

Introduction

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Abstract The uneven geographical distribution of economic activities is a huge worldwide challenge. Spatial inequalities are evolving through time following complex patterns determined by economic, geographical, institutional and social factors. The New Economic Geography approach, which was initiated by P. Krugman in the early 1990s, describes economic systems as very simplified spatial structures. This book aims at providing an overview of the existing state of knowledge and new perspectives of research to set the basis for developing a more sophisticated modelling of the economic activities visualised as being influenced by evolving trade networks with a specific topology that is determined by the number and strength of national, regional and local links. To achieve this objective the chapters combine recent approaches in economics with the most advanced mathematical and computational methods for analysing complex and non-linear systems to build an interdisciplinary understanding of the issue.

The problem of uneven geographical distribution of economic activities is a huge worldwide challenge. For the European Union (EU) regions this is shown by the deep differences within and across nations. According to the Eurostat regional yearbook 2013, the GDP per inhabitant of 41 EU-27 NUTS 2 regions, out of 270, is above 125 % of the average, whereas that of 68 regions falls below 75 % of the average; 25 of those “below average” regions are found in six of the EU-15 member

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States (Greece, Italy, France, Portugal, United Kingdom and Spain). The remaining 43 regions are in Member States that joined the EU between 2003 and 2007; 22 of which have an average GDP even below 50 % of the EU-27 average (these are found in Bulgaria, Hungary, Poland, Romania and Slovakia).

Regional disparities are significant not only across but also within countries (especially Turkey, Slovakia, but also Italy, Germany and the UK) due to historical, economic, financial, political, geographical, institutional and social factors. Spatial inequalities evolve through time. For the period 2000–2007 growth trends in the EU show some overall catching-up at the country level but with remarkable differences at the regional level. The economic crisis in 2008–2009 has slowed down the convergence process hitting some regions and nations more than others (IMF 2011 *Regional Economic Outlook: Europe*).

The complex nature of the distribution of economic activity across space and of its evolution through time requires necessarily different levels and tools of analysis. For the current volume, we differentiate between a macro—bird’s eye—perspective looking at regions and countries; a meso perspective looking at markets and institutions; and a micro perspective looking at single agents, in particular at producers. For each perspective, we provide reviews of the economic theory and of the analytic and empirical methods necessary for the respective levels of disaggregation.

1 Economic Geography Modelling

Krugman (1993)—with reference to Cronon’s famous book “Nature’s Metropolis: Chicago and the Great West” (Cronon 2009)—popularized the distinction between “first nature” and “second nature” in explaining why economic activity is not evenly distributed over space. First nature factors are exogenous to economic activity, such as endowment with natural resources (freely available as sunshine or other climatic features; or costly available such as minerals or coal), and geographic and geopolitical factors (location by the sea or river, geographic centrality, institutional or political differences). Traditional models of international commodity trade (such as the Heckscher–Ohlin model) and of international factor migration would predict for open economies an uneven distribution of economic activity that reflects the distribution of first nature factors.

More recently, regional growth models are also widely used in studying spatial processes of convergence or divergence. Also in this perspective, first nature differences—reinforced by local knowledge spillovers—mitigate regional convergence processes thus leading to an uneven distribution of economic activity.

However, the main focus of the present volume is on models of the New Economic Geography (NEG); its main achievement is to show that even with first nature symmetric regions the formation of Core-Periphery structures, in which economic activity is concentrated in one of the regions, is possible via endogenous (second nature) agglomeration processes that involve human activity and economic

incentives. In typical NEG models, the role of first nature is minimal. Economic activities tend to cluster together taking advantage of proximity to larger markets, scale economies, knowledge spillovers, lower transport costs etc. Even starting from undifferentiated regions and large dispersion once the process is set in motion all activities tend to agglomerate. A fortiori, the concentration process is favoured by first nature causes determined by territorial topography, endowments of natural resources and geopolitical factors. Indeed EU core regions are typically more urbanised (capital regions are often the richest) and well-connected to the transport network hubs whereas peripheral regions are often coastal, on borders or in rural areas, with a lower number of connections. The increase in the number and strength of territorial connections (transport networks and so on) is at the centre of many EU policies aiming to intensify economic, social and territorial cohesion and to enhance competitiveness (Fifth European Commission Report on economic, social and territorial cohesion).

From a modelling perspective, geographical space can be represented in discrete form as a set or matrix of locations connected by arcs or as a continuous plane in two dimensions. Economic activities taking place in one location, such as production and consumption, and flows connecting two locations, such as commodity trade and labour migration, can be represented in both forms leading to two alternative modelling strategies in geographical economics. The continuous specification has been the tradition both in economics and geography. However, it does not as easily lend itself to computations and fitting to actual data that are a discrete representation. More recently, the New Economic Geography uses primarily a discrete representation of geographical space, with the danger that space, in the sense of geometric shape and size, slips out.

The chapter by **Commendatore, Filoso, Grafeneder-Weissteiner and Kubin** reviews the NEG models that are formulated in discrete space and that explain the uneven distribution of economic activity across space employing endogenous agglomeration processes, and the interplay of agglomeration and dispersion forces. Unlike the two-region models that have a restricted applicability, this chapter focuses on the multiregional NEG models recently developed and reviews their contributions systematically. As unifying framework, the authors use the footloose entrepreneur model considering the role and nature of transport costs, and the welfare properties of the spatial equilibria and the design of optimal economic policies.

In his chapter **Puu** presents a detailed study of diffusion processes for some classical macroeconomic dynamic models in continuous geographical space; in doing so, the contribution also reviews the involved mathematical tools. More specifically, the author applies the so-called Laplacian operator to a Harrodian growth model of an open economy and to a non-linear business cycle model based on the classical accelerator mechanism. With this approach it is possible to show the spatial pattern of growth and decline—considering the projection on a horizontal planar space of the corresponding linear business cycle model—for the growth model; and the cyclical motion of an economic system represented as overlapping

shrinking flat surfaces in a three dimensional space for the nonlinear business cycle model.

The next two chapters that are by Mendes and Mendes, and by Basile, Kayam, Mínguez, Montero and Mur review pertinent empirical methods; in particular spatial econometric methods. In their contribution, **Mendes and Mendes** present *parametric* spatial econometric models that can be applied to regional economics. They introduce and discuss the basic terminology, the spatial data dependence, the specification of spatial effects, and some basic spatial regression models, i.e. the spatial autoregressive model (SAR), the spatial error model (SEM), the spatial Durbin model and two general spatial models. The maximum likelihood estimation for SAR and SEM models is also presented in detail. Finally, the contribution presents several empirical works in the context of the European Union focusing on particular areas of urban economics, economic growth and productivity, and studies dealing with agglomeration and externalities spillovers).

The other chapter on spatial econometrics by **Basile, Kayam, Mínguez, Montero and Mur** argues that modelling regional economic dynamics requires the adoption of complex econometric tools, which allow to deal with some important methodological issues arising in a spatial context, such as spatial dependence, spatial heterogeneity and nonlinearities; the authors argue that *semiparametric* approaches in the spatial econometrics literature have recently provided some instruments, which address these issues simultaneously. In particular, the authors present a spatial autoregressive semiparametric geospatial (SAR-Geo-AM) model and discuss technical issues concerning its estimation (including the use of restricted maximum likelihood methods that allow estimating the parameters of SAR-Geo-AM model in a single step). Finally, the authors review the empirical literature on regional economic dynamics and economic geography and present, in particular, an application of the SAR-Geo-AM to regional growth data.

2 Institutions and Markets

A closer look at different territorial levels (EU, national, regional and local) reveals that countries and regions are interconnected by various networks and that these networks play a crucial role in fostering growth and reducing regional disparities. Their functioning is shaped by market (but also nonmarket) institutional setups; more specifically, we focus on networks of financial markets and of labour markets.

Public and private finance are deeply interconnected across space, as the recent waves of financial turmoil have revealed, and can be described as a global network (with also a European scale) within which a few large centres assume a central position. At the same time these networks have also a local dimension, which stresses informational advantages enjoyed by financial intermediaries located in the proximity of firms. Over time, the networks evolve, some centres assuming higher importance whereas others fall back. The different aggregation levels are also interconnected and institutional reforms change their respective weights. For public

finance, we observe at the EU scale a growing burden of sovereign debts and large national budget deficits that may endanger economic and financial integration and that call for better policy coordination among national governments and monetary authorities. At the national level, as a consequence of the economic crisis, the share in national GDPs of public expenditure is rising. However, a marked process of decentralisation in public expenditure has taken place in the last few years (for example, two thirds of public investment is carried out, on average in the EU, by sub-national governments, regional or local) and there are categories of public expenditure that have a strong local impact (such as transport infrastructure and environmental policies). Institutional capacities however are unevenly distributed across space. Improving the quality of governance (at the various levels) and developing better linkages and coordination between central and local governments and among local administrations become strategic issues.

In their chapter, **Bougheas and Kirman** take a closer look at the network of financial institutions interconnected by financial exposure or by financial transactions. They review papers that describe the network structure for banking systems in various countries; and elaborate the relationship between the structure of the network, its topological properties and the propagation of an external shock (and thus the fragility of the entire system). The main focus of the review is on the use of complex network analysis techniques and their applications for analysing and pricing the systemic risk of a financial network.

Also labour markets have a network dimension and a spatial dimension. They are connected via a migration network and institutions heavily shape the functioning of labour markets and of the migration network. They are regionally fragmented because labour mobility is low as a consequence of institutional factors, such as language, territorial, cultural, gender, ethnic, age and other barriers across European communities.

The chapter by **Nelson** provides an overview of current research on networks in international migration. It begins with a short discussion of the relationship between networks and social capital. While controversial, this concept potentially provides a unifying thread linking various aspects of economic research and, potentially more importantly, providing a bridge linking economic research to parallel research in demography and sociology. The core of the chapter discusses the role of networks in the decision to migrate, the role of networks in assimilation, and the effect of global migrant networks on the pattern of international trade. In all three of these areas, recent years have seen substantial new research, both theoretical and empirical, on the ways networks interact with more standard economic variables. In each of these cases, networks are seen to play an essential role in the migration experience.

The chapter by **Bellmann, Gerner and Upward** “zooms in” on one particular labour market and investigates the role of institutions. It starts from the observation that the global economic and financial crisis, which began in 2008, had very different effects on the labour markets of EU economies; in particular, the German labour market might be described as more “resilient” than others in the face of shocks. In this chapter the authors propose a simple descriptive methodology that allows to shed light on many of the proposed explanations for the resilience

of the German labour market to the crisis, in particular on the role of various institutional arrangements intended to promote workplace flexibility, such as short-time-work and working time accounts. The paper focuses on Germany; however, the contribution also describes the used methodology in detail so that it can be consistently applied across countries (given that detailed linked employer-employee data are increasingly available)

Finally, **Varela, Rotundo, Ausloos and Carrete** provide a brief introduction to complex network analysis including computational issues. After an introduction to the foundations of the field, the authors add insights on the statistical mechanical approach, and on the most relevant computational aspects for the treatment of these systems. As it is the most frequently used model for interacting agent-based systems (that are often used in economics), a brief description of the statistical mechanics of the classical Ising model on regular lattices, together with recent extensions of the same model on small-world Watts-Strogatz and scale-free Albert-Barabási complex networks, is included. The authors provide many references for further studying these methods and review applications in the broader field of social sciences—with a special focus on applications in economics (such as business cycle coordination; financial markets, tax evasion, business and innovation networks, international trade and migration networks).

3 Industrial Interactions

Decisions that impact on population's well-being (labour migration movements, households residential choices as well as firms location decisions) may also be affected by lower scale interrelations: the number and strength of social ties contributes to explaining differences in occupational opportunities and wage outcomes; residential choices have a clear spatial dimension (characteristics of local housing markets, accessibility, neighbourhood quality) involving individual preferences but also linked to households interactions; firms compete in local as well as in international markets, where larger firms are involved with more scope for strategic interactions. Our aim in this part is to provide a disaggregated analyses of multi-level spatial economic systems focusing on the interrelationship between individual location choices and the economic, social and institutional environment; to analyze the social and economic networks that may emerge at various scales; and, finally, to identify possible interconnections among networks, to highlight how the properties of a network at some level (for example, the degree of interconnectedness) can be affected by processes taking place within networks at a different level. A secondary, but not unimportant objective is to provide more sophisticated descriptions of agents' behaviour that could suitably replace the oversimplified monopolistically competitive behaviour within NEG models.

Concentrating on the industrial interactions between agents, i.e. firms, we take a micro perspective in examining individual agent's behaviour and small scale interactions and networks. Firms may interact on a cooperative basis creating bilateral or multilateral links (i.e. building the so-called innovation networks, or other types of inter-firm networks). They may decide either to engage in competitive relationships, through various types of strategic behaviour; or create cooperative links such as innovation networks or other types of inter-firm networks. The existence of local links increases substantially the importance of local administration quality and interventions. Firms' location decisions may be affected by industrial interactions.

Starting from the first principles of industrial organization **Panchuk** develops the dynamics of industrial interaction where the competition between firms determines how intensely capital is utilized and the level of capital stock chosen by the firms at the end of each investment period. This chapter investigates how a market structure is developed when several firms are involved. Any new industry, not depending on how large it may expand in the course of time, is originally established through a few pioneering firms, and eventually starts growing in terms of the number of competitors, thus developing competition. It is supposed that the firms act under constant eventually decaying returns, and that they cause in competitors the need to renew their capital equipment from time to time, choosing its optimal amount according to the current market situation. Meanwhile, in the intervening periods the firms are subjected to capacity limits due to fixed capital stocks. As a result, the evolution of the system depends essentially on the number of competitors and the capital lifetime, and is also sensitive to the initial choice of individual inactivity times. In particular, the firms may merge into different groups renewing their capitals simultaneously, which leads to distinct dynamical patterns.

Firms not only interact through competition but also their spatial presence generates spillovers. R&D investments and spatial spillovers are considered in the chapter by **Bischi and Lamantia** that overviews the literature concerning oligopoly models where firms produce homogeneous goods and share R&D cost-reducing results through bilateral agreements and/or involuntary spillovers of knowledge. In these models the industrial interactions are expressed by the formalism of networks (i.e. theory of graphs) where firms represent nodes and agreements to share R&D represent arcs (or links). The authors describe several models and corresponding theoretical results, as well as some of their practical implications in industrial organization. The second part of the chapter describes a recent dynamic two-stage model of oligopolies with both R&D collaboration ties and spillover effects.

The following chapter by **Kopel, Pezzino and Brand** reviews the theoretical approaches employed to analyze a firm's strategic location choice in an oligopolistic environment by considering its investments and activities regarding R&D. They focus on a firm's sourcing channel choice and examine firms' strategic interaction by means of the analysis of a firm decision's influence on its competitors' strategies. They show the significance of a firm's strategic motives during its decision-making process for both itself and its rivals.

Location choice decision is determined not only through strategic interactions but also through other micro and macro factors. The chapter by **Basile and Kayam** examines the empirical methods employed in analysing the foreign firms' location decisions based on the theoretical literature on macro and micro perspectives of location choice. Starting from the most influential theoretical contributions, which have addressed the motivation of MNEs to be engaged in a horizontal or a vertical FDI, they discuss the various econometric specifications used in the empirical literature to test the hypotheses on the determinants of foreign firms' location. They provide a critical assessment of empirical approaches and their contributions to our understanding of the dispersion of multinational activities across space. Additionally, issues for further development, specifically for modelling multinationals' economic activity in space, are discussed.

Dynamics of geographic distribution of economic activities, including firms' location decision, cause space to become a key element in establishing interactions between individual agents. **Ausloos, Dawid and Merlone** emphasize that understanding of patterns emerging from such spatial interaction between agents is a key problem as much as their description through analytical or simulation means. They employ Agent Based Modelling (ABM) that has become a widespread approach to model complex interactions where agents can interact either indirectly through a shared environment or directly with each other. In such an approach, higher-order variables such as commodity prices, population dynamics or even institutions, are not exogenously specified but instead are seen as the results of interactions. The chapter reviews different approaches for modelling agents' behavior, taking into account either explicit spatial (lattice based) structures or networks. Some emphasis is placed on recent ABM as applied to the description of the dynamics of the geographical distribution of economic activities,—out of equilibrium. The Eurace@Unibi Model, an agent-based macroeconomic model with spatial structure, is used to illustrate the potential of such an approach for spatial policy analysis.

4 Final Remarks

We believe that the Chapters included in this Volume provide a useful overview of models and tools dealing with multiregional and spatial economies pointing out problems or issues for further development, such as asymmetric regions, multilevel network structures and interactive and strategic behavior leading to location decisions. The book integrates research perspectives on this topic across different disciplines, in particular it integrates specialists in economics and in regional science with specialists in mathematical and computational methods for analyzing complexity and nonlinear dynamics. This interdisciplinary approach allows trespassing the narrow limits set by conventional analytical methods and will allow deriving results where conventional methods have reached their limits.

We expect that this Volume will contribute to theoretical developments visualising the EU as a trade network with a specific topology determined by the number and strength of regional links; to the provision of a more sophisticated modelling of the dynamic processes governing the spatial distribution of industrial activities and financial resources; to the development of specific analytical tools in the field of networks analysis, agent based modelling, evolutionary game theory and nonlinear dynamics. We hope this approach to be more effective for addressing specific cogent issues linked to economic integration such as: easing economic disparities within and across European regions; economic and social cohesion policies; regulation of migration flows; counteracting delocation of production towards low-wage and less regulated emerging economies; upgrading of product quality to enhance the competitive strength of European industries; containing the spread across regions of the consequences of financial markets turbulence.

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