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The evolving nature of China's regional innovation systems: Insights from an exploration–exploitation approach

Yuandi Wang [a], Dylan Sutherland [b], Lutao Ning [c,*], Xin Pan [a,c]

[a] Business School of Sichuan University, No. 29, Wangjiang Road, Sichuan University, Chengdu, 610064 Sichuan, China
[b] Durham University Business School, Durham University, Mill Hill Lane, Durham DH1 3LB, UK
[c] School of Business and Management, Queen Mary University of London, Francis Bancroft Building, Mile End Road, London E1 4NS, UK

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ABSTRACT

The regional innovation systems (RISs) approach has become influential in analysis of innovation processes and the development of public policy. Much of the contemporary RIS literature, however, has adopted a structural, functional, effectiveness or triple helix analytical approach. This study enriches our understanding of RISs in East Asia by considering an alternative novel perspective at the RIS level: an exploration–exploitation approach. Though often used at the firm-level, we argue that it may also provide an alternative lens through which to understand the evolution of China's RISs. To this end we construct a provincial entropy index and use K-means to categorize provinces into explorative, exploitative and balanced RISs and their evolution between 1986 and 2011. Our findings contribute to the literature on China's RISs by illustrating in greater detail the persistence of certain RISs across many of China's provinces, as well as the dramatic step changes towards exploitative systems in others.

1. Introduction

During the 1990s the systems of innovation approach largely replaced the traditionally linear or Schumpeterian view of firms innovating in isolation (Tödtling and Trippl, 2005). The systems approach argues that innovation should be considered as an evolutionary, nonlinear and interactive process. It requires intensive communication and cooperation between different actors both within and between companies, as well as other institutions (such as universities, suppliers, customers, competitors, research labs, educational institutions, financing agencies, governments, and other partners) (Freeman, 1995; Edquist, 1997). More recently, the concept of innovation systems has been applied at the national level (Lundvall, 2002) and also to technological (Carlsson, 1997), sectoral (Breschi and MaLerba, 1997) and regional dimensions (Acs, 2000). Different dimensions of innovation systems may complement each other and together provide insights into better understanding the nature of innovation. All types of innovation systems consist of interaction among the different participating elements, which may eventually involve the generation, diffusion, and application of knowledge (Carlsson et al., 2002).

Scholars studying systems of innovation have forcefully argued that the regional nature of such systems is of considerable importance. Regions, for instance, generally differ in terms of their patterns of industrial specialization and other elements of their innovation systems, leading to differing innovation performances (Howells, 2002). This is particularly so in the case of China, a large country with considerable regional disparity. Moreover, knowledge spillovers, which play crucial roles in the innovation process, are often also spatially bounded (Jaffe et al., 2004). As such, research on regional innovation systems (RISs) has become increasingly popular in the analysis of innovation processes and regional public policy (Tödtling and Trippl, 2005; Cooke et al., 1997).

The RIS approach has been widely interpreted to explain some influential and successful high-tech industrial clusters (i.e. Silicon Valley and Route 128 in the United States). By identifying key actors, institutions, infrastructure and their interactions within a well-performing cluster or region, RIS scholars have attempted to explain why innovation may become concentrated in certain regions. It has also identified what types of actors, institutions, and linkages are at play (Audretsch and Feldman, 1996; Aoyama, 2009; Chang, 2009). Accordingly, regional public policy has been crafted based on such analyses, leading to focuses on high-tech or knowledge-based industries, increasing research excellence, attracting globally competitive firms, and stimulating university-based spin-offs (Cai and Liu, 2014; Lee et al., 2013; Solleiro and Gaona, 2012; Tiffin and Kunc, 2011). Recently, scholars have noted that innovation in a global learning economy is critical for all types of regions. This includes not only high-tech clusters in advanced economies but also

* Corresponding author.
E-mail addresses: wangyuandi@scu.edu.cn (Y. Wang), dylan.sutherland@durham.ac.uk (D. Sutherland), L.Ning@qmul.ac.uk (L. Ning), pxtony@foxmail.com (X. Pan).

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mid- and low-tech industries in developing countries (Tödtling and Trippl, 2005). Thus, regional innovation policy has been developed through analysis of specific regions.

This being said, some have noted the inconsistent policy prescriptions of much contemporary RIS literature, as well as the comparatively static methodological approaches that have been used at times (Carlsson et al., 2002; Lee et al., 2013; Lundvall, 2005; Cowan and Zinovyeva, 2013; Boschma and Fornahl, 2011; Doloreux and Parto, 2005). A broad range of the RIS literature adopts approaches used in studies of national innovation systems (NIS). This includes: the structural, effectiveness, functional and triple helix approaches. These commonly used approaches are static in nature, involving snapshots of a focal innovation system to describe structures, functions and interactions between key actors, including universities, industries and governments (Wang et al., 2012). Thus far, many scholars have therefore failed to provide a holistic approach to empirically delineate a RIS, particularly one incorporating longitudinal and dynamic analyses. Furthermore, inconsistent policy recommendations have been reached (Wang and Zhou, 2011). Additionally, continuing globalization and the rapid rise and fall of regional industrial clusters in developed and developing economies alike add considerable complexity to the spatial dynamism of innovation processes (Binz et al., 2014; Asheim and Coenen, 2005). It thus becomes increasingly relevant for innovation scholars and policy-makers to understand how innovative activity is organized regionally and how RISs evolve during the course of development. Further research using alternative methodological approaches for understanding RISs could therefore be beneficial, particularly if these approaches can capture the evolutionary dynamism of RISs and provide insights into policy-making.

Our objective here is twofold. First, we introduce and discuss a novel analytical approach for the study of RISs which we borrow from the exploration–exploitation framework, often used for firm-level analysis. Using this approach we categorize RISs into a limited number of classes and develop a patent-based measure of innovative activity. This gives us a workable method for undertaking longitudinal research on China's RISs. We also consider extant research on China's RISs and consider how our novel approach may contribute to further understanding it. Second, we undertake a preliminary application of this approach to Chinese provinces as the RIS unit of analysis. China has increasingly gained ground with respect to RIS development during the past three decades. Its emergence as an innovative economy and society, moreover, is crucial to its long-term growth. Indeed, so central has innovation become to China, developing better innovation systems is increasingly considered the key to escaping a potential middle income trap.

This paper is organized as follows. The second section discusses the primary analytical approaches in contemporary RIS (or NIS) studies and summarizes their application to the Chinese case. The third section discusses the novel RIS exploration–exploitation framework and the fourth section applies it to China's RISs. The conclusion argues that the qualitative evolution of patenting in Chinese provinces is striking though often overlooked aspect of Chinese RIS development. We show not only that provincial patent volumes increased dramatically during reform but also that their variety across technological classes has evolved significantly. This has led to the emergence of some regions with considerable depth and breadth in patenting activity, regions that may be considered as exploratory RISs.

2. Dominant analytical approaches in the study of RISs

Careful scrutiny of the current literature stream reveals that at least four separate though at times complementary approaches have been developed for the understanding of national and also RISs (see Table 1).

2.1. The structural approach

The structural approach is among the most popular methods for describing and identifying structural elements within innovation systems. These elements have consequently been used to interpret the systems' relative innovative performance (Freeman, 1987; Lundvall, 1992). Since Freeman's (1987) first articulation and use of the term 'national innovation system' (NIS), this approach has dominated the analytical toolbox. Likewise, with regard to RISs, the structural approach generally leads to detailed analysis of the main elements characterizing a RIS. It thus explores elements that characterize the main institutional actors, firms and other institutional actors that comprise the RIS. Following this approach, scholars usually stress the primary innovative profile of a region by characterizing innovation activities using indicators such as education, regional R&D investments, existing technological base and technological outputs (e.g., patents and new product sales) (Doloreux and Parto, 2005; Asheim et al., 2011). As a result, regional differences in terms of innovation activities and competitiveness have been attributed to elements that characterize RISs. Guided by this approach, local governmental authorities typically focus on the creation of primary elements to improve the RIS. For instance, regional governments may look to create centers of excellence, attract global companies and attract important innovation intermediaries.

2.2. The functional approach

The functional approach was introduced in the 2000s though its roots can be traced back to Edquist's (Edquist, 1997) discussion of the R&D function in NIS. Edquist states that different organizations or actors

Table 1
Advantages and disadvantages of four common approaches for analyzing innovation systems.

Approach	Brief description	Advantages	Drawbacks	Key policy instruments
Structural approach	Identifies key structural elements in the systems (e.g., well-functioning systems)	Visible, straightforward, with potentially useful implications for policy-making	Impossible to identify all of the elements and difficulties in conducting comparative analyses	Reinforces important elements and strengthens linkages among them
Functional approach	Simplifies considerably the number of elements to limited number of specific functions (i.e., activities) in a system	Reduces the complexity of systems and pays attention to several functions instead of the myriad elements	Hard to compare functions in different systems and within a system at different periods; also difficult to link functions to specific supporting elements	Instead of cultivating specific structural elements, more attention should be paid to specific functions related to knowledge generation, diffusion and use
Effectiveness approach	Links system inputs to their corresponding performance outputs to evaluate system efficiency and effectiveness	Avoids the hard work of unveiling the complex internal mechanisms in an innovation system	Hard to define innovation system inputs and outputs and to compare systems at different development levels	Improves innovation system effectiveness by optimizing inputs and improving system performance
Triple helix approach	Interactions between university, industry and government are key for an innovation system	Highlights the role of key actors (e.g., the university) for high-tech and emerging technologies or industries	Less applicable in mid- and low-high technologies or less advanced regions	Emphasizes universities' role in industrial innovations