts to build aggregate indicators of technological capabilities at the country level have recently been made (Archibugi and Coco, 2005). Despite this, the empirical analysis of innovation activities at a sub-national scale is still at an early stage and this is in large part due to the lack of data able to represent the complex and differentiated phenomenon of innovation at a regional level. The purpose of this chapter is to contribute to the long-standing debate on the choice of the best proxy to measure innovation and technological diffusion, by offering alternative variables which are tested empirically and to illustrate the methodologies followed by each of them, to explore their similarities and differences, and to compare the results.

3.2. Literature Review

For measuring the relation between internal and external innovation expenditures and innovation output econometric models will be applied. Crépon et al. (1998) developed a framework which relates innovation inputs and outputs and includes three relationships: (i) the innovation input linked to its determinants, (ii) the knowledge production function relating innovation input to innovation output, and (iii) the productivity equation relating innovation output to productivity growth.

The available literature on the relation between innovation input and output mainly concentrates on the relation between R&D (as an input) and patents or innovation introduction (as an output), mainly due to data availability. The introduction of the CIS waves has initiated an increase in this field of research with an increasing variation in measures.

Lööf and Heshmati (2002) focused on the relation between expenditures on innovation input and its effect on innovation output, as part of the model for measuring the relation to performance. They found that a 10 percent increase in investment in innovative activities per employee increases innovation sales by nearly 3 percent. Besides, they found that the most important source of knowledge for innovation comes from within the firm, while competitors seem to be most important external sources of knowledge for innovation. Firms that perform R&D on a permanent basis show a significant higher innovation output than firms not performing R&D on a continuous basis (Potters, 2009).

Mairesse and Mohnen (2005) found several positive relations between R&D (measured by employee or as a ratio of total sales) and innovation introduction (measured by probability to innovate and introducing products that are new to the market or to the firm). Looking at sector differences, they found that innovation output was generally more sensitive to R&D in low-tech sectors than in high-tech sectors. A greater R&D effort per employee leads to a higher probability of having a process innovation and a product innovation.

Concerning the acquisition of embedded knowledge and technology, Catozzella, Conte and Vivarelli (2008) investigated the impacts of total R&D investments and technology acquisition on innovation output. They found that R&D is strictly linked to product innovations, while technological acquisition is crucial for process innovations. With regard to sector differences, low-tech firms seem to rely more on technological acquisition, while high-tech sectors rely more on R&D input and labour productivity. Firms in more traditional sectors with lower technological opportunities for generating new products concentrate mainly on other innovation inputs for improvements of their production processes, such as the acquisition of new machinery and equipment.

The complementarity between internal and external innovation activities is confirmed in empirical research and case studies, depending on firm and environmental characteristics. Freeman (1987) provided an overview of early research on the importance of the use of external sources, combined with internal R&D, for successful innovation. The main conclusions were that the use of networks and the linkages with external sources of scientific and technical information and advice are decisive in determining the success of a single innovation. The interest for this research goes to the interaction affects between internal and external innovation activities. Cohen and Levinthal (1990) found a strong relation between a firm's own R&D efforts and the use of external sources associated with more basic science. This relation depends on the industry’s technological characteristics, such as the importance of basic fields of science for innovation.

At last Arora and Gambardella (1994) established the relation between firm and sector characteristics and the importance of external innovation activities. They argue that firms differ significantly in their ability to benefit from these collaborative relationships. This ability depends on the type of internal knowledge: scientific and technological know-how. The former is especially effective for screening projects and the latter for applying external knowledge. Veugelers and Cassiman (1999) showed how firm and environmental characteristics affect the choice of internal know-how development and external acquisition. They found that small firms are more likely to focus either on exclusive internal or external innovation activities, while large firms are more likely to combine both.

3.3. What is the Purpose of Measuring Innovation Processes?

Measuring innovation is an important issue, as business growth and profitability in the knowledge age depend on innovation. Continual acceleration in innovation will sustain revenue growth, which will then fuel more innovation. Therefore, sustainable growth requires sustainable innovation, which requires that innovation be institutionalized and its output made predictable. Innovation as an intuitive and creative process is a difficult process to measure.

Innovation historically is measured in terms of financials or counts. Innovation, being a complex and unknown process, proves to be a challenge when defining clear and correlating measurements. The financial- type measurements include new product- or service-specific sales or revenue growth, and count-type measurements include items like the number of patents, trademarks, articles, and product or service versions produced (Gupta, 2007). However, experience shows these measurements do not correlate to the innovation activity; therefore they should not be used as a business measure of performance. In order to establish measures of innovation, understanding the innovation process first is a must.

Therefore Innovation Indicators must be seen as essential tools in both private and government decision-making. In the enterprise, they may be crucial in defining competitive strategies. As regards public policies, innovation indicators can play a central role in the design and implementation of policies both on innovation promotion and on scientific-technological activities in general, and most importantly, in assessing them (Lugones, 2008). This is conditioned, of course, to the fact that the designed indicators should adequately reflect and facilitate interpretation by those responsible for formulating and managing Science, Technology and Innovation (STI) policies, the characteristics of, and prevailing trends in, innovation processes, their determining factors, the obstacles they face and the results achieved.

Measuring innovation effectively is contingent on understanding details of the innovation process, its inputs and outputs, and its controls. The importance and use of measuring innovation processes is directly related to the links between innovation, genuine improvements in competitiveness, economic growth and levels of well-being of societies, links which have been extensively demonstrated by empirical evidence and literature review.

3.4. What Theory Lies Beneath the Measurement of Technological Capabilities?

Various statistical measures are not devoted to explore causal connections between technology, on the one hand and economic and social performance on the other (Archibugi and Coco, 2005). Some of them (and in particular, WEF, 2001; UNIDO, 2002) have taken into account also an indicator of performance such as competitiveness, but our purpose here is to investigate the consistency of these statistics as faithful measures of technological capabilities and furthermore innovation.

First of all, a certain consensus emerges on the understanding of technological capabilities. Although the literature discussed here is aware that technological capabilities and production capacity are strictly interconnected, it broadly shares the view that the former is a stock of knowledge which should be kept conceptually separated from the latter (Archibugi and Coco, 2005). The two phenomena are clearly interdependent since technological capabilities generate production capacity and vice versa. However, since one of the main purposes of the economics of technological change is to quantify and specify the nature of this linkage, it is useful and necessary to separate the two concepts and finding independent measurement tools for each of them.

Second, the literature here discussed shares the view that technological capabilities are composed of heterogeneous elements, which can be summarised in the following three contrasts according to Archibugi and Coco (2005): a) Embodied/Disembodied, b) Codified/Tacit, and c) Generation/Diffusion:

a) *Embodied/Disembodied:* Technological capabilities are embodied in capital goods, equipment, infrastructures, and in disembodied forms such as human skills and scientific and technical expertise. There is ongoing debate on the relative importance of capital goods and disembodied knowledge, but there is a shared belief that both types of capability contribute vitally to the technological base of a country.
b) *Codified/Tacit:* The codified component of knowledge represented by manuals, blueprints, patents, and scientific publications are as important as the tacit components associated with learning by doing and by using. While it is relatively easy to quantify codified sources of knowledge, it is much more difficult to find reliable measures of tacit components: if they were easily quantifiable and measurable they would no longer be tacit! Yet, concentrating on the codified knowledge may overlook fundamental components of the

knowledge used in production. One way of quantitatively capturing these capabilities is by looking at the qualifications of the labour force, under the assumption that better educated employees have a higher learning potential.

c) *Generation/Diffusion:* Both the production of knowledge and its diffusion and imitation provide a valuable technological resource. Some countries can be heavy producers of new knowledge but may be slow to apply it to production, while other countries may benefit disproportionately from the knowledge generated elsewhere. This implies that technological capabilities should be measured according not only to indicators of the generation of inventions and innovations, but also indicators of their application and dissemination.

Third, these works share the methodological view that the various statistics describing the different aspects of technological capabilities can be summed together. Besides the numerical aspect of summing different statistical data, this practice has deeper theoretical implications: it is assumed that the various components of technological capabilities are complementary and not substitutes (Archibugi and Coco, 2005). The purpose of these works is to rank countries rather than mapping their similarities and differences. This implies that the indicators somehow inform different aspects of technological capabilities and it is commonly supposed that the position of a country is more favourable when its range of technological activities is wide and intense.

Fourth, these approaches also share the view that inter-country comparisons are meaningful, in spite of the social, cultural, and regional variety encountered in each of them (Archibugi and Coco, 2005). However, the analyses surveyed here share the belief that nations are still a meaningful statistical unit with which to measure technological capabilities. Of course, these works are fully aware of the differences inside nations, and of the existence of significant institutions within nations that should be considered with their own technological profile (Archibugi and Coco, 2005). Since nations vary considerably in terms of size, all of these attempts have provided measures that weights absolute values by the dimension of nations, either in terms of population or of GDP. Therefore it is better to consider measures of intensity rather than of size.

Fifth, the attempts reviewed consider both developed and developing countries. This places a number of limitations on the statistical sources that can be used, since both the data available and their reliability are much less satisfactory for developing countries. In fact, the selection of the factors to construct a composite indicator is directly associated with the number of countries taken into account: the more countries considered, the more problematic it becomes to find satisfactory measures (Archibugi and Coco, 2005). For a restricted group of developed capitalist countries (i.e. the OECD countries), there is a high number of indicators available and high reliability of data. But the method applied for OECD countries cannot be used for developing countries for the simple reason that relevant data are not available; rather, one can choose indicators that are available for more countries and be aware that the data are not as satisfactory and as accurate as they are for the OECD countries. Moreover, the nature of technological change differs at the various levels of development. This implies that the selection of indicators should be able to differentiate between countries that are at the top and at the bottom of the scale.

3.5. Measures of Innovation: Inputs and Outputs

As should be clear from the discussion above, the measurement of innovation is likely to be difficult due to the broad nature of the scope of innovative activities. One method of trying to assess innovation is to make the distinction between the outputs of innovative activity and the inputs to innovative activity.

3.5.1. Developing Effective Measures of Innovation

In order to identify innovation measures, understanding the purpose of innovation, its environment, and the input, in-process, and output parameters is essential. Furthermore, the relationships between input and output innovation variables must be implicit. To determine measures of innovation, understanding the role of each process in creating the desired innovation is essential.

According to Gupta (2007), if an organization attempting to develop measures of innovation must clearly state its objectives before establishing the measures of innovation. Given the presence of a glut of measurements with no use in most organizations, an addition of nice-to-know measures is often perceived as *"additional"* work and not received well within the organization. Therefore, the following are the steps which Gupta (2007) propose to establish, monitor and act on the innovation measures for a process or an activity:

i. Define the purpose of innovation in the organization.
ii. Establish expected deliverables (basic and specific) and their contribution to business performance, including growth and profitability.
iii. Determine the measures of success of key deliverables.
iv. Identify challenging opportunities for improvement in the innovation process.
v. List activities that must be performed to accelerate innovation. Identify input and output variables and measures of goodness of these variables.
vi. Determine the data collection capability of selected measures of innovation.
vii. Establish reporting and communication methods, and monitor (levels and trends) critical and practical measures of innovation
viii. Take actions to drive business growth and profitability.

3.5.2. Input Measures of Innovation

In order to get a better understanding of the innovation strategies (i.e. the use of innovation inputs) of sectors with different technological opportunities, the focus of this research will be on the impact of internal innovation inputs and external innovation inputs on the innovation output. This section will discuss the innovation inputs of interest for this research.

3.5.2.1. R&D

The level of R&D expenditure has been the most extensively used proxy for the level of innovative effort. Its advantages are that it is a relatively well understood term and it provides a dollar figure for use in subsequent analysis. However, the precise definition of R&D is subject to some debate. The Frascati Manual, produced by the OECD (2002: 30), defines R&D as:

> *"Research and experimental development (R&D) comprises of creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications"* (OECD, 2002: 30).

Nevertheless, it seems highly likely that, in commercial firms at least, R&D will be aimed at creating innovations for commercial exploitation. According to Rogers (1998), the definition above excludes a number of areas that might normally be considered as innovative activities such as market research, cosmetic modifications to products, management studies, and tooling-up. This means that R&D will not closely match the concept of innovation. The definition of R&D is unlikely to match exactly with innovation. But it is because of its wide availability and the expected high correlation between R&D and innovation effort, which makes it a valuable proxy for innovation activity (Potters, 2009).

The term R&D, in this sense, covers three activities, namely (Potters, 2009):

i. basic research (experimental or theoretical work undertaken primarily to acquire new knowledge, without any particular application or use in view),
ii. applied research (original investigation undertaken in order to acquire new knowledge towards a specific practical aim or objective), and
iii. experimental development (systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new or improved materials, products, services or processes).

• *Internal vs. External R&D*

There is a distinction which is made between intramural and extramural R&D. It refers to the same type of activities, but performed by other firms, organisations, such as public and private research organisations (OECD, 2002). Internal and external R&D are treated separately since the objectives and outcomes of both are somewhat different. As Potters (2009) stated, internal R&D can serve solely and is mainly aimed at (radical) product innovation, when on the other hand, external R&D is mainly combined with internal R&D and is used for more incremental innovations.

For example, the distinction between intramural and extramural R&D is that intramural R&D is the main source for more significant innovations (represented by patents), while extramural R&D is more productive in terms of incremental innovations (represented by utility models). Furthermore, *"isolated"* intramural R&D leads to both process and product innovations, while contracted R&D does not lead to significant innovations (measured by patents), unless they are combined with in-house capabilities (the *“absorptive capacity”* hypothesis) (Potters, 2009).

3.5.2.2. Intellectual Property Statistics

Intellectual property measures can also be considered as an input to the innovation process. The use of patent data, which has been by far the most studied component of intellectual property by economists, has been reviewed by Basberg (1987) and Griliches (1990). Griliches states a key problem with using patent data as an innovation measure as follows, "*inventions that are patented differ greatly in their quality*" (Griliches, 1990) (i.e. an individual patent could be worth millions of dollars or nothing). Basberg (1987) considers two further questions concerning the use of patents at the firm level

- To what extent do patents reflect the commercial use of technology?
- How does the usage of the patent systems vary across firms and industries?

Regarding the first question, the existence of a patent does not signal commercial use of the idea. Moreover, not all commercially valuable ideas can or will be patented. This is in part because not all ideas are legally patentable, but also because the process of obtaining a patent involves the full disclosure of the knowledge, which may be of indirect use to competitors. Hence, firms may rationally choose not to patent commercially valuable knowledge and instead rely on secrecy.

The failure of patent or other intellectual property data to fully reflect innovative activities is of particular concern if the patent-innovation relationship varies across firms and over time (Basberg, 1987). If this is the case some care must be taken in using such data for innovation analysis. There are methods of controlling for such issues, the most obvious being to restrict analysis to a sub-group of firms that use patents in a roughly consistent manner (e.g. large firms in manufacturing).

The use of trademark or designs data in analysis of innovation has been must less common than the use of patent data. Some surveys include questions that cover the purchase of trade marks (e.g. ABS Innovation Survey), but trademarks are usually grouped together will patents (Rogers, 1998).

3.5.2.3. Other Innovation Inputs

The use of designs as innovation indicators also seems to have been neglected. Larger projects will use data on trademarks and designs to investigate of the use of these IP rights by firms. Some firm-level data sets also include data on the value of intangibles assets. Intangibles assets, as reported in a set of accounts, are likely to be an overall valuation for goodwill, capitalised past R&D, as well as valuations of any holdings of patents, trademarks and licenses (Rogers, 1998). Thus, such a variable can be used as a measure of past innovation.

As stated before, buying in technology from other firms or institutions may be a key aspect of a firm's innovation strategy. With this in mind, data on the purchases of external technology has been used as an indicator of innovative activity (Rogers, 1998). Technology may also be embodied in capital equipment. A firm that purchases the equipment or machinery which are improved versions of existing machines can legitimately be regarded as innovative (Rogers, 1998). The ABS Innovation Survey considers this type of activity as *"expenditure for tooling-up, industrial engineering and manufacturing start-up"*. According to Rogers (1998) it is included only the expenditure that is associated with improvements in the firm's processes, or expenditure that is related to new products. Expenditure to replicate existing production methods should be excluded according to this definition. This, in turn, suggests a comparison between the *"expenditure for tooling-up, industrial engineering and manufacturing start-up"* and *"total investment expenditure"*. The difference between the two figures should be the investment solely used to replace existing machines and equipment with (approximately) identical ones.

The expenditure on the marketing of new products is often considered to be part of innovation. Data on marketing expenditures are often requested in surveys, with the containing question *"how much expenditure was associated with the launch of new or changed products (exclude expenditure on the building of distribution networks)"* (Rogers, 1998). Similarly, the expenditure on training that is related to the introduction of new and changed products and processes is also considered an innovative input. The inclusion of both marketing and training expenditures follow from the fact that innovation involves the entire resources of a firm in developing and extracting value from new ideas; thus, the marketing of the ideas, and the ability of staff to efficiency implement the ideas, is crucial (Rogers, 1998).

Lastly, innovation can also occur in the managerial methods and organisational structure of a firm (Rogers, 1998). As with marketing and training, in theory it is possible to include questions in a survey about the expenditure on introducing such changes. However, many surveys only ask questions that require a yes-no response. This may be due to the fact that firms have traditionally not recorded such expenditures, or that the expenditures are regarded as confidential.

Table 3.1 summarizes the various input measures of innovation that have been discussed above. The overall input into innovation can be regarded as the sum of all of these various inputs. However, as noted above, data on the expenditure on all the inputs is often not available. Therefore, the *"cost of innovation"* is often considered to be a sub-set of these activities.

Table 3.1.: Input Measures of Innovation

Input Measure	***Description***
R&D	Widely available. Problem with precise definition. Does not match exactly with innovation
Intellectual Property Statistics	Do not coincide closely with innovation. Virtually no research into trademarks or designs.
Acquisition of technology from others (patents, licenses)	Important element of innovation
Expenditure on tooling-up, industrial engineering and manufacturing associate with new products/processes	Relies on firm distinguish between this type of investment and investment purely for replacement.
Intangible Assets	Balance sheet figure will include goodwill and capitalized R&D. Change in intangible assets may be indicator of recent innovation.
Marketing expenditures for new products	
Training expenditures relating to new/changed product/processes	
Managerial and organizational change	Normally yes/no question surveys

Source: Rogers (1998), own elaboration.

3.5.3. Output Measures of Innovation

3.5.3.1. Firm Performance

Ultimately, the key output measure of innovative activity is the success of the firm. Firm success can be proxied by profits, revenue growth, share performance, market capitalisation or productivity, amongst other indicators. All of these indicators have drawbacks and, importantly, can be caused by factors other than the level of innovativeness (Rogers, 1998). However, the extent of firm success can be used as a measure of innovativeness if certain econometric techniques are used. The strength of using such techniques is that the extent of a firm's innovativeness can be quantified and directly compared to other firms (Rogers, 1998).

3.5.3.2. Introduction and Sales of New or Improved Products or Processes

An alternative measure of innovative output is to create variables for the number of new or improved products introduced. The Social Policy Research Unit (SPRU) data base (University of Sussex, UK) on major innovations uses a panel of industry experts to assess the most important innovations by UK firms over the period 1945 to 1983 (Rogers, 1998). The data set has subsequently been used for a variety of empirical research. The ABS Innovation Survey and the Business Longitudinal Survey ask firms directly whether they have introduced any new/improved products or processes (Rogers, 1998). The yes/no answers to such questions are a basic way of categorising firms into innovative or non-innovative categories. The answers to such questions, however, are subjective and give no indication of the number of innovations made or the importance of each. In this sense, such output measures are only crude indicators of the level of innovation.

3.5.3.3. Intellectual Property Statistics

Another potential set of output measures are Intellectual Property (IP) statistics, such as patents, trademarks and designs. The procedure for obtaining IP rights is to file an application which is then checked for novelty and legality. If the application is successful, a full property right will be granted for a period of years. An application for such an intellectual property right implies that the firm considers it has created some new knowledge that can be protected (Rogers, 1998). In addition, the fact that a firm has incurred the cost of applying for protection implies that the knowledge has some perceived value. This is one reason for using applications as a proxy for innovative output, since an innovation is defined as something that is new to the firm. In other words, even if the application is subsequently rejected on the basis on lack of novelty (i.e. some other firms are using, or have already registered, the property rights) the application still indicates innovative behaviour by the firm (Rogers, 1998). In broad terms, the grant of an intellectual property right indicates that the application represented a *"new"* advance on existing knowledge. In the case of patents, therefore, a grant indicates an invention (which is one aspect of innovation). A criticism of using patent data as an output measure is that patents do not necessarily represent a commercially exploited innovation. Instead, some researchers have considered patent and other IP data as indicators of inputs to the innovation process rather than outputs.

3.5.3.4. Scientific publications

A way to take into account the role of academic institutions is to use the number of scientific publications (Archibugi and Coco, 2005). This can be considered as an output indicator, which is closely associated to the public R&D expenditure input. The limitations of this indicator are similar to those for patents in that quality and sectoral distribution varies from country to country. Moreover, English-speaking nations are likely to be over-represented, since the vast majority of the journals monitored by the Institute for Scientific Information are in English. The advantage is that, as for US and European Patent Office (EPO) patents, the data are collected homogeneously for all countries and from reliable sources (Archibugi and Coco, 2005).

Table 3.2 summarises the various output measures of innovation discussed above. The last column of the Table shows the main Australian data sources available for such measures.

Table 3.2.: Output Measures of Innovation

Output Measure	***Description***
Introduction of new improve product(s) or process(es)	Survey question. Normally yes/no response that refers to a given time period
Percentage of sales of new improved product(s) or process(es)	Survey question. Relies on ability of respondent to asses percentage
Intellectual Property Statistics	Patent, trademark, design application and grants. Drawback is that these do not necessarily represent a commercialization of ideas
Firm Perfomance	Use econometric techniques to relate innovation indicators to firm performance
Scientific Publications	Closely associated to the public R&D expenditure input

Source: Rogers (1998), own elaboration.

3.6. The Composition of the Indexes

Below there are five different attempts to measure technological capabilities: the World Economic Forum (WEF) Technology Index, the United Nations Development Program (UNDP) Technology Achievement Index (TAI), ArCo, the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard and finally the Science and Technology Capacity Index developed by the Research and Development (RAND) Corporation and associated partners. Throughout this piece, they will be referred as WEF, UNDP, ArCo, UNIDO, and RAND. It also paid attention on the work carried out by the World Bank Institute programme *"Knowledge and Development"* Knowledge Assessment Methodology (KAM), although this is not strictly comparable with the others.

3.6.1. The WEF Technology Index

The first indicator considered is the Technology Index by the WEF Report 2001-2002 (WEF, 2001). The WEF Report contains a wealth of data and sophisticated statistical analyses. Moreover, it is continuously updated and improved on a yearly basis. WEF has introduced two main measures for competitiveness and economic development, the first devoted to the medium-term (Growth Competitiveness Index (GCI)) and the second to the short-term (Current Competitiveness Index (CCI)). The first index (GCI) is based on a battery of variables linked to growth grouped in three components: (1) the level of technology, (2) the quality of public policies, and (3) the macroeconomic environmental conditions and the second index (CCI) considers variables that concentrate on microeconomic aspects, such as the business environment around a firm, and the strategy and organisation inside a company. There is a general consensus that technology is an important component of competitiveness at the micro, sectoral, regional, and national levels, but it is clear that it is not the only component.

The WEF Technology Index includes three main categories of technology: (a) innovative capacity (measured by a combination of: patents granted at USPTO, tertiary enrolment ratio, and survey data); (b) ICT diffusion (measured by internet, telephone, PCs, and survey data); and (c) technology transfer (measured by non-primary exports and survey data) (WEF, 2001). These are weighted differently for a set of 75 countries, divided into two groups according to the number of patents produced: 21 core countries and 54 non-core countries. WEF (2001) considers the first two categories as a sufficient source of information for the core countries since it is assumed that those countries are much less reliant on technology transfer. All three categories are considered for the non-core group, but a lower weight is assigned to the indicators of innovative capacity.

3.6.2. The UNDP Technology Achievement Index

The second index considered is the Technology Achievement Index elaborated by Desai et al. (2002), and reported in the Human Development Report (Archibugi and Coco, 2005). The authors consider four dimensions of technology achievement, each of which is based on two indicators: (a) creation of technology (based on patents registered by residents at their national offices and receipts of royalty and license fees); (b) diffusion of newest technologies (based on internet hosts and medium- and high-technology exports); (c) diffusion of oldest technologies (based on telephone mainlines and electricity consumption); (d) human skills (based on years of schooling and tertiary science enrolment). These indicators are aggregated to define a synthetic index for a set of 84 countries.

3.6.3. The Technological Capabilities Index (ArCo)

The third index is ArCo Technological Capabilities Index (Archibugi and Coco, 2004). It takes three dimensions of technology into account: (a) innovative activity (based on patents registered at US patent office and scientific publications); (b) technology infrastructure (including old and new ones and based on internet, telephone mainlines and mobile, and electricity consumption); (c) human capital (based on scientific tertiary enrolment, years of schooling, and literacy rate). The analysis also is extended by examining 162 countries and attempting to provide data for two different periods (1990 and 2000).

In Archibugi and Coco (2004), it is also presented an index with an additional component, namely import technology, based on the assumption that an important source of technological capabilities is also represented by the possibility of a country to access technology developed elsewhere. This index considered three other indicators namely inward foreign direct investment (FDI), technology licensing payments, and import of capital goods. This fourth component, imported technology was given equal weight compared to the others and the overall index was labeled *"Global Technology Index"* (Archibugi and Coco, 2004).

3.6.4. Industrial Development Scoreboard UNIDO

The fourth study examined is from UNIDO (2002), and it collates a wealth of indicators for 87 countries. UNIDO (2002) consider four categories: (a) technological effort (based on patents at the US patent office and enterprise financed R&D); (b) competitive industrial performance (based on Manufactured Value Added (MVA), medium- and high-technology share in MVA, manufactured exports, and medium- and high-technology share in exports); (c) technology imports (based on FDI, foreign royalties payments, and capital goods); and (d) skills and infrastructures (based on tertiary technical enrolment and telephone mainlines). UNIDO (2002) create some indexes for each of the individual categories cited above, but do not produce a synthetic indicator that aggregates the various components into a combined index. However, the lack of a synthetic indicator prevents statistical comparisons between the UNIDO report and the other works presented here.

3.6.5. Science and Technology Capacity Index (STCI), RAND Corporation

The last study considered here is by Wagner et al. (2004) for the RAND Corporation. For a set of 76 countries, eight indicators are aggregated and divided into three categories: (a) enabling factors (based on GDP and tertiary science enrolment); (b) resources (based on R&D expenditure, number of institutions and number of scientists and engineers); (c) embedded knowledge (based on patents, S&T publications and co-authored scientific and technical papers). A synthetic index is created through a standardised formula, with different outcomes occurring according to the weights assigned to the three categories.

3.6.6. World Bank Institute, Knowledge Assessment Methodology

It should also be mentioned that the World Bank supplies the largest database on development indicators, including indicators of technological capabilities. Many of the studies cited above rely on original data produced by the World Bank, which are constantly updated, and which are also freely available on the web (World Bank, 2003). More recently, Carl Dahlman and his colleagues have developed, under the auspices of the *"Knowledge for Development"* programme, a detailed database, Knowledge Assessment Methodology that includes also statistics produced by other institutions (World Bank, 2003). Overall, the programme contains 76 variables, of which 20 relate to the innovation system, 16 to education and training, and 13 to information infrastructures. The programme has also made available a new on-line user-friendly statistical tool, which allows comparisons among countries for any of the variables listed. It also allows comparisons among groups of countries according to geographical location, income level, human development level, etc. The exercise, however, does not provide aggregate measures comparable to the other discussed above.

3.7. Measuring National Capabilities

To what extent can these concepts be operationalized empirically? Trying to put numbers on such concepts may be a difficult exercise. Still there have been some attempts in that direction which are being discussed in this section. For example a suggestion is to measure a country's innovation system (or its *"innovative capacity"*) through the number of patents and find that there are large differences in this respect across countries at similar levels of income.

According to Fagerberg et al. (2009) patents are referred to inventions, not innovations, and are used much more intensively in some industries than others. In fact, the global novelty requirement associated with patents implies that minor innovations/adaptations, which arguably make up the bulk of innovative activity world-wide, will not be counted since these are simply not patentable. Moreover, costs, both financial and opportunity, and the fact that in any case, their domestic IP systems may not function very well, may also lead to their low usage by inventors in developing countries. Most attempts to measure national technological capabilities or innovation systems in developing countries therefore is to try to take into account more information than just patents.

Based on the preceding discussion, Table 1, presents an overview of various factors that has been identified in the relevant literature as being particularly relevant for the measurement of technological and social capabilities along with examples of possible empirical indicators.

Table 3.3.: Measuring Capabilities

Dimension	***Measure***
Science, research and innovation	Scientific publications, patents, R&D (total/business), innovation counts
Openness	Openness to trade, foreign direct investment, research cooperation/alliances with foreign partners, technology licensing, immigration
Production quality/standards	International (ISO) standards, total quality management (TQM), lean production, just-in-time
ICT infrastructure	Telecommunications, internet, computers
Finance	Access to bank credit, stock-market, venture capital
Skills	Primary, secondary and tertiary education, managerial and technical skills
Quality of Governance	Corruption, law and order, independence of courts, property rights, business friendly regulation
Social values	Civic activities, trust, tolerance, altruism, conservatism, religious ethics, attitudes towards technology and science

Source: Fagerberg and Srholec (2008).

R&D expenditures measure some (but not all) resources that are used for developing new products or processes, while patents count (patentable) inventions coming out of that process. However, R&D data are not available for many developing countries. Patent data, on the other hand, are available for all countries but as noted above many if not most innovations are never patented. So, as for many other indicators, this gives only a partial view of what we wish to measure. Firms' own judgments about their innovativeness is another possible source of information but such data are only available for a relatively small number of countries and a limited time span.

Openness (or interaction) across country borders may facilitate technology transfer (spillovers) and stimulate innovation. This issue is as mentioned above particularly emphasized in work inspired by the *"new growth theories"*. The applied literature on the subject has mostly focused on four channels of technology transfer across country borders: trade, foreign direct investment, migration and licensing (Fagerberg et al., 2009). Some of these data sources are in scarce supply for developing countries, especially the latter two, with predictable consequences for the research that has been carried out on this subject.

A possible indicator of *"production capability"* might be the adoption of quality standards (ISO 9000). Although ISO certification is increasingly seen as a requirement for firms supplying high quality markets, and is therefore likely to reflect a high emphasis on quality in production. Moreover, although earlier studies such as Lall's (1992) did not place much emphasis on capabilities in ICT, nowadays a well-developed ICT infrastructure must be regarded as a critical factor for a country that wish to catch up (Fagerberg et al., 2009). Arguably this holds not only for production capability but for the ability to innovate as well. Possible indicators reflecting ICT use may be number of personal computers, internet users and fixed/mobile phone subscribers. These indicators are available for most countries.

The important role that a country's financial system may play in mobilizing resources for catching-up was pointed out already by Kim (1997) as *"investment capability"*. Authors in the capability literature attached a qualitative dimension to this that is difficult to measure with the available data. What we can measure is the (quantitative) development of the financial sector of a country, for example as reflected in the amount of credit (to the private sector) or by capitalization of companies listed in domestic capital markets (Fagerberg et al., 2009).

A different set of factors for which there is solid support in the literature, relates to education and skills. Both Abramovitz (1986) and Lall (1992) were especially concerned about specialized managerial and technical skills but this is again an example of information that is hard to come by, especially for a broad sample of countries on different levels of development. What is available for most countries are more basic education statistics such as the literacy rate, the teacher-pupil ratio in primary schools and the rates of enrolment in secondary and tertiary education.

The importance of governance and institutions, furnishing economic agents with incentives for creation and diffusion of knowledge, is generally acknowledged in the literature. Although such factors often defy as *"hard"* measurement, especially in a broad cross-country comparison, where exist some survey-based measures, often collected by international organisations. However, there is a useful distinction by Fagerberg et al. (2009) between, on the one hand, the *"quality of governance"* with respect to innovation and economic life more generally and the *“character of the political system”* on the other. For the former, survey data reflect how easy it is to set up and operate a business, whether property rights and laws exist and are enforced, how widespread corruption is conceived to be and courts are seen as being independent. All these aspects are potentially important for innovation and may, to some extent at least, be achieved within quite different political systems.

However, the impact of government's actions on innovation activities and development outcomes may as pointed out by Abramovitz (1986) also depend on the prevailing social values in society such as, for example, tolerance, honesty, trust and civic engagement. Such values, facilitating socially beneficial, cooperative activities, are often seen as expressions of so-called *"social capital"* (Fagerberg et al., 2009). The fact that the type of factors taken up by the literature on social capital may matter for economic development is widely accepted. The problem is rather how to measure it.

Given the relatively large number of potentially useful indicators there is obviously a lot of information to exploit when attempting to use these data to measure the various capabilities identified in the literature. One of the key challenges is how to combine this rich information into a smaller number of dimensions (e.g., capabilities) with a clear-cut economic interpretation. The most widely used approach to construct composite variables is to select relevant indicators and weigh them together using predetermined (usually equal) weights (Archibugi and Coco, 2005). The problem in this case is that the choice of weights tends to be quite arbitrary. An alternative approach the so-called *"factor analysis"* is based on the very simple idea that indicators referring to the same dimension are likely to be strongly correlated, and that we may use this insight to reduce the complexity of a large data set (consisting of many indicators) into a small number of composite variables, each reflecting a specific dimension of variance in the data.

Fagerberg and Srholec (2008) used factor analysis on data for 115 countries and 25 indicators between 1992 -2004. The analysis led to the selection of four principal factors jointly explaining about three quarter of the total variance of the set of indicators. The first (and quantitatively most important) of these loaded highly on several indicators associated with *"technological capability"* such as patenting, scientific publications, ICT infrastructure, ISO 9000 certifications and access to finance. However, it also correlated highly with education, so it cut across the distinction in the literature between *"technological"* (Kim 1997) and *"social"* capabilities (Abramovitz, 1986). They suggested interpreting it as a synthetic measure of the capabilities (or *"factors"*) influencing the *"development, diffusion and use of innovations"*, hence the name *"innovation system"* for this factor.

As evident from the factor analysis there is very close correlation between the *"innovation system variable"* and economic development as reflected in GDP per capita (Fagerberg and Srholec, 2008). This study indicates that the most advanced innovation systems are to be found in smaller countries (in terms of population) such as Australia, Denmark and Norway. These three countries, it may be noted, are low by international standards not only on patents but also on R&D, still they excel economically. The explanation for this difference may be that these countries have well developed capabilities for exploiting knowledge.

The finding that economic development and capability building go hand in hand is suggestive. But correlation, it may be noted, is in itself no proof of causation. Fagerberg and Srholec (2008) provided some evidence (in the form of econometric tests) supporting the proposition that capability building affects development positively. However, according to Fagerberg et al. (2009) since many of the relevant data sources used to measure capability-building exist only for few years though there is very limited scope for causality testing. Hence the possibility that economic development in some sense affects capability building positively cannot be excluded. As longer time series become available for many relevant data sources, it will be possible to learn more about these relationships and this is an important topic for future research.

Capability building may also be influenced by long-run factors related to the history of the country, its geography or nature. Failing to take this into account may lead to biased inferences (with respect to policy, for instance). Fagerberg and Srholec (2008) found that unfavorable factors related to history, geography and nature did indeed influence the possibility of developing a well-working innovation system negatively. They saw this as an additional argument for developing aid because it confirmed that some countries are much worse placed than others for reasons beyond the control of people living today.

3.8. Measuring Innovation at Regional level

3.8.1. The Traditional Indicators of Innovation Activities

Two basic families of S&T indicators are commonly used to explore technological innovation at regional level: R&D data — collected through national surveys according to the guidelines set by the Frascati Manual (OECD, 2002) — and patent statistics, the most important body of which is represented by the data pro-vided by the US Patent Office and the European Patent Office. Strengths and weaknesses of R&D and patent indicators are well known as they were mentioned above.

The indicators based on R&D and patent statistics, when used for regional analyses, also show some drawbacks: first, the regional attribution of R&D activities carried out according to the principle of residence does not allow us to grasp the actual technological potential of a given region (Evangelista et al., 2001). In the case of multi-plant firms (and in particular when plants are located in different regions), R&D activities are in fact attributed to the headquarters, independently from the place where R&D activities are actually carried out.

The same holds in the case of patent counts, where the principle of the inventor's residence is used in order to break down patent activities at a regional level. As in the case of R&D, this criterion does not seem to be the most appropriate for measuring the real technological capacity of a region, since patents are often the result of innovative activities carried out in regions which do not always coincide with those where the actual applying institution is resident. Furthermore, in the case of multi-plant firms with productive units located in different regions, all patents are attributed according to the region of residence of the headquarters, regardless of the location of the business unit which has actually developed the innovation. This criterion of attribution might lead to an underestimation of the real technological capability of some regions.

3.8.2. The Community Innovation Survey (CIS)

The need for collecting a more comprehensive set of data on the multi-faceted nature of innovation activities has brought about a widespread use of firm-level innovation surveys. The most consolidated conceptual and methodological framework to collect firm-level data on innovation activities is the one developed by the OECD in the so-called *"Oslo Manual"* (OECD, 1997). The manual has provided a specific set of guidelines for the design and actual implementation of national surveys aimed at covering a wide range of dimensions of innovation activities. The Oslo Manual puts in practice most of the recent advancements in our understanding of the nature and organisation of innovation activities within the firms and in the economic system as a whole. Although the Oslo Manual is specifically addressed to investigate the innovative phenomenon at a firm-level, it also provides specific guidelines to measure the existence and strength of systemic technological interactions between firms and the broader innovation system in which they operate (OECD, 1997; Evangelista et al., 2001).

In 1993 EUROSTAT coordinated a Community Innovation Survey (CIS) which has involved 41,000 European manufacturing firms (Evangelista et al., 2001). Thirteen countries took part in this exercise using a harmonised questionnaire, which was designed according to the guidelines contained in the Oslo Manual. CIS data have provided new insights on the different nature of innovation activities across industrial sectors and countries and, more in general, on the variety of firms' innovation strategies and performances (Evangelista et al., 2001). Surprisingly enough, much more rarely have CIS data have been used to shed light on the variegated nature of innovative activities at regional level. Any attempt in this direction should however take into account some critical methodological issues; among them the most important ones can be identified in the following.

According to Evangelista et al. (2001) a first and very general issue has to do with the extent to which *"administrative"* regions can be used to identify distinct and coherent sub-national innovative patterns. In some instances, regions are composed by a variety of localised productive subsystems or agglomerations of firms characterised by rather different technological profiles and performances. Second, CIS data cannot be regionalized according to the actual place where innovation activities are performed. This is in turn due to the fact that the basic unit of observation of CIS is the *"firm"* instead of the single *"production unit"*. This can lead to an underestimation of the technological potential of regions (especially the backward ones) which host production units controlled by headquarters located elsewhere (Evangelista et al., 2001). In particular, with this approach both cross-region and intra-firm technological spillovers cannot be taken into account. Last, as already mentioned, CIS has been designed also to capture the systemic nature of innovation activities, that is the existence of technological interactions between firms and the other relevant institutional actors involved in the innovation process. However, no specific information is provided regarding the geographical horizon of such interactions and the lack of this information hampers the possibility of identifying the geographical boundaries of innovation systems (Evangelista et al., 2001).

3.9. Concluding Remarks

In this chapter has discussed the various methods of measuring innovation. The multifaceted nature of innovation makes a concise measure of innovation, which is appropriate to all firms, impossible. Different firms will use different methods of innovation, and even the same firm will adapt and improve its methods of innovating over time.

Innovation is widely agreed to be a fundamental determinant of firm performance. Understanding the nature and role of innovation requires analysis of the various types of innovative activity. In turn, this means that the extent and characteristics of innovation must be quantified with data, despite the difficulties involved in measurement. Chapter 3 of this dissertation discussed a large range of innovation indicators. Survey data can provide a number of innovation indicators such as whether new products or processes have been introduced, or the share of sales attributable to new products or processes, over a set time period. Depending on the nature of the survey, such measures can be developed to include the number of product innovations and/or the perceived value of such innovations.

In addition to these measures, a number of quantitative measures of innovation are possible including: R&D, patents, trademarks, designs; as well as the expenditure on training, investment, marketing and new technology. The review of such measures leads to the conclusion that each of the measures has some validity, but none can act as a stand-alone measure of innovation. This, in turn, suggests the need to combine various indicators to form an overall measure of innovation. Moreover chapter 3 discussed the econometric literature that tries to assess the value of innovation, by linking indicators such as R&D and patents to the performance of the firm. The expansion of these methods to include other indicators is one method of providing an overall measure of innovation.

Indicators of technological capabilities are increasingly needed to understand how and why countries differ. A satisfactory quantification of current levels of technological capacity is required in order to understand why some countries innovate and have a more satisfactory performance than others. Even very aggregate indicators, such as those reviewed in this chapter, help to highlight the differences across countries and to identify their strengths and weaknesses.

From an analytical viewpoint, it is increasingly recognised that it is feasible and useful to develop measures of technology that combine different data. The attempts reviewed here share many similarities, and this is certainly encouraging. These similarities reflect a certain consensus on the nature of technology, although in some cases, the theoretical hypotheses were kept implicit rather than made explicit. Also it is been aware that in many cases, the choices have been dictated by availability of the statistical sources rather than by theoretical preferences. In fact, the indexes differ concerning the choice of the various technological dimensions (technology creation, diffusion, infrastructure, human skills), even if some common *"keystones"* are maintained: the use of patents as an indicator of technology creation, the recurrence of ICT indicators for technological infrastructure and diffusion, and tertiary education in science and engineering as an indicator of human skills.

This chapter is also concentrated on two level of analysis: the country and the region. Although there are good reasons to do so, we are aware that, in a globalising world, countries are not the only meaningful entity to study technological change. Regions and multinational corporations are equally important loci for technological competences and can be taken as meaningful statistical units.

The capacity of CIS data has been assessed to represent the innovation phenomenon at a regional level. The aim was to understand whether and to what extent information gathered by the CIS at the national level can be applied on a different geographical scale, offering a sufficiently reliable picture of regional specificities in innovation processes. It is also identified some critical methodological issues which need to be tackled when CIS data are used at regional level.

Table 3.4 proposes a tentative framework to assess in which cases inter-regional comparisons are statistically feasible and meaningful from an interpretative point of view.

Table 3.4.: The Use of CIS Data for Inter-regional Comparative Studies

	Low-Tech Industries	***Med-Tech Industries***	***High-Tech Industries***
Low Developed Regions	Feasible	Feasible with ad hoc aggregations of data	Not Feasible
Medium Developed Regions	Feasible	Feasible	Feasible with ad hoc aggregation of data
High Developed Regions	Feasible	Feasible	Feasible

Source: Evangelista et al. (2001).

In particular, it is suggested that the presence of a low number of innovative firms in the most backward regions can hamper comparative studies of innovation systems at a regional level. This constraint is particularly severe when data are broken down jointly by region and sector and when the analysis is focused on the most technologically advanced industries. So in all these cases ad hoc aggregations of data (either by sector, region or both) are usually needed.

A second problematic aspect of CIS data which needs to be tackled has to do with the limited information provided by this data-set on both inter-regional and intra-regional technological flows. From my point of view it is assumed that inter-regional technology flows and more localised interactions have the same nature, relevance and impact. This is in turn linked to the *"national innovation system"* perspective adopted by the OECD Oslo Manual and CIS.

In particular, at the present CIS data cannot yet be used to identify the geographical horizon of technological flows and interactions. This in turn hampers the possibility to detect and draw the boundaries of systems of innovation at a sub-national level. A possible option to measure the extent and direction of interregional technology flows could consist of asking firms to indicate the geographical destination of the technologies developed and to indicate the spatial organisation of their innovation activities. Such data would give the possibility to build proper matrixes for the measurement of inter-regional technological flows and interdependencies.

Furthermore the results are too frequently divergent. There is clearly a strong similarity in the rank correlations, but a similar position of countries would emerge even if taking entirely different social indicators into account (e.g. health indicators). Greater similarity in results should be achieved in order to make them more reliable.

This leads to the need to increase the efforts, and also the coordination, amongst the different attempts. Sources of data have increased, and new information technologies make data available in real time and in friendly formats. All the attempts reviewed here are fully transparent about the data sources and the methodology employed. It is not expected, and nor it is made desirable, to generate a unique measure of technological capabilities: methodological variety helps to create a better understanding of social phenomena.

Clearly the various teams are interested in slightly different aspects of technological change, and this has emerged in their choices as well as in their results. But even different and competing approaches can take advantage from coordination on the elaboration of the original data. In fact, it is somewhat surprising that none of the approaches discussed here, with the notable exception of WEF, is established on a firm basis or periodically updated. The only database so far that is periodically updated and maintained is that of the World Bank. The recent *"Knowledge and Development"* programme under the auspices of the World Bank represents a milestone in the field, and hopefully it will be able to continue to lead the way under increased coordination among the works reviewed here.

Although the comparison here made is limited to synthetic indicators, we wish to emphasize the importance of more detailed and disaggregated data. It is believed that the various *"ingredients"* of technological capability can be as relevant as the final measure. As already stressed above, two relevant exercises, UNIDO and KEM, have not bothered to generate a synthetic indicator and have concentrated their attentions on the various components. None of the works reviewed here underestimate the importance of the various components. When these measures are used to assess the impact of technological capabilities on economic and social indicators, it is strongly recommended taking into account also the individual indicators and the sub-indexes.

Indeed, it is expected that each component will play a different role in each country, also on the ground of its overall development stage. And there is no shortage of statistical techniques, which allow singling out the relevance of each component of technological capabilities. Moreover, they also point to the importance of looking at the sectoral compositions of certain indicators. Data on trade, patents, and bibliometrics are available at a highly disaggregated level and can inform about the content of the technological capabilities developed in each country.

4^{th} CHAPTER

INNOVATION AND ECONOMIC DEVELOPMENT

4.1. Introduction

Is innovation important for development? And if so, how? There is, however, another way to look at innovation that goes significantly beyond the high-tech picture. In this broader perspective, innovation – the attempt to try out new or improved products, processes or ways to do things – is an aspect of most if not all economic activities. It includes not only technologically new products and processes but also improvements in areas such as logistics, distribution and marketing. Even in so-called low-tech industries, there may be a lot of innovation going on, and the economic effects may be very large (Fagerberg et al., 2009).

Moreover, the term innovation may also be used for changes that are new to the local context, even if the contribution to the global knowledge frontier is negligible. In this broader sense, innovation may be as relevant in the developing part of the world as elsewhere. Although many of the outcomes are less glamorous than celebrated breakthroughs in the high-tech world, there is no reason to believe that their cumulative social and economic impact is smaller (Fagerberg, et al. 2004).

Economic growth, especially its long-run sustainability, has long been a focal point of academic researchers and policy makers. Numerous attempts have been made to provide a long list of factors that may have an impact on economic growth. Pioneering work on endogenous growth emphasizes the role of knowledge as an input to production. In their models, it is the technological advancement and industrial innovation that drive long-run growth.

According to Fagerberg and Verspagen (2002) *"the technology gap theory of economic growth"* is also an example of appreciative theorizing. It emerged mainly because of the failure of formal growth theories to recognize the role of innovation and diffusion of technology in global economic growth. These formal theories either ignored innovation-diffusion altogether, or assumed that technology is a global public good created outside the economic sphere, and therefore could (should) be ignored by economists.

However, it became obvious for many students of long-run growth that the perspective on which this formal theorizing was based had little to offer in understanding the actual growth processes. There were large technological differences (or gaps) between rich and poor countries, and engaging in technological catch-up (narrowing the technology gap) was perhaps the most promising avenue that poor countries could follow for achieving long-run growth. But the very fact that technology is not a global public good, implies that although the prospect of technological catch-up is promising, it is also challenging, not only technologically, but also institutionally. Hence, technological catch-up is not a question of replacing an outdated technological set up with a more modern one, but to continually transform technological, economic and institutional structures (Fagerberg and Verspagen, 2002).

Since then research on endogenous growth theory sparked many empirical studies exploring how and to what extent innovation might contribute to economic growth. Empirical evidence taken as a whole points to the fact that innovation tends to make significant contributions to growth, and there are also significant spillover effects of innovative activities (Hasan and Tucci, 2010). Grossman and Helpman (1994) refer that though technological change forms the engine of long-run growth, accumulation of other types of capital will still play an independent role during a transitional phase. This notion implies that how innovation activities can be translated into different rates of growth is closely linked to the variation of economic structures and policies.

ICTs have started to diffuse rapidly in the economic system in the last two decades. They have originated from the fast technological developments in the semiconductor industry, in the telecommunication sector and, more recently, in a wide range of new services linked to multimedia and the Internet. The convergence of these three streams of technological advances, commonly referred to as ICTs, may arguably constitute the rise of a new *“technological paradigm”*.

According to Castellacci (2006) a technological paradigm is a set of interrelated and pervasive innovations that increases productivity in many sectors of the economy. The new technological paradigm based on ICTs may have important economic effects on growth, wealth and welfare in the near future, and may lead to radical changes in firms' production structure and organizations, in the patterns of consumption, and in institutional settings.

One major question relates to what consequences that the diffusion of ICTs have for catching up and developing economies. Does the new technological paradigm based on ICTs create new windows of opportunity or further obstacles for catching up countries? The answer to this question is a matter of considerable controversy in the literature on innovation and catching up, and it is rather difficult to discuss because of the fundamental elements of uncertainty, complexity and unpredictability that it entails. It is possible to identify, by and large, two different positions in this respect.

The first is a more optimistic stand, which stresses the new windows of opportunity opened up to catching up countries by the creation and diffusion of the new information and communication technologies. According to this, developing countries may exploit their backward position by imitating and implementing advanced foreign technologies created by the leader economies, and by rapidly investing in the new technologies. In the new era, catching up countries are less committed to the mass production technological paradigm prevailing in previous decades (in terms of investments in physical capital, machineries, and infrastructures), so that they may find it easier to make the jump into the new technological system based on ICTs.

Secondly, anticipating future changes in the patterns of global competition, Carlota Perez (2006) pointed out already two decades ago the new possibilities open up for developing countries in the era of ICTs because for them, she argued, it is possible to attempt a direct entry without going through the technological stages it leaves behind. For each country, this implies a fundamental rethinking of its relative advantage position within the new techno-economic paradigm to identify new possibilities.

The rapid catching up process of Asian Newly Industrialized Countries (NICs) in the last few decades shows that the opportunities opened up by the diffusion of the ICT-based paradigm can indeed be successfully exploited by catching up countries, provided that the development strategy that they pursue emphasizes the need to actively invest in the new technologies and in the related infrastructures and skills (Castellacci, 2006). The tigerish growth of China and, to a less extent, India in the last decade provides more recent examples of the importance of ICT-related manufacturing and service activities for the catching up process. According to several accounts, the current rapid diffusion of the ICT-based paradigm marks the initial phase of a fifth long wave, and thus provides new growth opportunities for many countries in the world economy (Castellacci, 2006).

The increasing privatization of scientific commons together with stronger intellectual property laws make innovation more important than ever in enabling firms, industries or even countries to achieve positional advantages and better economic outcomes. The quest for understanding what drives differences in innovation performance has led to three prevailing theoretical explanations which revolve around the role of international trade, Foreign Direct Investment (FDI) and industrial R&D (Wang and Kafouros, 2009). The conceptual and methodological benefits of evaluating the determinants of innovation performance in a unified research framework allow us to better understand the relative contribution and role of each factor. Also explains why some empirical findings indicate that the effects of international trade, FDI and R&D are positive and high.

In this broader perspective, innovation becomes as important for developing countries as for the rich part of the world, an argument which is also strongly supported by evidence from the surveys of innovation activities in firms. It is fair to say that the question of how technology and innovation influence economic development is a controversial issue, and has been so for a long time (Fagerberg et al., 2009).

In this chapter, the line of research is extended by arguing that not only the quantity but also the quality of innovation matters in promoting economic growth. Furthermore, it is investigating whether the effects of innovation on economic growth largely depend on the economic structure and stage of development in different countries.

Until relatively recently there has not been much data available that could be exploited to explore the relationship between innovation and diffusion of technology on the one hand, and economic development on the other. But during the last few decades, national governments and international organizations started to devote more efforts to collect statistics on factors relevant for innovation and diffusion, and various attempts have been made to capitalize on these investments to produce indicators of the technological capabilities (or competiveness) of countries, including the developing ones.

4.2. Theoretical Framework

4.2.1. Competing Paradigms for Explaining the Relation Between Growth and Technology

Two major approaches emerged during the 1980s and 1990s as the dominant approaches to the analysis of the relationship between technology and growth. According to Verspagen (2004) these are the neoclassical approach, which is also dominant in other fields of economics, and the neo-Schumpeterian or evolutionary approach. While the neoclassical approach consists of a relatively homogenous set of interrelated sub-approaches (models), the field of neo-Schumpeterian or evolutionary economics consists of a more loosely connected set of contributions. The evolutionary approach includes formal models as well as more *"appreciative"* or historical approaches, as will be explained in more detail below. Even the label used to describe this approach is not yet common understanding. Here, it is used the short description of "*evolutionary economics*" but it is included a broad category of work, including what some have called *“neo-Schumpeterian economics”*.

Both of these approaches agree on basic issues such as the importance of innovation and technology for economic growth, as well as the positive role that can be played by government policy for science and technology. Yet they disagree on the behavioral foundations underlying these respective theories. These differences can be characterized by saying that the neoclassical theory sacrifices a significant amount of realism in terms of describing the actual innovation process in return for a quantitative modeling approach that favors strong analytical consistency, while the evolutionary approach embraces the micro complications of the innovative process and applies a more eclectic approach (Verspagen, 2004).

4.2.2. The Role of International Trade, FDI, and Industrial R&D in Explaining Innovation Performance

One important determinant of innovation performance is industrial research, as measured by the level of R&D spending. It is commonly thought that investments in R&D enable organizations to create an internal stock of scientific knowledge that may further lead to global knowledge diffusion. This stock, in turn, assists firms in developing and introducing new products to the market, reducing production costs, pricing their products more competitively and, consequently, in improving corporate revenues and performance (Wang and Kafouros, 2009). R&D is also associated with indirect effects pertaining to increased organizational learning. According to the concept of absorptive capacity, R&D increases a firm's ability to understand external ideas and technologies, and to apply them to commercial ends. Such knowledge may also enhance a firm's own understanding, bridge distant technological contexts and help firms to recognize gaps in the technological landscape (Wang and Kafouros, 2009).

Another important driver of innovation performance is foreign direct investment. FDI is viewed in both theoretical and empirical literature as a main channel for the dissemination of technological advances. Previous research indicates that MNEs have become important agents of international technology transfer enabling firms that operate in host nations to achieve improved performance. Similarly, according to Wang and Kafouros (2009) interactions between local and foreign firms through component supply, subcontracting, licensing, and technical cooperation may further support the innovative activities that both local firms and foreign investors undertake. Additionally, they have emphasized that FDI triggers significant spillover effects that often originate from the leading technologies and technical know-how that foreign investors bring with them. Also spillovers may occur in different directions, implying that they may improve the innovative outputs of both local and foreign firms in a given country.

A third innovation performance driver involves the role of international trade. International trade may facilitate technology creation and diffusion. Participation in export markets enables firms to explore new technologies and enhance organizational learning by analyzing the innovations of their foreign competitors (Wang and Kafouros, 2009). Organizations that export their products may also enhance their innovation performance by accessing diverse knowledge, ideas and information about competing products and customer preferences. Furthermore, they may also benefit from exposure to more intense competition, which in turn may force them to enhance their innovation performance. Firms also have the opportunity to learn from exporting as overseas buyers may, for example, suggest ways to improve the manufacturing process, and share information (Wang and Kafouros, 2009).

In a similar vein, technology and innovation may also be affected by importing. Scientific knowledge and technologies can be imported in either embodied or disembodied form. In both cases, imports are likely to influence the propensity to innovate. Empirical evidence confirms these arguments that there is a strong association between foreign technology and the organizational learning and inventions of importers. Similarly, the study of Kumar and Aggarwal (2005) emphasizes the importance of imported goods and technologies, and suggests that firms often seek to develop their innovation capabilities by analyzing and absorbing the knowledge and scientific advances embodied in such goods.

4.2.3. The Moderating Role of Technological Opportunities

A key factor that moderates the relationship between innovation performance and its key drivers is the level of technological opportunities, defined as the set of possibilities for technological advance. It seems that technological advance proceeds much more rapidly in areas where knowledge is strong than where it is weak because industries vary considerably in their sources of technological opportunities. Firms in industries with high technological opportunities gain more by accessing a larger pool of knowledge. Accordingly, it is expected that the effects of R&D on innovation performance should be more pronounced in industries with higher technological opportunities as compared to those with lower technological opportunities (Wang and Kafouros, 2009).

Furthermore, the organizational foundations and innovative ability of companies that participate in technology-intensive sectors differ significantly from those of firms in less technology-intensive sectors. The fact that the possibilities for technological advance are renewed quickly in high technological opportunity industries may also motivate companies in these sectors to exploit systematically the know-how (Wang and Kafouros, 2009). This may improve organizational learning, assist those firms in realizing FDI spillovers, and improve innovation performance.

Similarly, Kumar and Aggarwal (2005) suggest that exporting firms embrace technological opportunities because of their need to adapt products and processes for foreign markets. Additionally, firms in technology-intensive sectors may have higher absorptive capacities, arising largely from the level of prior related knowledge in the form of recent scientific and technological developments in a given field (Cohen & Levinthal, 1990). These capacities enable firms to decode, interpret and apply knowledge from external sources. Therefore, firms in technology-intensive sectors are better able to understand the technologies embodied in imported products. In a similar manner, firms in technology-intensive sectors, because of their superior absorptive capacity, are better able to analyze the technologies created in countries to which they export their products (Wang and Kafouros, 2009).

4.2.4. The Moderating Role of the Level of Foreign Presence

With regard to FDI, MNEs, particularly those from developed economies, have strong scientific and technological capabilities. Hence, it is more likely that both local firms and foreign investors which participate in industries with high foreign presence will benefit more from FDI spillovers, demonstration effects and increased organizational learning. Previous empirical findings are consistent with this argument, showing that higher levels of foreign investment are strongly associated with such effects.

By contrast, in industries where the level of foreign presence is low, the possibility of improving innovation performance through inward FDI is expected to be lower. Therefore, in order to increase their technical understanding and innovation performance, firms in these industries must rely more on imported products and their own research. Similarly, it is likely that the technical know-how and experience gained from exporting will be more important in low foreign presence sectors in which the opportunities of realizing FDI spillovers are lower (Wang and Kafouros, 2009). Therefore, it is expected that the effects of international trade on the innovation performance of low foreign presence industries will be higher than the corresponding effects for the industries where foreign presence is high. Nevertheless, it is also noted by Wang and Kafouros (2009) that while FDI and international trade assists the integration of emerging countries into the global economy, it also leads to the structural reform of such countries which, in turn, may influence the expected moderating role of foreign presence.

As for the effects of industrial R&D, tend to be less significant in cases where intense competition does not allow firms to capture its full value because higher levels of competition make the appropriation of the fruits of innovation particularly difficult (Wang and Kafouros, 2009). As foreign presence in liberalized industries often leads to higher levels of competition, it is expected that the economic returns to R&D will be lower in high foreign presence industries. A counter-argument to this view is that highly competitive domestic conditions stimulate product innovation.

4.3. Evolutionary Economics and Technology Dynamics

The term *"evolutionary economics"* is associated with a less formal strand in economics that focus on evolution as a process of qualitative change and the roles of technology and institutions in this process. Usually, these contributions draw inspiration from Schumpeter's notion of disequilibrium dynamics resulting from the introduction of (basic) innovations (Fagerberg and Verspagen, 2002).

Any model that limits itself to pure economic factors (such as R&D, capital investment or human capital) provides a much too narrow perspective on economic growth. The perspective offered by Fagerberg and Verspagen (2002) is one of the world economy as a process of constant transformation. Technologies and institutions change through time, and what drives economic growth in one era (e.g. economies of scale in relation to mass production) might become much less important, or substituted by a different factor (e.g. network economics) in a different era. In terms of economic growth rates, such a process is quite different from the neo-classical notion of steady state growth. Among the factors mentioned, there are shortening technology cycles, changes in financial markets enabling easier financing of innovative activities (venture capital), the increasing role of networks and alliances in technology development, and the closer link to science (Fagerberg and Verspagen, 2002).

The notion of the world economy as a constant process of transformation is perhaps most clearly reflected in the literature on *"long-waves"* and *"technological revolutions"*. A *"bunch"* of innovations may lead an upswing of economic growth once it creates a bandwagon of follow-up, incremental innovations. However, after the new technological paradigm has diffused throughout the economy, Wolff's law of decreasing marginal technological opportunities ultimately brings a slowdown of economic growth (Fagerberg and Verspagen, 2002). Although, this is clearly a theory of technology driven growth, the role for other factors is vast. Perez (1983) is particularly strong example of contribution in which the notion of technological paradigms is linked to broad institutional change, firm strategy or industry dynamics.

This discussion leads us to the following two median conclusions and will guide our analysis in the remainder of this chapter:

1. Economic growth is first of all a process of transformation, not of convergence to a steady state growth path. The transformation of capitalism involves interaction of the economic sphere with other domains, such as science and technology, and institutions. This has three major implications. First, differences in economic growth (both over time and between countries) are hard to predict ex ante, but often have clear underlying explanatory factors ex post. Second, in the long-run, economic growth is not a process of general convergence. It might be observed historical periods of convergence during times, but periods of divergence of economic growth must also be expected. Third, any distinction between trend growth and cyclical variations around the trend is problematic.
2. Technology is a key factor shaping economic growth, and the changes in growth rates. This leads to two issues. First, the distinction between radical and incremental innovation becomes of crucial interest. Radical innovations open up new possibilities for long-run changes in the trend rate of economic growth. When radical innovations occur, they disrupt the existing economic structure and dependencies in the economy. This leads to changes in growth rates that are hard to predict in a detailed way ex ante. Incremental innovations are associated with the diffusion of the radical innovations throughout the economy and depend crucially on the specific historical and institutional context. Second, the distinction between innovation and imitation receives central importance. Technology cannot be fully appropriated by the firm that develops an innovation. With time, technological knowledge spills over to other firms and other nations. While innovation may lead to divergence between firms or nations, imitation tends to erode differences in technological competencies, and hence lead to convergence.

4.4. The Role of Innovation in Economic Growth

However, before these issues are examined there is the question of why is innovation so important to regional development? We should not ignore the fundamental fact that science can create and sustain wealth, yielding in turn much wider social, cultural and economic benefits. According to Howells (2005) there are two important reasons why innovation policy is so important to the regions, but also why the regional dimension is important to national (and pan-national) level innovation policy. The first relates to the link between innovation, growth and economic performance and the second is associated with the fact that wide disparities remain in innovative activity between regions.

In theoretical terms the link between innovation, knowledge and economic growth has long been acknowledged. From Marshall through to Kuznets there has been a recognition that, directly and indirectly, knowledge changes economic activity and economic activity changes knowledge in constant rounds of change (Howells, 2005). However, early neo-classical approaches viewed knowledge and technology as being completely exogenous to the system and that the same technological opportunities were equally available to individuals and firms in all places (Solow, 1956). In turn, this was linked to viewing technology as being a public good implying that in the long run the rate of technological progress would be the same everywhere. In turn, growth paths of different countries or regions would also converge over the long term.

By contrast, newer growth-theoretic models have emerged based on endogenous and neo-Schumpeterian interpretations of economic growth. Thus, endogenous growth models sought to build into their models the endogenous component of technological progress as an integral part of the theory of economic growth. More specific, technological progress is seen as arising out of directed actions and investments by people through the allocation of key resources linked to human capital and, more particularly, the amount of resources allocated to research (Romer, 1990). Neo-Schumpeterian models in turn introduced notions of monopolistic competition and the existence of intellectual property rights over new technology (Howells, 2005).

Associated with these two growth-theoretic perspectives was that technology should be considered more like a private good rather than a public good and the acceptance that there could be increasing returns to knowledge generation. Under this neo-Schumpeterian perspective in particular, not all countries or regions will be equally placed to generate and benefit from innovations and there will be strong tendencies for cumulativeness. Innovation will therefore be a strong disequilibrating factor in the processes of economic growth, giving rise to the pervasive differential growth rates between geographical areas (Howells, 2005).

What may be seen as hybrids of both neo-classical and new growth models have also emerged. There have been further synthetic, moderated developments of such new growth models, in particular in two spheres. Firstly, there has been recognition that innovation and technological advance should include both endogenous and exogenous elements (Howells, 2005). Secondly, there has been the realisation that monopoly rents over technology remain incomplete and temporary. As such, technology has characteristics that become more like a public good over time and that knowledge and technology spillovers will occur (Romer, 1990).

At the macrolevel there appears that this moderated view has been at least partially vindicated by empirical study. For instance, even for a large national economic system such as the United States, around half of its productivity growth comes from foreign technology improvements. Similarly, in terms of geographical spillovers and neighborhood effects between nation states, studies have suggested that growth spillover effects (both positive and negative) do occur, and, linked in part to technology are evident in terms of certain parts of the world (Howells, 2005).

What about innovation and growth in terms of evidence at a more micro, empirical level? Firstly, there does appear to be a continuing link between innovation and economic performance. At a European level, a clear correlation between Innovation (as measured by the *"Revealed Regional Summary Innovation Index"* (RRSII)) and economic activity and performance (as measured by *"relative per capita Gross Domestic Product"* (GDP)) is indicated (Howells, 2005). A UK study by Huggins has also revealed that an index of knowledge-based businesses, and linked to innovative activity, is most strongly correlated to regional output growth and to the overall improvement of competitiveness (based on a composite index) between 1993 and 1999 (Howells, 2005). However the correlation between innovative inputs and innovation outputs does not necessarily remain constant and nor is R&D activity necessarily linked to other economic performance measures, such as changes in productivity levels.

The second observation is that significant differences in innovative capacity still remain in Europe. Variations at a regional and sub-regional level of innovative activity remain significant and there is little evidence that there has been any substantial narrowing of the gap over recent years. Moreover spillover effects do occur at a regional level as well. Thus, it has been revealed that areas close to existing successful innovative areas stand a much better chance of success; by contrast, poor regions surrounded by other poor regions do much less well in terms of economic performance. *"Innovation poor"* regions will therefore not benefit as much in terms of economic development and growth. Given that there are strong, cumulative feedback processes at work here, these regions will suffer in future rounds of innovative activity and investment and so can be locked into a *"vicious"* circle of innovation stasis or decline (Howells, 2005).

What might be concluded from such a theoretical and empirical review of innovation and growth in relation to regions? According to Howells (2005) there are four thinks we need to keep in mind. Firstly, knowledge and innovation matter when it comes to economic growth and productivity change, whatever perspective is selected. Secondly, although endogenous technology is important, if for a large economic system such as the United States around half of all productivity comes from external (foreign) technology, for a smaller system, such as a region, it is likely to be even more significant in terms of overall growth and performance. Thirdly, because knowledge and innovation remain uneven, geographical spillovers and proximity, whether they are intended by individuals and the firm concerned, or unintended through copying, seem to be important. Lastly, the analysis and modeling of this process remains at best imperfect. The gap between macro growth models and more detailed micro-level analysis of innovation and technological change needs to be bridged if a better modeling with the relationships involved is been achieved.

4.5. The ICT-Based Techno-Economic System

Information and communication technologies are diffusing rapidly in the economic system. A widespread adoption of ICTs, in this view, will lead to radical changes in the patterns of production and distribution in the near future, and these transformations are likely to determine important consequences not only in the industrialized world, but for catching up countries as well (Castellacci, 2006). This section focuses on the major characteristics of the changing techno-economic system, and, relatedly, on the new windows of opportunity opened up for developing countries, and on the new challenges that policy makers have to face to sustain the catching up process in the fifth long wave.

4.5.1. A More Intangible and Information Intensive Production

Differently from the previous mass-production technological paradigm, which had a strong energy and materials intensity (Abramovitz, 1986), the new paradigm based on ICTs is characterized by great information intensity (Castellacci, 2006). An important consequence of this is the rise of importance of intangible assets and productive factors. These changes towards an information intensive and intangible knowledge-based economy may open up new windows of opportunities for catching up countries, and, consequently, determine new challenges for policy. Three main aspects appear to have a particular importance in this respect.

First, the knowledge-based economy is less dependent on raw materials and natural resources (Castellacci, 2006). This makes the catching up process possible even for countries that are not well endowed in terms of natural resources and raw materials. Important changes in the patterns of comparative and competitive advantages may occur, as human skills and knowledge become the key factors to compete in the international arena. However, as human skills and knowledge increase their importance, there is the growing risk that countries with better levels of education and human capital may use them to rapidly improve their economic performance, while less-developed countries find it more difficult to catch up by cumulatively improving their knowledge assets. The process of creation of technological knowledge is dynamic and cumulative, so that knowledge-based growth may risk of leading to growing disparities between rich and poor countries. In this respect, then, the catching up process needs to be strongly sustained by education and training policies, aimed at enhancing technological capabilities and at improving absorptive capacities of follower countries.

A second window of opportunity is provided by the fact that besides the traditional form of infrastructure, based on tangible assets and communication channels, the new

ICT-based technological paradigm is increasingly dependent on an intangible type of infrastructure and communication system, based on high speed transmission of data. These changes may provide new opportunities for countries with a low level of traditional infrastructures, if they will be able to heavily and rapidly invest in the new technologies of communication, particularly in wireless-related devices (Castellacci, 2006). The new investments that are necessary in order to build up and develop the new infrastructures, though, have to cover large initial costs that may be difficult to sustain for local firms. An active effort of the State may therefore be of great importance in sustaining this process, especially in the initial phase when foreign advanced technologies need to be adapted to local contexts (Castellacci, 2006).

Thirdly, a catching up country that has invested less resources in infrastructures and physical capital related to the technological system prevailing in previous decades, may have better opportunities to rapidly transform its productive structure towards the new activities (Castellacci, 2006). In addition, the fixed investments required to enter the new ICT-based paradigm are lower than those needed to compete in the mass production technological system (Perez, 1985). The information intensive and intangible characteristics of the knowledge-based economy may thus enable a more rapid process of structural change, and determine possible advantages for latecomers. The opportunities arising from rapid structural change refer also to the productivity gains that the use of ICTs may lead to in traditional and low-tech sectors, which still account for a large share of production and employment in many catching up countries (Castellacci, 2006).

However, the rapid process of transformation of the economy may lead to greater risks of technological unemployment. It is therefore important that the State undertakes an active effort to promote training and re-training policies with the purpose of enabling a more rapid shift of labour resources towards the more advanced activities (Fagerberg and Godinho, 2003).

4.5.2. The Flexible Production System

The new ICT-based paradigm determines a shift from the mass production to the flexible production system. The adoption of ICTs in the productive process determines important changes in the production patterns, and favors the shift towards the flexible production system. In the latter, economies of scope and of specialization based on flexibility replace the more traditional economies of scale based on plants' size; real time and on-line monitoring of demand substitutes the previous periodic planning of production; and the productive system tends increasingly to be user - rather than producer-defined (Perez, 1985; Freeman and Louca, 2001). These transformations are the results of flexible production capabilities and of greater information intensity of equipment and products.

As a consequence of these changes, as pointed out by Castellacci (2006), the accumulation of physical capital becomes a relatively less important engine of economic development in the modern knowledge-based economy. The modern knowledge-based economy is in fact more dependent on human skills and competencies, user-producer interactions, learning by using and learning by interacting mechanisms, and the related investments in intangible and advanced knowledge assets. This opens up new possibilities for technological and economic catching up for those countries that will be able to exploit the advantages of the flexible production system.

4.5.3. The Rise of the Service Sectors

Strictly related to those discussed above, another major trend in modern capitalism is the rise of the service sectors. As the process of structural change goes on, service industries assume greater significance and an increasing share in the overall production and employment not only in major industrialized countries, which are leading these trends, but in catching up countries as well (Castellacci, 2006). The rise of services may provide new windows of opportunity for follower countries for at least three main reasons. The first is the strict relationship between the development of ICTs and the rise of services. Many service activities have recently improved both the efficiency of the productive process and the quality of the provided service by adopting ICTs in their back-off operations. ICTs lead first to improved efficiency, then to improved quality, and, eventually, to totally new services. The reverse sequence of the product cycle for the case of services as opposed to manufacturing industries has important implications: *"standardization"* becomes less important, while the *"customization"* of services takes greater significance over time (Castellacci, 2006).

The second reason is the limited appropriability of innovation in service activities. The conditions of appropriability in service industries are to a large extent different than those prevailing in manufacturing sectors, precisely due to the intangible nature, the high information content, and the closer user-producer interactions that characterize service activities (Castellacci, 2006). This may hinder the innovative process by decreasing the incentives to innovate (the *"incentive effect"*), the other side of the coin is that the scope for imitation and knowledge diffusion may be greater in the service economy, both within services and towards manufacturing industries (the so-called *"efficiency effect"*) (Castellacci, 2006). Catching up countries may exploit these new opportunities by imitating the advanced services produced in the leader countries, as well as by enhancing the diffusion of knowledge across sectors within the economy.

There is also a third important characteristic of the service economy that may turn out to have important consequences for catching up. In service industries non-technological types of knowledge are those that do not have an ultimate scientific and engineering base. One such types of knowledge is the ability to organize and re-organize productive activities in a complex and uncertain environment, namely organizational capabilities (Castellacci 2006). Other non-technological types of knowledge are the specific and context-dependent knowledge about markets, about consumers' habits and tastes, about national institutions and regulations, and so on. Improvements in these types of knowledge and capabilities may lead to a sort of *"expertise-field innovation"*, whose result is the *"opening up of new markets, the diversification (internal and external) or renewal of product ranges, and the creation of a competitive advantage or monopoly in terms of knowledge and expertise"* (Castellacci 2006).

Catching up countries may thus exploit these new opportunities by trying to rapidly promote not only science- and engineering-related technical knowledge, but also non-technological types of knowledge, which may eventually favour the development of modern and competitive *"Knowledge Intensive Business Services"* (KIBS) (Castellacci, 2006). Here again, public policies have an important role to play in this respect: first, because the public system of basic and advanced education has the concrete possibility to develop and to enhance the education level of the workforce; secondly, because the State may actively enable the development of a modern training and re-training system in the private sector, so to accelerate the process of structural change towards the new knowledge intensive service activities (Castellacci, 2006).

4.5.4. Organizational Changes: The Network-Firm and the E-Commerce

The new paradigm based on information and communication technologies is characterized by some important organizational changes as well. One of these, arguably the most relevant, is that ICTs favour a stricter connection and a more rapid communication between economic agents situated in different locations. According to Perez (1985) networks take different forms, such as partnership between firms, their cooperation with customers and users, or with subcontractors and employees, and they also favour the integration of different functions within the same firm. ICT-based networking is characterized by an increased speed of communication, and by a rapid access to new and wider sources of information. This gives great advantages to the participants of a network, which may exploit a much greater pool of knowledge than it would be the case if they were operating as individual agents.

Organizational changes are not only important for the supply side of the economy, but for the demand side as well. ICTs make it possible the on-line monitoring of demand, which substitutes the previous practice of periodic planning and makes it possible the development of the flexible production system, where users and consumers take an increasingly important role (Castellacci, 2006). The current rapid development of e-commerce, in addition, may in the future determine radical transformations in the distribution chain, and, consequently, in the patterns of competition in global markets.

It is rather difficult to predict the implications of these organizational changes for the development process. According to Castellacci (2006) on the one hand, ICT-based networking between firms may open up new opportunities for the developing world to gain access to new and wider sources of advanced knowledge in global production chains, provided that private enterprises in catching up countries will be able to develop the advanced skills and capabilities that are required to cooperate and to participate in networks with more advanced firms in the leader countries. Moreover the diffusion of e-commerce may also provide new opportunities for emerging markets, as it may favor the commercialization of products and services produced in peripheral regions of the world economy.

On the other hand, however, these opportunities are rather difficult to exploit, and they may very well turn out to be factors of greater competitive advantage for private firms of the leader countries (Castellacci, 2006). In fact, the network-type of organization of the productive process, as well as the e-commerce-related organizational changes on the demand side, do not overcome the issue of power relations within the networks (Freeman and Louca, 2001). If some of the participants to a global production network have an initial advantage in terms of advanced capabilities, resources and economic power, then the network may turn out to be a vehicle of cumulative growth where the strongest participants will increase their power and market shares over time, while the less endowed participants will shrink. Thus, the new opportunities offered by the rise of the *"network firm"* and by the diffusion of e-commerce may be better exploited by catching up countries if their Governments will play an active role as regulators of the competitive process by promoting greater competition and enhancing efficiency and determine an oligopolistic structure and an unbalanced relation of power within firms' networks (Castellacci, 2006).

4.5.5. The Globalisation of Technological Activities

One of the important transformations leading to the techno-economic sphere is the globalisation of technological activities. This refers to the fact that *"the generation, transmission and diffusion of technologies are increasingly international in scope"* (Castellacci, 2006). The main reason why innovative activities are becoming more global in scope is that technical feasibility has increased significantly in the ICT-based paradigm, while economic costs have been dramatically reduced. The globalisation of innovative activities can be described by using a three-category taxonomy. Based on the latter, this section considers the implications that each of the three channels of globalisation of technology may have for catching up countries, in terms of new opportunities, as well as new challenges for policy.

The first channel of globalisation of innovative activities according to Castellacci (2006) is the international exploitation of technology, which may be regarded as the technological equivalent of international trade flows. This occurs when a new technology is exported in order to exploit the relative benefits in the world markets. The innovation being exploited in international markets can be either embodied in exported high-tech products, or in disembodied form (e.g. sale of licences, patents and know-how).

The trends towards a global ICT-based competition may have important implications for catching up. On the one hand, some small open economies have been able to catch up rapidly in the last few decades by shifting their productive structure and specialization patterns towards the technologically most progressive industries (Castellacci, 2006). These countries have greatly and rapidly improved their production capabilities in ICT-related technologies, and this has made it possible for them to become competitive in global production networks, and to exploit economies of scale in foreign markets.

On the other hand, this first channel of globalisation of innovation may provide new opportunities for catching up through imports of high-tech product and machineries, as well as by attracting FDI from more technologically advanced countries (Castellacci, 2006). These channels of international technology diffusion have frequently been pointed out as possible sources of knowledge spillovers and growth of host economies. The process of technology transfer towards less developed economies is not an easy and automatic outcome, but it requires the upgrading of capabilities and absorptive capacities of local firms. An active involvement of the State in the process of upgrading of domestic technological capabilities, skills and infrastructures is therefore a fundamental requirement for catching up.

The second channel of globalisation of innovative activities is the global generation of technology. This can be regarded as the technological equivalent of FDI, and it is realized either when Multi-National Enterprises (MNEs) move part of their R&D labs abroad, thus setting up global research networks, or when they acquire existing R&D labs in host countries. Developing countries have the possibility to exploit the global generation of technology by trying to attract investments related to R&D activities of foreign MNEs. The learning effect related to this second channel, however, can only be exploited if catching up countries have a sufficient level of infrastructures and educated workforce, which would make it possible to attract foreign R&D labs and to enjoy the relative benefits in the host economy (Castellacci, 2006). These new opportunities are better exploited in countries where public policies actively favour the creation of a dynamic learning environment.

The third channel of globalisation of new technologies is constituted by techno-scientific collaborations (Castellacci, 2006). These can be undertaken either by private firms, or by the public research sector. Differently from the previous two channels of globalisation of innovation techno-scientific collaborations enable learning, knowledge diffusion and economic growth in both countries participating to a joint venture, and thus favour the emergence and intensification of new forms of collaboration in the international arena (Castellacci, 2006). In such a positive sum game, international cooperation is increasingly becoming a major source of competitive advantage, and catching up countries have therefore the concrete possibility to exploit this opportunity to augment their stock of advanced scientific and technological knowledge.

For a developing economy, the best way to do so is to enhance domestic competencies, capabilities and infrastructures, so to increase its effective participation to the new forms of collaborations in the global arena. Policies at the national level may use several different instruments to achieve this objective, such as promoting international scientific projects and exchange programmes, increasing student flows to more technologically advanced countries, participating to international organizations, developing infrastructures for technological collaborations and promoting University-industry linkages (Castellacci, 2006).

Considering them together, the three channels of globalisation of technological activities provide new opportunities for catching up countries, at the same time as they lead to greater risks of marginalization and increasing disparities in the near future. The crucial point is that, as the rules of the game change and the process of competition in the international arena becomes more demanding for developing economies, public policies must take an increasingly important role for sustaining catching up and knowledge-based growth in the globalising learning economy.

Table 4.1.: The techno-economic system: windows of opportunity and policy challenges for catching up countries in the fifth long wave

Characteristics of the ICT-based Techno-Economic System	***Windows of Opportunities for Catching-Up Countries***	***Policies needed to sustain the Catching-Up***
Information Intensive and Intangible	Less importance of raw materials and natural resources, greater importance of human skills and knowledge	Education and Training Policies
	ICT-related infrastructures and communication channels (based on cable and wireless transmission of data) complement the more traditional type of infrastructures	Investments in the Infrastructures and Communication Channels
	Less commitment to the previous technological paradigm may enable rapid structural change	Training and re-training policies to accelerate structural change, and to avoid the surge of technological unemployment Improving users' competencies, and sustaining user-producer interactions
Flexible Production System	Decreasing importance of physical capital accumulation, and increasing role of users' skills and competencies	Improving Users' competencies and sustain user-producer interactions
The Rise of Services	The increasing use of ICTs in services make standardisation less important, and leads to greater customisation over time	Incentives to innovation, R&D and entrepreneurship; IPRs regulations
	The limited appropriability of innovation in services may increase the scope for knowledge diffusion within services and to manufacturing industries (the 'efficiency' effect)	Sustaining education and training in non-technical fields to promote knowledge diffusion
	Non-technological and organizational types of knowledge are increasingly important for the diffusion of advanced knowledge ('expertise field innovation', consultancies and KIBS)	
The 'Network-Firm'	Increased speed of knowledge diffusion, and rapid access to new and wider sources of information	Large firms (MNEs) may exploit economies of scales in global production and distribution networks: competition and regulation policies are important to enhance market efficiency
E-Commerce	Changes in the distribution chain may favour the commercialisation of products produced in peripheral regions of the world economy	
Globalisation of Technological Activities	The international exploitation of technologies, the global generation of innovations by MNEs, and techno-scientific collaborations may favour the international diffusion of advanced knowledge Education and training policies	Industrial policies to sustain foreign competitiveness of high-tech sectors; Policies to upgrade domestic capabilities, skills and infrastructures, which may increase the benefits related to the new forms of competition and collaboration in global markets

Source: Castellacci (2006), own elaboration.

4.6. Concluding Remarks

This chapter has focused on the literature on innovation and development. Until recently most people would have considered it odd to consider innovation as an important issue for developing countries, and many probably still see it that way. This skepticism is based on the widely shared view that innovation primarily is of interest for high-tech firms in advanced environments.

The analysis of this chapter started with a discussion about the character of economic growth at the country level. Changes in the trend rate of economic growth over time, or differences in the growth performance of countries are too numerous for the notion of a steady state to be interesting. Moreover economic growth seems to be a process of constant transformation rather than adjustment to a long-run fixed target. Recent periods show us both large differences in trend growth between countries, and for some countries, the first signs of what might be a take-off of trend economic growth rates.

Furthermore, the evolutionary approaches to economic growth that are discussed suggest that radical innovations are important for economic growth, and especially for changes in trend growth. With the analysis and the interpretation of what was discussed earlier, one is tempted to conclude that ICTs are a recent example of such radical innovations. The changes in global growth dynamics that have been researched in this chapter are related to the increasing role of ICT in the world economy, and that the latter is one potential source for divergence (Fagerberg and Verspagen, 2002). For instance, evidence based on data on the diffusion of several types of ICT equipment and services (mobile telephones, computers, etc.) suggest a very uneven rate of diffusion of new ICT.

Continuing, the effects of industrial R&D in emerging economies are higher than those in developed economies. Taken together, these findings from the analysis have important implications, suggesting that many manufacturing industries in emerging economies, may shift over time from an *"imitation"* strategy to practices that place more emphasis on their own R&D efforts and technological capacity. Additionally, impact of R&D on innovation performance is considerably higher than that of FDI and international trade suggests that the acquisition of foreign technology through FDI and trade cannot alone substitute the research efforts undertaken in a given industry (Wang and Kafouros, 2009).

According to this perspective new technologies emerge in advanced economies and gradually diffuse to the developing part of the world. Since technology in this perspective has strong public good properties such diffusion may be expected to yield relatively quick benefits in the developing part of the world. To avoid this outcome, legal instruments that prevent such easy, costless diffusion are needed. According to Fagerberg et al. (2009) followers of this perspective therefore place great emphasis on intellectual property rights as in incentive to secure steady technological progress in the advanced corners of the globe and hence in the global economy as a whole.

However, it is also acknowledged that such protection can never be perfect and will be temporary in any case. Thus, diffusion of new technology, created through innovation in the advanced part of the world, should according to this perspective be expected to work as powerful equalizer in the global economy, making it possible for poor countries to quickly raise their standards of living. But without indigenous innovation, the income gap between developed and developing countries can never be closed. This needed complementarity of indigenous and foreign innovation efforts is due to several self-reinforcing reasons as they are pointed out by Fu et al. (2010).

First, technology diffusion and adoption is not costless and unconditional. The speed of diffusion and adoption, and thereby of technological capabilities building, depends on the firms' absorptive capacity and complementary assets. Second, only in the presence of local innovation capacity will MNEs adopt a more integrated innovation practice, which has greater linkages with the local economy and thereby enables greater opportunities of knowledge transfer. Third, the greater use of external knowledge is accompanied by a parallel decrease of the presence of internal R&D departments, especially in research-intensive industries. This special issue could not support the hypothesis of positive spillover effects from R&D activities of MNEs on the innovation and technical change of local firms, due to significant disincentives on local firms and crowding out of local R&D. Fourth, the inappropriateness of foreign technology in these emerging markets contributes to explain the poor statistical significance and even the negative effects of FDI spillover. The higher a country moves up the industrial ladder, the more important local capabilities and innovation are (Fu et al., 2010). While FDI can facilitate the development of basic operational capabilities, they may be less efficient means of deepening capabilities. Collective indigenous innovation efforts are found to be a major driver of indigenous technical change.

Admittedly, developing countries face a dilemma of resource constraints to meet the high investment costs and high-risk challenges of innovation. Experiences from the emerging economies suggest that, in order to maximize the benefits from innovation and accelerate catching-up, the explicit and well-focused encouragement of indigenous innovation and acquisitions of foreign knowledge must work in parallel (Fu et al., 2010). Neither autonomous innovations nor FDI-reliant strategies can be used independently. Relying solely on one of them would not be optimal for technological capability development and catching up.

The Chinese model (and to a lesser degree also the Indian and Brazilian ones) of walking on two legs proposes a strategy to maximize the benefits for the developing country. How to select and shape the best combinations at different stages of development and for different countries and industries is a question of utmost relevance for future research. Fu et al. (2010) suggest that there are multi-tier choices of technology rather than the simple bi-dimensional divides. Technologies developed in labor-rich emerging economies will be more appropriate to the factor endowments mix in other populous developing countries; and technologies created in land/resource-rich emerging economies will be more appropriate to other land/resource abundant countries. They will also be easier to diffuse and absorb by other local firms. Following this hint, trade and FDI will represent effective vehicles for the diffusion of these technologies, and policies should follow suit consistently. In sum, the encouragement of indigenous R&D and innovation activities remains an indispensable center piece of an innovation strategy targeting the assimilation and adaptation of foreign technology and the acceleration of technological learning and capabilities building to achieve economic growth.

5th CHAPTER

INNOVATION AND REGIONAL INEQUALITIES

5.1. Introduction

The *"New Economic Geography"* literature describes how the interactions of centripetal and centrifugal forces determine the locational decisions of firms and workers between two or more regions involved in trade. The interactions of these forces endogenously determine the size and the productivity of the regional economies. The market outcome is typically affected by the degree of integration among regions.

Starting from high levels of trade costs, reductions in these initially encourage agglomeration. If agglomeration at intermediate levels of transport costs opens interregional wage differences, two things can happen. Either workers move and this strengthens firms' propensity to agglomerate while closing wage differences. Or if workers do not move, then for low enough trade costs it will be firms that move, and this can bring about convergence both in terms of industrial employment and of income. At the same time, anything that prevents interregional wage differences from arising can hinder such catch-up. Economics of agglomeration traditionally used to explain the uneven spatial distribution of economic activities, firms and workers that may nevertheless have a propensity to agglomerate in some regions (Puga, 1999).

Taking into account such general equilibrium effects also brings equilibrium closer to real world outcomes, instead of the catastrophic changes from a completely even spatial spread of industry to the complete concentration of industry in a single region which characterize simpler related models, where may be a process of gradual change in which regions have industrial sectors of different size (Puga, 1999).

Krugman (1991) shows that the interaction of labour migration across regions with increasing returns and trade costs creates a tendency for firms and workers to cluster together as regions integrate. While agglomeration within national boundaries, in an international context, raise barriers to migration and may limit the role of labour mobility as a force driving agglomeration. Yet, one of the main differences between interregional and international agglomerations of industry is where resources are drawn from (Puga, 1999). In a regional context, when industry agglomerates it is likely to draw workers both from other sectors and from other regions; while in an international context, firms will and it will be more difficult to hire workers from other countries.

Increasing returns play a major role in these models that assume decreasing costs of production within each firm. According to Nocco (2005) pecuniary externalities arise because of the assumptions of increasing returns at the firm level and trade costs in the manufacturing (or modern) sector. Moreover pecuniary externalities induce mobile agents, workers or firms, to move towards regions where the size of the manufacturing sector is bigger. In this way, either consumers or firms, may reduce the share of goods on which trade costs should be paid, if they did not move, and agents had to import them from other regions.

However, each manufacturing firm (or consumer) that moves where pecuniary economies are larger, increases the incentive for its customer firms and workers to move in the same direction. These movements, in turn, increase the size of the region of destination and, therefore, the incentive for other firms and consumers to move towards the same region. Hence, concepts such as Myrdal’s "*cumulative causation*" turn out to be fundamental.

Centripetal forces, which favor cumulative causation and, therefore, a spatial concentration of the sector with increasing returns, are generated by three main factors according to Nocco (2005):

i. workers' mobility when the final sector exhibits increasing returns;
ii. backward and forward linkages between firms producing intermediate and final goods, when intermediate goods are produced under increasing returns;
iii. technological advantage of production in a particular region.

On the contrary, centrifugal forces are generated by:

i. immobile demand sources;
ii. stronger competition for limited productive factors, and in good markets for firms that operate in core regions;
iii. technological knowledge spillovers from regions with a more productive modern sector towards less developed regions.

Whenever centripetal forces are stronger than centrifugal forces, the modern sector tends to be completely agglomerated in one region, while a uniform distribution of the economic activity emerges when centrifugal forces are stronger (Nocco, 2005).

Furthermore the pace of technology has increased in the 20th century. In particular Freeman and Soete (1997) note that innovation changed and, from being the outcome of initiatives of inventors became mostly the outcome of specifically designed R&D departments of the firms. In such a context, the comparative advantage in terms of material resources is not anymore the main factor explaining the differentials of income among territories, and the main cause of competitive advantage, for both firms and regions, has become the ability to produce new technical knowledge (Fratesi, 2003).

Innovation is a difficult process to export from one place to the other, due to its characteristics, for this reason, once technology has become the most important factor in the competition among countries and regions interest has grown in the development policies targeting R&D (Rodriguez-Pose, 2001). Among all the characteristics of technology, the one that appears to play the largest role in inducing regional disparities is its cumulativeness, since new technology can only be built upon previously existing one (Fratesi, 2003).

The focus on knowledge creation, however, differently from an ordinary physical factor of production, the same knowledge can in theory be used in many different places and many productions at the same time. For this reason innovation, for our purposed defined as the creation of new knowledge, is only a part (even if the basic) of the mechanism and imitation and diffusion that also play an essential role (Fratesi, 2003). Since knowledge is *"sticky"*, the location is relevant, but the extent of this relevance depends on the speed of spatial diffusion. This has been affected, especially in the last decade, by the expansion of the ICTs that has made easier, faster and much less expensive the transfer of blueprinted knowledge from one place to the other.

Puga and Venables (1999) observe that the:

> *"Economic development may not be a gradual process of convergence by all countries, but instead involve countries moving sequentially from the group of poor countries to the group of rich countries"* (Puga and Venables, 1999: 292).

They show that an exogenous productivity increase of all primary factors strengthens centripetal forces in developed countries by increasing immobile workers' wages. In turn, this may lead some firms to start their production in a less developed country, where wages are lower. Besides, firms that start their production in newly industrialized countries may adopt the same technology as that used by firms in the leading countries. In other words, they do not focus on technological differences.

By contrast, in this chapter it is stressed that when there are technological differences, the lagging regions may not always be able to catch up with the leading ones, even though there are *"potential"* technological knowledge spillovers. In fact, it is underlined that some conditions must be satisfied before there can be a process of catching up, and therefore potential technological knowledge spillovers do not take place automatically towards firms in a lagging region. In this respect, we concur with Verspagen (1991) when he claims:

> *"The basic (implicit) intuition behind the convergence hypothesis seems to be that international knowledge spillovers take place automatically. In the (economic) literature dealing with the nature of technological change in more detail (e.g. Dosi, 1988) it is argued that this assumption is indeed a heroic one. Since the process of (international) technology spillover is essentially a process of adoption of new techniques at the microeconomic (firm) level, the capabilities of the "receiving" country (firm) to "assimilate" (foreign) technological knowledge are critical to the success of diffusion. If countries (firms) do not have the relevant capabilities to assimilate new knowledge, spillovers may not take place at all"* (Verspagen, 1991: 361).

The purpose of this chapter is to account for the fact that the lagging regions are not always able to catch up completely with the leading regions. A complete catch up can be achieved as pointed out by Nocco (2005) when (i) the technological gap between the two regions is not too wide and (ii) firms in the lagging region have enough opportunities to learn by interacting (e.g. watching the technologies used by firms in the leading region). In particular, this may occur only if the lagging regions' learning capabilities to assimilate potential technological spillovers are sufficiently large.

The chances of benefiting from these spillovers depend on the opportunity to interact with firms operating in the leading regions. Since this opportunity is higher when regions are more integrated, our work stresses the relevance of trade costs levels in allowing a successful process of catching up. More precisely, trade costs are represented as iceberg costs that are particularly suitable to describe the cost of the *"distance"* between any two regions, as well as the cost of all other natural and artificial barriers to trade (Nocco, 2005). Therefore, while knowledge spillovers may take place from a leading region towards a neighboring lagging region, they fail to occur if the lagging region is very far or if trade costs are too high, because its firms have fewer opportunities to interact with firms in the more developed region.

It is also investigated the interaction between the creation and the diffusion of technology in order to detect the effects in brings on regional disparities. It is shown that an increase in the pace of innovation, as the one that took place in the 20th century, can engender regional income disparities but if, successively, the speed of diffusion also increases enough, these disparities can fade out (Fratesi, 2003). However, this chapter does not enter in the vicious cycle of an open debate if the advancements in the ICTs and the *"New Economy"* will reduce disparities or lead to the *"dead of distance"* since, as Gillespie et al. (2001) noted:

> *"Communication technologies should not be seen as simply pulling the balance of centrifugal and centripetal forces in one direction at the expense of the other, but rather at simultaneously strengthening both"* (Gillespie et al., 2001: 110).

To address the research question, Fratesi (2003) built a base model that concentrates on location and technology as the causes of regional income disparities, without modeling growth and physical capital accumulation. For this reason the model is more a supplement to existing theories than a substitute. This base model was used for the study of innovation and diffusion mechanisms. It showed us that the most important factor determining the existence of income disparities is the ratio between the speed of spatial diffusion of knowledge and the speed of innovation. In particular, when the ratio is low, the model predicts equilibrium with technology and income disparities. For intermediate values there will be technology disparities but not wide enough to generate income disparities. For higher values technological disparities will fade out and, consequently, income disparities will no longer exist.

5.2. The Disparity Debate: Theoretical Dilemmas

The effects of the market on the spatial, social and sectoral concentration of wealth and power have been the main concern of the disparity debate over the years. According to Suarez-Villa and Cuadrado Roura (1993) those who follow neoclassical precepts have assumed free or unimpeded factor movements to promote interregional convergence. Also, the persistence of regional disparities would, from the neoclassical perspective, be due to factor market imperfections and to the temporal lags inherent in the process of development. Cultural, behavioral, institutional and political factors are all subordinated to economic imperatives by this model. International trade theory has been much influenced by this school, although it has largely ignored the regional dimensions of national markets. Only recently have some contributions acknowledged the importance of geographical space in influencing trade flows (Krugman, 1991).

A second school, dissenting from the neoclassical model, has viewed unrestrained market processes as the cause of disparities. In this view, as pointed out by Suarez-Villa and Cuadrado Roura (1993) market processes tend, by their very nature to concentrate wealth and power. Furthermore agglomeration economies, externalities, and, within sectors, economies of scale and scope therefore only reinforce concentration, to the detriment of lagging areas and regions. Similarly, labor markets, affected by skill and other human capital limitations, are assumed to be overwhelmingly biased against whole segments of the population and, in particular, against the poorest areas. Processes of circular and cumulative causation, and growth pole dynamics have been conceptualized to explain the phenomena that crystallize or increase interregional disparities.

In many ways, however the potential of some backward areas to disengage from the assumed division of labor, through their lower cost advantages (vis-a-vis advanced regions) and through infrastructural investments is seriously underestimated (Suarez-Villa and Cuadrado Roura, 1993). Also, the endogenous resources of certain regions, if carefully nurtured and supported, can make a difference in allowing such areas to gain momentum in their development. At the same time, a selective concentration on serving certain markets through export trade has also driven some backward regions out of a fairly rigid or static domestic division of labor, and into the larger and more fluid global division of labor, where their goods and resources may be more competitive than those of the core regions to which they are subservient (Suarez-Villa and Cuadrado Roura, 1993).

The overturning of the predominance of advanced or core areas by some previously peripheral regions is perhaps the most important spatial phenomenon of the late twentieth century. Regional inversion has become a reality in several advanced nations, giving rise to new technologies and to new political and economic influence in areas that would have hardly been thought good candidates for development only two decades ago (Suarez-Villa and Cuadrado Roura, 1993). Disparities between such regions and the advanced areas of their respective nations have been reduced in almost every case, despite all previous assumptions. Nevertheless, the emergence of previously peripheral regions, and their prospects for passing the traditional heartland areas are undeniable and need to be considered in the context of a changing regional division of labor.

Predicting the effects of supranational economic integration on interregional disparities is a very uncertain task. None of the existing theories of development and inequality offer clear directions to evaluate the dynamics that will be set in motion by a rapid process of integration. It is also difficult to predict which nations will benefit relatively more from integration, and which regions will be the main long term beneficiaries within each nation. Basing long term forecasts on the assumption that agglomeration economies will continue to favor advanced regions over the periphery or that previous spatial concentrations of political and economic power will continue to be predominant seems rather risky (Suarez-Villa and Cuadrado Roura, 1993).

It remains equally unclear whether greater access to the supranational markets, afforded by integration, will work to benefit lower cost peripheral regions within some nations. Moreover for certain nations, the advantages of further concentration in the advanced regions may well offset the lower cost advantages of peripheral areas. In such cases, disparities may persist and could even increase over the long term. Also, the differential effects of infrastructural development in many peripheral regions are difficult to predict, especially when these are better linked with supranational networks that are highly influenced by the advanced nations. Clearly, the inadequacies of the existing paradigms, with their heroic simplifications and assumptions, and the complexities posed by integration provide little ground to analyze a rapidly changing regional dynamic.

5.3. International Technology Diffusion and Technological Upgrading In Developing Countries

As discussed earlier, innovation is costly, risky, and path-dependent. This may provide a rationale for poor countries to rely on foreign technology acquisition for technological development. Foreign sources of technology account for a large part of productivity growth in most countries. International technology diffusion is, therefore, an important condition for economic growth. If foreign technologies are easy to diffuse and adopt, a technologically backward country can catch up rapidly through the acquisition and more rapid deployment of the most advanced technologies (Grossman, 1994; Romer, 1994; Soete, 1985).

Technology is non-rival. The marginal costs for additional use are negligible. Although frontier technology created through innovation enjoys rents, the public good nature of knowledge suggests that it can generate positive externalities (or spillovers) to others who are also exposed to this knowledge in various ways. However, according to Fu et al. (2010) although some of the technologies can be codified, a large amount of technological knowledge is tacit so, knowledge spillovers are geographically bounded due to the requirement of proximity for the transfer of tacit knowledge.

Some knowledge is transferred intentionally from the knowledge owner to the recipient—and this may spur a learning process—but a large proportion of knowledge spillovers take place as unintended knowledge leakage (Fu et al., 2010). In recent years the mode of innovation is becoming more and more open and is making good use of external resources. International knowledge diffusion can, therefore, benefits firms' innovation at every stage of the innovation process. The growing technological diversification of companies makes successful integration of new external knowledge into the innovation process increasingly important. Such successful integration further fosters innovation performance. The factors that explain the accelerating trend of utilizing external sources of knowledge include, among other things, technological convergence, declining transaction costs of acquiring external R&D inputs, and shortening product cycle times (Narula, 2003).

5.3.1. Foreign Direct Investment and Technology Transfer

Foreign direct investment as a bundle of technological, managerial knowledge, and financial capital has been regarded as a major vehicle for the transfer of advanced foreign technology to developing countries. Multinational Enterprises (MNEs) are regarded as the major driver of R&D in the world. MNEs are also found to have internal incentives to transfer technology across border to share technology between parent companies and subsidiaries (Fu et al., 2010). Therefore, it is expected that in the medium- to long-run, local firms will benefit from MNEs spillovers and linkages.

The competition effect of FDI is also expected to push inefficient firms to exit from the market and force other local firms to innovate to be competitive. Technology transfer may take place within the foreign-investing firm through imported machinery and equipments and through labor training. Horizontal technology spillovers may occur from foreign investing firms to other firms in the same industry and/or the same region via demonstration effects and the movement of trained labor from foreign to local firms (Fu et al., 2010). There may also be vertical technology spillovers taking place between foreign and local suppliers and customers within the value chain through forward and backward linkages (Fu et al., 2010).

However, despite the possible benefits of technology transfer and FDI spillovers, these may also have significantly negative effects on technological upgrading in the domestic firms. FDI may make the competing domestic firms worse off, and even crowd them out from the market as pointed out by Fu et al. (2010). Also the strong competition from foreign subsidiaries may reduce local firms' R&D efforts. Moreover, foreign subsidiaries may remain as enclaves in a developing country with lack of effective linkages with the local economy.

Many developing countries have established Export Processing Zones (EPZs) to attract FDI. Trade-oriented FDI in selected areas of the region, which is based on cheap unskilled or semi-skilled labor available in the host country, generated limited linkages and weak spillovers across regions which exacerbated the existing regional inequalities. Moreover there are depressive effects of foreign R&D labs on local firms. This is likely due to the strong competition for talents, resources, and markets between foreign and indigenous firms, and to the limited linkages between foreign and local firms. Most of the foreign R&D labs indicated that they have no intention to collaborate with local firms, universities or research institutions due to concerns on IPR protection (Fu et al., 2010).

5.3.2. FDI is not an Unalloyed Blessing

FDI is not an unalloyed blessing for technology transfer in developing countries. There are many necessary pre-conditions to meet for an effective technology transfer process according to Fu et al. (2010). First, trade policy matters. It is argued that openness facilitates linkages and directs resources to the *"right"* sectors, as well as a competitive and dynamic environment. Second, legal and regulatory policies especially those related to IPRs are important. Foreign firms will not bring core technology into their subsidiaries in developing countries with weak IPR protection. Third, there need to be sufficient linkages between foreign and local firms to make effective technology transfer possible. Fourth, FDI with different characteristics also benefit technology transfer to a different extent. Technological gaps between foreign and local firms also matter. The relationship between the strength of spillovers and the technology gap follows an inverted-U shape. Spillovers are found to be present when the technology gaps are moderate and when they are much larger. Finally, the most necessary condition for effective technology transfer is sufficient absorptive capacity.

Technology spillovers from FDI may also take place along the spatial/regional dimension (Fu et al., 2010). Although knowledge is a non-rival public production asset, which can generate positive externalities or spillovers to others, knowledge spillovers are geographically localized and there may be geographic boundaries to information flows or knowledge spillovers among the firms in an industry. Social bonds fostering trust and frequent face-to-face contacts may facilitate knowledge and information flows among agents located within the same area. In locations with a strong clustering of innovative foreign firms, local firms benefit from knowledge spillovers and are themselves more likely to introduce product innovations. The clustering of only innovation activities by foreign firms has a knowledge spillover impact on local firms. These spatially bounded knowledge spillovers allow companies operating nearby important knowledge sources to introduce innovations at a faster rate than rival firms located elsewhere.

5.3.3. Imports and Technology Transfer

Imports of machinery and equipments are another important channel for foreign technology acquisition. Cross country studies on bilateral imports data suggest imports as an important channel for countries to acquire advanced technology and enhance competitiveness (Freeman and Soete, 1997). Note, however, that technology transferred through imports of machinery and equipments is embedded in this machinery. Products that used these imported machines will probably be of higher quality, but this does not mean that developing countries thus necessarily master the technology of designing and producing those advanced machines. Substantial technological learning and reverse engineering are required to grasp the technologies embedded in the imported machinery. However, according to Fu et al. (2010) investing in foreign technology alone does not enhance innovation in domestic firms, unless it is coupled with an industry's own in-house R&D effort. On the contrary, domestic technology purchases alone are found to contribute to innovation, suggesting that indigenous technology is much easier to be absorbed by domestic firms.

5.3.4. Internationalization of R&D and Technology Transfer

Internationalization of R&D activities by MNEs has been a major trend in recent years. Many developing and developed countries introduced various selective policies to attract R&D-related FDI, with the hope that such investments would contribute to the technological capabilities building of the host country. The evidence on these effects is not clear-cut yet, but Fu et al. (2010) provide original evidence from a comparative study of the innovation practices of multinational affiliates in emerging economies, through the analysis of the technological asset-seeking patterns pursued by MNEs.

The results suggest that MNEs have different levels of involvement with local productive and innovation systems in different countries. Such heterogeneity in technological assets-seeking MNEs behavior combined with different country competences in attracting knowledge intensive foreign investments have created different opportunities for these countries to transfer technology and enter Global Value Chains (GVCs). Furthermore R&D activities of foreign invested firms at the industry level exert a negative spillover effect on technical change of indigenous firms. Foreign R&D activities may well intensify competition for the limited domestic talent pool and crowd out indigenous firms from local labor, resource, and product markets (Fu et al., 2010).

5.4. Space, Convergence and Inequality

The convergence literature is concerned with the question of whether poor economies catch-up to wealthier economies over time, while the inequality literature has tended to focus on a more detailed analysis of the nature of income differentials across economies at one point in time. The role of space has only recently begun to attract attention in the regional convergence literature, while the older literature on regional inequality has been virtually silent on the complications that spatial data pose.

The empirical studies on economic growth can be divided into two distinct categories according to Rey and Janikas (2005). Confirmatory analysis draws on formal growth theories in order to construct econometric equations which in turn are estimated using observations from economies at various scales. The second type of studies is exploratory, where innovative techniques are applied to data in order to generate hypotheses about the underlying dynamics of the economic system. While some studies have asserted the complementary aspects of the two empirical methodologies, most of the findings from the two sets of studies tend to be in conflict.

The controversies and the conflicts between the two empirical literatures have given rise to several calls for focused attention on the underlying empirical strategies used in the econometric analysis of growth patterns. The main concerns in these calls have been with traditional econometric issues of endogeneity of regressors, collinearity between regressors and the modeling of parameter heterogeneity. However, as it pointed out by Rey and Janikas (2005) issues associated with spatial effects can be profoundly important in the analysis of growth patterns, both for the confirmatory and exploratory approaches. Moreover spatial dependence (i.e., autocorrelation) can invalidate the inferential basis of traditional econometric methods since a key assumption of observational independence no longer holds.

Spatial dependence can arise in a number of ways. From a substantive viewpoint, technology spillovers, labor and non-labor migration, commodity flows, and a host of other types of spatial interaction can tie the fortunes of neighboring economies together. At the same time, an implicit assumption in most empirical growth research is that the administrative boundaries used to organize data series coincide perfectly with the actual market boundaries over which economic processes operate. If this is not the case then a form of measurement error will induce spatial autocorrelation into the data series (Rey and Janikas, 2005). This issue takes on heightened importance in a dynamic context as market boundaries themselves are likely to be evolving over time.

The inherent dynamic aspect of the convergence question poses numerous challenges for the application of spatially explicit methods given that these methods are designed for cross-sectional analysis (Rey and Janikas, 2005). As such, there is a pressing need to extend spatial analytical techniques to include dynamic components. At the same time, there is a wealth of sophisticated time-series methods that have been brought to bear on the convergence question. However, these tend to provide only limited insights as to the geographical properties of the underlying income series. From this perspective there is a parallel need to extend time-series methods to more fully incorporate space.

5.4.1. Confirmatory Analysis of Regional Convergence and Divergence

Initial work on the convergence hypothesis was most often based on neoclassical growth theory. This work emphasizes the principle of transition dynamics as a mechanism to account for growth rate differentials. The principle posits that the growth rate of an economy is proportional to the distance between its current position in the income distribution and its steady state position (Rey and Janikas, 2005). The speed of convergence, which is often taken to be homogeneous across economies, is the rate at which the gap separating a country's current position and its steady state position is closed.

However, this notion of convergence does not imply that all countries are converging to the same position in the income distribution. Instead, this principle attributes differences in growth rates to countries having different steady state income positions and/or different gaps between their current incomes and these steady state positions. This reasoning has given rise to an extensive literature of empirical studies using so-called *"growth regressions"* which relate the growth rate in per capita income for a period to an initial level of income and a set of steady state determinants (Rey and

Janikas, 2005). As the speed of convergence is a function of the b parameter, this form of convergence is referred to as β-convergence.

Recently, the growth regression approach has been extended to consider the role of spatial effects in the econometric analysis. Spatial dependence, when present and accounted for, can affect the quantitative and qualitative inferences made about regional growth processes. In addition to spatial dependence, however, there is also a need to extend growth regressions to account for various sources of spatial heterogeneity. Indeed, the assumption of a single steady state existing for all regions in a national system is largely at odds with empirical evidence of spatial variation in production technologies as revealed in Rey and Janikas (2005). Incorporation of such heterogeneity is crucial to an improved understanding of regional dynamics. In addition the challenges that changes in spatial scale pose for our understanding of economic growth and change are equally deserving of attention.

5.4.2. Exploratory Analysis of Growth Dynamics

An alternative set of empirical strategies takes the distribution of regional incomes as the unit of analysis rather than the individual economies themselves. Proponents argue that these empirical methodologies allow for the analysis of economic growth without having to impose prior restrictive assumptions on the growth processes. Various methods have been employed to analyse the distribution of regional incomes. Pioneering work focused on how the dispersion of incomes in a region altered over time. This notion of economic change is known as σ-convergence and has continued to attract attention in the literature (Rey and Janikas, 2005).

While the concepts are intuitively simple, there are a number of limitations inherent in the measures of σ-convergence (Rey and Janikas, 2005). There has been evidence that the focus on dispersion can conceal important geographical patterns that may be changing over time. Furthermore, the income distribution is viewed at an aggregate level which masks any mixing and mobility of individual economies. Lastly, other aspects of the distribution such as skewness and modality are ignored. More sophisticated distributional approaches have recently appeared, such the estimation of regional income densities using a variety of parametric and nonparametric methods.

Quah (1993) has pioneered the use of stochastic kernels to estimate the underlying regional income distribution and to analyse its evolution over time. Stochastic kernels have been used to study a number of characteristics of spatial income distributions including changes in modality, distributional mixing, stochastic dominance, as well as the long run steady state income distribution.

Closely related to the work on stochastic kernels has been the use of Markov chain modeling to represent the dynamics of regional income distributions, again pioneered by Quah (1993). This can be viewed as a discretization of the income distribution into non-overlapping and exhaustive income intervals. This discretization is then used to estimate the probability that an economy that was in one interval in one time period transitions into another interval (or remains in the same interval) in a future time period. Estimation of the full set of transition probabilities allows for the analysis of a number of important characteristics of the distributional dynamics including: the ergodic steady state income distribution, the transitional speed to the steady state distribution, convergence and/or polarization tendencies (Rey and Janikas, 2005).

A final approach to distributional modeling is based on regression trees. A form of classification analysis, regression trees allow for the identification of convergence clubs and permits parameter heterogeneity in the underlying growth models. While the confirmatory approaches to convergence analysis can be extended to search for the existence of convergence clubs, the regression tree approach offers a less ad-hoc method for detecting this form of spatial heterogeneity (Rey and Janikas, 2005).

Kernel densities, σ-convergence analysis, Markov chains, and regression trees provide important complementarities to the confirmatory approaches to convergence analysis, particularly in regards to the study of heterogeneity within growth processes. However, all of these approaches rest on the implicit assumption that each economy represents an independent observation providing unique information that can be used to estimate the income distribution or its growth path (Rey and Janikas, 2005). Unlike the case of the classical approaches to convergence, where the issue of spatial dependence has begun to attract attention, the implications of spatial autocorrelation for the exploratory approaches to convergence analysis have been virtually ignored.

5.4.3. Regional Income Inequality

Closely related to the topic of regional income convergence is the question of regional inequality. A large literature has examined the question of regional inequality relying on methods that are distinct from those used in the convergence literature. One of the more popular approaches to regional inequality is the decomposition of a global measure of inequality (i.e., variance) into inequality *"between"* or *"within"* regional groupings. By partitioning a group of *n* spatial observations into *v* mutually exclusive and exhaustive groups, a global inequality measure such as Theil's (Rey and Janikas, 2005) can be decomposed.

The decomposition allows the analysis to move beyond a simple α-convergence study to consider the amount of spatial polarization for a given level of inequality. This is important, as it is entirely possible for a general decline in σ-convergence to coexist with increasing polarization within the income distribution (Rey and Janikas, 2005). The relative importance of the inter- and intra-group components has been the subject of a number of regional studies.

The relationship between spatial autocorrelation and inequality is important for a number of reasons. First, the spatial dependence poses challenges for the development of methods of inference in regional inequality analysis. Second, when viewed in a dynamic context the covariation of inequality measures and spatial autocorrelation measures may reveal deeper insights about spatial economic change than would be possible by using either measure in isolation. Finally, there is a need to explore the relationships between convergence, inequality and spatial clustering. Here again, because the methods used in inequality analysis are distinct from those of convergence analysis, the combined application of these alternative approaches holds the potential for a more comprehensive study.

5.5. Innovation-Diffusion, Convergence and Divergence

In order to look at technology diffusion and catch-up based growth in more details, we will draw on the technology gap growth model developed by Fagerberg (1987, 1988). This model takes the distinction between the development of new knowledge (in a country) and the diffusion of knowledge (between countries). Fagerberg (1987) summarized the basic hypotheses of this approach in four points as follows:

i. There is a close relation between a country's economic and technological level of development.
ii. The rate of economic growth of a country is positively influenced by the rate of growth in the technological level of the country.
iii. It is possible for a country facing a technological gap, i.e. a country on a lower technological level than the countries on *“the world innovation frontier”*, to increase its rate of economic growth through *“imitation”* or *“catching-up”*.
iv. The rate at which a country exploits the possibilities offered by the technological gap depends on its ability to mobilize resources for transforming social, institutional and economic structures.

In an attempt to test the first of these four relationships, Fagerberg (1987, 1988) regressed the level of GDP per capita on two different technology indicators: external patents per dollar of export, and total R&D expenditures as a fraction of GDP. The hypothesis was that this relation should be expected to be log-linear rather than linear, because countries close to the technological frontier depend more on the development of new knowledge (or innovation) than technologically lagging countries (which were assumed to rely more on imitating knowledge developed elsewhere, that is diffusion). Fagerberg's original regressions, which were undertaken for selected periods prior to the early 1980s, confirmed the hypotheses under test.

According to Fagerberg (1987, 1988) the correlations between the economic and technological levels of development are in both cases positive and significant for all time periods. What does this imply? A given increase in relative GDP per capita requires a larger increase in relative innovative activity (patenting) in the 1990s than it did one or two decades earlier. Hence, that means it has become technologically more demanding to catch-up economically. A possible interpretation might be that this reflects increasing technological divergence in the global economy between, on one hand, a group of technological leaders who compete neck to neck with each other, and on the other a group of laggards for which technological competition in the form of patenting becomes less and less relevant. The fact that this tendency is somewhat more manifest for patents than for R&D might be explained by the fact that R&D is a broader measure of technological capability than patents and that R&D continue to be of high relevance also for poorer economies that wish to catch-up through imitation (Fagerberg and Verspagen, 2002).

A really thorough analysis of such changes in dynamics between technology and economic growth, however, requires a more dynamic framework than the static correlations studied so far. Hence to what is done in the following Fagerberg and Verspagen (2002) are trying to re-estimate the dynamic specification of the technology gap growth model. So the dependent variable in this new model is the average annual compound growth rate of GDP. The model explains economic growth as the joint outcome of three sets of factors:

- innovation (a possible source of divergence, measured through patent growth),
- the potential for diffusion (a possible source of convergence, proxied by the level of productivity or GDP per capita) and
- complementary factors that contribute to the exploitation of this potential (absorptive capacity).

Among the complementary factors influencing the realization of catch-up potential, it is included, as in the original model of Fagerberg (1987, 1988), investment as a fraction of GDP (average over the period indicated). In addition, it is included two variables reflecting the industrial structure of the country, the share of manufacturing and services, respectively, in GDP. While investment is generally viewed as a growth-inducing factor, the inclusion of the structural variables may be more controversial. Manufacturing was included to take into account the argument of *“manufacturing as an engine of growth”*, i.e. that manufacturing is technologically much more dynamic than other sectors of the economy and therefore should be regarded as a growth-inducing factor in its own right. However, it is commonly argued that this positive role for manufacturing is now history, and that the role of *“engine of growth”*—or *“carrier branch”* for the most progressive technologies of the day has been taken over by the services sector (Fagerberg and Verspagen, 2002). To take into account this possibility, they included also the share of services in GDP as a possible complementary factor.

The model is estimated for the pooled sample of observations of 29 countries and the three time periods as used (1966-1972, 1973-1983, 1984-1995). The main lessons to be drawn from the estimations as pointed out by Fagerberg and Verspagen (2002) are the following:

a) In general, the test confirms the basic hypotheses underlying the model, i.e. that innovation, diffusion potential and other (complementary) factors related to the exploitation of this potential matter for economic growth.
b) The scope for diffusion, as measured by GDP per capita (log form), appears to be lower after 1983 than it previously was (especially when compared to the 1973-1983 period).
c) The importance of innovation (as measured by patent growth) for economic growth appears to increase over time. The impact is especially significant in the most recent period.
d) The opposite holds for the role of manufacturing which had a much more positive and significant impact before 1973, than it is shown to have later. Services, on the other hand, were found to have a positive impact in all three periods, with the most pronounced effect between 1973 and 1983.

There are also several interesting features about the growth rates differentials between countries according to Fagerberg and Verspagen (2002). The first is that it clearly points to the scope for diffusion as the most important factor behind catch-up and growth (even in the most recent period). Investment plays a more subordinate role except for Japan. Differences in innovation (patent growth) also explains relatively little initially, but emerges as a very powerful factor in the most recent period, in which it turns up as the single most important factor behind the continuing high growth of the Asian NICs. Before 1983, the high growth of the Asian NICs was mainly explained by the large scope for diffusion. Now this matters much less for these countries, and has had to give way to innovation as the major growth-inducing factor.

Finally, it should be noted that structural factors were indeed important in explaining the difference in growth between the US and other country groupings. In particular, it seems to be the case that the relatively important role played by services in the US economy has been a major growth-inducing factor there, explaining to some extent the failure of most other economies to catch-up. Initially, the US was also helped by its relatively high specialization compared to most other economies (except Japan) but this effect soon faded away and has since the early 1980s been of negligible importance.

5.6. Technological Evolution and Stability

Technology transfer and spillovers are of central importance to endogenous growth theories of regional change. Despite this, the literature in this area has been slow to develop spatially explicit models of technology change and diffusion, and has instead posited that the speed of technology adoption by lagging regions is proportionate to the gap separating their current level of technology with that of the leading technology regions (Rey and Janikas, 2005).

The role of spatial externalities and spillovers in shaping economic growth and income mobility has been highlighted as an important issue. Together with the geographical targeting of programs aimed at alleviating poverty and the evaluation of federal government efforts to reduce regional income disparities. So there is a clear need to develop spatially explicit analytical measures for policy analysis and formulation.

Verspagen (1991) points out that the learning abilities of a lagging region or country depend both on an intrinsic capability, and on its technological distance from the leading country. Furthermore, he maintains that the intrinsic learning capability is determined by a mixture of social factors, education of the workforce, the level of the infrastructure, the level of capitalization (mechanization) of the economy, the correspondence of the sectorial mix of production in the leading and following country, and other factors.

However, learning through knowledge spillovers processes is also enhanced when firms in the less developed regions have more opportunities to observe and learn how all the different phases of production are conducted by firms active in the more developed regions. According to Nocco (2005) such an observation is more likely to occur when the level of integration is higher because natural and artificial barriers to trade are lower. Thus, the productivity of firms producing in a less developed region may be increased through a process of learning by interacting with firms that produce in the more developed region. Since knowledge spillovers do not take place automatically, it is reasonable to assume that their chances to occur increase when trade costs are *"small"*, while knowledge spillovers fail to take place when trade costs are *"high"*. Therefore, low trade costs act as a stabilizing force because they favor knowledge spillovers and it is illustrated the importance of trade as a mechanism of international knowledge spillovers.

In order to illustrate the fact that trade acts as a channel through which knowledge spillovers take place, it is assumed that learning capabilities depend upon trade costs. Trade costs can be seen as a short-cut for the volume of trade that is the natural candidate for spillovers in technology. However, Keller (2001) finds that, for manufacturing industries in the world's seven major industrialized countries during the years between 1970 and 1995, *"the scope for knowledge spillovers is severely limited by distance"*. Furthermore, Keller finds (2001) that *"trade patterns account for the majority of all differences in bilateral spillover flows, whereas foreign direct investments and communications flow differences account for circa 15% each"*, and that *"these three channels together account for almost the entire localization effect that would be otherwise attributed to geographic distance"*.

Specifically, it is assumed that when trade costs are above a certain threshold value, firms in the lagging region are unable to assimilate any of the potential knowledge spillovers from the leading region, so that the actual learning capabilities of this region are equal to zero. However, when trade costs are below, the region's learning capabilities rise as trade costs fall. For simplicity, we assume that there are no interregional differences in these other factors.

In order to describe how the learning ability affects the production activity in the lagging regions, it is assumed that the technological level depends on learning capabilities and on the technological gap between the two regions. It is described the fact that if there are no technological spillovers, productivity differences between the leading and the following region tend to increase over time due to cumulative processes. This specification draws the fact that the technological advantage of a region tends to increase over time unless the technological gap between the two regions can be closed thanks to interregional learning capabilities. Furthermore, it is taken into account the fact that when learning capabilities are small firms in the lagging region may recover their technological lag only when it is not too wide. In fact, when the technological gap is very wide, the amount of knowledge spillovers required by firms in the lagging region to catch up is very wide. And because trade costs are high, the lagging region will definitively fall behind.

Therefore, according to Nocco (2005), it might be possible to observe a stable equilibrium with no firm producing the modern good in the region if learning capabilities of this region are very low. In this case, trade costs are going to be too high to allow firms in the region to assimilate technology spillovers from other regions, which are the technological leaders, when its technological lag is sufficiently wide. When this is so, the technological advantage of the leader region continuously increases over time.

The *"symmetric"* equilibrium characterized by stability, when trade costs are low enough to allow firms in the receiving regions to assimilate technology spillovers. Moreover the symmetric equilibrium is stable only if learning abilities in both regions are positive. However, when learning abilities are positive but not too high because trade costs are not low enough, the lagging region may benefit from interregional knowledge spillovers provided that its technological lag is not too wide (Nocco, 2005). In fact, firms in the lagging region may benefit from knowledge spillovers only when the level of the technology of this region is not too low. In other words, firms in the lagging region may recover their lag only if the technological gap from the leading region is small.

The width of the recoverable lag increases (decreases) when learning capabilities increase (decrease), namely when the economic integration between the two regions becomes higher (lower). In short, according to Nocco (2005), as far as concerns the lagging region, the following three cases may occur for respectively high, low or intermediate trade costs.

Case 1: When trade costs are too high, the symmetric equilibrium can never be reached because firms in the lagging region cannot benefit from technology spillovers from the leading region, given the low level of integration.

Case 2: When trade costs are low, firms in the lagging region can successfully exploit potential technology spillovers from the leading region and the symmetric equilibrium is stable.

Case 3: For intermediate trade costs the process of catching up of the lagging region with the leading region may be completed because trade is sufficiently developed to allow firms in the lagging region to interact with the most productive firms in the leading region. However, this happens only when the technological gap between the two regions is not too wide for the given learning abilities.

The fact that the symmetric equilibrium is unstable for the highest range of trade costs values is not a new result in economic geography models. Specifically, Helpman (1997) states that:

> *"Whenever brands of the differentiated product are poorly substitutable for each other and the demand for housing is low [...], the relative utility in a region declines with its population when transport costs are negligible and rises with its population when transport costs are prohibitive. In the former case, there exists a unique stable equilibrium in which both regions are occupied while in the latter case, in a stable equilibrium, the entire population lives in one region"* (Helpman, 1997: 42).

Helpman's (1997) and Nocco's (2005) results show that dispersion is not always a stable equilibrium for high trade costs. However, in this case, if trade costs are high enough, the lagging region cannot benefit from any potential knowledge spillovers process, and the initial technological gap increases over time leading to the agglomeration of the manufacturing sector in the leading region, which is a sustainable equilibrium. By contrast, even when the two regions are sufficiently integrated, and therefore the process of technological catching up may be implemented through learning by interacting processes, the other centripetal forces may be strong enough to make the dispersion of the economic activity unstable. Finally, if the economy is at the symmetric equilibrium, and this equilibrium is stable, technology may still evolve since this equilibrium is compatible with equal exogenous growth rates for the two regions (steady state equilibrium). It is reminded that a necessary condition for this equilibrium to be stable requires that trade costs must be sufficiently low to allow for successful technology spillover processes.

To summarize, trade costs play a different role in the process of knowledge spillovers and in the process of interaction between the standard centripetal and centripetal forces (for given technology development levels). More precisely, from the point of view of technology spillovers processes a reduction in trade costs, when they are high, may enhance the recovery of the less developed region, but from the other point of view (that is, the interplay of centripetal and centrifugal forces evaluated at fixed technology levels), the reduction in trade costs may strengthen centripetal forces. As a consequence, in this case, there is a trade-off in the role played by trade costs in knowledge spillovers processes and in determining the result of the conflict between standard fixed-technology centripetal and centrifugal forces (Nocco, 2005).

5.7. Regional Innovation Systems and Regional Inequalities

Over the past decade the national systems approach has gained considerable currency amongst both academics and policy makers. At the same time, a number of writers have called for the systems concept to be extended to a variety of levels: global, regional and sectoral (Oughton et al., 2002). Growing international competition and integration strengthens the importance of the regional dimension because there is a well-defined set of external economies that are realised at that level. If firms are to compete in an increasingly global environment it is important that they exploit all economies, including those that are realised at local and regional levels.

From a theoretical perspective, the rationale for focussing on regional innovation systems lies in the fact that the factors that the national innovation systems theory identifies as important, such as the institutional framework, the nature inter-firm relationships, learning capability, R&D intensity and innovation activity, all differ significantly across regions. According to a study of Oughton et al. (2002) there is significant variation across nation states in average levels of innovation activity for all indicators except government expenditure on R&D as a percentage of GDP. Hence, different nation states have very different rates of innovation activity and there is justification for looking at the national systems of innovation to understand why these differences occur. Another point is that for all indicators of innovation activity the variation across regions is significantly greater than the variation across nation states. Taken together, the data of this study suggest that variations across regions within nation states are greater than variations across nation states providing strong empirical evidence in favour of extending the analysis of national systems of innovation to the regional level (Oughton et al., 2002). In short, the data indicate that there must be a set of regional factors that shape differences in R&D intensity, innovation activity and competitiveness.

Regional innovation systems can be seen as *"essentially social systems"* composed of interacting sub-systems. As it pointed out by Autio (1998):

> *"The interactions within and between organisations and sub-systems generate the knowledge flows that drive the evolution of the regional innovation systems"* (Autio, 1998: 134).

The regional dimension is important because many of the factors that are known to influence innovative capability at the national level have strong regional dimensions. Regional systems may be distinguished from national innovation systems by observed differences across regions in industrial structure, R&D and technology provision, policy initiatives, business service provision, governance structures and the institutional framework, particularly the nature and extent of inter-relationships between key players (Oughton et al., 2002). The industry-government-university nexus identified by *"the triple-helix model"* is central to the innovative capacity of nations and regions but functions differently at national and regional levels. Similarly, knowledge transfer, learning, agglomeration economies and external economies are factors that operate differently and in some cases exclusively at regional level.

Knowledge flows are of central importance to regional innovation systems because *"tacit"* or *"implicit"* knowledge is more easily transferred within a local or regional context where constant interaction and exchange is easier and cheaper. The innovative capacity of the regional firm is directly related to the *"learning ability"* of a region. Innovative capacity and the regional learning ability are associated and are directly related to the density and quality of networking within the regional productive system according to Oughton et al. (2002). Moreover inter-firm and public-private co-operation and the institutional framework, within which these relationships take place, are key sources of regional innovation.

Regional systems also have the capability to exploit a range of external economies. These include agglomeration economies, spillovers of knowledge, pools of skilled labour and collective external economies. Joint investments, that are made by firms or organizations and the collective external economies that result differ from the other three types of external economy, require the coordinated and active involvement of actors, which in turn requires trust and communication. This is in contrast to other sources of external economies—agglomeration economies, pools of skilled labour and spillovers of knowledge—which require no coordinated action by players. The realisation of collective external economies requires the active (rather than passive) involvement of firms/organisations in the form of joint commitment of resources, which in turn requires communication and trust (Oughton et al., 2002). The regional dimension is clearly important in the formation of networks of firms because communication and trust are facilitated by proximity and repeated interaction which is easier and cheaper in a local/regional context.

Finally, the regional institutional framework shapes the learning process in a regional economy. The regional government can play a major role in articulating and dynamising a regional innovation system, understood as the process of generating, diffusing and exploiting knowledge in a given territory with the objective of fostering regional development. In this dynamic and systemic sense, the regional system is itself subject to the process of learning, and becoming an efficient *"learning region"* (Oughton et al., 2002). Also the nature of the regional governance system and the wider institutional framework shapes the effectiveness and the efficiency of regional knowledge building/transfer among the different integrating parts of the system.

Returning back to the study of Oughton et al. (2002), its figures provide empirical confirmation of the regional innovation paradox: regions that lag behind in terms of GDP per capita and that ceteris paribus need to increase their R&D intensity and innovation activity in order to catch-up, actually devote less resources even as a proportion of GDP. It is notable that rather than counteract this tendency, government spending on R&D, and R&D spending in the education sector (much of which is financed by public funds) reinforces it. Governments across the world spend more on R&D in leading regions and less in lagging regions both in absolute terms and as a percentage of GDP. This is contrast to industrial policy where there is an inverse relationship between government spending on industrial policy and GDP per capita because public funds are targeted at poorer regions (Oughton et al., 2002).

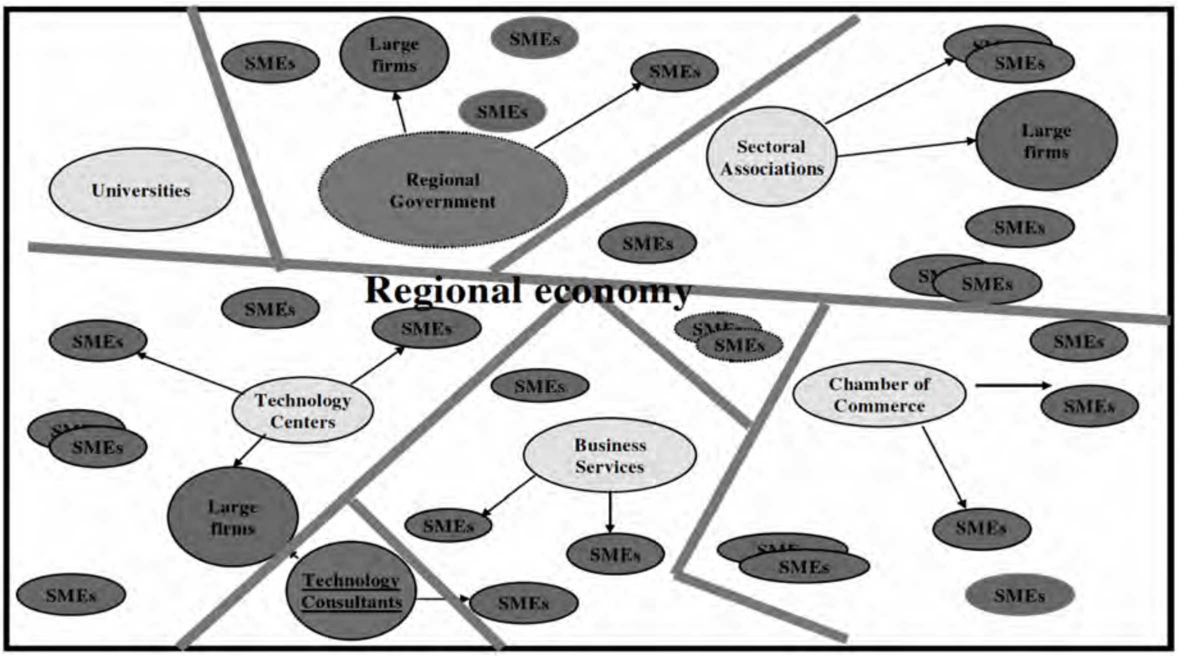
The relationship between innovation activity, R&D intensity and living standards across regions captures the empirical dimension of the *"regional innovation paradox"*. The paradox reflects the difficulty that lagging regions have in absorbing funds for R&D activity even when these are offered in the form of public subsidies (Oughton et al., 2002). The data also provide insight into the nature of the absorption problem. According to Oughton et al. (2002) government expenditure on R&D, business expenditure on R&D and spending by the education sector on R&D are all positively and significantly correlated, which means that they are complementary. Given that, increasing innovation activity and R&D intensity is unlikely to be achieved by working in the single dimension of government expenditure on R&D.

Policy must also increase the level of R&D spending by the business and education sectors that is necessary to increase a region's capacity to absorb public funding of R&D and the expenditure/investment capacity of the business sector. Understanding the interaction between these three sectors and types of innovation activity (government-industry-university) in the context of regional innovation systems is central to resolving the regional innovation paradox.

The main cause of the regional innovation paradox is not primarily the availability of public funds in lagging regions. In particular, firms in lagging regions often articulate little demand for R&D and other innovation inputs and tend to lack a tradition of cooperation and trust, both amongst themselves or with regional innovation actors, such as universities (Oughton et al., 2002). Firms do not demand innovation inputs or services. At the same time, as it is referred by Oughton et al. (2002) the regional research and technological infrastructure is not embedded in the regional economy, and therefore suppliers of innovation services (technology, training/education, venture capital) are unable to identify the innovation needs and capabilities of firms in the regional economy. Thus, there is a lack of integration between regional supply (of innovation services) and demand for innovation (inputs/services).

In short, the regional innovation system is fragmented (Figure 5.1) and lacks either the necessary interfaces and co-operation mechanisms for the supply of innovation inputs to match firms' demand, or the appropriate conditions for the exploitation of synergies and cooperation among regional innovation actors which could eventually fill gaps and avoid duplications in service provision.

Figure 5.1: The Regional Innovation Paradox



Source: Oughton et al. (2002).

5.8. Concluding Remarks

As economic integration lowers barriers between regions and dissolves national boundaries, will industry become more or less agglomerated in space? And what will be the associated changes in the spatial distribution of income?

This chapter has revealed that the analysis of the dynamics of regional income convergence and inequality have both a temporal and spatial dimension. While the role of space has begun to draw attention in the analysis of economic change, the literature review indicated a variety of gaps where further research is needed. The integration of existing spatial econometric methods could shed light into the effects of spatial dependence and spatial heterogeneity on convergence. It was noted that current exploratory methods of income dynamics could suffer from boundary mismatch when the spatial dependence is unaccounted for. It is also referred that there are interesting possibilities regarding the comparisons between the predictive performance of exploratory and confirmatory approaches. In empirical growth patterns there is a clear need to identify the causal processes giving rise to these spatial effects. Given the temporal dimension of regional growth, it is also critical that these spatial effects be viewed in dynamic context.

This chapter followed the steps of Fratesi (2003), which despite using a simplified framework has managed to analyze the modeling of innovation diffusion and evidenced the consequences this process entails for regional disparities. Regional disparities can be caused by different technological endowments, when these differences are wide enough. Also it could be featured the possibility of identifying who will produce the varieties, whose knowledge is common between the regions and in which way it becomes symmetric and apt to represent bi-regional systems where a region is similar to the other. In particular this feature is useful for the representation of flows of knowledge from one region to the other and vice versa.

Moreover it is clarified the ability to study the dynamics of the flows of knowledge and evidence that, for higher values of the speed of innovation, it becomes more probable to have income disparities, whilst, if diffusion becomes faster, income disparities become less probable. For given technological levels, it is found that full agglomeration of the manufacturing sector in a region is unsustainable for high trade costs because centrifugal forces are stronger than centripetal ones. By contrast, full agglomeration may be an equilibrium for low trade costs.

Furthermore, the introduction of differences in the technology levels allows us to show that the existence of technological differences may give rise to a non-monotonic relationship between the sustainability of agglomeration and the levels of trade costs (Nocco, 2005). For given equal technological levels, the traditional result of a stable symmetric equilibrium for high trade costs may holds. Further, it is referred that when the technological advantage of a region is very high with respect to the other region, full agglomeration of manufacturing in the leading region is sustainable even for the highest values of trade costs. More precisely, when obstacles to interacting, proxied by trade costs, are high, the symmetric equilibrium becomes unstable and centripetal forces induce the agglomeration of the manufacturing sector in the more developed region. Besides, low trade costs may yield either the agglomeration in the more productive region, or the dispersion of the modern sector.

In particular, the symmetric equilibrium can be attained only if the lagging region can complete a catching up process with the leading region. The key variable is the ratio between the speeds of diffusion and innovation. When it is low, the system present multiple equilibria in which there are regional technological and income disparities. For intermediate values, even there exist multiple equilibria, in which a region is more technologically advanced, the spatial diffusion mechanism allows the other region to have the same income. For higher values of the ratio, there exists only one equilibrium in which the two regions are equally endowed of technology and have the same income.

Hence, it was shown that the symmetric equilibrium is unstable when trade costs are too high, because firms in the lagging region cannot benefit from the potential knowledge spillovers from the leading region. In this case, firms in the less developed region do not have enough opportunities to interact with firms in the leading region and, therefore, they are unable to assimilate the more productive technologies used by the latter. As a result, the technological gap between the two regions increases, and the manufacturing sector ends up being completely concentrated in the leading region.

By contrast, when trade costs are sufficiently low, firms in the lagging region can benefit from knowledge spillovers and the symmetric equilibrium may be stable if all the centripetal forces are weaker than the centrifugal ones. Moreover, for intermediate trade costs values, the symmetric equilibrium can be stable, provided that the initial technological gap between the two regions is not too wide. In fact, when it is very wide, firms in the lagging region are unable to assimilate the potential knowledge spillovers. When this is so, the agglomeration of the manufacturing sector in the leading region is the only sustainable equilibrium (Nocco, 2005).

To sum up, there is a trade-off in the role played by trade costs in knowledge spillover processes, and in determining the result of the conflict among the other fixed-technology centripetal and centrifugal forces. The results of this trade-off depend on which of the effects produced by different trade costs levels prevail. Particularly, if trade costs are very high, manufacturing ends up being completely agglomerated in the region that has an initial technological advantage, because firms in the lagging regions are unable to benefit from the interregional potential knowledge spillovers.

The conclusion of this chapter is that a process of *"technological revolution"*, like the one that took place in the 20th century, could have contributed to generate regional disparities. The evidence presented here implies that some degree of regional inequality is hardly avoidable, at least at the initial stages of development of countries starting from relatively low levels of GDP per capita. Even if a reduction in the speed of innovation is not envisageable, if the diffusion of technology becomes fast enough, regional disparities can decrease. The main reason for this is that growth is essentially driven by innovation and technological progress which are unlikely to appear everywhere at the same time (Barrios and Strobl, 2009). It follows that some degree of heterogeneity in regional economic development will necessarily appear as countries are engaged into fast economic catching-up.

The regional innovation paradox suggests the need to integrate technology/innovation policy and industrial policy and recognises that complementarities between private and public sector investment in R&D and innovation activity require a policy approach that networks key players and acts on both the supply and demand side of the system to catalyse investment (Oughton et al., 2002). From my point of view RSs may help prepare the ground so that those responsible for innovation promotion at regional level can better respond to the need of increasing the regional innovation potential and addressing the problem of the *"regional innovation paradox"*. This can be done through a strategic approach involving key regional actors, resulting in new innovation projects consistent with regional policy objectives. Social capital, learning (inter-firm, inter-organisational and inter-regional) and networking to promote collective external economies of scale are crucial to this process. Thus, RS seems to be a fertile ground for further experimentation and learning in the quest for efficient regional innovation systems that can consolidate sustained and sustainable economic development processes in those regions where these are most needed.

It is pointed out that the transfer of blueprinted knowledge is not by itself enough to make other people able to use that information; however, the ICTs revolution which is taking place is making smoother the diffusion of innovations from one region to the other. At the same time, the speed of innovation might increase further. Since innovation is a cumulative process, in fact, there must be a technological base wide enough to build upon it; if a region is lagging behind and does not possess front-line technology, even implementing strong innovative efforts it will not be able to create a large quantity of new knowledge, and, in addition to that, a large part of the *"new"* discoveries, could even be already *"old"* for the most advanced regions.

It can be therefore an easier and more effective strategy, when trying to make an under-developed region to catch up with the richer, to target, at least in the first phase, the spatial diffusion of knowledge and to allow in this way the lagging region to enter rapidly in competition with the foremost regions in the production of goods which remain invented by the most advanced regions (Fratesi, 2003).

6th CHAPTER

INNOVATION POLICIES TO DECREASE REGIONAL INEQUALITIES

6.1. Introduction

The capacity to innovate and commercialize new goods and services remains vital to the future competitiveness of all the participants in the global economy. Reinforcing and sustaining this capacity is particularly salient as research, development, manufacturing, and the delivery of services made possible by new information and communications technologies, become ever more global (Wessner, 2007). The emergence of new participants in the global economy focused on attracting and developing high-technology industries within their national economies, is increasingly significant. Responding to these structural changes in the global economy, other advanced economies have already initiated major programs, often with substantial funding, that are designed to attract, nurture, and support innovation and high-technology industries within their national economies.

Responding to this challenge requires the recognition of that the nature and terms of economic competition are shifting as nations in generally and regions in particularly cooperates and competes in a global economy. Policy makers need to be aware of the wide variety of innovation and competitiveness policies that many nations have adopted. According to Wessner (2007) these policies are designed to build research capacities and to acquire knowledge, and then to transition that knowledge directly to companies and support their development. The power of such well-financed and integrated national programs to shift the terms of international competition is often underestimated. Yet, they too can have a significant impact on the terms of competition. It is important to understand that the pace of competition is accelerating. A comparative perspective is necessary to help us understand what policies are succeeding and why, how selected policies might be successfully adapted in the lagging regions' context, and what existing programs might be enhanced.

The terms *"innovation policy"* and *"technological policy"* are often synonymously used, although innovation policy represents the intersection of research and technology policy (Koschatzky, 2005). With regard to a broad definition of innovation, innovation policy aims at the support of science and economy from the first generation of an idea up to its introduction onto the market. Technology policy is defined more closely and is understood as *"... policy concentrated on scientific-technical areas"* (Koschatzky, 2005). Its main objective is the promotion of application-oriented research and development as well as the use of R&D results in the form of new technology in industry.

Innovation policies in numerous countries and regions are relatively new and largely had to be invented from scratch. Clearly, many policy-makers felt tempted to develop their innovation policy purely in relation to the known fields of R&D or technology policies and therefore did not adapt them to the far more complex process of innovation (INNO-Grips, 2011). This has led to innovation policies lagging behind in terms of their being translated into effective interventions. First and foremost, one must understand innovation, as a business-led process, based on matching new ideas with market opportunities. Such new ideas may be based on R&D, but not necessarily so. Thus, innovation policy to support all kinds of innovations must go beyond R&D support and technological diffusion. This broader concept of innovation policy is closer to innovation processes, as they occur in reality; it makes it harder to develop straightforward, concrete plans of action especially in light of the current economic crisis.

The systems of innovation approach recognises the relevance of competition. More importantly, however, this approach emphasises the role of horizontal and vertical interaction as a prerequisite of innovation processes. Innovation policy within the system approach acknowledges path-dependencies of countries and regions. Consequently, special insights into the national system are crucial when it comes to finding the right points at which to intervene to enable effective policy development. Innovation policy does not imply any a priori preference for high versus low technology. Rather, the systems of innovation approach introduces a vertical perspective on the industrial system, conceptualizing it as a network and as value chains where certain stages might be more suitable for firms in a specific country (INNO-Grips, 2011).

As can be seen in Figure 6.1, innovation policy should be thought of as a cross-sectional policy which integrates numerous policy fields such as education or labour market policy. Science and technology policies, along with their respective sub-fields, constitute building blocks of innovation policy. Innovation policy pays special attention to the institutional and organizational dimension of innovation systems, including capacity-building and organizational performance.

“Best-practice” models are not transferable from one region / country to another and linkages amongst market actors are more important than the singular firm‘s innovative capacity. Consequently, innovation policies that focus on subsidizing and protecting suppliers of knowledge at best are incomplete – at worst they increase the gap between technological opportunities and absorptive capacity (Lundvall and Borrás, 2004). Innovation systems may be seen as frameworks both for innovation and for competence building. Competence building involves learning and renews the skills and insights necessary to innovate. Moreover innovation processes are processes of joint production where innovations and enhanced competence are the two major outputs. Learning takes place in an interaction between people and organizations. The *“social climate”* including trust, power and loyalty contributes to the outcome of learning processes. This is why innovation policy needs to take into account the broader social framework even when the objective is to promote economic wealth creation.

Figure 6.1.: Innovation Policy

Source: Lundvall and Borrás (2004).

6.2. Strategic Innovation Policy

While the importance of public science's contributions to economic and social objectives has been recognized for decades, the context in which it operates has continued to evolve (OECD, 2004). The changes give renewed importance to certain fundamental elements of innovation systems which help science and technology to meet the challenges of economic growth, health, sustainable development, security and safety, and a host of others. This section will briefly elaborate recommendations which aim at improving the innovation systems in the long-term. Then it will discuss the potentially most effective innovation policy instruments for short-term effects that are likely to trigger additional private R&D activities which can lead to a faster recovery from the financial and economic crisis.

All regulations with relevance to R&D activities should enable fair and open competition. Besides competition, cooperation emerged as a key component of successful innovation systems. Interactions and knowledge exchange should be at the centre of innovation policy. One particularly promising route to achieve this, according to INNO-Grips (2011), is to focus on industry clusters and Public-Private Partnerships (PPPs) with strong local roots which can nevertheless act on a global level. Furthermore, PPPs are likely to play a vital role in turning R&D results into marketable products. However, marketable outcomes are less impressive. This indicates a potential institutional governance problem rather than a government spending shortfall.

Another point which was emphasized is the tendency for poor regions to emerge poorer from a crisis while strong regions benefit from a crisis in the long term. Consequently, it is vital to make innovation policy complementary to regional development policy, and to support regions which are likely to suffer disproportionally during crises by means of other policy measures. In the long term, however, innovation policy is likely to yield better macroeconomic results when R&D support is channelled on the basis of excellence (INNO-Grips, 2011).

Public financial support for private R&D activities is nonetheless likely to be effective. Stable or increasing R&D activities during economically difficult times hence can foster a faster recovery from the crisis. However, it should also be mentioned that from the perspective of the efficiency of public subsidies and the proper functioning of markets, intervening in all stages of the innovation processes with public funding is not an appropriate measure. Public measures should be tailored precisely to suit the needs of sectors in which there are market failures. The INNO-Grips (2011) has discussed three supply-side policy instruments which aim at different stages of R&D process: (1) subsidies and grants, (2) venture capital and (3) soft loans.

6.2.1. Subsidies and Grants

Subsidies and grants are the instruments with the most pronounced direct effects during an economic downturn. According to INNO-Grips (2011) they can be used very selectively and are therefore put taxpayers' money to the most efficient use. Thus, this positive effect may be supported by introducing a compulsory private investment as a condition for receiving public funds. In order to make access to funding easier during economically difficult times, the share of such compulsory co-financing may be reduced. Keeping the crisis in mind, it is also relevant to consider what kind of additional support policy-makers have to provide to different recipients (INNO-Grips, 2011). A distinction should be drawn between private and public recipients in that respect. While private R&D entities have significant incentives to use the financial support for projects which are likely to result in short-term successes, public R&D organizations like universities need support in order to be able to turn R&D results into marketable products and services. PPPs offer a particularly promising avenue in that respect.

6.2.2. Venture Capital

Venture capital originates in the private sector, although it is the responsibility of the public sector to create the enabling environment for capital flows. Although it may be tempting for policy-makers to also bring public funds to the venture capital market as entrepreneurial activity promises disproportionate economic effects, such action may ultimately harm the venture capital *"ecosystem"* as it is pointed out by INNO-Grips (2011). Any intervention, especially in economically difficult times, should be based on the clear separation between public and private venture capital stakeholders' individual roles. In light of the financial and economic crisis, attention should also be paid to the phase when start-up companies are most vulnerable. Even the most promising and economically successful innovations can be at risk during this phase. For such companies, quick and selective support is needed.

6.2.3. Soft Loans

(Soft) loans offer a potentially effective solution in such cases. They also offer more general R&D support in a financial and economic crisis. While it is true that interest rates have been falling during the current financial and economic crisis, banks‘ risk aversion has not changed. Thus, if the objective of innovation policy is to secure financial means for companies from creditors during the crisis, it is more important to consider the credit-provider‘s risk rather than interest rates alone. As firms at least fulfill minimum criteria as regards their technical and financial soundness, this instrument also carries relatively little risk in terms of lock-in effects. Rather, it is likely to make a significant contribution to rescuing viable innovation projects which started before the crisis hit.

6.3. Regional Innovation and Technology Policy

Important framework conditions of technology development still have a national or even regional component, such as the R&D infrastructure, human capital and the general innovation environment (Koschatzky, 2005). However, it cannot be assumed that each nation or region has the same chances and starting conditions in innovation competition, as the development of globally distributed competence centers shows. Through the interaction of the different factors determining regional innovation and by changes in institutional and organizational framework conditions, the adaptive flexibility of economic and scientific actors can be increased, and thus the regional knowledge base broadened in order to bundle and strengthen the research potentials. Moreover, regional institutions will be enabled, by means of regionally organized learning processes, to participate in and enhance international knowledge generation.

With regard to the theoretical foundation of a regionally-oriented innovation policy, its major purposes should be the promotion of regional clusters, the improvement of the efficiency of regional innovation systems and the stimulation of competition between regions according to Koschatzky (2005):

- A promotion of clusters seems appropriate for industries and technologies that are in an early phase of their life cycle. In order to structure critical masses, the localizing effect of *"tacit knowledge"* and spatially limited spillovers demand a high degree of regional concentration during that early development phase. The cluster approach seems to be less suitable for mature industries or technologies. In cluster promotion, region-oriented innovation policy can have positive effects not only for the private sector, but also for regional development. At best, catching up processes of less innovative regions can be accelerated by a constant allocation of public money over time. Regarding technology or sector-specific promotion, however, long-term and sustainable growth impulses can be given, especially if the technology or industry emerges as *"key technology"* and if the external effects are localized over a longer period. In the long run, the strong specialization of a region might lead to lock-in situations, causing obsolescence and resulting in mono-structures. This danger can be effectively avoided by a mix of technologies and industries of different maturity stages.
- For national measures for improvement of the efficiency of regional innovation systems, three starting points exist: (i) the improvement of the integration of regional innovation systems into the national innovation system, (ii) the strengthening of the constituent elements of regional innovation systems and (iii) the better networking of the elements of regional innovation systems. In these cases, national innovation and technology promotion should be limited to supporting and stimulating functions. The central, regional or local governments have the function of creating suitable basic conditions for enabling firms to innovate and - where this is efficient - to allow for spatial concentration. Incentive systems by public financial assistance also seem to be possible, but only to the extent that they strengthen the regional self-initiative and the motivation for the development of endogenous objectives and supporting measures.
- The third element of a regionally-oriented innovation policy is the stimulation of the competition between regions. Competition between regions and their

institutions represents an experimental procedure for uncovering superior institutional arrangements because, without the competition of alternative solutions, it is not known which constitutional arrangements or political orders are better suited to serve the interests of the population.

With regard to policy intervention at the regional level, the question of the appropriate policy level is usually raised. Supranational or national state policy actors must only become active on the regional level if for example the lack of financial resources inhibits a regional self-organization process, or if interregional aspects such as the balance-orientation of regional policy are to be considered. Furthermore, superior levels fulfill an important function in regions if they create incentives through public partial funding, which strengthen the regional initiative and the motivation to develop endogenous targets and promotional measures.

However, the shift of responsibilities to lower political levels also means that institutions are entrusted with political management and controlling tasks for which they are not qualified. Although the RIS programs try to strengthen the political-administrative competence on the regional level, those regions, however, are still not capable of applying for funding for innovation-promoting measures and spending funds efficiently, which would need funding most (Koschatzky, 2005). The necessary absorptive capacity, which is a pre-condition for efficient and effective political action, is still missing there. Oughton et al. (2002) describe this fact as *"regional innovation paradox"*. Before innovation-promoting measures can be successfully implemented in regions, political implementation competence must be improved in these regions.

To implement regionally-oriented innovation policy measures, the following tasks must be mastered (based on Koschatzky and Gundrum, 1997):

a) Activation and targeted promotion of the regional innovation resources to strengthen the collective learning capability and to develop and apply new technologies and services: in order to achieve this it is first necessary to ensure and develop the competence in formulating, implementing, and administering policy measures in political institutions. In further steps, the needs and deficits of regional innovation actors must be ascertained, the offer to and the demand for available resources must be identified and the activation of relevant resources must be organized. The main task in this context is the creation of framework conditions for regional structural change and for regional growth.

b) Coordination and coupling of these resources in regional innovation networks in order to generate regional system innovations. This involves integrating all process steps from research and development to production and marketing by combining all relevant actors from industry, science, politics, and society. For this it is necessary to identify individual actors, possible promoters, and the existing informal and formal networks, to mediate the establishment of networks and to provide financial support as well as to accompany the development of the networks in the course of time.

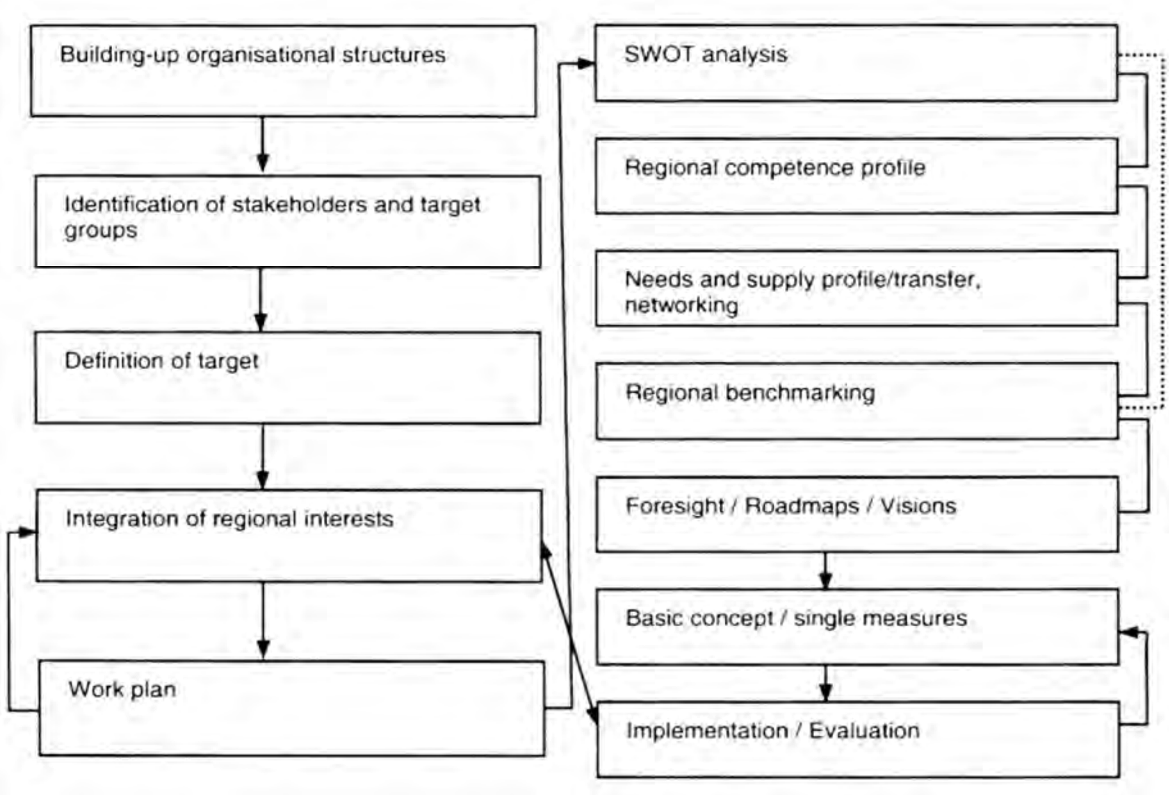
c) Integration of these regional networks in national and international knowledge and technology networks by creating active interfaces and promotion of supra-regional cooperation to ensure and increase regional competitiveness. Regional openness for new, problem-solving approaches are necessary even if they lie outside existing routines, as well as the willingness to participate as a region in regional competition (benchmarking).

A look at regional innovation initiatives suffices to see that the business community is often only very slightly involved. In order to improve this situation, according to Koschatzky (2005) two basic principles can be followed: the demand orientation of the activity and its bottom-up approach. As private-sector enterprises realize innovations contribute to their own and to regional competitiveness. The industrial sector must be integrated in all phases of the development process, in order to increase social capital. The creation of trust in combination with common values and norms support the development of a regional culture and contribute to a positive regional development through regional learning.

When it comes to the elaboration of a regional innovation strategy and the definition of concepts and measures, the following process has proved to be successful (Figure 6.2): a sound organizational basis (left side) and a mixture of different approaches (right side) by which sufficient information about regional competencies, regional innovation potentials and development prospects can be collected and transferred into the formulation of a regional innovation strategy. In such a strategy, the particular focus should be on a further development of industry- and application-oriented research. R&D-and innovation-related services should assist enterprises in their innovation activities, but also bring new stimuli and new knowledge into the private-industry sector (Koschatzky, 2005).

The (partial) strategies often contain programs to create networks between industry and the research sector and/or between industry and educational institutions. Further strategic elements are the promotion of existing technological capacities in the region. A further important factor is the allocation of adequate financial resources for innovation projects. Finally, as it is referred by Koschatzky (2005) specific measures for certain groups of enterprises could be envisaged, for example, the promotion of young enterprises or company start-ups. In addition, support for the market success of the innovation projects - for example by consulting on commercialization or assistance in marketing and export - also belong to these strategic elements.

Figure 6.2.: Elaboration of a Regional Innovation Strategy



Source: Koschatzky (2005).

The involvement of the business sectors by public-private partnerships is a basic pre-condition for creating new regional development options, as the enterprises, their inter-company networks, and their interactions with scientific institutions are the central innovation actors. If enterprises cannot be persuaded to change existing behavioral patterns (i.e. routines), then it will also not be possible to abandon traditional paths of development.

6.4. Regional Typology and Path Dependence

It has already been mentioned that regions are not identical functional or political-administrative spatial units, but vary in size, political structure, and economic strength. According to the regional framework conditions, different factors influencing innovations affect and influence the innovation behavior of the enterprises. Therefore, innovation support measures must be regionally specific and oriented towards the special starting situation. In so-called new economy innovation systems, the status of policy measures is lower, because of the dominant influence of economic factors, than in innovation systems that are strongly characterized by public promotional measures and innovation infrastructure. According to the different theoretical concepts and their empirical analysis, three major types of regions can be distinguished (Koschatzky, 2005):

I. Globally interlinked centers of national and international technological and scientific excellence. Examples are Silicon Valley, the Greater Boston Area, Ile de France, Tokyo, and Singapore. In the theoretical and empirical literature these regions are named as *"global cities"*, *"global hubs"*, *"gateway regions"*, or *"technological clusters"* and *"competence regions"*. Their common characteristics are:

- Globally acting transnational companies.
- A specialized, scientifically excellent research infrastructure with international co-operative linkages.
- A great deal of localized knowledge and learning.
- A pronounced entrepreneurial climate supported by national and international venture capital.

- ❖ High innovation and R&D expenditure and advanced technological competencies of the firms.
- ❖ An excellent innovation, transportation and communication infrastructure defining the reference for many other regions.

II. Regions which are intensively integrated in national and international innovation networks. Examples are Baden-Wurttemberg, Rhones-Alpes, Lombardy, and Catalonia. The regions are important national locations of technological development and the home-base of many large national and international enterprises. Their major characteristics are:

- ❖ Complex production and innovation networks.
- ❖ Learning processes mainly organized within the production environment.
- ❖ A well-developed innovation, communication, and transportation infrastructure meeting national and international standards.
- ❖ Close linkages between industry, science, and administration.
- ❖ At least partial political and financial autonomy.

III. Regions with underdeveloped innovation potentials. Examples are old industrial districts and regions in economic transformation. Regions of this type are characterized by heterogeneity. They may be regarded as traditional industrial clusters, industrial districts (to some extent), and peripheral-rural regions. A common feature is the industrial basis, which can be partly highly specialized, consisting of predominantly small and medium-sized and few large-scale enterprises. These are supported by a standard supply of technical and advisory services. The political and financial autonomy is lower than in the type of region (II) and permits the endogenous management of regional economic development in only a limited way. The regional knowledge base consists of a high proportion of codified knowledge, which is complemented by production and market experiences. External and spillover effects can only be realized to a small extent.

While in many, but not in all type-I regions development is mainly market-driven and policy intervention is confined to the creation of innovation and investment-friendly framework conditions, type-II regions can be described by a balanced relationship between market forces and public intervention (Koschatzky, 2005). In this type of region the state government supports market forces in an intelligent way, but is also engaged in defining own technological priorities as incentive for regional firms to develop and adopt new technologies. Development in type-III regions is mainly policy-driven and therefore heavily dependent on public intervention (Koschatzky, 2005). These different regional starting conditions have to be taken into account when it comes to the question to what extent and with which measures a regionally-oriented innovation and technology policy is able to foster a structural change in the regions.

This regional typology leads directly to the question of the path dependency of regional innovation systems. When innovation-oriented support measures are implemented in the region, their objective should be, against the background of the national framework conditions and the regional context, to intensify the innovation activities in the region and in addition to promote development and competitiveness. It is difficult, however, to define the optimal development path and to set targets for regional development. In principle, recognizing existing potentials and deriving possibilities to support them creatively (*"new combination of the resources"*) take center stage. In each regional type, the particular factors influencing development are present to a varying degree, thus depending on the technological potentials of a region so the use of not only technology policy but also innovation policy promotion instruments seems justified.

In regions with high technological excellence, the creation of framework conditions for the generation of new technologies and technology diffusion is the principal focus of policy intervention as it is pointed out by Koschatzky (2005). Therefore, the promotion of technology development and the increase in technological performance can be a crucial element of regionally-based development concepts, especially if the region is suited to fulfilling the interests of a national technology policy. In many other regions, the emphasis lies on the improvement of the general innovation capabilities of regional institutions, and on jointly generating innovative ideas and concepts. This kind of innovation policy is mainly maintained by regional policy actors and regional institutions.

The resulting question of whether a highly or a less concentrated distribution of R&D potentials is more efficient seems to be a rhetoric one, at least in the short run, because countries with both spatial structural characteristics have gained technological competitiveness in certain fields, paying the price of still existing regional inequalities. Nevertheless, this question is important, especially when major centers of R&D activity are unable to fulfill the needs for technological change and for establishing new localized technological paradigms. Regarding the breaking-up of path dependencies, the question is not whether centralized or decentralized systems are more efficient, but whether economies succeed in flexibly adjusting their spatial distribution of R&D and innovation activities to the challenges of global technological competition (Koschatzky, 2005).

Policy measures, however, if oriented towards innovation and technology promotion or regional development, are only able to establish new, fundamental development paths in exceptional cases. Exactly those ingredients can be found in a region which forms the basis of new technologies. A technology policy of this type would not be oriented towards regional development and regional structural change, but will follow national efficiency and growth criteria. The spatial concentration of public funds and thus the intensification of special technological-economic development processes in single regions of an economy becomes an instrument for improving national competitiveness in the international technology competition (Koschatzky, 2005).

The growth-oriented technology policy of a regional character is faced by the regional innovation policy which is more balance-oriented. It can also contribute to establishing new regional development paths, but only if it succeeds in removing traditional behavioral patterns in enterprises and other institutions and in persuading them to reform (Koschatzky, 2005). Corresponding to the balance-oriented target of the policy measures, these paths serve to reduce regional disparities and to align regional development levels. They perform important functions within individual regions and, if achieving the balance objective, also within the economy as a whole, then public funds can be utilized for other tasks.

6.5. Concluding remarks

In this chapter there have been addressed questions related to optimal regional policy design. Regional technology and innovation policy is always in conflict about targets. If the view is predominantly directed towards the conflict between spatial balance and overall economic efficiency of a regionally-oriented innovation and technology policy, it has to be questioned whether a preference is to be given to the development of specialized regions, with the consequence of a possible increase in regional disparities, or to the broad innovation promotion in a multiplicity of regions with the possible consequence of decreasing national technological competitiveness.

This conflict makes clear that regional innovation policy finds itself in the border area to regional structural and balance policy. This is particularly the case when measures are not implemented exogenously (i.e. *"from above"*), but are formulated on the region's own responsibility (i.e. endogenously) and own initiative and coordinated with the next higher policy level, thus placing the interests of the individual region (and not of all the regions of a country) in the center of political action.

In the last few years, regionally-oriented innovation policy and (innovation-oriented) regional policy have converged in various aspects. According to Koschatzky (2005) characteristics of the convergence process are:

- The focusing of political activity on the region.
- The emphasis of the importance of innovation and technological development to ensure regional and national competitiveness. Whereas this is a central element of innovation policy, regional policy coming from the regional level increasingly includes innovation-oriented targets in its measures.
- The recognition that one policy alone cannot provide a comprehensive approach to solving complex regional development problems. The promotion of regional and inter-regional networks which is practiced in both policy fields.
- The experimental character of the policies.

- The introduction of contests as an element to increase the efficiency of allocating public funds.
- Public-Private Partnerships as a possibility to achieve additional leverage effects of the promotional measures with the use of limited funds.

On the one hand, the use of regional policy know-how improves the knowledge of innovation policy makers about the specific conditions of the regional action level. Measures could be formulated in a more targeted manner and special regional impacts better achieved. Regional policy makers can learn from the experiences of innovation policy makers and improve the regional education and competence level by investments aimed at research and educational institutions, as well as at the creation of regional learning networks. An efficiency-oriented, regionally implemented *"picking the winner"* strategy does not provide an answer to the question about the perspectives of regions without prerequisites for high-tech developments and cannot alleviate existing disparities between regions. Thus, from the regional viewpoint, the conflict between balance and growth orientation defuses itself, since each region should have its own interest in pursuing a growth-oriented strategy, which refers to the endogenous strengths and potentials. However, these strengths do not necessarily correspond to leading-edge potentials in the interregional comparison, which can oppose the (national) efficiency target.

On the other hand, some theoretical concepts favor a decentralized competence structure and a stronger distribution of potentials within a state. A regional orientation in policy measures appears to be very promising to exploit additional development and innovation potentials, above all if with comparatively few public funds leverage effects, by means of public-private partnerships and the qualification for promotional programs, can be achieved (Koschatzky, 2005).

Having low levels of investment in innovation inputs implies that the complementarity between private and public expenditure on innovation activities will also be low. As a result regions frequently get trapped in a vicious circle of little private sector demand and poor public funding supply which is difficult to break out (Oughton et al., 2002). The optimal design of regional policy depends on the level of trade costs and the degree of pecuniary externalities, magnitude of localized inter- and intra-industry knowledge spillovers and the elasticity of substitution.

The welfare costs of a distortionary regional policy forcing relocation of activity with a regional policy based on direct income transfer financed over non distortionary tax schemes. Ulltveit-Moe (2007) found that the relocation alternative is the most costly one for intermediate trade costs and high intra-industry knowledge spillovers. But for high trade costs, insignificant intra-industry knowledge spillovers and relatively more significant inter-industry spillovers the opposite is found to be true: A policy of relocation is actually less costly than one based on direct income transfers. For intermediate trade costs and relatively weak intra-industry spillovers, such a policy may even be welfare improving relative to the market outcome.

Also it is emphasized that optimal policy design will, however, also be a function of the government's underlying societal values. The role played by different societal values mirrored through different social welfare functions. If the government has a negative attitude towards inequality, not only may this affect the ranking of the alternative regional policies, but for low trade costs a regional policy initiative based on direct transfers may deliver equity as well as higher social welfare than the market outcome (Ulltveit-Moe, 2007).

The regional government moreover can play the role of catalyst to strengthen government-industry-university links and regional learning. It is best placed in terms of political legitimacy and economic powers, including its ability to facilitate the articulation of the regional innovation system regarding two key aspects in particular (Oughton et al., 2002). Articulating ways of linking regional actors and matching firms' innovation needs with knowledge supply, in search of synergies and complementarities among the different actors, policies and sub-systems. Both of these factors are central to improving the regional innovation system.

The complementarity between business, government and education funded R&D implies that policy must work on both the supply and demand side of the system and must coordinate the activities of these actors. In addition, there needs to be greater integration of technology policy and industrial policy. Attaining real convergence requires structural funds policies to be more closely focused on technology and innovation services and technology policy to work in conjunction with, rather than in opposition to industrial policy. Closer integration of these two strands of policy can be achieved by institutional change that fosters a process of learning and knowledge transfer between different actors in the system.

This according to Oughton et al. (2002) includes three steps, firstly, the facilitation of cooperation and coherence between the different agents and policies which are integral parts of the regional innovation system. Secondly, the initial important task of identifying and helping to express innovation demand and needs of regional organisations, most notably business, especially SMEs. And finally, the coordination of firms' demand for innovation inputs and regional supply and eventually to open gates to external innovation sources and partners capable of addressing the innovation needs of the regional economy.

The recognition of the importance of a region's innovation system in shaping its innovation performance, competitiveness and prosperity implies a role for policy measures to improve the innovation capacity of lagging regions. The analysis of regional innovation paradox and regional innovation systems suggests that it should be incorporated measures designed to resolve the innovation paradox by improving the systemic capacity of a region to absorb investment in innovation activity. Analysis of the regional innovation paradox also implies that engineering policy integration and systemic improvements requires a strategic approach based on bringing together key players in a region.

Positive impacts on regional growth and regional structural change are then to be expected if it is possible, by a skillful combination of both policy areas, to arrive at a more efficient utilization of public promotional funds. In this way, development processes in individual regions could be initiated in a more targeted manner, which strengthen the innovation and technology competence of enterprises, broaden the regional knowledge base, and give impetus for continual learning process (Koschatzky, 2005). As a result, the chances could be improved to create regional competence centers within single nations which would contribute to the growth of the economy as a whole and to a reinforcement of the technological and economic competitiveness.

However, the relative welfare cost of regional policy depends on the magnitude of inter-relative to intra-industry externalities. If the latter type of positive externalities is more prevalent than the former, a policy inducing the relocation of activity will tend to be more costly than one based on direct income transfers. Empirical analysis according to Ulltveit-Moe (2007) suggests that regional knowledge spillovers in countries may indeed be much more important in an intra-industry than an inter-industry context. If so, regional inequalities may be more efficiently eliminated through direct income transfer to the periphery than by inducing relocation.

7th CHAPTER

CONCLUSION

Changes in the techno-economic system are opening up new windows of opportunity for developing countries, and are increasing the range of public policies to sustain the catching up process. However, institutional changes are leading to a new international regime where significantly reduced the scope and the resources available for State interventions. This leads us to a paradox that suggests the existence of an incompatible connection between the techno-economic and the socio-institutional system. This connection makes the catching up process more difficult for the developing world. The cause of this incompatible connection is from my point of view the widening of the technology and income gap between rich and poor countries that the world economy has experienced in recent decades.

The future of the world economy though, is predicted ominous because of the increasing inequalities and the greater divergence between industrialized and developing countries. On the contrary, recent successful cases show that a rapid process of innovation- and imitation-based on catching up is possible. The performance of Singapore, China and India, indicates that it is possible to adopt a development strategy where public policies and market forces, actively strengthen the development process by investing in the new technologies and in the related infrastructures, capabilities and skills. Moreover these successful paradigms show that development and transition are possible.

The neo-Schumpeterian framework, if we take it on a longer-term perspective, believes in the temporary nature of the incompatible connection between the techno-economic and the socio-institutional system. Neo-Schumpeterian theory also points out, though, that once the harmonic complementarity between the two systems is restored, a new mode of development eventually sets in, sustaining growth and catching up for the following decades (Castellacci, 2006). The optimistic scenario of the long-term perspective foresees that after a long period of trial and error, social turbulence and political struggle, the international regime will eventually support innovation, diffusion and catching up not only for industrialized countries, but for the developing world as well. Then, the complementarity between the techno-economic and the socio-institutional system will favour the emergence of a more equal and more sustainable way of development.

Moreover, there are also other omens of future divergence in the world economy. The re-estimation of an applied *"evolutionary"* growth model, suggests two major forms of transformation in the technology-economy domain. The first is that diffusion seems to have become more *"difficult"* and demanding over time. That might be because of the radical technological change in the last decades, with ICT-based solutions substituting earlier ones, in conjunction with the derived change in the demand for skills and infrastructure. The second is that innovation becomes more important over time. Particularly, as far as concerns the technology frontier, the differences between countries in terms of *"pure"* innovative efforts become more and more important for explaining differences in growth performance. So we reach up to a dead-end where both tendencies increase the probability of divergence in the world economy.

Furthermore in this dissertation we seek to understand what factors determine innovation performance in an emerging economy context. Literature assisted significantly in regarding the mechanisms underlying innovation and technological change, but it still difficult to incorporate them in a unified analytical framework, thus there are number of limitations in order to explain how differences in innovation performance arise. In examining the determinants of innovation performance, empirical support is provided, which underlines the importance of international trade, FDI and R&D. These two exogenously determined factors of foreign presence and the set of technological opportunities enable some industries to enhance their innovation performance. More specifically the role of innovation determinants tends to be stronger in low foreign presence industries and in sectors with high technological opportunities. These findings also highlight the critical role of FDI and international trade as important sources of innovation performance for other emerging countries. Additionally, in recent years, in emerging economies such as China, it is found that the crucial role of industrial research efforts has increased substantially.

Empirical evidence on the gains from international knowledge spillovers is mixed, despite the possible benefits from international technology transfer and the prospect of income convergence among countries brought by technology diffusion. It is observed by cross country studies an increase in income inequalities between rich and poor countries and the marginalization of the poorest. One of the explanations is laid on foreign technology which may be inappropriate for the local socio-economic and technical conditions which are established in these territories, since technological change is based on a *"localized learning by doing"* process (Fu et al., 2010).

Spillovers are one of the main features characterizing R&D as a commodity. Moreover, there is a large variation of ways through which R&D externalities may influence an economy: some of them have positive consequences, other negative. It is obvious that spillovers which are beneficial to an economy, in order to reduce negative influences, must be supported by policy design. Today empirical evidence cannot provide a unique clear-cut result about the effect of R&D spillovers. Nonetheless, spillover effects provide support to some of the most important findings, the causal relationship between R&D and growth, which is the assumption that shows the path to the literature on endogenous technological change. According to Denti (2009), many works provide support for the beneficial effects exerted by R&D externality on the economy, even though there are space constraints and pervasiveness changes depending on the type of R&D activity under consideration.

Moving forward to the subject of measurement of innovation many corporations are skeptical of adding new measurements to the existing portfolio of measurements. The current measurements do not, however, get fully utilized through analysis for extracting business intelligence or continually creating new opportunities. Several institutions, corporations and consultants are developing measurements of innovation. Some are interested in developing innovation scorecards and innovation indexes. However, most of the measures lack a consistent definition of innovation and its elements. Eventually all these measures will converge if we want to have a better understanding of the innovation process. Since the understanding of innovation is currently fragmented, so are the measurements.

If we want to understand economic and social transformations we need new and improved measures of technological capabilities on the performance of nations, both policy analysts and academic researchers. Governments constantly require information about the performance of their own country, and this is often better understood in comparison to the performance of their partners and competitors. Not surprisingly, countries are more and more ranked according to various statistics of performance in science and technology activity (for example, European Commission, OECD). Policy makers are often inclined to read data on science and technology with the assumption that the countries with higher levels of performance are better off because of the interpretation of statistical data which is not uniform. We cannot say of course, that activities in the field of technological knowledge are not a positive factor in social and economic life. But it is a common belief that a better understanding of the effects of knowledge on economic and social variables should still be gathered.

In recent years, new efforts have been made towards understanding, measuring, and explaining the technological capabilities. However, to measure technological capabilities is more complicated than to measure other economic and social indicators. The very nature of technology makes it difficult to aggregate its heterogeneous aspects and components into a single meaningful indicator. Despite these limitations, the available statistical sources have grown during the last decade, and it is expected that this growth will continue for the next few years.

Many researchers are uneasy, and with good reason, with the idea that a single *"number"* could be used to describe the technological activities of a country. According to Archibugi and Coco (2005) one of the key features of technology is precisely its variety; research activities, infrastructures, human skills, the stock of capital, and many other components constitute the technological capabilities of a country, and it is a hard task to aggregate them in a logically meaningful way. Some attempts to measure sectoral differences in national innovation systems have already been carried out, but they all share the view that there is no single number that can provide comprehensive information of the whole technological capabilities of a country.

Hopefully, this is just the beginning of the story. These measures have been developed because there is an underlying assumption that technology is a crucial explanatory variable for aspects as different as growth rates, productivity, competitiveness, job creation, and well-being. It is a matter of time that the new wealth of data that come into light, will help us to better understand the complex relationships between technology, development, and welfare.

Further economic evidence is provided on the effect of technological progress in affecting income per capita growth. The ideas/innovation/technology affect positively income per capita growth rate. In confirming the role of technological opportunities, our inferences support our theoretical framework with empirical findings for developed countries which showed that industries with higher levels of technological opportunities renew the possibilities for technological progress quickly and enjoy high economic returns to R&D.

Moreover the dissertation explores in depth the role of indigenous and foreign innovation efforts in technological change and catching up, and their interactions in the emerging economies. The benefits of international technology diffusion can only be delivered with parallel indigenous innovation efforts and the presence of modern institutional and governance structures and a conductive innovation system (Fu et al., 2010). In this sense, indigenous and foreign innovation efforts are complementary. Without proactive indigenous innovation efforts, foreign technology remains only static technology embedded in imported machines which will never turn into real indigenous technological capability. Without indigenous innovation, the income gap between developed and developing countries can never be closed. This needed complementarity of indigenous and foreign innovation efforts is due to several self-reinforcing reasons.

Innovation performance also is enhanced by international trade which enables firms to adopt new technologies, interact with international clients and absorb foreign knowledge through reverse engineering and inspection. Nevertheless, on average, we can admit that the effects of international trade are not as important as those of R&D in dissertation's literature. Although the exchange of goods may encourage knowledge to spread, it appears that as tangible assets do not inevitably embody tacit knowledge, the contribution of international trade tends to be lower than that of R&D.

However there is also and the other side of the insignificant role of FDI in the groups with both lower and higher levels of foreign presence. In these cases either very low or very high levels of foreign presence may be detrimental to the performance-enhancing effects of FDI. Wang and Kafouros (2009) support that a moderate level of foreign presence is needed to generate positive spillovers, and enable local firms to acquire new foreign technologies. Similarly, there are results from other studies in the literature, indicate that the externalities generated by FDI tend to be curvilinear and that the effects of productivity spillovers begin to fall at higher levels of foreign presence.

In the future, instead of merely promoting R&D, FDI and international trade, science and technology policies should also focus on the factors that moderate the relationship between innovation performance and its key drivers. In recent years, emerging economies have adopted the strategy of outward-oriented development with the aim to enhance innovation performance through FDI and international trade. Nevertheless, from the study of the empirical literature is shown that the effects of these policies should not be taken for granted as the benefits and impacts of FDI, exports and imports on innovation are moderated by a number of factors. In other words, instead of relying on the simplistic assumption that R&D, international trade and foreign investment will benefit all firms in an emerging country, policy makers should increase a nation's or region's capacity to innovate by paying more attention to the mechanisms that may enable a firm to benefit from these performance-enhancing effects (Wang and Kafouros, 2009).

The appearance of the locally differentiated capabilities needed to sustain growth in an internationally competitive selection environment is a major factor for the creation of competitiveness. A range of different actors may improve their competitiveness together through these capabilities that are created through innovation, because capabilities are varied and differentiated, and the creative learning processes for generating capabilities are open-ended and generally allow for multiple potential avenues to success. Innovation is a positive sum game that consists of the efforts of many to develop new fields of value creation, in which on average the complementarities or spillovers between innovators tend to outweigh negative feedback or substitution effects, even if there are at least some actors that lose ground or fail. This phenomenon is observed whether we are speaking of countries, of national groups of firms in an industry, of subnational regions, or of individual companies. Indeed, it is worth emphasizing that the degree of interaction between innovators in search of competitiveness has tended to rise substantially historically, and has attained new heights in recent years.

Regions are less independent than they were, and they now all float in a much deeper sea of background knowledge, which Cantwell (2004) refers to as the *"public"* element of technology. The sharing of knowledge between regions implies that technology must be developed through an interactive social and cultural evolution, but also that followers and innovative adapters may stand to make greater gains than the original leaders. The outcome of a conscious effort, shifting back the dividing line between what is potentially public and what is tacit, is named codification of knowledge. So regions that become especially adept at codification may find that this is a source of competitive advantage since they can draw more readily on the public pool. Further the interaction effects between regions has been further compounded by the role of ICT as a means of combining fields of knowledge creation that were previously kept largely apart. ICT thus broadens the field for potential innovation by linking formerly separate areas of innovative activity. ICT potentially combines the variety of technological fields themselves and so increases the scope for wider innovation.

The context here is what seems to be the growing significance of a local science base for the construction of corporate capabilities and hence competitiveness, including and perhaps especially in latecomer economies. Note that this newly emerging view reverses the *"traditional"* perspective that developing countries should concentrate on (organizational innovation in) lower-skill activities, and leave science to the largest most developed economies. Coming to competitiveness at the firm or regional level, it is emphasized a renewed focus on the role of interregional interaction in knowledge creation and innovation and through regional alliances or cooperative agreements. Today, we now know more of the details of the localized character of innovation, and of the steady growth in technology-based alliances as a means of facilititating competitiveness through knowledge exchange and spillovers. That we need is to work on knowing more about the specificities of knowledge flows between regions, of how and where technological knowledge is sourced by regions, and then how such knowledge is effectively combined in networks of interrelated innovation within and between regions.

A generation ago, the entrepreneurial firm within the context of regional clusters did not seem to be prominent in the public policy approach to enhancing growth and creating employment (Audretsch and Aldridge, 2009). However, the more recent insights concerning the role of entrepreneurship and regional clusters have become a focal point in the debate to foster growth and employment. Clusters of high-tech industry, such as Silicon Valley, have received a great deal of attention from researchers and in the public policy arena. National economic growth can be fueled by development of such clusters. Innovation and entrepreneurship can be supported by a number of mechanisms operating within a cluster, such as easy access to capital, knowledge about technology and markets, and collaborators.

Policy makers around the world are anxious to find tools that will help their regions emulate the success of Silicon Valley and create new centers of innovation and high technology. Little is actually known about which specific instruments will best serve public policy in creating knowledge-based entrepreneurial clusters. What has become clearer is that these two fundamental changes in the organization of economic activity, one at the spatial level and the other at the enterprise level, hold the key to generating economic growth, jobs and competitiveness in a globalized economy.

Taking contrasting perspectives of regional innovation, the analysis has sought to highlight the often different perspectives and policy concerns that emerge. There is not only one received view of innovation policy and regional development as some studies claim, but in reality there are often radically different ones. Coordination and reconciliation of all these different perspectives is needed to be effective innovation policy at the regional level. This does not necessarily mean that there always has to be agreement about objectives or strategies. The *"right"* answer may vary depending on what perspective one is taking so perspective matters in policy debate and formation. Many of the resolutions to making regions more innovative can only be resolved if the contrasting positions and issues are addressed together. Regional innovation policies that seek to accommodate top-down and bottom-up issues and both supply led and demand-led considerations are therefore important here.

It is crucial the need of acknowledging and accepting that with devolution of innovation policy and practice in advanced developed economies comes with increased threat of diversity and possible conflict. This diversity in evolutionary terms may be conceived as good in the sense that it helps maintain a healthy, progressive and adaptive system. This also encourages new and innovative policies to emerge that otherwise would not have been developed in a more centralised framework. Maintaining potential for choice and diversity is important therefore, but we must understand that we need to maintain the coupling and connectivity between these choices if innovation policy is going to have any relevance to the regions, or for the regions to realise their full potential for the benefit of the wider nation state.

Returning back to the main question of this essay if innovation affects the regional inequalities, it is obvious to say that the gap between developed and developing countries, without indigenous innovation, can never be closed. This needed complementarity of indigenous and foreign innovation efforts is due to several self-reinforcing reasons. First, technology diffusion and adoption is not costless and unconditional. The speed of diffusion and adoption, and thereby of technological capabilities building, depends on the regions' absorptive capacity and complementary assets. Second, only in the presence of local innovation capacity will MNEs adopt a more integrated innovation practice, which has greater linkages with the local economy and thereby enables greater opportunities of knowledge transfer. Third, the greater use of external knowledge is accompanied by a parallel decrease of the presence of internal R&D departments, especially in research-intensive industries. Fourth, the inappropriateness of foreign technology in these emerging markets contributes to explain the poor statistical significance and even the negative effects of FDI spillover. As it is suggested by several studies (Fu et al., 2010), the higher a country moves up the industrial ladder, the more important local capabilities and innovation are. Collective indigenous innovation efforts are found to be a major driver of indigenous technical change.

Admittedly, the technology gap in several regions remains remarkably persistent and developing countries face a dilemma of resource constraints, to meet the high investment costs and high-risk challenges of innovation. In order to maximize the benefits from innovation and accelerate catching-up, the well-focused encouragement of indigenous innovation and acquisitions of foreign knowledge must work in parallel as it is emphasized by experiences from the emerging economies. Relying only on one of them would not be optimal for technological capability development and catching up. As inference, neither autonomous innovations nor FDI-reliant strategies can be used independently. Until today, how to select and shape the best combinations at different stages of development and for different countries and regions is a question of utmost relevance for future research.

For now, from my point of view, it is wise to follow different oriented technologies according to the advantages that are posed by the different economies. So, technologies developed in labor-rich emerging economies will be more appropriate to the factor endowments mix in other populous developing countries; and technologies created in land/resource-rich emerging economies will be more appropriate to other land/resource abundant countries. They will also be easier to diffuse and absorb by other local firms. Following this hint, trade and FDI among adjacent countries and regions with the same credentials will represent effective vehicles for the diffusion of these technologies, and policies should follow suit consistently. In sum, the encouragement of indigenous R&D and innovation activities remains an indispensable centerpiece of an innovation strategy targeting the assimilation and adaptation of foreign technology and the acceleration of technological learning and capabilities building.

The logic of the *"public good"* approach to the role of technology and innovation gradually became evident that it could not be the whole story. Rightly speaking, two pieces of evidence in particular came to undermine the approach. First it became evident that the convergence in technology and productivity that the approach predicted did not materialize. In a long run perspective differences in technology and productivity were at the increase, not the other way around. To shed a light on this, the pace at which differences in technology and productivity increase, is decreasing, but this trend for increasing differences in the end exists, just in a slower rate. Second, the most famous examples of countries that managed to escape the low development trap and raise their standards of living towards developed country levels relatively quickly were far from being passive adopters of new, developed countries technologies. These examples of countries which were among the prime success stories placed great emphasis on generating *"technological capabilities"* through a concerted effort by public and private sector actors and apparently it paid off handsomely.

These were some of the questions that gradually became more central for politicians, development experts and economists through the beginning of the next millennium and the 21st century. Arguably, a stream of research, mainly among economic historians and economists with a more heterodox leaning, disagreed with economic historians who came up with generalizations that were far from the liberal *"hands off"* approach, and focused on *"capability building"* of various sorts as essential for development processes. The term *"technological capability"*, originally developed as a tool for analysing the Korean case, gradually became more widely used among scholars of development processes, and a large amount of research emerged using this approach to understand the performance of firms, industries, regions and countries in the developing part of the world.

It is fair to say, however, that in spite of these developments, many economists continue to be unconvinced by the *"capability"* approach. However, new developments, which follow similar efforts in the developed part of the world, have demonstrated that the *"high tech"* approach to innovation which has framed much thinking and policy advice on the subject is misleading when it comes to understanding the relationship between innovation and development (convergence or divergence). In fact, the evidence from these new developments shows that innovation which is quite widespread among developing country is associated with higher productivity (development) and is dependent on web of interactions with other private and public actors. This is not to say that innovation in developed and developing countries are identical in every respect but in qualitative terms innovation is found to be a powerful force of growth in both countries and therefore an issue that it is imperative to get a better understanding of, theoretically as well as empirically.

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