Research Policy 43 (2014) 107–114

Contents lists available at ScienceDirect

Research Policy

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

Scientific knowledge dynamics and relatedness in biotech cities

Ron Boschma[a,b,*], Gaston Heimeriks[c], Pierre-Alexandre Balland[b]

[a] CIRCLE, Lund University, Sölvegatan 16, S-22100 Lund, Sweden
[b] Department of Economic Geography – URU, Utrecht University, Heidelberglaan 2, 3508 TC Utrecht, The Netherlands
[c] Department of Innovation Studies, Copernicus Institute, Utrecht University, Heidelberglaan 2, 3508 TC Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 8 November 2012
Received in revised form 27 June 2013
Accepted 23 July 2013
Available online 29 August 2013

JEL classification:
O33
R11
L65
D83

Keywords:
Relatedness
Co-occurrence analysis
Knowledge dynamics
Geography of biotech
Title words

ABSTRACT

This paper investigates the impact of scientific relatedness on knowledge dynamics in biotech at the city level during the period 1989–2008. We assess the extent to which the emergence of new research topics and the disappearance of existing topics in cities are dependent on their degree of scientific relatedness with existing topics in those cities. We make use of the rise and fall of title words in scientific publications in biotech to identify major cognitive developments within the field. We determined the degree of relatedness between 1028 scientific topics in biotech by means of co-occurrence of pairs of topics in journal articles. We combined this relatedness indicator between topics in biotech with the scientific portfolio of cities (i.e. the topics on which they published previously) to determine how cognitively close a potentially new topic (or an existing topic) is to the scientific portfolio of a city. We analyzed knowledge dynamics at the city level by looking at the entry and exit of topics in the scientific portfolio of 276 cities in the world. We found strong and robust evidence that new scientific topics in biotech tend to emerge systematically in cities where scientifically related topics already exist, while existing scientific topics had a higher probability to disappear from a city when these were weakly related to the scientific portfolio of the city.

1. Introduction

The geography of scientific knowledge production is very uneven. For instance, the world's most influential scientific researchers reside in a very small number of cities (UNESCO, 2010). This is reinforced by research linkages which connect in particular the scientific hubs (Gertler and Levitte, 2005; Laudel, 2005; Gittelman, 2007; Zucker and Darby, 2007; Hoekman et al., 2009; Trippl, 2009). At the same time, there is a process of ongoing globalization in scientific research (Cooke, 2006; Moodysson, 2007; Hoekman, 2012), as illustrated by the ever increasing number of countries that contribute to scientific publications. Scientific knowledge production in biotech, for instance, has shifted away in relative terms from the US toward Asian regions, like Seoul, Tokyo, Beijing and Singapore, which have become world players in biotech (Heimeriks and Boschma, 2013).

This calls in question how knowledge in biotech science evolves over time, and to what extent regions still contribute to this evolution in the context of globalization. Where is new scientific knowledge created, and to what extent does new knowledge build on existing regional knowledge? Recent studies show that product relatedness is a main driver of industry dynamics at the regional scale, as new industries tend to build on and exploit capabilities in related regional industries, and existing industries are more likely to disappear when few or no related industries are present in the region (Neffke et al., 2011; Boschma et al., 2013). The question is whether the rise and fall of scientific knowledge is also depending on the degree of relatedness with existing knowledge, and whether the body of scientific knowledge available at the regional level matters in that respect. Systematic evidence is yet lacking.

The main objective of the paper is to investigate the impact of scientific relatedness on knowledge dynamics in biotech science at the city level worldwide during the period 1989–2008. More in particular, we assess the extent to which the emergence of new scientific topics in biotech and the disappearance of existing topics in cities are dependent on their degree of relatedness with existing topics present in those cities. In order to measure knowledge dynamics in biotech science, we make use of title words in scientific publications over a long period of time, in order to identify the rise and fall of key scientific topics in biotech. Inspired

* Corresponding author at: CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy), Lund University, Sölvegatan 16, P.O. Box 117, Lund, Sweden. Tel.: +46 46 2223362.
E-mail addresses: Ron.Boschma@circle.lu.se, r.boschma@geo.uu.nl (R. Boschma), g.j.heimeriks@uu.nl (G. Heimeriks), p.balland@uu.nl (P.-A. Balland).

0048-7333/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.respol.2013.07.009

by the 'product space' concept (Hidalgo et al., 2007), we construct a 'scientific space' in which the degree of relatedness between 1028 scientific topics in biotech is determined by means of co-occurrence analysis. Then, we combine this relatedness indicator between topics in biotech with the topic portfolio of 276 biotech cities worldwide, in order to determine how close a new topic that entered a city (and an existing topic that exited a city) is to the scientific portfolio of that city. We analyzed knowledge dynamics at the city level by looking at the entry and exit of topics in the scientific portfolio of 276 cities in the world. Our main finding is that new scientific topics in biotech emerge systematically in cities where scientifically related topics already exist, while existing topics were more likely to disappear from a city when these were weakly related to the scientific portfolio of the city.

The paper is structured as follows. Section 2 sets out the main theoretical ideas, especially the process of branching of scientific knowledge dynamics at the regional level. Section 3 describes the methodology and the data used. We explain how we define the relatedness between scientific topics in biotech, and how we use that information as an input for our econometric exercise in which we assess the impact of scientific relatedness on the rise and fall of topics in biotech science. Section 4 presents the main findings. Section 5 concludes.

2. Scientific knowledge dynamics, relatedness and regional branching

In evolutionary thinking, knowledge production is often described as a cumulative, interactive and path-dependent process (Dosi, 1982; Nelson and Winter, 1982). Because of bounded rationality, search for new knowledge is highly uncertain. As a result, agents tend to draw on knowledge acquired in the past, which provides opportunities but also sets limits to what can be learned (Atkinson and Stiglitz, 1969; Heiner, 1983). As Cohen and Levinthal (1989) argued, agents are more likely to understand, absorb and implement external knowledge when it is close to their own knowledge base. This also implies that knowledge is widely dispersed among many heterogeneous agents, and that the process of knowledge creation heavily depends on combining different capabilities of agents (Antonelli, 1995; Nooteboom, 2000). Therefore, interaction between agents is central, and knowledge production is more than ever an outcome of socially constructed learning processes (Amin and Cohendet, 2000).

This path-dependent and interactive nature of knowledge production becomes manifest not only at the organizational but also at the regional level. To transfer knowledge in an effective manner, not only absorptive capacity of actors but also close and intensive face-to-face contacts between actors are needed. Geographical proximity accommodates this type of interaction, especially for more tacit forms of knowledge (Gertler, 2003). So, knowledge dynamics unfolds at the level of organizations but is situated in a social and geographical context. As regions specialize in particular competences, these offer opportunities to local organizations for further improvements in similar fields of knowledge, and discourage the creation of knowledge that does not match the regional knowledge base (Boschma, 2004). In sum, the regional accumulation of tacit knowledge provides an intangible asset that is difficult to copy by non-local agents, as geographical distance may form an insurmountable barrier for the transfer of tacit knowledge (Maskell and Malmberg, 1999).

Knowledge also accumulates at the regional level because some mechanisms through which knowledge diffuses across organizations, like spinoff activity, labor mobility and social networking, are often spatially bounded (Capello, 1999; Boschma and Frenken, 2011). That is, new spinoff companies tend to locate in the same region as their parent organization, where these new ventures exploit the knowledge they acquired from the parent (Klepper, 2007). And most employees still change jobs in the same labor market region, which means that the transfer of knowledge and skills through labor mobility primarily occurs between local organizations (Eriksson, 2011). And there is evidence that knowledge sharing through social networks tends to be often local (Breschi and Lissoni, 2009).

This is further reinforced by the regional institutional context which shapes the interaction between agents. As knowledge is more and more distributed among heterogeneous actors, there is a strong need to connect, combine and integrate different capabilities. Institutions (like cultural values, conventions and social practices) are important enablers to deal with this increasing complexity of knowledge creation, because they decrease uncertainty and create mutual understanding between actors, especially at the regional level, as geographical proximity favors institution building (Storper, 1995). Accordingly, linkages among agents across different institutional contexts tend to be less widespread and are not always very productive in terms of learning and innovation (Gertler, 2003). Moreover, these regional institutional settings are difficult to replicate in other places as these have evolved over long periods of time. In other words, knowledge often accumulates at the regional level, in which the territory shapes combinatorial knowledge dynamics by providing physical proximity and institutional closeness between agents (Strambach and Klement, 2012).

This is not to say that regions are the sole drivers of knowledge dynamics. On the contrary, there are tendencies of globalization in knowledge production, and it is widely accepted that knowledge dynamics is a multi-scalar phenomenon (Asheim and Isaksen, 2002; Bathelt et al., 2004; Moodysson, 2007; Martin, 2012). Nevertheless, place still matters in processes of collective interactive learning. Studies have recently demonstrated that region-specific capabilities operate as sources of diversification. That is, regions are more likely to expand and diversify into sectors that are closely related to their existing activities (Neffke et al., 2011; Boschma et al., 2013). This means that geographically localized capabilities provide opportunities but also set constraints for regions to diversify into new industries (Neffke, 2009). Boschma and Frenken (2011) describe this process as regional branching, in which new industries arise from technologically related industries in regions in which existing competences are recombined. Moreover, apart from the fact that sectors that are technologically related to other sectors in the region are more likely to enter, Neffke et al. (2011) also found that sectors have a higher probability to exit a region when these have few or no other sectors in the region to which they are technologically related. In other words, the rise and fall of industries is heavily conditioned by the presence of technologically related industries in the region.

Although the literature on the evolutionary geography of scientific knowledge production is still underdeveloped (Frenken et al., 2009; Hoekman, 2012), it seems rather straightforward to apply this line of reasoning to scientific knowledge dynamics. Especially in science, knowledge is widely dispersed among many heterogeneous agents, and it is increasingly difficult for a researcher to possess the necessary skills and knowledge to solve scientific problems alone (Cronin et al., 1998; Wuchty et al., 2007; Hardeman, 2012). Therefore, the spatial concentration of research may bring all kinds of advantages like lower search costs for research partners and new personnel (Carvalho and Batty, 2006). In their programmatic paper on spatial scientometrics, Frenken et al. (2009) explained why interactions in science tend to be spatially biased toward physically proximate actors. There is ample evidence that research collaboration is indeed triggered by geographically and socially proximate partners (Breschi and Lissoni, 2009), as in the case of university–industry research collaboration