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Geographic concentration of innovative activities in Germany

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ABSTRACT

The geographic concentration of industries has attracted much attention in recent economic and geographic literature. One mechanism employed to explain the emergence and comparative advantage of industrial agglomerations is based on the relationship between industrial agglomeration and local knowledge production and diffusion, and the resulting innovation activities. This paper analyses this relationship by identifying geographic concentrations of innovation activities and examining different causes for the emergence of these concentrations. The paper applies different concentration measures to patent data for German regions. We analyse 43 technological fields separately to identify which of these technologies tend to cluster in geographic space. The results are discussed in light of theoretical predictions of why specific technological fields concentrate while others do not. These explanations include the concentration of industrial activities, the role of dominant firms, dependence on scientific knowledge, and local interactions.

1. Introduction

The geographic concentration of industries has been repeatedly studied in the literature (Ellison and Glaeser, 1997; Braunerhjelm and Carlsson, 1999; Lafourcade and Mion, 2005; Brenner, 2005; Sternberg and Litzenberger, 2004; Alecke et al., 2006). Ellison and Glaeser (1997), for example, identified that in general, industries show different degrees of geographic clustering, but in the majority of industries an agglomeration of firms in a few regions can be observed.

This paper takes up the core issue of geographic concentration but is focusing not on industrial but on innovative activities. Studies examining such spatial distributions of innovation activities are rare. Such a lack of research on the existence of concentrations of innovative activities is particularly interesting, since such activities are a central element linked to the development of industrial clusters which are seen as a core driver of regional development.

In the literature it is argued that firms that are located in industrial agglomerations are more innovative than firms outside such regions (Audretsch, 1998). This would imply that innovation activities follow the concentration pattern of industries but are more pronounced. At the same time, it is argued that innovation activities cause firms' success and growth (Smolny and Schneeweis, 1999). As a consequence, industrial activity should follow the spatial distribution of innovations. In addition, many arguments for the emergence of geographic concentrations of industries are based on mechanisms, such as knowledge spillovers, accumulation of technological knowledge, and cooperation, that function rather on a technological than an industrial level.

We can conclude that innovation activities should also be geographically concentrated, probably causing geo-

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graphic concentration of industrial activity, and at the same time being affected by these industrial activities. By identifying the causes of technological concentration, additional insights into the emergence and operation of industrial clusters can be generated. Additionally, explaining the existence of local knowledge pools helps to understand why firms locate within such pools, and to design policy measures that support the emergence of knowledge pools.

The aim of this paper is to measure the spatial concentration of innovation activity, to provide and discuss several potential explanations for such concentrations of innovative activities, and to examine their relevance in a comparative empirical study. This is helpful in two ways. On the one hand, it allows judging *whether* it is possible to influence the spatial distribution of innovation activities directly or whether this distribution is caused by economic activities, so that these activities would have to be changed in order to influence the spatial distribution of innovation activities indirectly. On the other hand, it provides information about *how* the spatial distribution of innovation activities can be influenced through investigating various causes and their impact on this distribution.

Our paper differs to previous studies such as Feldman (1994), Audretsch and Feldman (1996), Paci and Usai (2000), Zitt et al. (1999), and Caniëls (1999). Feldman (1994) analysed the geographic distribution of product innovations. She found that product innovations cluster in certain regions, and that regions have a tendency to focus on innovations in specific industries. Innovative clusters are identified by comparing the regional rate of innovative activities to the national rate of such activities in a certain industry. Feldman explains this clustering mainly by the impact of local conditions, focusing on certain inputs for the product innovation process, such as the technological infrastructure. Other authors, such as Paci and Usai (2000) and Zitt et al. (1999), use patents as proxies for innovative activities, but apply a similar calculation method. These papers use Gini or Herfindahl concentration indices to calculate the level of concentration, and most focus on the identification of concentration while saying little or nothing about the factors that lead to this tendency for concentration.

In order to study the mechanisms behind the geographic concentration of innovation activities, we examine geographic concentration in 43 technological fields in Germany. The main idea of the paper is to utilise differences in the geographic concentration of technological fields in order to identify the characteristics of technologies which cause them to be more, or less, geographically concentrated. Having identified the characteristics which tend to lead to the spatial concentration of innovation activity, one can study the relationship between technological concentration and spatial concentration.

In common with the literature in this area, we use patent applications as a proxy for innovation activity. The shortcomings of patent data are extensively discussed, e.g. by Grupp and Schmoch (1999) and Pavitt (1985). First, patents are only granted to 'products'. Many services and immaterial goods are therefore not patentable. Further, as Schumpeter discussed, innovation is more than product innovation; it includes processes, organisational change, marketing and the supply side (Leo et al., 2007). Second, not all innovations are filed as a patent, even when they are patentable. Firms sometimes decide against the temporary monopoly a patent provides in order to keep their inventions secret (Rammer, 2003). Hence, only a fraction of all patentable innovations are actually covered. Despite these shortcomings, patents still provide a rich source of data and information, and are a powerful indicator of technological output (Griliches, 1990; Audretsch, 1995).

In order to analyse the geographic concentration of industrial activities, we will calculate four indices based on German patenting data for different technologies. These are the Gini coefficient, the Herfindahl index, the Ellison and Glaeser approach, and Moran's I. These indices provide us with some quantitative measures of the geographic concentration of different innovation activities, and their spatial autocorrelation.

The indices are used in two ways. First, we intend to give a general overview of the geographic concentration of innovation activity. We will discuss how the results vary using different indices, and which technological categories tend to cluster geographically.

Second, the indices are used to test theoretical propositions concerning why specific technological fields concentrate in space while others do not. We examine the characteristics of the different technologies and how these characteristics relate to the technologies' spatial concentration. The hypotheses we test are formulated on the basis of the different potential explanations for the geographic concentration of innovations.

Our findings indicate that technologies have quite different tendencies to concentrate in geographic space. Of particular importance is the role played by relatively few ('dominant') firms within a technology, and the geographic concentration of industrial activities that are related to the technologies. The dependence on scientific knowledge is found to have some relevance, while the importance of local interactions only in some instances affects the technological concentration.

The remainder of this paper proceeds as follows. In the next section the potential causes of spatial concentration in innovation are theoretically discussed, and a set of core hypotheses derived. In Section 3 we discuss the data set and the methods that are applied to the data. Section 4 presents the empirical findings on the tendency of different technologies to concentrate in geographic space. Furthermore, this section empirically tests the factors assumed to shape these different concentration tendencies. Section 5 concludes and discusses future research options.

2. Theoretical considerations

In this section we discuss the different mechanisms that may lead to a geographic concentration of innovation activities. Three fundamentally different causes are distinguished. The analysis of each cause proceeds in two steps. First, the mechanism itself is discussed and its characteristics are analysed. Second, we deduce predictions for the different tendencies of technologies to concentrate in geographic space. These predictions depend on the relevance of the respective mechanism. Hence, the hypotheses are for-