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China's regional innovation capacity in transition: An empirical approach

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ABSTRACT

Drawing upon regional innovation system literature, this paper estimates a stochastic frontier model to explain the increasing disparity in innovation performance between Chinese regions. The estimated results show that government support, the constitution of the R&D performers, and the regional industry-specific innovation environment are significant determinants of innovation efficiency. Due to the large difference in the firms' innovation performance across the regions, when regional innovation modes are transformed from university and research institute dominant to firm dominant, the overall innovation efficiency between regions becomes more and more disparate, which actually underlies the widening gap in regional innovation performance.

1. Introduction

In innovation literature, cross-country comparisons of innovation performance focus on the structures and dynamics of national innovation systems and are mainly carried out through comparative case studies (Freeman, 2002; Lundvall, 1992; Nelson, 1993). As noted in Liu and White (2001b), however, an aggregate level of analysis at the national level is subject to a great deal of questions and criticism. This is because of the regional and industrial diversity within a nation, especially in transitional and developing economies. Innovation performance varies not only between nations, but also between sub-national regions; such as states or provinces (Acs et al., 2002; Evangelista et al., 2001; Fritsch, 2002). For large countries, the national innovation system approach is probably less relevant (Edquist, 2005). In the case of China, this is particularly true. As one of the largest developing countries in the world, China's economy and innovation systems are under transition from the former centrally planned regime to a market-driven system. One prominent feature of the Chinese economy is the increasing variation in development levels between regions. One can even argue that multiple-level "systems" of innovation coexist (Tylecote, 2006). With this as an initial condition, the concept of a regional innovation system, with a focus on lower levels of economy, seems to be an appropriate lens through which the large variation in innovation performance can be analyzed and compared (Asheim and Isaksen, 1997; Cooke et al., 1997).

Although remaining open and flexible, the innovation system approach is often criticized for its vague concepts and unclear boundaries, which bring about many difficulties, including data collection and the measurement of theoretical constructs, in theoretically based empirical studies. A lack of correspondence between the theoretical studies and the empirical studies has compromised the rigor and specificity of this framework. The innovation system approach is therefore usually regarded as a useful analytic tool, but not as a formal theory (Edquist, 2005). Recently, Furman et al. (2002), Furman and Hayes (2004), and Hu and Mathews (2005) empirically investigated the disparity in innovation performance between nations in terms of innovation capacity (Suarez-Villa, 1990). The eclectic approach they adopted is only partially built on the national innovation system approach. Nonetheless, their analysis demonstrates the importance of integrating conceptual specification and empirical work in clarifying the properties of innovation systems.

This paper will follow this line of empirical research and explore the underlying determinants of innovation disparity at the regional level. More specifically, the regional variation in innovation performance in China during its transition period from 1998 to 2005 is investigated. This study particularly focuses on the development of innovation and leaves aside two other innovation system functions: the diffusion and use of innovation. Following the literature, I take different measures of patent counts as a proxy of innovation output and conduct robust checks. The role of both system components and institutional links are taken into account in an empirical estimation.

Examining the statistics of Chinese institutional patents, one can find that, since the late 1990s, the number of both patent applications and grants has increased dramatically in China. During the

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same period, the distribution of patent counts among regions has become progressively uneven, and disparity in regional patenting has become increasingly prominent. One can argue that the increase of R&D sources, in terms of both expenditures and Full-time Equivalent (FTE) Personnel, can at least partly explain the surge in patenting. However, it is unknown what factors are causing the increasingly large variation between regions, since the distribution of R&D sources among regions remained almost unchanged during the same transitional period. Within a productivity analysis framework, this study treats patenting as a function of knowledge production and assumes that the change in the behavior of leading R&D performers influences the production efficiency of innovation and patenting. The results show that it is not the uneven increase of R&D input, but the transition of inherent innovation modes, that leads to the large variations in patenting between regions. Innovation modes are the distinct ways in which the leading innovators in a region perform R&D and patenting activity. In some regions of China, the firms are the major R&D and innovation performers, but in others the universities and research institutes take the lead. The inherent differences in incentives and knowledge bases imply that firms perform different forms of innovation activities than universities and research institutes. In this sense, each region demonstrates an innovation mode that is determined by the majority of the R&D performers in the region. During the transitional period, many regions have moved from a university-research institute dominant mode to a firm dominant mode. However, the geographical distribution of R&D input among regions has not changed much, and neither has that of potential patent counts. It is the disparity in innovation production efficiency that has led to the ever-increasing regional concentration of patents.

The conceptual framework and econometric model are fundamentally different in this study from that of Furman et al. (2002). Many researchers have noticed that the innovation systems in developing economies and transitional economies have quite different systematic characteristics from those in developed countries (Hu and Mathews, 2005; Gu and Lundvall, 2006; Liu and White, 2001b; Radosevic, 2002). The very term "transition" is an exact reflection of these differences. For instance, although firms are the primary locus of innovation systems in developed countries, this is not so in transitional economies. The conceptual framework developed by Furman et al. (2002), drawing upon Romer (1990), Porter (1990) and Nelson (1993), emphasizes the role of firms in innovation, and is fundamentally not applicable to transitional economies like China. As alluded to above, this study uses a framework of productivity analysis and does not distinguish between firms and their counterparts' universities and research institutes in terms of their roles in innovation, since all are major R&D performers in the Chinese regions. Furthermore, to incorporate the effect from the main elements and from the links in the innovation system, this study uses stochastic frontier models to identify and estimate their influence, which is again methodologically different from that of Furman et al. (2002) and Furman and Hayes (2004).

By comparing innovation performance between regions and identifying the determinants of innovation capacity, this paper draws upon and contributes to three streams of research: the regional innovation system, innovation capacity at the regional level, and transitional economies. Furthermore, by focusing on the econometric analysis of innovation efficiency, this paper helps to bridge the gap between theoretical work and quantitative analysis, and addresses the researchers' appeals for increasing the rigor and specificity of the innovation system approach.

This paper is structured as follows: Section 2 describes the features of China's innovation capacity at the regional level, and poses the research questions. Section 3 introduces a conceptual framework and the empirical models. Section 4 discusses the construction of data. In Section 5, findings and results are discussed in detail. Finally, Section 6 forms a conclusion.

2. Regional innovation systems in China

To compare innovation performance across regions, it is necessary to first make a decision concerning the unit of analysis to be used, second put forth a conceptual framework and then further specify an econometric model. In this section, why the provincial-level regions are selected and treated as independent innovation systems is explained, their distinctive features are described, and the research question is further clarified.

2.1. Regions as innovation systems

Regional innovation studies show that innovation activities are not evenly distributed spatially and the production of new technological knowledge tend to localize spatially. Since the uncertainty, complexity and tacit form of new knowledge make it transferable only through personal interaction, spatial proximity is instrumental in facilitating interactive learning and knowledge flow and regional boundaries influence the transfer flow. In this sense, as Fritsch (2002) argued, regional systems of innovation are an adequate approach for analyzing innovation activities.

No matter how difficult and controversial it is to specify the boundaries of regional innovation systems, the concept of a regional innovation system is very useful for helping researchers formulate hypotheses and conjectures. In this paper, 30 administrative provincial-level regions[1] were chosen as the unit of analysis. The decision was based on the following considerations (see also Tödtling and Kaufmann, 1999).

First, provinces in China are administratively and economically independent geographical regions. Since the open-door reform, provincial governments have gained autonomy for formulating economic and social development policies (Gu and Lundvall, 2006; Liu and White, 2001b). Although all are subject to the same legal and political institutions that are under the control of the central government, each has its own governance rules. Technology policies and innovation plans have strong regional features.

Second, the dialect, customs, conventions and cultures have both local and regional characteristics. People living within a province usually share the same spoken language (dialect) and culture. During the long history of China, each region has developed and formed its own distinctive historical, cultural and geographic features. Arguably, this "social capital" is locally embedded and influences the evolutionary processes of innovation in a region.

Finally, the mobility of labor is restricted and limited between provinces in China. Due to the strict regulations on registered permanent residence under the central-plan regime, the Chinese people were not allowed to work or live outside their registered permanent residence. Although this regulation has been gradually lifted during the process of reform, tacit knowledge and social capital developed in the past are strongly tied to regions, and can only be accessed within a particular region. Moreover, the mobilization of labor forces happens more often from within, rather than between provinces.

Based on these considerations, the high degree of "coherence" and "inward orientation" at the provincial level justifies the valid-

[1] Here an administrative unit is a province, a municipality or an autonomous region. Since Hong Kong, Macao, Taiwan and Tibet differ in their economic conditions from most of the other regions, and since information from these regions is not available, I exclude them from the analysis and thus only 30 regions have been included. In the following, I will refer to the administrative units as regions and do not make distinctions between provinces, municipalities, and autonomous regions.