

# Introduction

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Technological change is widely recognized as the primary engine for economic development, a force that can lead to the establishment of a thriving knowledge-based economy. This accumulation of a wide variety of relevant knowledge is essential to ensure innovation. Firms, as individual entities, can play a key role in this development of specific innovations but the process that fosters and disseminates technological change throughout an economy involves a complex network of interactions between different firms as well as other organizations and institutions.

As firms attain an increasingly higher degree of specialization they become more heavily dependent on acquiring complementary knowledge from other organizations. Firms will seldom innovate in isolation, but rather will establish linkages with a range of actors that include, among others, customers, suppliers, universities and technology transfer institutions. Due to the ever-changing competitive environment, innovation is today considered a collective undertaking in a global complex of interactions between business networks.

Analyses of innovation data reveal that it is the large EU agglomerations that tend to be the principal engines of innovation and growth in national economies. Major gaps are still to be found between core and peripheral regions in terms of R&D expenditure and the numbers of R&D personnel employed and patent applications made, all of which has an impact on future development opportunities. Agglomerations are responsible for a high proportion of the outcomes that are considered the accomplishments of national and regional systems of innovation. Such agglomerations provide firms with specific resources, the exploitation of which generates significant externalities. Among others, they offer a supply of factors of production and infrastructure, including the quality of available labour (with specific skills and forms of training), the availability of capital (i.e., venture capital institutions), communications and research infrastructures (including universities and research institutes), and the socio-cultural infrastructures that are often vital for guaranteeing the effective operation of the entire economic system.

In many European countries, labour supply is falling as the population ages and this may have a negative effect on economic growth. A rapid increase in productivity will be required to offset the problems arising from these labour shortages, while production processes will need to become more knowledge-based to permit the necessary increases in productivity.

The situation described above produces high levels of uncertainty and creates what has been termed a 'turbulent environment', leaving companies increasingly vulnerable. European companies and their workers will need to prepare themselves for fierce competition from stronger firms that often emerge elsewhere in this turbulent field, and they must be prepared to respond by implementing more complex and effective strategies. Among other measures, companies will have to specialize and learn to enhance their innovation capacity continuously.

Researchers and policy-makers in this field have devised the notion of the 'innovation system' in discussing this situation. This concept is also concerned with the structuring of the problem, in other words, with the effective coordination and management of the processes of knowledge creation, acquisition, distribution and use. While innovation may be seen as a basic characteristic of market systems in general, the growing popularity of the concept reflects the fact that systemic innovation is a major contributing factor to industrial dynamics.

This book examines all these topics in detail. In fact, the book gathers together studies reported at the Final Open Conference, entitled 'Knowledge and Regional Economic Development', which was held in the Facultat de Ciències Econòmiques i Empresariales in the Universitat de Barcelona between 9 and 11 June 2005. This conference was the last event in the A17 COST Action entitled 'Small and Medium Enterprises, Economic Development and Regional Convergence in Europe'. COST is an intergovernmental European framework for international cooperation between nationally funded research activities. It creates scientific networks and enables scientists to collaborate in a wide spectrum of activities in research and technology. Its activities are administered by the COST Office ([www.cost.esf.org](http://www.cost.esf.org)).

The main objective of the COST Action was to determine the factors that stimulate the birth of small and medium-sized enterprises, and the factors that attract them to locate in a particular region, together with a discussion of the way in which these two processes might promote regional convergence in the European Union, in particular in the wake of the integration of countries from Eastern Europe.

More than 20 European countries participated in this Action, which was divided into two working groups. The first was concerned with the study of policies to support the development of SMEs and regional

growth, with particular attention to regional externalities. The second examined the way in which small and medium-sized firms contribute to regional development in terms of employment, investments and regional product.

The results of the research carried out as part of this COST Action have been presented at various meetings as well as at the Final Open Conference held in Barcelona. Evidence of the quality of this research is the fact that much of it has been accepted for publication. Specifically, two books have been published, *Regional Economic Growth and the Wider Europe*, published in 2004, and *Regional Externalities*, published in 2007, as well as a special issue entitled 'The Knowledge Production–Economic Growth Complex', which appeared as volume 39(4) of the journal, the *Annals of Regional Science* in December 2005.

The Action concluded with the celebration of the aforementioned conference, which enjoyed a high level of interest among COST and non-COST members alike. Some 110 delegates from many European (Spain, Italy, Germany, the Netherlands, France, Sweden, Austria, among others) and non-European countries (United States, Japan, Israel, Malaysia) were able to participate. The presence of David Audretsch, Philip McCann and Gianmarco Ottaviano as keynote speakers provided considerable added value. What is clearly undeniable is the current relevance, both academically and politically, of questions of innovation, knowledge, human capital and agglomeration economies within the wider field of economic development. Furthermore, in a period of increasing delocalization, the studies were able to send out an optimistic message in the belief that Europe can continue to be the reference for future regional growth. Indeed, Europe has the potential for improvement in many of the factors considered crucial for growth and development: flexibility, training, accessibility, logistics, knowledge-based production processes, etc.

The Conference was structured around nine broad topics: (1) firms, innovation and location decisions; (2) public research centres and innovation; (3) regional innovation systems and innovation clusters; (4) knowledge externalities and agglomeration economies; (5) growth and regional convergence; (6) economic development, innovation and regional policy; (7) labour market and human movements; (8) human capital and education; (9) information and communication technology (ICT). A selection of papers from each of these areas makes up this book.

The book is structured in three parts: Part I provides a theoretical examination of regional innovation systems, agglomeration economies and knowledge spillovers; Part II examines the same concepts within an empirical framework; while Part III considers innovation and human capital as determinants of regional economic growth and convergence.

Part I of this volume contains four chapters that analyse the notion of regional innovation systems and that examine the importance of agglomeration economies and spillovers for the creation of knowledge. The concept of knowledge spillovers is used to explain a number of major economic phenomena, including the geographical clustering of inventions and patents; the social returns to R&D that significantly exceed private returns; and the sizeable disproportions that exist between firms in terms of their R&D inputs and outputs, with small firms being responsible for far more product innovations than large firms relative to their measurable knowledge resources.

In Chapter 1, ‘Theorizing regional knowledge capabilities: economic geography under “open innovation”’, Philip Cooke examines issues related to the management of complexity that arise from increasing rates of globalization, knowledge-dependence and the externalization of the production of goods and services in the modern economy. Unusually, this chapter focuses on the activities of economic governance agencies that design enterprise support mechanisms by brokering ‘regional innovation systems’. As the ‘knowledge economy’ has evolved, making the value of the research knowledge generated by small and medium-sized enterprises and universities, in particular, of far greater value than ever before, governments have begun to promote regional innovation system-building. However, knowledge demands mean heightened complexity in the crossing of boundaries between ‘epistemic communities’. Managing knowledgeable interactions in environments that demand greater and greater innovation is eased but not entirely overcome by means of digital knowledge flow platforms (DKFPs). Reference is made to cases of DKFPs evolving in practice in economic governance organizations, but at a later date and in ways that differ from the methods used by firms.

In Chapter 2 on ‘Knowledge spillovers and organizational heterogeneity: an historical overview of German technology sectors’, Mark Lehrer departs from the mechanisms accounting for the local boundedness of knowledge spillovers. The most frequently cited explanation for why knowledge spills over locally rather than globally pertains to the tacitness and stickiness of knowledge. However, it could also be the case that many knowledge flows are localized for the same reasons that certain types of business transactions remain localized. Thus, Lehrer provides a historical review that tracks the differential nature of knowledge spillovers that were ostensibly important in four German technology sectors during the late 19th and late 20th centuries. The review suggests that in the domains in which Germany was highly successful (organic chemicals and electricity around 1900), and also in those in which German high-tech performance was mediocre (biotechnology and computing during the late 20th century),

knowledge spillovers were far from automatic and required special organizational effort on the part of firms and/or policy-makers.

The intersectoral comparisons made by Lehrer also point to why experimentation with ways of managing knowledge spillovers is an important process in the development of technology-based industry. In three of the four sectors discussed (organic chemicals, electricity and biotechnology), key knowledge spillover processes took place within the context of complex contractual arrangements that varied substantially from one industrial setting to another: long-term relations between university professors and firms (organic chemicals), turbulent strategic alliances (e.g., AEG and Siemens in the Berlin electricity cluster), and regional technology start-up incubators (biotechnology). These arrangements and their disparity lend credence to the idea that firms experience a priori difficulty in knowing how to organize activities to capture knowledge spillovers and to the consequent need for organizational innovation. The disappointing results of most post-war German high-technology policies based on more or less automatic knowledge externalities likewise calls into question the notion of local knowledge spillovers as a kind of knowledge leakage across organizational boundaries, suggesting instead the notion of knowledge flowing in tandem with complex transactions and organizational arrangements.

Jérôme Vicente, Yan Dalla Pria and Raphaël Suire deal with the complex link between geographical proximity and innovation in Chapter 3, 'The ambivalent role of mimetic behaviors in proximity dynamics: evidence on the French "Silicon Sentier"'. Their chapter analyses the complex links between proximities and clusters, from empirical monographs investigating the relational aspects of proximity to econometric analyses applied to the study of knowledge spillovers. In their chapter, they choose to focus on just one of these, but perhaps the most original, namely the role of sequential interactions and mimetic behaviours in co-location processes. Their purpose is to understand why firms tend to converge rapidly in their decision to locate near to one another (geographical proximity), and how this convergence process gives rise to other forms of proximity, defined at this stage as socio-economic proximities. First, they show that geographical proximity is not a sufficient condition for the collective performance of clusters. Second, they focus on the convergence of locational choices through the process of mimetic (or herd) behaviours. Their purpose is to show that according to the mimetic process of co-location, the nature of socio-economic proximities can be very different and have a strong influence on the stability and the performance of clusters. They also introduce the notion of mimetic behaviour of location in order to show that co-location processes can be the result of sequentiality, uncertainty, legitimacy

and non-market interactions, rather than the outcome of full rational and isolated decisions and pure strategic market interactions.

Vicente, Dalla Pria and Suire show, first, the utility of analysing clustering processes based on the supposition that firms decide to locate sequentially and that they have heterogeneous preferences of location. Second, they demonstrate that this sequentiality provides a firm basis for communication, observation and coordination between companies, which can give rise to rational mimetic interactions and convergence in location decision-making (geographical proximity). Third, they also show that the very nature of socio-economic proximity depends on the mimetic process at work in the aggregation process. If uncertainty and legitimacy dominate, the convergence of location decision-making can give rise to cognitive proximity, while if coordination and innovative interdependences dominate, depending on the degree of competition and of division of labour, the convergence process leads to a relational proximity.

The final theoretical contribution is provided by Flora Bellone in Chapter 4, 'IT adoption, industrial structure and agglomeration economies'. In this chapter, she departs from the idea that information technology (IT) offers large growth potential for peripheral regions suffering from economic backwardness. She argues that the IT revolution has not brought about uniform increases in the growth performance of the European regions. Major regional imbalances have been detected in recent empirical studies of the location of IT-producing sectors and the dispersion of IT investments in user sectors. Bellone shows that economic geography is not only an important component of the incentives to invest in IT-producing sectors, but also that of the incentives to provide IT to user sectors. She applies the theory of circular causation in accounting for the propensity of IT investments to cluster even in user sectors.

The analytical framework adopted by Bellone is centred on a small open economy endowed with a fixed amount of labour and engaged in the competitive production of homogeneous final consumption goods based on that labour and an endogenous variety of IT intermediate inputs. Within this framework, the importance of fixed local entry costs and the existence of pecuniary externalities due to demand complementarities among the local providers of IT goods and services are highlighted. These key features of IT-based production processes are what allow for spatial agglomeration in IT investments and that give rise to localized cumulative causation processes despite the very low level of variable transport costs characterizing trade flows in IT goods and services. In addition, the model explains how technological constraints interact with market failures. In this sense, even if technological constraints are relaxed (as a consequence of a proper investment in infrastructure), coordination failures may still

appear, particularly in regions without a sufficiently well-developed industrial base.

Part II once again focuses on the notion of innovation systems, agglomeration economies and knowledge spillovers, but here the studies are conducted within a specifically empirical framework.

Models of economic geography and growth usually make two assumptions: first, externalities result from diversity and, second, that they are geographically bounded. In addition, most empirical studies that analyse agglomeration processes use spatially aggregated data and focus on either pecuniary or knowledge externalities. Within this framework, Chapter 5 by Corinne Autant-Bernard and Nadine Massard, 'Pecuniary and knowledge externalities as agglomeration forces: empirical evidence from individual French data', represents an advance in the study of the mechanisms underlying the agglomeration effects of economic activity given that, using individual data for firms, they propose an empirical framework that jointly models pecuniary and knowledge externalities. The authors, thus, seek to build an econometric model with a unified analytical framework for traditional agglomerating forces and knowledge externalities so as to clarify the degree of localization of these phenomena in both geographical and technological space. Specifically, Autant-Bernard and Massard analyse three potential sources of externalities: pecuniary externalities resulting from a decision to locate close to other firms; pecuniary externalities related to the labour market and to the local area insofar as it provides a market for final goods; and knowledge externalities associated with R&D spillovers. In each case, the authors undertake an evaluation of its geographical and sectoral dimension.

Based on a sample of 822 French firms, the authors test a Griliches production function, where (in its simplest version) the sales of each firm are explained by the workforce employed at the company; purchases of goods, raw materials and other supplies; and the firm's internal R&D expenditure. In order to consider potential pecuniary and knowledge externalities and to evaluate their geographical and sectoral dimension, the Griliches production function is widened (in a more complete version) to include the number of firms and employees in the same sector and in the other sectors in the same French *département* and in neighbouring French *départements*, together with the R&D expenditure of other firms in the same sector and in other sectors present in the same French *département* and in neighbouring French *départements*. In addition, sectoral dummies are included to verify the presence of spatial autocorrelation in the residuals of the regressions.

The preliminary results from this study indicate that proximity to other firms in the sector appears to be an overwhelmingly attractive force. However, their results are inconclusive as to which industrial structure – specialized or

diverse – is superior, as their findings point to benefits that can be gained from both types of structure: while specialization seems to favour pecuniary externalities originating from proximity to other firms, diversity facilitates knowledge externalities and pecuniary externalities derived from the labour market and from the proximity to final consumers. The tension between these forces might in part explain the co-existence of specialized towns alongside more diversified areas.

In Chapter 6, ‘The adoption of ICTs – why does it differ across regions?’, Lucia Piscitello, Andrea Bonaccorsi and Cristina Rossi take up the topic of knowledge diffusion and focus on the existence of disparities in the adoption of information and communication technologies (ICTs). Several studies have reported remarkable disparities in the adoption of ICTs both between developing countries (global digital divide) as well as between regions in the same country (local digital divide). The authors investigate whether such disparities in ICT diffusion are due to heterogeneity in the characteristics of firms (in line with equilibrium models) or whether ICT diffusion is influenced by epidemic effects (non-adopters choose a new technology when they come into contact with adopters in neighbouring areas and learn about it).

Specifically, Piscitello, Bonaccorsi and Rossi propose a spatial econometric framework for analysing disparities in ICT adoption by Italian firms at the province level (Italian NUTS 3), taking into account both the potential existence of spatial heterogeneity and spatial dependence, in a similar approach to that adopted in the previous chapter. The penetration rate is then used as a proxy for the level of ICT adoption in each province, measured by the percentage of firms (located in the province) that had at least one domain name registered in the Registration Authority databases in 2001. In order to account for the differences in ICT adoption, a number of explanatory variables are defined: local absorptive capacity (proxied by means of the number of patents and publications by university researchers in relation to the number of firms in each province), the characteristics of the firms (average firm size), and sectoral composition. The results show that ICT adoptions in a province are positively influenced by its industrial composition and, in particular, by its local absorptive capacity, showing that areas that are poor in general technological activity and research are less likely to make active use of the Internet. By contrast, firm size was not a significant factor. In addition, a significant spatial heterogeneity (North–South duality) and spatial dependence pattern were detected, confirming in the second case the presence of epidemic effects in the diffusion process. Thus, ICT adoption in each province is dependent on ICT adoption in its neighbouring provinces, demonstrating that proximity remains a key factor.

The literature emphasizes the problems involved in using individual indicators including patents, R&D expenditure, percentage of sales related to new products, etc. to measure the global concept of innovation. In this context, Chapter 7 by Mikel Buesa, Mónica Martínez Pellitero, Thomas Baumert and Joost Heijs, 'Novel applications of existing econometric instruments to analyse regional innovation systems: the Spanish case', seeks to get to grips with the measurement of national and regional innovation systems. The authors present novel applications of existing econometric instruments for the measurement and evaluation of regional innovation systems using multivariate analysis.

They seek to develop new ways of measuring innovation (systems), on the understanding that the concept is not directly observable. In creating 'combined' indicators that might reflect different aspects of regional innovation systems, they employ factor analysis. Having obtained the factors, 'standardized factor values' are assigned to each region. They first establish a typology of regional innovation systems by cluster or conglomerate analysis, with the factor scores being used as independent variables. They then create the IAIF index of regional innovation that comprises the weighted sum of four partial indexes and that offers the possibility of summarizing these typologies and quantifying and analysing their development over time. Third, they estimate a knowledge production function using the number of patents as the output variable and the corresponding factorial scores as independent variables. And finally they compare the efficiency of the regions by conducting a data envelopment analysis.

The approaches adopted in analysing Spain's regional innovation systems in this chapter employ existing information for variables and indicators related to science, technology and innovation, from the perspective of resources and results and incorporate aspects of an institutional nature as well as factors of the productive structure. The study considers the period 1994 to 2000 and examines the 17 Autonomous Communities (corresponding to NUTS 2). The study identifies four factors as determinants of regional innovation systems: the first factor is related to the regional and productive environment of innovation, the second to the role of the universities, the third to the role played by the civil service in innovation, and the fourth is concerned with innovating firms. Having identified five regional innovation systems in Spain, a highly heterogeneous structure is detected, with strong asymmetries between the strengths and weaknesses of each region. As for the production function, the authors detect a strong influence of environmental variables in the quantified innovation flows across the weighted sum of patents. Specifically, a large productive structure plays a key role in achieving results related to technological innovation, which ratifies the importance of a certain critical mass and a minimum

market size. Other factors (innovating firms, the civil service and the universities), while being shown to play a significant and positive role, are nevertheless reported as being of secondary importance.

In Chapter 8, 'Over-embeddedness and under-exploration issues in cohesive networks. An application to territorial clusters', Francesc Xavier Molina-Morales and María Teresa Martínez Fernández explore the potentially negative effects of social networks on innovation by analysing the territorial agglomerations of firms. It has been argued that industrial districts represent local configurations that are high in social capital, given that they are characterized by mutual trust, cooperation and an entrepreneurial spirit as well as by the existence of a multitude of small local firms with complementary and specialized skills. Thus, proximity provides frequent, repeated, non-marked, informal contacts, all of which facilitate strong ties and the density of the network of ties. These social interactions stimulate exchanges of information about competitors, production technologies, recent developments and so on. In addition, such interactions and the development of trust facilitate the exchange and combination of knowledge resources and as a result improve the innovation capacity of firms. However, these cohesive networks have been criticized in terms of the costs involved in their maintenance, the lack of autonomy that they might constitute, and the obligations derived from prevailing norms and values. In fact, some studies report cases in which excessive interaction between the same actors can undermine the efficiency of economic actions and, on occasions, bring about the economic decline of an industrial district.

In this context, the authors have conceptualized the limitations of the cohesive network in the district using the notions of over-embeddedness and under-exploring. The former might occur when all the firms in a network are connected through embedded ties. When the impact of social capital goes beyond a certain level of social interaction and trust, the result will be parochialism and inertia. Under-exploring, on the other hand, refers to the absence of autonomous relationships in exploring strategies to capture new and exclusive resources, which means there are few or no links to outside members that can potentially contribute innovative ideas. Using information drawn from a questionnaire distributed among 154 firms located in the east coast of Spain (Valencia region), the authors obtain evidence that the effect of social interactions and trust on innovation can be described as an inverted U-shaped curve. In addition, Molina-Morales and Martínez-Fernández verify the effect of local institutions (universities, research institutes, technical assistance centres, professional associations, etc.) on the capacity of a district's firms to innovate. They conclude that the involvement of local institutions has a positive and linear effect on innovation, as such institutions can be considered intermediate agents that allow

districts to escape the obligation of exploring restrictions, since they can monitor what is happening outside the district.

Finally, the authors outline the best course of action to be taken by a firm. They encourage firms to interact with local institutions and other cluster participants so as to enhance their environmental conditions. In addition, and as a consequence of the vital role played by the entrepreneur and employees alike as mechanisms of knowledge transmission, the authors encourage the implementation of policies that both improve the quality of local labour and foster the internal mobility of employees and the creation of new ventures. Finally, the authors stress the need for policies to encourage cooperation between the members of a district and to build social capital, since both are important for the innovative capacity of firms.

Following on from this discussion of the need to promote links between local institutions and to encourage interactions between firms so as to increase technological innovation, Chapter 9 by Joaquín M. Azagra Caro, entitled 'The regional dimension of university–industry interaction', examines university–industry interactions (UII) and their regional dimension. More specifically, the study seeks to determine the type of firm manager and faculty member that interacts most frequently and whether these interactions occur within or outside the region. In conducting the analysis, Azagra Caro uses data from the Valencian Community, a Spanish region with a low R&D absorptive capacity. In a survey undertaken in 2001, he gathered data about managers working in the manufacturing and telecommunications sectors (700 observations) and about faculty members at the five public universities in the Valencian Community (380 observations).

Using ordered probit models with a sample selection, the author presents evidence to support the claim that belonging to large firms in science-based sectors has a significant positive effect. This constitutes a limit to UII given the abundance of micro-firms in supplier-dominated sectors in similar regions. However, certain personal characteristics of company managers, such as a higher academic degree, positively influenced their propensity to interact with universities. In addition, it seems that promoting engineering and technology, as well as the exact and natural sciences, has a positive effect on contracts with firms. Similarly, the time devoted to R&D also has a positive effect. But the managers in the survey were found to cooperate only rarely on matters of R&D with universities outside the region; the frequency of contacts depending on whether the manager worked within a group of firms. The frequency of cooperation inside the region, however, depends solely on firm size. In the case of faculty members with a greater propensity to contract, Azagra Caro reports that they do not stand out for the frequency of their interactions, some were even found to interact less frequently than the rest (the case of those holding a managerial position)

or to interact more frequently outside the region (men). By contrast, faculty members with less propensity to contract – those who had undertaken research abroad for longer periods, were found to interact as frequently with firms inside the region as with firms outside the region.

Finally, the author concludes that improving a firm's human capital is vital, since it enhances UII, and constitutes a more viable policy than seeking to change the economic structure. However, the propensity of faculty members to interact relies on personal characteristics that do not guarantee they will interact more frequently inside the region than they will outside the region, since firms in regions like the Valencian Community may not be able to absorb academic R&D. This is not necessarily a caveat, because the region may benefit indirectly from the interactions taking place outside it.

Lluís Santamaría Sánchez, Andrés Barge Gil and Aurelia Modrego Rico in Chapter 10, 'Which factors underlie public selection of R&D cooperative projects?', stress the importance of R&D as a factor of economic growth. Here two closely related subjects are pertinent to the discussion: (1) the interrelationship between the public and private sectors as sources for R&D financial backing and (2) the decision-making process that determines which R&D projects should receive financial support and the subsequent assessment of the projects. Specifically, the authors present initial data, which are not altogether positive, about the criteria used by public sector evaluators when deciding which projects to finance. Drawing on data for the period 2000–03, following the issue in Spain of a public notice to finance R&D projects, which required the involvement of universities and/or research centres together with private firms, the authors are able to shed some light on the criteria adopted in the selection of R&D projects by the public sector: that the 'input characteristics' are more important than the 'output characteristics'; that support is given per se to projects with low budgets and those requiring many hours of work; that the results depend on the year in which the public notice is issued or on the research area chosen; that equal support is not given to projects that are already recipients of financial backing. All in all, these indicators are not very positive and seem to demonstrate a certain lack of valour as regards the taking of risks when financing such projects.

The problems discussed in this study concerning the ex ante evaluation of projects submitted, together with the failure to undertake an adequate monitoring and ex post evaluation of the projects, are aspects that require considerable work. And it is probable that greater consideration of these areas would help ensure greater efficiency in the use of the public resources allocated for research.

It should also be stressed that the criteria adopted and the type of projects financed by the public and private sectors do not coincide. Some of

these differences may be due to the different time schedules for the two project types, or to the actual nature of the research work. But undoubtedly there must be serious doubts as to whether the selection process in public competitions for grants is the most appropriate and whether the most relevant projects receive financial support.

In Part III, attention shifts to stress the importance of a catch-up mechanism, which sees technological improvement as the combination of two distinct types of activity: innovation and imitation. The former is generally associated with technologically advanced economies or economies that are at the technological frontier, and can be thought of as pure research. The latter involves the identification of a growth mechanism resulting from technology transfers among economies and as such should be of relevance for less developed economies. In this case, stocks of human capital increase the capacity to adopt and implement innovations or new technologies from more advanced countries, which potentially ushers in a process of growth or catch-up between countries. The chapters in this section are all concerned, therefore, with the impact of human capital and other types of knowledge acquisition on economic growth.

In 'Convergence clubs and the role of education in Spanish regional growth', Chapter 11, Adriana Di Liberto investigates the returns on education in the Spanish regions by measuring the stock of regional human capital. The study examines the extent to which these have differed in the country's regional clubs and whether different levels of education have different impacts on growth. In addition, by examining the levels of educational attainment in the labour force disaggregated by sector, Di Liberto is able to estimate whether or not excluding the public sector from the analysis significantly changes results on returns to schooling.

Her findings suggest that in Spain, while primary education seems to contribute to growth in poorly developed areas, more highly skilled human capital has a stronger growth-enhancing effect in more developed economies. This means that there is likely to be heterogeneity in the rates of return on education across economies since the effect of schooling in growth regressions is influenced by an economy's level of development. The failure to take this heterogeneity into account in empirical analyses may produce misleading results. Moreover, her results suggest that educational policies should take into account the link between stages of development and growth and expand human capital coherently by taking into account its composition as much as its level. She also finds that the coefficients of human capital variables do not change significantly when the public sector is taken into account.

In the second chapter of Part III, entitled 'Non-linearities, spatial dependence and regional economic growth in Europe: a semiparametric

approach', Chapter 12, Roberto Basile sets out to test the presence of spatial externalities in the economic growth of European regions. In so doing, he maintains the functional form as flexibly as possible so as to detect the existence of heterogeneity in convergence speed and growth behaviour.

The econometric results provide strong evidence of non-linearities in the effect of initial per-capita incomes and school attainment levels. Specifically, the negative marginal effect of initial conditions increases with the level of initial per-capita income while a threshold effect in secondary school enrolment ratio is reported: an increase in the rate of schooling is associated with an increase in the growth rate only when the level of schooling investment is above the EU average. These results confirm that the assumption of a common linear model for a set of very different economies is misleading: non-linearities are important in regional growth in Europe even when spatial dependence is taken into account. Thus, the proxy for human capital investment is only associated with a positive impact on growth if it exceeds the European average rate of schooling.

Moreover, the specification used allows the author to identify the effect of interactions between the characteristics (initial conditions and human capital investment) of each region and those of its neighbours. Thus, regions with schooling rates lower than the EU average also seem to benefit from externalities generated by the accumulation of human capital in nearby regions and have the opportunity to grow faster than other regions. Finally, the effect of the interaction between the initial per capita income and the corresponding spatial lag suggests that regions surrounded by richer regions have higher expected growth rates than regions surrounded by poorer regions. The evidence presented by Basile is in line with the argument that spillovers from nearby regions can compensate the mechanisms of decreasing returns to scale to capital accumulation and allow rich economies to grow.

In the final chapter of Part III, Chapter 13, Frank van Oort and Otto Raspe, under the title 'Urban heterogeneity in knowledge-related economic growth', analyse urban economic growth in the framework of the knowledge economy. Specifically, they seek to verify the hypothesis that larger cities enjoy greater opportunities for economic growth in a knowledge economy, since these cities offer the best opportunities for interaction, variety and specializations.

They enhance the conceptualization and measurement of the knowledge economy and urban heterogeneity by using eight indicators grouped under three main factors (knowledge of workers, innovation and R&D). So as to identify the key elements in urban growth, they then describe how these three factors manifest themselves in the Dutch municipalities. They are

now in a position to compare the main spatial interrelations between these three factors, and to identify the characteristics of the municipalities and those that contribute most to economic growth. Their results are to some degree surprising inasmuch as they show that not all the factors contribute equally to growth and that the largest municipalities do not occupy the best positions in this process. Particular attention, therefore, needs to be paid to the dimensions, indicators and factors used to measure the concept of the knowledge economy, and to the results that interrelate the different municipalities (in terms of their size, location within the Netherlands and the type of city) with their contributions to economic growth.

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We trust that this volume will provide many interesting insights for further discussion and debate among economists and regional policy-makers alike.

