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## **COMPLEXITY IN REGIONAL ECONOMICS. THEORETICAL MODELLING AND EMPIRICAL APPLICATIONS**

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## INTRODUCTION

Regions are part of a global network in which commodities and services are produced and traded (Becattini, Rullani, 2000; Scott, Storper, 2003). Their capacity to play a key role within such network depends on the local endowment of resources: advanced workforce's skills, capital, local (natural and cultural) amenities, and the degree of connectivity with the rest of the world (*ibid.*). Local institutions (rules and organisms) also play an important role in supporting regional performances through the production and delivery of public and collective goods (Arrighetti, Seravalli, 1999). On the one hand, a region that is home to such device has the potential to become a hub of the international network thus experiencing a dramatic growth (Krugman, 1991). On the other hand, a region that does not concentrate a critical amount of the aforementioned resources may become a peripheral region, not integrated within the international network, or positioned at the very end of the hierarchical scale of it (Camagni, 2002). In this vein it can be demonstrated that regions compete at the global scale for agglomerating the best factor of production.

Hierarchy is a key issue within the international network of regions. Some regions, such as metropolitan regions, for instance, act as command places, or hubs, for global economy ("*Cities are strategic places that concentrate command-and-control functions for the global economy*" – Sassen, 1991). This is due to the large concentration of resources (human capital, capital, and institutions), and their political importance (often such regions are administrative centres for large territories or nations). This kind of regions are often characterised by multiple specialisations in high value added sectors (Taylor, 2005). However, although they cannot experiment multiple specialisations as in the case of metropolitan regions, smaller regions can become important hubs within the international network if they are specialised in a given sector that has a key importance on the global economy. It is the case, for instance, of San Jose (Silicon Valley) in the United States, "industrial districts" localised in the so-called *Third Italy* (Bagnasco, 1977), and some other regions taking advantage from a remarkable endowment of natural or cultural *amenities* attracting international tourism (Pezzini, 2003).

The positioning within the international network is also subject to lock-in dynamics. Once a region has reached a given level of specialisation it keeps on agglomerating resources connected somehow to the local specialisation, thus enforcing its capacity to compete on the international market (Myrdal, 1957; Krugman, 1991). Vice versa, when a region has not such a critical concentration of resources, it can be challenging to concentrate factors of production. In other words, regional competitiveness presents path dependence (Arthur, 1988). Path dependence, in turn, is strongly affected by the

technological progress and the evolution of the international economy. For instance, whenever a new product or process is invented (technological shock), a given region has the possibility to start a new process of agglomeration of specialised factors of production, thus improving its positioning within the international economy.

The probability of such improvement depends on a variety of factors. Although it is challenging to set a list of *preconditions for local development*, some factors *facilitating* regional growth are: (i) the presence of a given know-how linked to the local tradition or culture (Becattini, 1979); (ii) the possibility to link such local know-how with the international market (Becattini, Rullani, 2000); (iii) the concentration of human capital; and, finally, (iv) the presence of effective institutions (i.e. the presence of an *integrated basket of public goods*) supporting local development. All these “forces” act at the same time and within an international and evolving framework. The result is complexity. A large number of agents interacting both at the local and international level generates a barely predictable dynamic of the local system.

Conventional economics cannot describe such dynamics. Even traditional agent-based approaches can barely reproduce the “real world” (i.e. a valuable counterfactual). Because of this theoretical limit (initially originated by the assumption of decreasing returns of scale), for a long time, competitive advantages featuring a given region were not properly detected. The most famous examples of this mismatch between reality and theory are the Italian (*Marshallian*) industrial districts, which generated a decades-long debate, since theory was not able to describe what was clearly detected by the empirical (on field) analysis (Brusco, Sabel, 1981). Nowadays, although industrial districts and other firms’ agglomerations have become important units of analysis, regional economics are still far to be part of the mainstream economics.

The present research aims at discussing the current improvements made by economics in studying regional dynamics and suggests an innovative approach based on the implementation of new methodologies (i.e. introducing instruments to analyze complexity) and/or traditional ones yet used under new perspectives. In other terms, the classical problem of regional economics, e.g. “*which are the interacting forces generating or enhancing agglomeration dynamics in a given portion of territory?*” has been analyzed with theoretical instruments that allow the model to retain the original degree of complexity characterizing the context. In the same vein, the problem of understanding “*what the functional linkages within a regional economy are*” is assessed through the traditional input-output approach, which proves very helpful to define the drivers of local development, and evaluate the sustainability of regional growth. The aim is to create a set of tools for economic analysis to design regional policy.

In the first part, the essay will assess regional economic dynamics as a *self-reinforcing mechanism*: a positive (or negative) feedback that characterizes the evolution of a dynamic system. The concept of self-reinforcing mechanism can be expressed as a dynamic system, with path dependence and a positive feedback, which tends to a large variety of asymptotic states. Every evolutionary step of the system influences the next one and then the evolution of the entire system, thus generating *path dependence*. Such a

system has a high number of asymptotic states, and the initial state (time zero), unpredicted shocks, or other kind of fluctuations, can all conduct the system in any of the different domains of the asymptotic states (Arthur, 1988). Furthermore, the system selects the state in which placing itself. It is worth noting that, the concept of positive feedback is relatively new for the economic science. The latter generally deals with problems of optimal allocation of scarce/insufficient resources, thus the feedback is usually considered to be negative (decreasing utility and decreasing productivity). Self reinforcing dynamics can be used to assess many different economic problems with different origins: from those related to the international dimension, e.g. to assess the reaction of a region to exogenous shocks, to those typical of the industrial economy, and, last but not least, problems related to regional economics. Specifically, this model demonstrates that the final state of the system (the level of productivity characterising a given region that depends on its actual capacity to attract/reproduce factors of production) will depend on the particular trail it has been covering during its dynamic evolution from an (instable) equilibrium towards another (instable) equilibrium, and so on. Under this perspective, the research focuses on three issues. First of all, identifying forces that act as attractors for the system; second, if these forces exist, assessing the possibility that the system has to move from a lower equilibrium to a higher one (and if so, in which way and how); finally, whether this transition from a level to another is spontaneous or need some particular policy (effectiveness of policies). The stylized facts confirm that the process of regional development is discontinuous and unexpected: as in the case of new territorial agglomeration (clusters) created by a collective reorganization of the local productive framework. Moreover, place-based policies are biased in their implementation by exogenous and endogenous factors. Therefore, policy effectiveness depends on a number of factors, among which the most important is the capacity of the local community of correctly detecting its competitive advantage and designing the policy expressly to enhance it.

Regarding the identification of the local drivers of economic development, the essay discusses the application of an input-output model to measure regional competitiveness. Although this is a well-known methodology, the essay discusses the possibility of using this model to measure sectoral productivity improvements and emerging clustering within a regional economy. Invented in the 1930s by V. Leontief to study national economies, the input-output approach has been revived because of the flourishing of statistical researches at a regional scale that have started to collect highly detailed social and economic data. The input-output model can be applied fairly easily to small regional economies and provides local planners with information of immense value. The transactions matrix is a detailed snap-shot of the input-output linkages existing in a given region. Input-output matrix can be used to forecast the consequences of any planned or potential changes in the demand for region's output. Moreover, the rationale for building a transaction table for a regional economy is to predict the consequences of exogenous demand shocks. Once interdependencies between sectors have been quantified, it is possible to estimate the effect of any changes in final demand on the entire system. Despite some well-known limits, as for instance the absence of economy of scale, when a

“time series” of transactions matrixes is available, it is also possible to estimate the evolution of some key indicators such as local employment and labour productivity.

The first conclusion that can be reached after implementing the different approaches discussed above is that regions should invest in sectors in which they have a sound competitive advantage at the international level. Concentrating resources on these sectors will determine a positive effect for the local economy as a whole thanks to a mechanism of transmission throughout the regional labour market. Such a conclusion is in line with that reached by other scholars in modelling regional economies (Cfr. Aoki, 2002).

Defining the unit of analysis is another key step in assessing regional economies. The misinterpretation of the functional region would bias the empirical assessment of the socioeconomic trends and, in turn, the setting of local policies. There are three different methodologies to define a functional region. First of all, it is possible to take into account the administrative boundaries of a region. The assumption will be that the presence of a local government or a local governance device shapes the socioeconomic trend of the area and favours the creation of a homogenous economic area. Second, it is possible to focus on the morphology of the region: the form of the built environment and the presence of key infrastructures (mainly transportation facilities) assuming that the availability of such infrastructure increases the possibility of having business linkages. Finally the last approach tries to define the functional region by taking into account population size and population densities, and the commuting flows, i.e. the effective dimension of the local labour market. Obviously the last approach is by far the most precise in defining local linkages and the effective dimension of a given region. However, it is worth noting that there is a trade-off between the definition of a functional region and the possibility to measure local socio-economic trends. In many cases, the lack of administrative boundaries prevents the availability of statistical data and so the possibility of assessing the performances of the economy (OECD, 2007). This essay focuses on the definition of urban functional regions and takes into account two different methodologies: the two-component model, and the partitioning model. The first one, based on the assessment of commuting flows, is very effective in defining monocentric urban regions, while the second is usually implemented to define polycentric urban region and is based on the definition of small interacting labour pools.

The second part of the essay focuses on the Madrid metropolitan region and tries to verify some of the conclusions reached in the first part. The Madrid metro-region, recently assessed by the OECD in a Territorial Review (OECD, 2007), has been capturing advantages of globalisation by becoming a metropolitan region of 6 million, which attracts foreign workers and firms. The capital region has experienced impressive dynamic economic growth in recent years. It absorbs more than a half of the total FDI in Spain and has extended its economic relations with Latin American countries. Growth has occurred largely in the service sector (finance, banking, business services) as well as in logistics. Unemployment has reached a low level (6.5% in 2006) and growth rate has surpassed the national average and the average for OECD metro-regions. There is however a concern on how to sustain this positive economic path in the long run. Main

challenges to be addressed include a relatively low productivity level, insufficient specialisation in high-value added manufacturing activities, job-skills mismatches (especially for immigrants), and low innovation capacity.

Finally, in the last part of the essay, the productive framework of the Madrid metro-region is further analysed through an input-output approach. A cluster analysis conducted on the Leontief inverse matrix shows that Madrid is a de-specialised region. This is a common feature among large metropolitan regions. Moreover, through the Leontief inverse matrix, the essay assesses backward and forward linkages within the regional economy. Surprisingly enough, mature manufacturing sectors enjoy the most intense functional linkages with the rest of the regional productive framework. This conclusion supports the hypothesis that regional growth, albeit significant, may not be sustainable over the long run.

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