Research Policy 43 (2014) 1681–1696

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

The emergence of new technology-based sectors in European regions: A proximity-based analysis of nanotechnology

Alessandra Colombelli[a,b,c,*], Jackie Krafft[a], Francesco Quatraro[a,c]

[a] University of Nice Sophia Antipolis, GREDEG-CNRS, 250 rue Ablert Einstein, 06560 Valbonne, France
[b] DIGEP, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129 Torino, Italy
[c] BRICK, Collegio Carlo Alberto, Via Real Collegio, 30, 10024 Moncalieri, Italy

ARTICLE INFO

Article history:
Received 2 June 2012
Received in revised form
25 November 2013
Accepted 25 April 2014
Available online 4 August 2014

JEL classification:
R11
N94
014.

Keywords:
Product space
Technological diversification
New industries
Capabilities
EU regions

ABSTRACT

This paper analyzes the emergence of new technology-based sectors at the regional level focusing on nanotechnology, an infant technology whose evolution can be traced on the basis of patent application filings. We employ a methodological framework based on the 'product-space' approach, to investigate whether the development of new technologies is linked to the structure of the existing local knowledge base. We conduct a 15 EU country analysis at NUTS 2 level using patent data for 1986–2006. The results of the descriptive and econometric analysis support the idea that history matters in the spatial development of a sector, and that the technological competences accumulated at the local level are likely to shape the future patterns of technological diversification.

1. Introduction

The mechanisms involved in the emergence and evolution of new industries over time have for long been attracting the interest of economics scholars. There is a stream of research inspired by Klepper's work highlighting the role of cumulated technological competences in specific sectors within local contexts. In this view, technological competence is seen as a determinant of successful entry, exit and survival of firms in new industries (Klepper, 2007, 2011; Buenstorf and Klepper, 2009; Klepper and Simons, 2000).

Klepper's theory stresses the importance of accumulated competences for the entry of new firms in specific sectors at the local level. However, there is no systematic evidence on the effects of the existing industrial structure on the probability of observing the birth of new industries in similar contexts. The 'product-space' approach has been proposed (Hidalgo et al., 2007; Hausmann and Klinger, 2007; Hausmann and Hidalgo, 2010) to support the hypothesis that the patterns of product diversification observed in different countries are driven by existing patterns of revealed comparative advantage. In other words, countries tend to diversify in productions which, in the product-space, are close to those in which they already have a comparative advantage. Boschma et al. (2013) implemented a regional level analysis to investigate the emergence of new industries in Spain. They propose a framework for empirical investigation of the emergence of new industries at the regional level, adapted from the country level product-space approach. However, the focus is on products and does not take account of technological aspects, and especially the role of accumulated technological competences emphasized in the 'heritage' theory.

In this paper, we attempt draw on both heritage theory and the product-space approach to analyze the emergence of a new technology-based sector focusing on the path-dependent nature of this process. There is a large theoretical literature in the economics of innovation which originated in the seminal contribution of David (1985), that investigates the mechanisms underlying path-dependence in different contexts and at different levels of analysis. This body of work emphasizes that history matters in economic,

* Corresponding author at: DIGEP, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy.
E-mail addresses: alessandra.colombelli@polito.it (A. Colombelli), jackie.krafft@gredeg.cnrs.fr (J. Krafft), Francesco.quatraro@unice.fr (F. Quatraro).

http://dx.doi.org/10.1016/j.respol.2014.07.008
0048-7333/

social and technological change processes. However, in-depth analysis of these issues is lacking, and more work is needed especially on how new technology-based sectors emerge at the regional level. The present paper is contributing to this research agenda.

We analyze the path-dependent emergence of new technological fields, with a special focus on the nanotechnology sector,[1] in the EU 15 countries in the period 1986–2006. There are several studies of nanotechnology but to the best of the authors' knowledge, there is no evidence on the path-dependent dynamics of its evolution or on how cumulated technological competences within a local context sustain (or not) the continuing development of the sector. We use patent data from the Patstat database to implement a 'technology-space' analysis at NUTS 2 level. We investigate whether the development of revealed technology advantage (RTA) in nanotechnology is related to the structure of the technological competences already developed in the region, that is, whether regions with RTA in technologies that are close to nanotechnology in the technology space are more likely to or more able to develop RTA in nanotechnology in the future. The results of the descriptive and econometric analyses suggest that history matters in the spatial development of technology-based sectors. In general, regions tend to develop new RTA in technologies that are close to those already part of the local technology base. These results also hold if the analysis is restricted to the emergence of a new sector, such as nanotechnology.

The rest of the paper is structured as follows. Section 2 presents the theoretical framework for analyzing the emergence of new industries based on technological diversification at the local level. Section 3 discusses the evolution of the nanotechnology sector and Section 4 describes the data and the methodology. Section 5 presents the empirical results of the descriptive and econometric analyses. Section 6 concludes.

2. Theoretical framework

Since Marshall's (1919) seminal contribution, the dynamics underpinning the evolution of industries at the local level have been studied by economics scholars, leading to an increasing overlapping between industrial dynamics and economic geography. Marshall's work looks at the mechanisms that promote the clustering of industries in some specific regions based on agglomeration externalities. A key process in this respect is represented by the birth of new industries, as "subsidiary trades grow up in the neighbourhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material" (Marshall, 1890: p. 225). The localization of industry enhances the division of labour at the industry level promoting horizontal and vertical diversification. Marshall's arguments were developed by Young (1928), who grafted Adam Smith's analysis of division of labour onto a dynamic Marshallian framework in which specialization leads to speciation of new closely intertwined industries. Young stressed that the main effect of the growth of production is industrial differentiation, which leads to the diversification of the production of both final goods and intermediate goods.

Boschma and Frenken (2007) suggest a possible integration of these issues within an evolutionary approach to economic geography. Their starting point is the dynamics by which organizational routines affect the spatial evolution of economic activities (Nelson and Winter, 1982). Building on the work of Penrose (1959) and Richardson (1960, 1972),[2] routines are defined as consisting mainly of tacit knowledge, and represent the basic competencies that shape the competitiveness of economic agents. In this respect, dynamic capabilities stand for the "ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p. 516). Routines, and hence competencies or capabilities, are developed over time as a result of costly efforts that represent a major element of dynamic irreversibilities. Thus regional development emerges out of a process of industrial diversification, in which the introduction of new varieties is constrained by the competencies accumulated at the local level. From the spectrum of possible new activities, the birth of industries that are closely related to already existing local production is more likely. The new activities exploit (at least in part) already developed routines.

Similar concepts are contained in 'heritage' theory, according to which the spatial evolution of industries is shaped by the set of technological, organizational and institutional competencies accumulated at the local level. Previous experience matters and affects the emergence and performances of new industries (Buenstorf and Klepper, 2009; Klepper and Simons, 2000). In studies of the television, automobile, and tyre industries, Klepper and co-authors discuss the agglomeration effects claimed in the literature. In these three industries, which are characterized either by a concentration of firms in areas where production was initially negligible or by a progressive dispersion of firms leaving formerly highly concentrated areas, the agglomeration effect does not apply. To explain this, they propose a hypothesis based on the ideas of organizational birth and heredity.

The key role of the competencies accumulated in the past on the future development of the region points to the importance of *path-dependence* in regional development processes, as well as to the need to adopt a historical approach to their analysis. In path-dependent phenomena history matters in a very peculiar way, as the phenomenology at the time t is dependent on the choices made at the time $t-1$. At each point in time individuals are able to make choices that are likely to influence the transition to the new state. The existence of a multiplicity of alternatives makes the new state only one of several possible outcomes, which makes it impossible to fully anticipate the final outcome based on the initial state. Path-dependent processes are different from past-dependent processes. The latter are a kind of processes which are strongly shaped by the initial conditions; the former are instead processes which are reshaped at each moment in time as the result of changing local conditions (David, 2001; Antonelli, 2006; Antonelli et al., 2013).

The notion of path-dependence is linked strictly to the notion of lock-in that traps the region in a "basin of attraction that surrounds a (locally) stable equilibrium" (David, 2001: p. 25). When idiosyncratic and irreversible decisions are made, agents are likely to based their future choices on existing endowments, which results in convergence towards a specific path from which it is difficult to escape (Colombelli and von Tunzelmann, 2011). The

[1] Although many developments take time to develop into marketable products, patenting of nanotechnology is underway and primarily involves universities and research institutes, small firms related to academia, and some large R&D companies (Schellekens, 2010). Note that the analysis focuses on the generation of technological knowledge in the field of nanotechnology, and not primarily on its application within the geographical areas in which it is developed.

[2] According to Penrose (1959), production activities require appropriate experience and skills. Companies grow along the directions set by their capabilities and the development of competitive advantages requires the exploitation of existing and newly developed internal firm-specific capabilities. Richardson (1972) suggests considering an industry as conducting several activities that are carried out by organizations with the appropriate capabilities, knowledge, experience and skills. He proposes a distinction between similar and complementary activities: activities that require the same capabilities are similar activities while activities that represent different phases in the production process (and consequently, do not necessarily require the same capabilities) are complementary activities. The dynamic capabilities literature has developed this idea (Loasby, 1991, 1999; Teece and Pisano, 1994; Langlois and Robertson, 1995; Teece, 1996; Krafft, 2010).