



Exploring pathways of regional technological development in China through patent analysis



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ARTICLE INFO

Article history:

Received 22 May 2015
Received in revised form
19 May 2016
Accepted 15 June 2016

Keywords:

China
Patent
Regional
Growth
Disparities
SIPO

ABSTRACT

Recently, China has experienced a surge in patenting and become the leading applicant nation worldwide. The technological substance of this growth, however, has become increasingly doubted as China's governments continue to promote patenting as a target per se. Against this background, the paper explores the structure of Chinese patenting from a regional perspective. Firstly, it analyses the technological profile, public component and outward orientation of specific provinces' technological ecosystems. Secondly, it connects these specific profiles to regions' recent growth in patent applications. Concluding, it finds that there are indications of both politically induced and technologically substantial growth in applications.

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1. Introduction

In the course of the past two decades, China has evolved from a mainly manufacturing nation to a technologically dynamic one with the ambition to catch up with the world's leading economies by 2050 [1,2]. Since 2011, it has become the nation with largest annual patent output in the world [3,4]. At the same time, however, it remains a large country, in which substantive disparities continue to prevail, in general economic as much as in technological terms [5–8]. For a long time, talking about new technological trends and growing capacity in China was synonymous to talking about new developments in Beijing, Guangdong, and Greater Shanghai [9,10]. At the same time, it also meant talking about two separate research systems, a public and an industrial one, that were distinct not only in terms of their legacy and internal logics [11], but also in terms of their geographical representation [9,10]. As a result, meaningful knowledge transfer between the two only occurred in a limited number of 'islands of innovation', where regionally unique systems of co-operation had developed over the years [10,12,13].

Five years ago, this author gave a comprehensive overview of the regional distribution of research and innovation activities in China, which complemented earlier studies [7] and relied on data

up to 2008 available at that time [5]. This study provided a snapshot of a Chinese economy in which both basic research and technological development had begun to play a substantial role, while a strong regional, sectoral and technological concentration of R&D activities continued to prevail. This was particularly marked for those technological activities measurable in patents.

More recent anecdotal evidence suggests that this picture has since changed [13]. Moreover, recent cross-sectional analyses of patent data suggest that technologically advanced industries are moving further inland, while additional regional innovation systems have developed outside the traditional 'islands of innovation' [14]. In parallel, an increasing number of central and local government policies are emphasising 'self-sufficient' or 'indigenous' innovation as well as the need to improve meaningful science-industry collaboration across the country [15]. At the very least, this push has induced substantial efforts to bridge the gap between the public and the private sector [2,16,17]. Despite these new trends, however, the existing technological hotspots of Beijing, Greater Shanghai and Guangdong continue to develop dynamically and consolidate their leading position [9,18].

2. Conceptual background

As prior studies have shown, many transforming innovation systems tend to be characterised by strong dependence on external,

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international knowledge inflows. In China's provinces, the broad basis of foreign-invested technology firms that has developed over the past few decades has created a framework for efficient external knowledge adaptation and processing that differs markedly from that of most Western countries [19–22]. For quite some time, however, these foreign firms' activities did in many places not connect strongly with other parts of the Chinese economy [23]. At the same time, China also harbours substantial capacities in its diverse domestic public research sector [9,10]. While, with a view to its dependence on external knowledge inflows, it may display some structures similar to that of a developing nation, it differs markedly with a view to its substantial, endogenous capacity for knowledge generation, in particular at universities [12,24], which remains unmatched among all the emerging economies [1,2]. For quite some time, therefore, China has overcome its formerly very pronounced dependence on foreign knowledge inflows and its government is eager to support and promote any opportunity for "indigenous innovation", i.e. new developments based on national sources of technology [1,4,25–27].

Secondly, transforming innovation systems like China's tend to be characterised by strong institutional frictions, if not divides [10]. For a substantial period of time, the country's industrial structure used to be characterised by a dichotomy between a number of major players in the state-owned sector on the one hand and foreign-invested firms and a few key players in the private sector on the other [9,28,29]. While state-owned firms play a dominant role in traditional, mature industries [1], private and foreign-invested enterprises have come to dominate more modern branches like IT or telecommunication [30,31]. Although this dichotomy may no longer be as clear cut as it used to be [13,32,33], it continues to fuel different logics of developments across industries and technology fields. Depending on their institutional composition, industries and regional innovation systems are exposed to different factors of influence to different degrees and develop accordingly [32,34].

Furthermore, recent figures on patenting and financial investment in enterprise sector research and development suggest that a transformation from technology absorption and adaptation to the genuine creation of new, world market-relevant innovations in domestic firms may be imminent if not already underway [9]. Contrary to past years, where such innovations were mostly limited to single firms in specific regions, like Huawei or ZTE [28,33,35], a broader basis of internationally-relevant technological capacities appears to be emerging [36]. At the same time, it remains unclear to what extent current patenting is the result of new technological capacities, and to what extent it is triggered by political encouragement or pressure to increase domestic applications regardless of their quality [4,37] with the aim to create an image of 'indigenous' innovation.

Finally, China's industries, like those in every other country, have to respond to international technological trends [21,38,39]. While these trends drive long-term transformation and regional rearrangements on the one hand, they also form the short-term frameworks for different provinces' growth perspectives and resilience in the face of a specific sector's cyclical crisis on the other [32,23]. In concert with the aforementioned national trends, this international framework will co-determine the extent to which specific locations will be able to strengthen and maintain their position in the overall national system of technological production or, in the case of followers, catch up with the established leaders.

In conclusion, a number of different dimensions have to be taken into account when analysing recent trends in the regional architecture of China's innovation system. In a first step, therefore, the following paragraphs identify key dimensions of analysis based on the existing literature. The second step presents a very brief,

literature-based overview of the status quo in the regional architecture of China's innovation system and then proposes a number of research questions.

2.1. Dimensions of analysis

Based on the existing literature, four main structural attributes can be identified that are relevant for the emergence of growth trends in China's regional innovation systems. Conceptually, these have been posited in the regional science literature for more than a decade and have recently also been taken up in a number of China-specific studies.

Firstly, differences with regard to the *overall level of technological activity*. In some of China's provinces, technological activities have developed earlier and faster than in others [9,24,40]. In general, such regions are in a better position to muster the critical mass needed to build up functioning regional innovation systems or consolidate and improve existing ones [41–43]. Empirically, moreover, high levels of pre-existing technological activity were found to be closely connected with the development of relevant clusters of internationally competitive firms in Chinese provinces. Hence, the overall level of technological activity is relevant when assessing a regional system's capacity to trigger or sustain mutually reinforcing dynamics at a local level [32].

Secondly, the *relative roles of the public and the private sector*. Just like the overall level of activity, the potential for local complementarities between pre-competitive research and concrete technological development constitutes a key requirement of dynamic regional development in China [10]. As Landabaso [43], Cooke et al. [42] and Feldman/Kogler [44] have shown, a certain level of technological activity may be a necessary condition for mutually reinforcing dynamics, yet only critical mass on both sides of the spectrum will prepare the ground for genuinely self-supporting regional innovation systems. Typically, the efficacy of science-industry relations and hence their ability to trigger and fuel local technological dynamics is limited by the availability of relevant partners in the region [17,18,45,46].

Thirdly, *technological specialisation and sectoral focus*. As demonstrated many years ago in the literature, different sectors are subject to different technological and business cycles [47,48]. In particular, modern and constantly evolving fields like information technology or telecommunications are subject to short cycles, while more mature ones, like general machine building or chemistry are – as a tendency – characterised by longer cycles [32,23]. Technological specialisation in the Chinese context can be taken as a proxy for the internal structure of the patenting firm sector that dominates the regional innovation system. While some sectors are characterised by large, state-owned enterprises that are more prone to respond to political targets [4], others are characterised by private players targeting international markets [49].

Finally, *international orientation*. Right up to the present day, the question of whether a province's industries are internationally oriented remains crucial for its economic and technological development [50], even though this role cannot be considered conducive by definition [23]. In China, the question of market orientation plays a crucial role, not only for foreign-invested [51], but increasingly also for leading domestic firms [49]. While this is influenced by the different sectors' varying inclinations to internationalise [44], other factors can be equally as important. Not least, globally-oriented patent applications have to meet higher thresholds with a view to 'new to the world' criteria [52] than SIPO applications, which are still regarded as rooted in a political as much as in a technological context [4,37].

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