Research Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

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

Knowledge space oddity: How to increase the intensity and relevance of the technological progress of European regions

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ARTICLE INFO

Keywords:
Knowledge space
Technological knowledge base
Technological cumulativeness
Technological diversification
Technological relatedness
Technological progress

ABSTRACT

This work contributes to previous research on the relationship between specific features of a regional knowledge space and the technological progress of the region. In particular, the main element of originality of this work is to have singled out the determinants of the technological progress intensity and relevance. We acknowledge the importance of knowledge assets for new knowledge production, and we identify path-dependent processes that allow a region to become increasingly competitive in terms of innovation potential. In particular, adopting an evolutionary view of regional development, we describe the regional knowledge space through four crucial characteristics: 1) technological knowledge base, 2) technological cumulativeness, 3) technological diversification, and 4) technological relatedness. We then measure to what extent each of the knowledge space's characteristics differently affects the technological progress intensity and relevance of the region. A longitudinal study of 269 European regions over the period 1996–2012 was organized using data from REGPAT and Eurostat databases. Results show that technological relatedness affects positively both the intensity and relevance of the technological progress of European regions and that the other components of the knowledge space show a different impact on the two features of the technological progress. Finally, implications for EU policies supporting and stimulating regional technological progress are discussed.

1. Introduction

Over the last ten years, the role of knowledge in fostering regional development and technological progress has been of particular interest for European policy makers, as well being expressed in the Lisbon Agenda in 2005, and in the most recent Europe 2020 strategy, where actions are planned to "improve the conditions for innovation, research and development" (EUCO, 2010). The objective is to sustain in Europe a dynamic knowledge-based economy, based on the production and use of advanced technologies (European Commission (EC), 2010).

From a theoretical point of view, many authors have applied the endogenous growth theory to the understanding of the drivers of sub-national economic development, either at the city or the regional level (Cheshire and Magrini, 2000; MacKinnon et al., 2002; Acs and Armington, 2004; Harrison, 2006, 2007; Button et al., 2011; Stimson et al., 2011; Plummer et al., 2014). In this article we depart from studies that focus on the importance of endogenous technological progress for growth (Romer, 1990; Aghion et al., 1998), and concentrate on, among the various factors influencing technological progress, the role of regional knowledge space in shaping new knowledge production and innovation.

Literature based on an evolutionary economics approach (Dosi, 1982; Dosi et al., 1988), which underlines the main role of learning processes for understanding technological development, offers a fertile ground for further research at different levels of analysis (industry, firm, local system of production, region). The learning capacity of regions is anchored on the availability of specific regional assets for the production and dissemination of knowledge (Hudson, 1999). Since the competitive advantage of regions relies increasingly on knowledge assets and knowledge management, it is important to ask which factors provide the basis for being successful learners.

Our first research question (RQ1) is as follows: What types of pre-existing knowledge are best suited to new knowledge creation in European regions? Some recent studies (Kogler et al., 2013; Tavassoli and Carbonara, 2014; Castaldi et al., 2015; Rigby, 2015; Miguelez and Moreno, 2018), grounded on evolutionary economic geography theory, have tried to investigate the features of the knowledge produced within a region that improve the chances of knowledge recombination and

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https://doi.org/10.1016/j.respol.2018.06.002
Received 14 October 2016; Received in revised form 3 June 2018; Accepted 5 June 2018

new knowledge creation. In these contributions, the knowledge space is often approximated with measures of innovation input and output (such as research and development (R&D) expenditures and patents). The main focus in the above cited literature is on the relatedness argument, disregarding other important aspects of the regional knowledge space, such as, for instance, the path dependent processes that shape the technological trajectories of regions. In this realm, it is important to underline that innovation activities have a strong cumulative nature (Feldman, 1994; Breschi, 2000). The literature on the technological regime (Malerba and Orsenigo, 1993, 1996; Lee and Lim, 2001), offers an important point of view to understand how knowledge cumulativeness could influence the generation of new knowledge, thus opening up to a new set of indicators characterising the knowledge space. Our work aims to respond to this research question from an original perspective, which considers together the more commonly used indicators of technological relatedness, with less explored indicators of the technological knowledge base and technological cumulativeness.

The second research question (RQ2) pertains to an evaluation of the output of the knowledge production process: Which are the features of the knowledge space that are able to increase the intensity of the technological progress in European regions? And are these the same, affecting the relevance of their technological progress? In the literature on regional innovation, the majority of studies have focused on innovation intensity, which is a stock measure of innovation output (Acs et al., 2002; Rigby, 2015; Paci and Usai, 2009). Recently some research works have devoted attention not only to innovation intensity, but also to the quality of the innovation output, in terms of type of innovation (radical vs. incremental - Castaldi et al., 2015) and technological impact (Jaffe and de Rassenfosse, 2017; Miguelez and Moreno, 2018) or technological importance (Benson and Magee, 2012; Nemet and Johnson, 2012). We build upon these contributions, sharing the goal of increasing the understanding of differences in the determinants of general innovation and breakthrough innovations.

By answering these research questions, this research work sheds light on the relative impact of the technological knowledge base and cumulativeness, the technological diversification and relatedness, on the capacity of regions not only to be innovative, but to be a high-quality innovator. Since existing research works on the topic adopt different units of analysis (European regions, US States, specific European countries), thus not helping to compare the empirical evidence provided, due to the variety of capitalism (Hall and Soskice, 2003) and the cultural differences (Hofstede, 1984) arguments, the definition of a unified system of indicators useful to answer the RQs is crucial.

In our work we take into consideration both measures of technological progress: innovation intensity (based on the number of patents), which is a stock measure of technological progress, and innovation relevance (based on the number of forward citations), which is a quality measure of technological progress. In more detail, the innovation relevance reflects the adoption and dissemination of innovations, mirroring the technological importance for subsequent technological developments and the economic value of innovations (Trajtenberg et al., 1997; Lanjouw and Schankerman, 2004; Hall et al., 2005; Gambardella et al., 2008; Jaffe and de Rassenfosse, 2017).

The unit of analysis is the region, and the empirical setting is Europe. Theoretically grounded in the literature of evolutionary economic geography, this study adds to the debate on the drivers of technological progress by 1) accounting for the marginal effect of the different features of a regional knowledge space, and 2) accounting for the two main features of the technological progress (intensity and relevance).

The paper proceeds as follows. In Section 2 we review the literature on regional space and technological progress, focusing on features that are more likely to encourage technological progress at the regional level, and present the research hypotheses. In Section 3 we define the methodology and provide the empirical analysis. Results are shown in Section 4. Section 5 offers some concluding remarks.

2. Theoretical framework and hypotheses

According to recent economic geography studies, regions are a key unit of analysis for understanding the dynamics of learning and innovation (see the debate on regional innovation system and learning region: Asheim, 1996; Cooke et al., 1997; Morgan, 1997; Braczyk et al., 1998; Hassink, 2001; Asheim and Gertler, 2005; Iammarino, 2005).

The competitiveness of regions is based on innovation and on the capacity to understand, explore and exploit knowledge assets conducive to continuous technological progress. In this context, we are moving increasingly towards a knowledge-based economy in which knowledge is fundamental to enhancing productivity and economic value (Castells, 1996; Cooke, 2002) at regional and national levels. With this in mind, it is important to understand how the accumulation of knowledge in a region can influence its capacity to produce new knowledge and thus lead to technological progress. Studies that focus on the role of knowledge in economic systems consider knowledge to be the most important strategic resource and learning the most important process (Lundvall and Johnson, 1994). In particular, Lundvall and Johnson (1994) argue that know-how has become the key resource for firms in order to stay abreast of product and process innovation. Alongside this perspective, the literature on innovation highlights that the invention process is path-dependent, since the inventions that come before influence those coming after (Jaffe and de Rassenfosse, 2017) and pays attention to the role of previous knowledge in leveraging incremental (Bierly and Chakrabarti, 1996; De Carolis and Deeds, 1999) and radical innovation (Hill and Rothaermel, 2003; Miller et al., 2007; Zhou and Li, 2012).

Nevertheless, not all types of pre-existing knowledge are equally distributed and successfully combined to contribute to technological progress; therefore, the aim of this paper is to investigate how different characteristics of the regional knowledge space (technological knowledge base, technological cumulativeness, technological diversification, and technological relatedness) could impact on the technological progress in terms of innovation intensity and relevance.

2.1. Technological knowledge base and technological progress

The accumulation of technological knowledge creates increasing returns in scale in many contexts (Grossman and Helpman, 1991); thus, a region with a consistent base of technological knowledge has a better chance of activating learning processes that will increase the capacity to produce new technological knowledge than regions without a consistent base (Arthur, 1996). Moreover, technological innovation is commonly understood to be a cumulative process in which most new artefacts are being invented by recombining existing technologies in a new manner (Arthur, 2007; Tria et al., 2014; Castaldi et al., 2015). Consequently, the stock of knowledge accumulated in a region increases its future invention/innovation capacity. It follows that the size of the knowledge base is related to the region's technological change (Ahuja and Katila, 2001; Fleming, 2001). Smith et al. (2005) point out that existing knowledge influences the extent to which new knowledge is created, and new knowledge that is created in turn becomes part of the knowledge stock. A dynamic and self-reinforcing system of knowledge production is in place. The accumulation of knowledge leads to improved performance in terms of technological progress, giving rise to a sort of Matthew effect, in which "the rich get richer" (Merton, 1988); i.e., regions with a larger knowledge base are more likely than those with a smaller knowledge base to produce new knowledge and to maintain their status of being rich in knowledge assets. A higher innovation potential is typically joined by a larger organizational and institutional thickness of the regional innovation system, able to provide better infrastructures and research support for knowledge transfer, knowledge spillovers and innovation processes (Asheim et al., 2011). This leads to the articulation of our first baseline hypothesis.