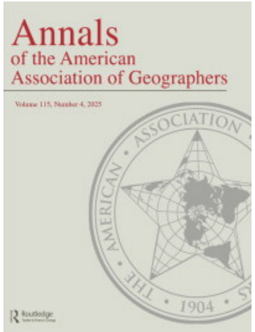

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Prometheus in the Periphery? The Extent, Drivers, and Nature of Innovation in the Urban Peripheries of Chinese Cities

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Despite recent correctives to established views on the urban rather than suburban location of innovatory processes, we still know very little about the extent, drivers, and nature of concentrations of innovation in urban peripheries. This article makes several contributions. First, it presents an exploratory spatial data analysis method for identifying innovation centers in urban cores and peripheries from both geographical and functional perspectives. Second, we offer an initial, admittedly simple, econometric testing of some of the most critical drivers of innovation in urban peripheries. Third, we bring greater specificity to conjecture on the nature of innovation activities found in urban cores and peripheries, respectively. Drawing on an extensive time series data set of more than 7 million geocoded patents that were applied for by Chinese applicants between 2009 to 2018, we find that China's urban peripheries have become more innovative overall, with an increasing number of cities that have developed at least one peripheral innovation center and a growing share of innovation activities in peripheral innovation centers. Governmental interventions, including the planning of polycentric spatial structures, the construction of development zones, high-speed railway stations, and college towns in urban peripheries, are shown to be key drivers underlying the emergence of peripheral innovation centers. Innovation in urban peripheries differs significantly from that in urban cores, being more specialized, less technologically complex, and more reliant on intercity technological collaboration. *Key Words: China, innovation, knowledge complexity, spatial structure, urban peripheries.*

In Greek mythology, Prometheus stole fire from the Olympian gods, bringing knowledge and technology to humanity. In economic geography and economics, the common assumption has been that he brought these powers of invention and innovation to the urban cores so often identified as the high points of civilization (Glaeser 2011; Florida 2014). Most of the empirical studies that have investigated geographically peripheral patterns of innovation do so at the interregional and interurban scales within nations. Although there is just enough in this literature and in diverse disciplinary sources elsewhere to allow us to hypothesize that the Promethean fire might also burn in the urban periphery (Fitjar and Rodríguez-Pose 2011; Phelps 2012; Shearmur and Doloreux 2016; Martinus 2018), there is a dearth of comprehensive quantitative economic geographical evidence on the extent, drivers, and nature of intraurban patterns of innovation in urban peripheries. This article seeks to fill this research gap.

This article reveals and explains the geography of urban innovation in China, focusing on urban peripheries between 2009 and 2018. The questions that motivate the empirical analysis contained in the article are as follows: (1) To what extent is innovation apparent in urban peripheries? (2) What are the most significant drivers of innovation in urban peripheries? (3) What is the nature of innovation in urban peripheries? To answer these questions, we construct a unique extensive time series data set of geocoded patents to offer a comprehensive evolutionary perspective of innovation across the peripheries of Chinese cities,

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which moves beyond extant survey- and case-based empirical studies. Specifically, we make three contributions when addressing these questions. First, we provide a novel method for identifying peripheral innovation centers free from some of the arbitrariness of delimiting suburbs (Eder 2019). By considering both geographical and functional perspectives during the identification process, the method corresponds to what Glückler, Shearmur, and Martinus (2023) called a relational definition of the periphery. Second, we build a simple econometric model to test some of the planning and policy-related drivers for innovation in the peripheries of Chinese cities. Third, we provide a theoretical framework for evaluating the nature of innovation in urban peripheries in terms of specialization, technological complexity, and the geography of knowledge sources.

The article contributes to contemporary theory and policy. It advances theory in both urban and economic geography by providing further evidence and arguments to reexamine received theory from "the outside in" (Phelps 2010; Keil 2014), to move beyond "methodological cityism" (Brenner and Schmid 2014), and to better acknowledge the new functional linkages that bind extensive metropolitan realms (Lang and Knox 2009). Specifically, there is a continued need to rethink theory regarding intraurban spatial economic structures in ways that acknowledge the extent and ways in which externalities and agglomerative forces are less anchored on historic urban cores than commonly assumed; urbanization continues to be distinctly multinodal (Walker and Lewis 2001; Phelps 2010); and urban areas embody a diversity of specialized and partially agglomerated trading places (Bogart 2006). This latter thought extends to better understanding the distinct and different contributions that a variety of (sub)urban places, their sociodemographics, and built form characteristics make to creativity, innovation, and invention. In policy terms, the findings highlight the opportunities for urban planning to promote polycentric development, leveraging economic dynamics to ameliorate residential–jobs mismatches and contribute to the sustainability of contemporary urban forms. The China case indicates that these opportunities continue to entail traditional infrastructure and land-use planning policies, as much as recent emphasis on the "aestheticization of the urban" (Scott 2011) entailed policies oriented to urban design, amenity, and social inclusion.

The remainder of this article is structured as follows. We first review and discusses some of the evidence for and theoretical speculation on the rise of innovation in urban peripheries, as well as its underlying drivers and nature in the Chinese context. We then describe the data and methodologies underpinning the empirical work, providing a novel method for identifying significant innovation centers in urban peripheries. Following that, we analyze the evolving spatial distribution of peripheral innovation centers within Chinese cities, the drivers underlying this evolution process, and the nature of innovation activities in urban peripheries. The article concludes with a discussion of the theoretical significance of our findings and avenues for future research on intraurban patterns and processes of innovation.

Innovation in Urban Peripheries: Debates on the Extent, Drivers, and Nature

Due to a dearth of literature on innovation in urban peripheries, we draw insights from the literature on innovation in the context of interurban, regional, and global peripheries (Fitjar and Rodríguez-Pose 2011; Shearmur and Doloreux 2016; Martinus 2018; Fritsch and Wyrwich 2021a, 2021b) to develop our theoretical hypotheses on the extent, drivers, and nature of innovation in urban peripheries.

The Extent of Innovation in Urban Peripheries

Urban peripheries are hardly unimportant in terms of their shares of extant built environments or urban populations when considered at the national or regional scales. Still, the weight of literature in urban economics suggests that accessibility as well as amenity, density, morphology, and other "micro-foundations of agglomeration" (Duranton and Puga 2004) all contribute to innovation being overwhelmingly concentrated—and being perceived by analysts to be—in urban cores. These features ensure that urban cores enjoy urbanization or Jacobs's (1969) externalities of diversity and reciprocity that, in turn, ensure that they concentrate innovation nationally and regionally (Florida, Adler, and Mellander 2017). Urban peripheries are unlikely to be devoid of innovative activities, however. There is now a wealth of studies detailing the presence of notable employment (McMillen and McDonald 1998), head office, research and development facilities (Muller 1997; Mozingo 2016), and new enterprise formation (Keeble and Tyler 1995; Renski 2008) away from urban cores, all of which imply some accompanying measure of innovation. In a more recent study by Holl, Martínez, and Casado (2024), a convergence trend between urban and suburban locations of patenting activities was found to exist. Moreover, the likely presence of urban periphery-located innovation leads to questions about the drivers and nature of that innovation.

A conceptual problem here is that the relativity of the notion of a periphery present at the national and regional or interurban scales (Eder 2019; Glückler, Shearmur, and Martinus 2023) is also apparent at the intraurban scale, and this affects the measurement of the extent of innovation in urban peripheries and cores in various ways. For example, the outward expansion of cities and the periodic redrawing of jurisdictional boundaries both affect definitions of suburbs and urban peripherality (Phelps 2012). The literature from outside economic geography celebrates the rise of suburban-located high-technology industries in processes of urbanization that no longer can be regarded as physically or functionally peripheral (Fishman 1987; Castells and Hall 1994)—a feature we seek to respond to in the method we use to identify urban peripheral clusters of innovation. In our method for determining concentrations of patented innovations in urban peripheries, we do not define urban peripherality with regard to jurisdictional boundaries or geographically with regard to the extent of the built environment at a given time. Instead, we define clusters of urban peripheral innovation in terms of their geographical and functional independence from an initial urban core cluster of innovation. To this end, we draw on the dual core–periphery framework proposed by Glückler, Shearmur, and Martinus (2023), who argued that *periphery* is better understood as geographical and network positions in a field.

The Role of Public Policy and Planning in Facilitating Innovation in Urban Peripheries

Innovation in peripheral settings has been frequently discussed under the umbrella of multiple dimensions of proximity (Boschma 2005), different forms of knowledge base (Asheim and Hansen 2009), different types of innovation modes (Jensen et al. 2007) and regional innovation systems (Trippl, Grillitsch, and Isaksen 2018), and the relationship between global pipelines and local buzz (Bathelt, Malmberg, and Maskell 2004). Based on these theoretical frameworks, existing studies have pointed out that firm-related factors are usually more important than place-based characteristics for innovation processes in peripheral settings.

Nonetheless, we should not underestimate the characteristics of urban peripheries in facilitating innovation. The microfoundations of agglomeration economies in suburban employment nodes and "edge cities" (Garreau 1991) might be questioned (Lang 2003), but significant business communities are active in these areas (Phelps et al. 2006), and a portion of these edge cities will likely gain in the breadth and depth of their economies and urbanity (Phelps 2010; Day et al. 2022). Moreover, in the Chinese context, we hypothesize that government intervention has generally enriched the innovation-related endowments of urban peripheries. More specifically, the attractiveness of China's urban peripheries for innovation is likely improved by the consciously planned polycentric urban spatial structures and development zones, the accessibility generated by high-speed railway stations, and the construction of college towns, in which local governments all have a strong role to play.

First, purposeful planning has driven the evolution of polycentric spatial structures in many Chinese cities (Wang, Wang, and Kintrea 2020; Y. Li and Derudder 2022). Although the relationship between polycentricity and a city's innovation capacity remains an open question (Y. Li and Du 2022), it can be argued that polycentricity could lead to a more decentralized intraurban distribution of innovation activities. Chinese cities have been built out in various master-planned "zones" (Phelps, Miao, and Zhang 2023) that have scale and their own hierarchy of urban centers offering possibilities for face-to-face communications.

Second, development zones' regulatory and incentives-based specificities are intended to promote industry specialization. Thus, development zones have been likened to the edge cities found in the United States (Cheng et al. 2017), offering some economies closely associated with the rise of innovation in China's urban peripheries (Y. Li and Wang 2019; Miao et al. 2019).

Third, although poor accessibility has often been argued as a critical factor limiting the innovation capabilities of peripheral settings (Shearmur and Doloreux 2016), the accessibility and connectivity of urban peripheries in many Chinese cities have been significantly improved through the construction of high-speed railway stations. By extension, the role of high-speed railways in the improved economic performance of China's less developed areas, as found in some studies (Chen and Haynes 2017), is suggestive of their positive impacts on innovation in urban peripheries specifically.

Fourth, the presence of a university or university branch is an advantage that could compensate for an erstwhile lack of a critical mass of innovating entities in urban peripheries. Studies confirm that universities can foster innovation in peripheral settings if there is a good match between the strength of universities and the needs of firms (Pinto, Fernandez-Esquinas, and Uyarra 2015). In China, most new universities or university campuses have been built in urban peripheries. Urban peripheries in cities large and small that are host to several universities or campuses are known as college towns (Zhong and Li 2024). Although the construction of college towns has been criticized as land-centered speculation by some scholars (Z. Li, Li, and Wang 2014), the impact of these college towns on innovation in urban peripheries remains underexplored.

The Nature of Innovation Activities in Urban Peripheries

Even though governmental intervention might offset the locational disadvantages of urban peripheries, it remains unlikely that urban peripheries provide enterprises with all the necessary inputs for innovation found in urban cores. Therefore, studies have argued that it is primarily the adaptation of entities and entity-related characteristics crucial for peripheral settings to evidence innovation (Eder 2019). Research suggests that there are three major characteristics of innovation activities in peripheral settings—specialization in certain activities, types of innovation products and services, and access to extralocal knowledge—that most distinguish the nature of innovation in urban peripheries, which we investigate further here.

First, following Jacobs (1969) and product cycle considerations, where innovation does occur in urban or interurban peripheries, it likely will involve "sterile divisions of labor" more specialized than those found in urban cores and can benefit primarily from Marshallian externalities. Studies provide empirical evidence showing that specialization externalities matter more for firms operating in peripheral regions (Caragliu, de Dominicis, and de Groot 2016). The need for entities to specialize in certain activities is also prominent in China's urban peripheries. For instance, as the primary containers for manufacturing enterprises in urban peripheries, development zones in Chinese cities usually focus on certain types of industries that are specified by local governments (Y. Li and Wang 2019). Such specialization is often achieved by dividing development zones into subzones (*yuan zhong yuan*), each specializing in a specific industry (Miao and Phelps 2022).

Second, innovation activities in urban peripheries could be less technologically complex than those in urban cores. Case study evidence has shown that slow innovators relying on non-market-sourced information and firms in pure science-based industries tend to concentrate in peripheral areas, whereas fast innovators relying on market-sourced information and firms in creative industries are inclined to concentrate in urban cores (Spencer 2015; Shearmur and Doloreux 2016). Holl, Martínez, and Casado (2024) found that disruptive innovations are more likely to concentrate in urban areas in the context of Spain. Given the lack of empirical evidence, however, we are left to hypothesize that innovation in urban peripheries might focus on those that are more specialized, more incremental, and less technologically complex because they might not require frequent interactions with customers and suppliers and the exploitation of Jacobs externalities.

Third, innovation taking place in urban peripheries might lack access to the "buzz" of urban cores and instead rely on nonlocal sources of knowledge. Over time, the geographical availability of externalities has become more extensive to the point that even some technological externalities have become ubiquitous with codification (Phelps 2004) and, more recently, with the paradigmatic shift from linear innovation to open and distributed innovation (Shearmur and Doloreux 2016). Studies indicate that innovative firms in peripheral regions actively access extralocal knowledge through the lens of innovation networks and formal cooperation (Glückler 2014; Grillitsch and Nilsson 2015; Martinus 2018). The geographical scope of extralocal knowledge is usually not well defined. We still know relatively little about the geographical scale at which innovation activities in urban peripheries access nonlocal sources of knowledge.

Data and Methods

China is a very suitable laboratory for exploring whether urban peripheries have become more innovative. Compared with their Western counterparts, the urban peripheries of Chinese cities have undergone significant orchestrated development due to the rapid scale and rate of urbanization over the last decade. The construction of innovation-related spaces and infrastructures in urban peripheries has not only increased the innovation capabilities of Chinese cities in general (Prodi, Nicolli, and Frattini 2017) but also improved the attractiveness of urban peripheries for high-tech firms, universities, and research institutes (Y. Li and Wang 2019; Miao et al. 2019). This allows observing potential changes in the spatial distribution of innovation activities within Chinese cities. It can be expected that the extent of agglomeration of innovation activities in urban peripheries will be apparent in the formation of innovation centers outside of urban cores. Therefore, our analysis begins by identifying innovation center(s) within a city's administrative area.

Identifying Innovation Centers of Chinese Cities with Patent Data

Earlier studies have mainly drawn on survey data. Although such firsthand data are of great value, they could lead to biased responses and are not always conducive to systematic comparisons and generalizations at the national scale. Here we draw on patent data that have also been used in recent related studies (Fritsch and Wyrwich 2021a, 2021b). We acknowledge the limitations of using patent data (Griliches 1990; Martinus, Suzuki, and Bossaghzadeh 2020). For example, patents do not encompass all types of innovations, and the quantity and value of patents can vary significantly across different sectors. The choice to use patent data can be justified as follows, however. First, many studies have shown that the spatial distribution of patents is highly related to innovation activities, especially at the city or regional level (Acs, Anselin, and Varga 2002; Balland et al. 2020; Y. Li and Rigby 2023; J. Li et al. 2024). Second, patent data are longitudinal and contain detailed information about location, applicant, and sectoral classification codes. Third, in contrast to survey data, patent data are uniform and can be used to compare innovation across urban peripheries of Chinese cities.

We retrieved invention patent data from the China National Intellectual Property Administration (CNIPA) database. Compared with design patents and utility model patents, invention patents better reflect the genuineness and novelty of innovations. Considering that most Chinese cities had a limited number of patents before 2009, we only retrieved patents that were applied for by Chinese applicants between 2009 and 2018. Almost 7.1 million invention patents were collected from the CNIPA database, which were then geocoded according to the applicants' addresses and matched with the administrative areas of 286 Chinese cities at the prefecture level and above.

To ensure consistency, we did not include several cities upgraded to prefecture-level cities and those with adjusted administrative boundaries during the study period. Note that the 286 cities at the prefecture level and above accounted for over 95 percent of China's total domestic invention patent applications. In the case of copatents, they were geocoded based on their first applicants' address for the following two reasons. First, copatents only account for 5.4 percent of all the patents used in this study, which is expected to only exert limited influence on identifying innovation center(s) at an aggregate level. Second, the first applicant is usually the primary entity responsible for the novelty of a copatent in the Chinese context. Third, the CNIPA database only contains the location information of each copatent's first applicant, which also reflects the importance of the first applicant. Another major concern in the geocoding process is that a multiplant enterprise might register all the patents at its single headquarters location. Some studies, however, have found that this is not the case in Chinese cities where the patents of many multiplant enterprises are widely distributed (Zhang and Rigby 2022; Y. Li and Rigby 2023).

The ESDA-Based Identification Approach

Existing studies on urban polycentricity have adopted various approaches to identify urban centers (Y. Li and Liu 2018; Y. Li, Xiong, and Wang 2019; Natalia and Heinrichs 2020; Yu et al. 2021; Y. Li and Derudder 2022). The three most commonly used approaches are the minimum cutoff approach, which sets minimum cutoffs of specific indicators (e.g., population density, employment density, nighttime light, similarly from now on); the modeling approach, which uses parametric and nonparametric estimation methods to estimate the density gradient of certain indicators; and the spatial statistical approach, which relies on objective spatial statistical techniques to reveal the inherent structure of spatial distribution of certain indicators. Although the minimum cutoff approach is easy to operate, it suffers from arbitrariness in setting thresholds. The modeling approach often requires a priori or contextual knowledge of the research region for model specifications. In contrast, the spatial statistical approach is more suitable for conducting comparative analyses, as it sets uniform rules for all cities and does not require local contextual knowledge to define a city's main center in advance. Additionally, it has advantages in detecting centers where a strong spatial correlation exists. This approach also has shortcomings, though, mainly related to defining innovation centers, choosing the basic unit of analysis, and selecting the spatial weight matrix.

This study adopts the spatial statistical approach for two main reasons. First, we aim to identify innovation centers across 286 Chinese cities during the period from 2009 to 2018, which requires the results to be comparable across time and cities. Second, innovation activities are generally more inclined to agglomerate than population or employment, which might exhibit spatial distributions with strong correlations. Specifically, we first divide its administrative area into 1 km $\times$ 1 km grids for each city, ensuring that we obtain enough grids for smaller cities. We aggregated the number of patents for each grid to reflect patent density. Then, drawing on the exploratory spatial data analysis (ESDA) method, we calculate the local Moran's I index with a queen contiguity[1] weight matrix as the spatial weight matrix to detect spatial clusters of grids with high or low patent density. Grids with statistically significant values of local Moran's I were classified into four types: (1) LL-type grids (low patent density grids surrounded by low patent density grids); (2) LH-type grids (low patent density grids surrounded by high patent density grids); (3) HL-type grids (high patent density grids surrounded by low patent density grids); and (4) HH-type grids (high patent density grids surrounded by high patent density grids).

Among the four types of grids, only the HH-type grids are considered part of potential innovation center(s). This stands to reason because grids of innovation center(s) should not only have relatively higher patent density but also be expected to exert strong impacts on their surrounding grids. HH-type grids are further combined into contiguous areas under the criterion of Rook contiguity. We retained only areas containing at least three grids (i.e., 3 km^2) and with more than 200 patents. Although this criterion is somewhat arbitrary and relatively low (e.g., an edge city such as Tysons Corner, Virginia, covers 11 km^2), it enables us to identify innovation center(s) in smaller cities in earlier years, which is crucial for our evolutionary and comparative analysis. Moreover, innovation centers identified under such a criterion generally align with observations from the reality of some typical Chinese cities. To test the robustness of this approach, we explored and compared empirical results under other criteria (e.g., two grids with more than 100 patents, three grids with more than 300 patents). Although the number of identified innovation centers is different, the general trend of the rise of innovation in urban peripheries remains stable.

We now turn to the definition of innovation centers (if any) in urban peripheries, which is crucial but often ambiguous in existing studies (Eder 2019). Drawing on the dual core–periphery model proposed by Glückler, Shearmur, and Martinus (2023), we defined peripheral innovation centers from both geographical and functional perspectives. Geographically, we first defined each city's built-up areas in 2018 as the urbanized areas within which innovation centers are to be classified as central or peripheral. This distinction is necessary because some smaller innovation centers are located in remote town areas that are not continuously connected to the main urbanized areas and therefore do not qualify as urban peripheries. Such cases are typically found in cities with economically developed but geographically remote counties or districts, where large manufacturing enterprises dominate patent applications. A notable example is Changzhou in Jiangsu Province, where we excluded one identified innovation center within Liyang, a county-level city of Changzhou, because it is not continuously adjacent to the main urbanized area. Data on built-up areas are retrieved from the Global Human Settlement Layer (GHSL) project of the European Commission's Joint Research Center (see https://ghsl.jrc.ec.europa.eu/), which provides detailed information about the distribution of the world's built-up surfaces from 1975 at five-year intervals.

We then used the extent of the built-up areas in 1975 as the scope of each city's original urban core, which is usually the starting point of a city's expansion. Furthermore, we consider innovation center(s) that are within or intersect with the scope as the potential core innovation center(s). In doing so, we avoid the difficulty of precisely delimiting the boundaries of urban cores in different years while obtaining the locations of core innovation centers. We find that most of the cities' largest innovation centers (in terms of the number of patents) are within or intersect with the scope of a city's original urban core. Some exceptional cases exist, however, such as Dongguan in Guangdong Province and Shaoxing in Zhejiang Province, where the largest innovation centers are outside their original urban cores.

We then adopted a functional perspective to adjust the scope of the core innovation center(s). An innovation center needs to meet two criteria to be considered part of core innovation centers from a functional perspective. First, it should be located closer to potential core innovation center(s) than the farthest innovation center. Second, more than half of its copatents should be related to the potential core innovation center(s), which suggests that the center has relatively stronger linkages with the potential core innovation center(s). Based on identifying core innovation centers, we consider the remaining innovation centers as peripheral. Figure 1 uses Shanghai as an example to illustrate the process of determining its innovation centers in 2018.

We believe the ESDA-based approach has several advantages. First and perhaps foremost, the approach captures the agglomeration of innovation activities by identifying innovation centers (if any) within a city. It does not require delimiting the dynamic boundaries of urban cores and peripheries, which is often complex and not very precise. The rationale behind this approach is that innovation centers are expected to emerge in urban peripheries if they become innovative. Second, this approach identifies peripheral innovation centers that are both geographically away from and functionally independent of core innovation centers(s), which responds to the call for reconceptualizing the periphery (Glückler, Shearmur, and Martinus 2023). Third, the approach treats a grid at the 1 km^2 level as the basic unit of analysis, which helps reveal a fine-grained core–periphery spatial distribution of innovation activities within cities. This complements existing studies that have mainly focused on peripheral regions or countries. Fourth, the approach adopts a uniform criterion to identify innovation center(s) across different cities and in different years, which enables a horizontal and vertical comparison of empirical results.

To smooth the fluctuations of patent data that could potentially influence the empirical results, we count the number of patents each grid contains every two years from 2009 and center it on the latter year. This means that we identify innovation center(s) of Chinese cities in 2010, 2012, 2014, 2016, and 2018.

The Rise and Extent of Urban Peripheral Innovation Centers in China

Overall, we find that urban peripheries have played an increasingly important role in fostering innovation in China (Table 1). For instance, the number of Chinese cities with at least one peripheral innovation center more than tripled from 29 in 2010 to 117 in 2018. This means more than 40 percent of Chinese cities had developed at least one peripheral innovation center by 2018. The mean and median values of the patent shares of peripheral center(s) to all centers also increased remarkably, with the former rising from 0.261 in 2010 to 0.354 in 2018 and the latter from 0.248 to 0.358. In addition, the maximum value of the patent shares increased from 0.563 in 2010 to 0.959 in 2018. Importantly, the rise of peripheral innovation centers suggests that Chinese cities generally became more polycentric from the perspective of innovation distribution, which also resonates with the findings of other studies focusing on population distribution (Y. Li and Derudder 2022).

To further illustrate the growing importance of urban peripheries for innovation, Figure 2 shows the changing distributions of innovation center(s) of three types of Chinese cities between 2010 and 2018, each representing different evolution types of innovation in urban peripheries. Specifically, in the case of Tangshan, a typical manufacturing city in

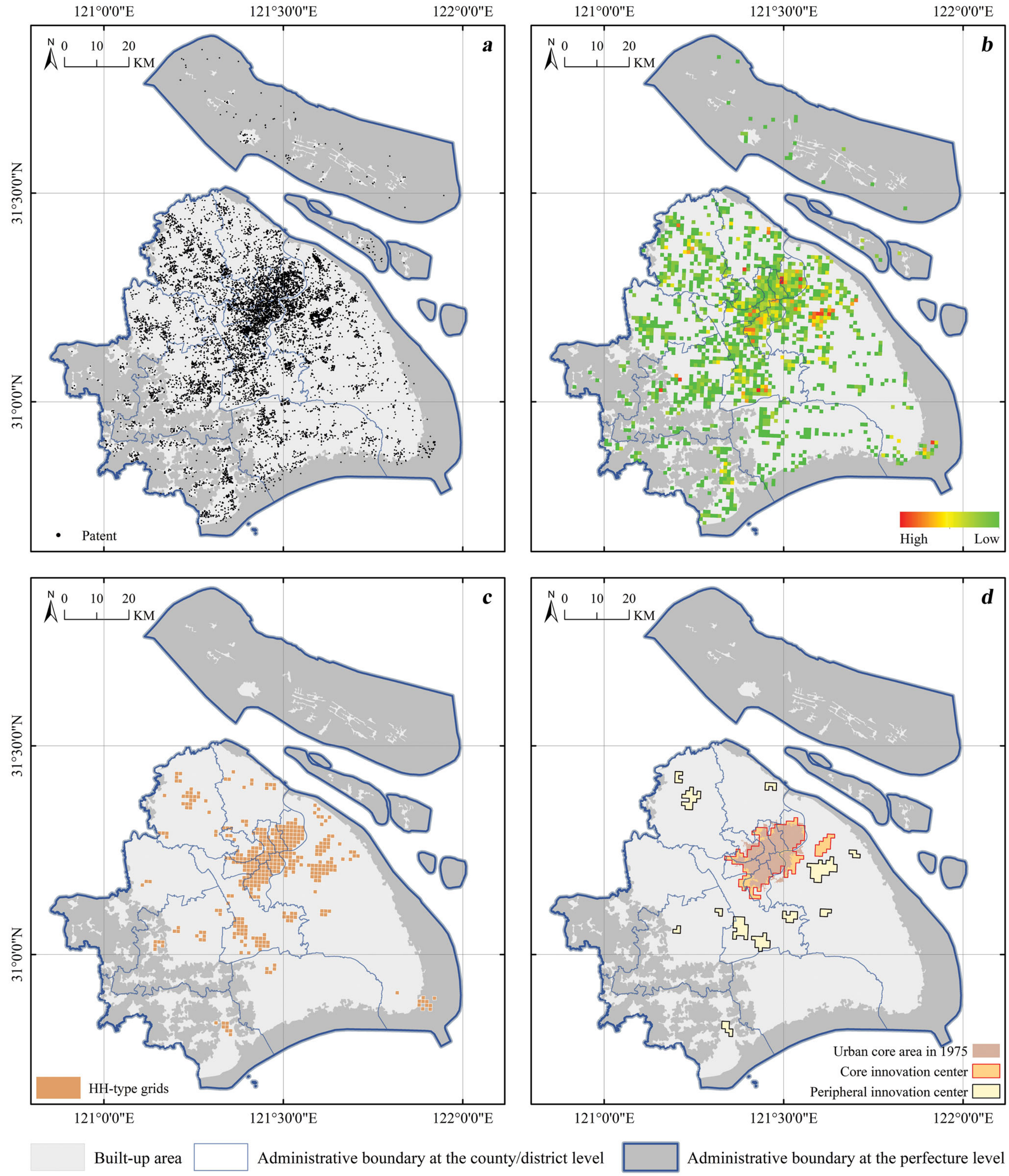

Figure 1. The process of identifying Shanghai's innovation centers in 2018. (A) The distribution of patent points. (B) Grids with different numbers of patents. (C) The distribution of HH-type grids. (D) The distribution of innovation centers.

Table 1. The number of Chinese cities with at least one peripheral innovation center and the descriptive statistics of the patent shares of peripheral centers to all centers, 2010 through 2018

Year	No. of cities with at least one peripheral innovation center	Patent share of peripheral center(s) to all centers				
		Minimum	Maximum	M	Median	*SD*
2010	29	0.040	0.563	0.261	0.248	0.165
2012	44	0.049	0.801	0.290	0.275	0.171
2014	70	0.015	0.901	0.328	0.295	0.196
2016	97	0.013	0.936	0.354	0.339	0.194
2018	117	0.026	0.959	0.354	0.358	0.200

the east of Hebei Province with a relatively lower innovation capacity, we can see that there were no peripheral innovation centers in 2010 and only one peripheral innovation center in 2018. In fact, this is a typical case for Chinese cities with relatively lower innovation capacities.

The second case is Chengdu, the capital city of Sichuan Province in western China. It experienced remarkable growth in the number of peripheral innovation centers, increasing from two in 2010 to eight in 2018. Accordingly, the patent share of its peripheral centers to all centers rose from 0.207 to 0.266. This case is also typical for other major Chinese cities that had already developed some peripheral innovation centers in earlier years. Empirical studies focusing on the polycentricity process of population distribution have also identified a similar pattern for some major Chinese cities (Y. Li and Derudder 2022).

The case of Dongguan is somewhat specific because innovation activities have mainly agglomerated in its urban peripheries. As a major manufacturing city in Guangdong Province, Dongguan has constructed several new districts and towns outside its original urban cores, such as the Songshanhu Hi-tech Industrial Development Zone and Binhaiwan Bay Area. These new districts and towns, where the city's high-speed railway station and college town are located, are now home to the (regional) headquarters of some significant innovators of electronics, such as Huawei, OPPO, and Vivo. The agglomeration of these enterprises in development zones and college towns has significantly changed the distribution patterns of innovation activities in the city, driving the rise of innovation centers in urban peripheries.

The Drivers of Governmental Intervention in the Emergence of Peripheral Innovation Centers

Based on the previous theoretical framework, we construct a panel data set in conjunction with a simple logistic regression model to investigate how governmental intervention has influenced the emergence of peripheral innovation centers. It should be noted that the panel data set contains five two-year periods because innovation centers are identified every two years.

Our dependent variable is the dummy variable PERI_CENTER, the value of which equals one if a city has at least one peripheral innovation center and zero otherwise. Two alternative dependent variables are the number of peripheral innovation centers and the patent shares of peripheral center(s) to all centers. We find, however, that some peripheral innovation centers became core innovation center(s) and some new peripheral innovation centers emerged during the study period, which leads to fluctuation in the number and patent shares of peripheral innovation centers. Such fluctuation, which might make it difficult to interpret the impact of governmental intervention, can be smoothed by using the dummy variable.

Our key variables of interest are as follows. Specifically, PLOY_NUM and POLY_SHARE measure the polycentricity degree of urban spatial structures, with the former reflecting the number of a city's population subcenter(s) and the latter representing the population share of a city's population subcenter(s) to all population centers. Here we follow the approach adopted by Y. Li and Derudder (2022) to identify population center(s) of each

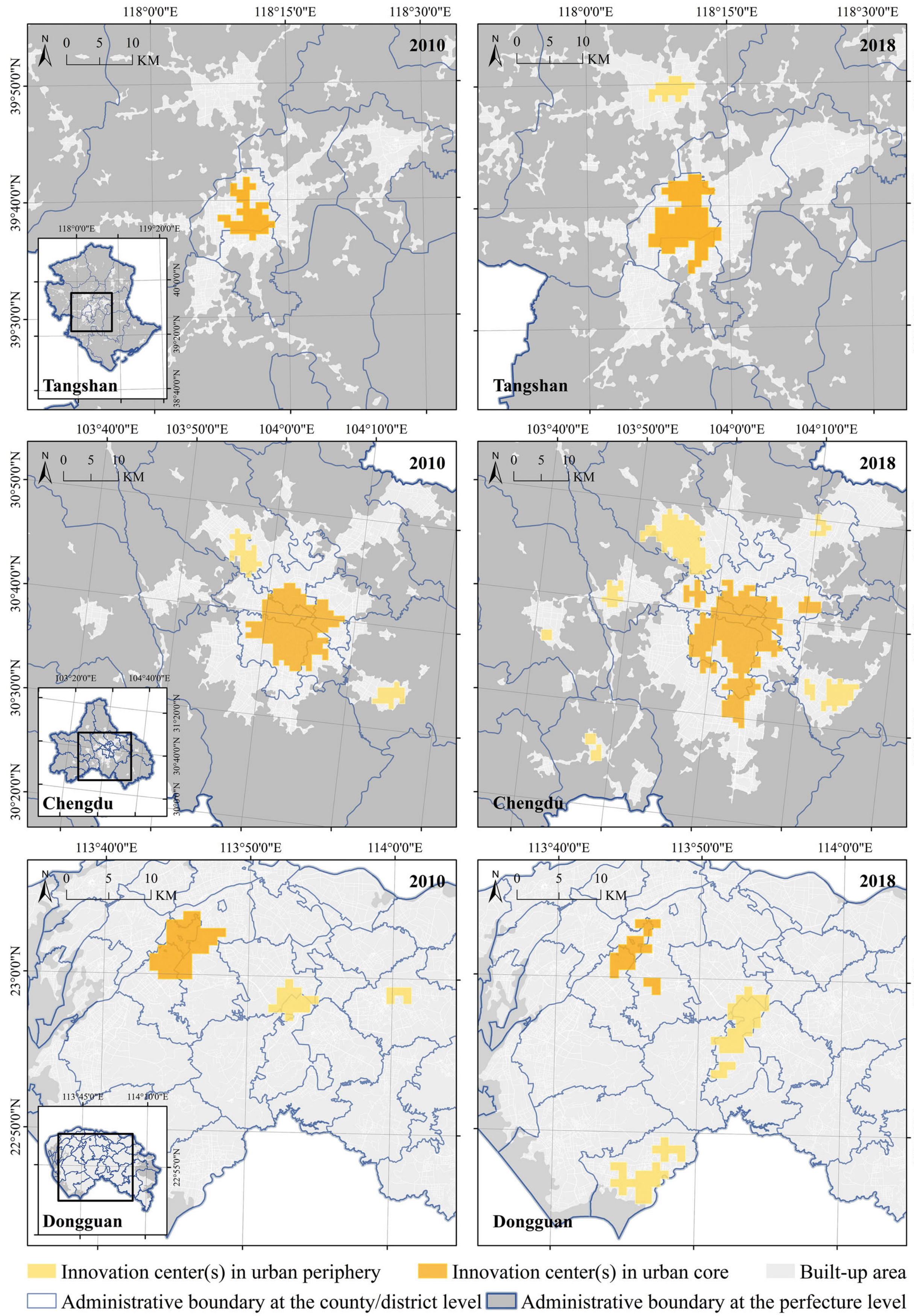

Figure 2. Different example cases of evolution patterns of core and peripheral innovation center(s) in Chinese cities.

Chinese city and define the main center and subcenters (if any). For each two-year period, we calculate the average values of PLOY_NUM and POLY_SHARE, respectively. The correlation coefficient between the number of population centers and innovation centers is 0.407 during our study period. Additionally, the average number of population centers is 3.558, whereas the average number of innovation centers is 1.467. This indicates that Chinese cities are more polycentric when evaluated by population centers than by innovation centers.

DEVELOP_ZONE, which represents the impact of development zones, is measured by the average number of a city's national-level development zones during each two-year period. Notably, development zones in China are usually certified at the provincial or national level. Compared with provincial-level ones, though, national-level development zones often enjoy more preferential policies, thus making them more attractive for high-tech enterprises. Data on DEVELOP_ZONE is collected from the China Association of Development Zones (see https://www.cadz.org.cn/).

The dummy variable HSR_STATION reflects the impact of high-speed railway stations. The value of HSR_STATION is assigned to one when and after a city opened its first high-speed railway station and zero otherwise. An alternative variable could be the number of a city's high-speed railway stations. With the accelerating development of high-speed railways in China, however, many cities have constructed high-speed railway stations of different sizes. Given that a city's first high-speed railway station is usually bigger and the impact of smaller high-speed railway stations could be relatively weak, we use the dummy variable to mitigate the potential impacts of size difference on empirical results. Data on HSR_STATION are collected from the Web site of the Chinese high-speed railway (see http://crh.gaotie.cn/).

The dummy variable COLLEGE_TOWN reflects the impact of college towns. The value of COLLEGE_TOWN equals one when and after a city's first college town was put into use and zero otherwise. The reason we do not use the number of a city's college towns as an alternative variable is similar to the one for HSR_STATION. Because no official data on COLLEGE_TOWN exists, we manually searched this information for each Chinese city from different channels, such as government work reports and urban master plans. Because universities and colleges mainly agglomerate in major Chinese cities, we find that most cities do not have college towns during the study period.

In addition, we use PER_GDP and POPU_DEN to control for the impacts of per-capita gross domestic product (GDP) and population density, respectively. These two variables typically have been used as controls in regression analyses of the geography of innovation (Y. Li and Du 2022). Data on the two variables are collected from China City Statistical Yearbooks, and the values of the two variables are averaged over a two-year period. The definitions and descriptive statistics of all the variables are shown in Table 2 and Table 3, respectively.

Table 4 shows the logistic regression results of our panel data set based on different models. From Model 1 to Model 5, we compare the regression results between fixed effect models and random effect models. Although the Hausman test suggests that the fixed effect model could be more appropriate than the random effect model, we provide the regression results of random effect models as a reference. Because the values of the dependent variable for many cities did not change over time, almost 70 percent of observations would be omitted when we control for the city-fixed effects. Therefore, we choose to control for the province-fixed effects as a compromise measure. We also include the year-fixed

Table 2. Definitions of variables

Variable	Definition
PERI_CENTER	Dummy (PERI_CENTER = 1 if a city has at least one peripheral innovation center and 0 otherwise)
POLY_NUM	The number of a city's population subcenter(s)
POLY_SHARE	The population share of a city's population subcenter(s) to all centers
DEVELOP_ZONE	The number of a city's national-level development zone(s)
HSR_STATION	Dummy (HSR_STATION = 1 when and after a city opened its first high-speed railway station and 0 otherwise)
COLLEGE_TOWN	Dummy (COLLEGE_TOWN = 1 when and after a city's first college town was put into use and 0 otherwise)
PER_GDP	Per-capita gross domestic product (GDP) of a city (10,000 Yuan)
POPU_DEN	Population density of a city (100 persons/km^2)

Table 3. The descriptive statistics of variables

Variable	Observations	*M*	*SD*	Minimum	Maximum
PERI_CENTER	1,430	0.250	0.433	0.000	1.000
POLY_NUM	1,430	3.558	2.756	0.000	25.000
POLY_SHARE	1,430	0.360	0.214	0.000	0.828
DEVELOP_ZONE	1,430	1.090	1.322	0.000	11.000
HSR_STATION	1,430	0.522	0.500	0.000	1.000
COLLEGE_TOWN	1,430	0.241	0.428	0.000	1.000
PER_GDP	1,430	4.641	2.985	0.490	21.132
POPU_DEN	1,430	4.332	3.383	0.050	26.322

Table 4. Regression results

Dependent variable: PERI_CENTER	Fixed and random effects					Lagged fixed effects			
	Fixed	Fixed	Fixed	Random	Random	Lag = 1	Lag = 2	Lag = 3	Lag = 4
	1	2	3	4	5	6	7	8	9
POLY_NUM	0.166***	0.306***		0.451***		0.296***	0.299***	0.316***	0.342***
	(0.038)	(0.047)		(0.110)		(0.055)	(0.062)	(0.072)	(0.098)
POLY_SHARE			1.444*		4.516***				
			(0.743)		(1.522)				
DEVELOP_ZONE	1.293***	0.896***	1.078***	1.142***	1.424***	1.180***	1.558***	1.355***	1.340***
	(0.137)	(0.164)	(0.161)	(0.327)	(0.334)	(0.193)	(0.236)	(0.282)	(0.324)
HSR_STATION	0.929***	0.645**	0.812***	1.683***	1.946***	0.746***	0.798***	0.210	0.129
	(0.247)	(0.275)	(0.266)	(0.452)	(0.455)	(0.260)	(0.273)	(0.321)	(0.485)
COLLEGE_TOWN	0.781***	0.608**	0.691***	1.140**	1.514***	0.784***	0.594*	1.018**	1.177*
	(0.227)	(0.246)	(0.234)	(0.548)	(0.539)	(0.265)	(0.306)	(0.427)	(0.680)
PER_GDP		0.492***	0.369***	0.917***	0.890***	0.494***	0.408***	0.467***	0.494***
		(0.070)	(0.059)	(0.187)	(0.191)	(0.078)	(0.093)	(0.130)	(0.190)
POPU_DEN		0.217***	0.230***	0.492***	0.527***	0.215***	0.173***	0.111*	0.111
		(0.056)	(0.053)	(0.137)	(0.133)	(0.062)	(0.059)	(0.057)	(0.086)
Constant	−8.108***	−11.304***	−9.574***	−14.068***	−14.327***	−11.872***	−10.752***	−9.608***	−8.626***
	(0.828)	(1.349)	(1.164)	(2.077)	(2.075)	(1.328)	(1.495)	(1.630)	(1.626)
No. of observations	1,275	1,275	1,275	1,430	1,430	1,020	765	510	237
Pseudo R^2	0.497	0.578	0.551	—	—	0.580	0.573	0.526	0.466
Province fixed effect	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses and are clustered at the city level.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

effects to control for the unobserved macroeconomic dynamics. From Model 6 to Model 9, we replace the independent variables in Model 2 with their lagged values based on different lag periods, aiming to alleviate the potential impact of endogeneity and test the robustness of empirical results. For all nine models, we cluster the standard errors of point estimates at the city level to account for within-city autocorrelation of error terms.

In Model 1, we only investigate the impact of key explanatory variables on peripheral innovation without considering the effect of control variables. The result shows that the coefficients of all the key explanatory variables are statistically significant at the 1 percent level, and their positive signs are also as expected. This suggests that peripheral innovation centers are more likely to occur in a city characterized by a more polycentric urban spatial structure, more national-level development zones, or the existence of high-speed railway stations or college towns. Because the four factors are all closely related to governmental intervention, the result indicates that Chinese local governments have played an important role in facilitating the agglomeration of innovation activities in urban peripheries.

In Model 2, we include both the key explanatory and control variables. The signs and statistical significance of the coefficients of key explanatory variables remain unchanged. In addition, the coefficients of the two control variables are positive and statistically significant at the 1 percent level, suggesting that cities with higher per-capita GDP and population density are more likely to form innovation centers in urban peripheries. By replacing POLY_NUM with POLY_SHARE, Model 3 replicates the regression specification of Model 2 to test whether the impact of polycentric urban spatial structures is robust. The coefficient of POLY_SHARE is also positive and statistically significant at the 10 percent level.

In Models 4 and 5, we control for random effects rather than fixed effects to check the result robustness. All the variables' signs and statistical significance remain unchanged, suggesting that regression results based on fixed effect models still hold for random effect models.

In Models 6 through 9, we lag the independent variables with different periods to conduct further robustness checks. It is reassuring to see that the signs and statistical significance of the coefficients of POLY_NUM, DEVELOP_ZONE, and COLLEGE_TOWN remain unchanged across different regression specifications. Although the coefficients of HSR_STATION are only statistically significant when we use the variable's one- and two-period lags, their signs remain positive across all the regression specifications.

Overall, we can see that the likelihood of the emergence of peripheral innovation centers is positively related to the degree of polycentricity of a city's urban spatial structure, the number of a city's national-level development zones, and the existence of high-speed railway stations and college towns. The empirical results generally align with our hypotheses on the drivers of peripheral innovation. In the Chinese context, all these factors would facilitate the formation of agglomeration economies in urban peripheries, which is crucial for attracting innovation activities. For instance, to mitigate agglomeration diseconomies in urban cores, local governments usually pursue polycentric development by establishing development zones and college towns in peripheral areas. Additionally, an investigation of center location reveals that peripheral innovation centers in many Chinese cities have originated from science and technology parks or college towns, such as the Zhangjiang Science Park in Shanghai.

The Nature of Innovation in China's Urban Peripheries: Diversity, Complexity, and Connectivity

This section constructs three indicators to compare the diversity, complexity, and connectivity of innovation activities between core and peripheral innovation centers. In cases where a city has two or more innovation centers in its urban cores or peripheries, we combine the patents of innovation centers according to their locations. Specifically, we first use the Shannon–Wiener index (Shannon 1948), which generally reflects the diversity of species in a given community, to measure the diversity of innovation. The calculation of the index is expressed as follows:

$$SW = -\sum_{i=1}^{s} p_i * \ln(p_i) \tag{1}$$

where SW represents the Shannon–Wiener index of innovation activities, s is the number of patent classifications, and p_i represents the proportion of the number of patents belonging to classification i to the number of total patents. A higher SW value of suggests a higher level of diversity of innovation activities.

Table 5 shows the differences in the mean values of SW between core and peripheral innovation centers. To check the result robustness, we calculate the index based on the international patent classifications at the three-digit and four-digit level, respectively. In general, the mean values of SW for core centers are constantly higher than those for peripheral centers, suggesting that innovation activities in core centers are generally more diversified than those in peripheral ones. The paired t tests for the differences in the mean values of SW are statistically significant at the 5 percent level, confirming that innovation activities in peripheral centers are more specialized. Overall, this result aligns with our

Table 5. The differences in diversity of innovation activities between core and peripheral innovation centers, 2010 through 2018

Year	Mean values of the Shannon–Wiener index at the three-digit level			Mean values of the Shannon–Wiener index at the four-digit level		
	Core	Periphery	Difference	Core	Periphery	Difference
2010	3.575	3.260	0.315***	4.713	4.159	0.554***
2012	3.624	3.292	0.332***	4.772	4.259	0.513***
2014	3.562	3.268	0.294***	4.652	4.177	0.475***
2016	3.478	3.256	0.222***	4.535	4.175	0.360***
2018	3.623	3.534	0.099**	4.755	4.529	0.226***

**$p < 0.05$.
***$p < 0.01$.

theoretical expectation and resonates with the findings of other studies (Caragliu, de Dominicis, and de Groot 2016). Due to location disadvantages, innovation activities in urban peripheries often have to be more specialized to benefit from specialization externalities. In China, we can also observe that clusters of specific industries usually occur in development zones in urban peripheries (Miao and Phelps 2022).

We then investigate whether the technological complexity of innovation activities in peripheral innovation centers is significantly lower on average compared to those in core innovation centers. In this context, technological complexity refers to the level of intricacy and sophistication involved in producing and applying technologies within a given city. To that end, we follow the approach of existing studies that adopts the method of reflections to calculate the complexity of technologies (Balland et al. 2020; Y. Li and Rigby 2023). First, we calculate the location quotient for each technology (represented by a four-digit international patent classification) in each Chinese city. If the location quotient is greater than or equal to one, we consider that this city has a revealed technological advantage (RTA) in that technology, assigning a value of one; otherwise, the value is zero. We then construct a bipartite network connecting cities to technologies, represented as a 286×629 matrix $\mathbf{M}$ where the binary values of RTA are displayed. We further row-standardize matrix $\mathbf{M}$ and its transpose $\mathbf{M}^T$ to compute their product $\mathbf{C} = \mathbf{M}^T \times \mathbf{M}$. The technological complexity values for all 629 four-digit technologies are derived from the second eigenvector of the square matrix $\mathbf{C}$. To test the robustness of this approach, we also calculate technological complexity at the three-digit level. Importantly, we calculate the complexity of technologies through the study period to ensure that the differences between core and peripheral innovation centers are not affected by fluctuations in the complexity of technologies across two-year periods. The technological complexity of innovation activities in core and peripheral innovation centers for each city is then calculated as follows:

$$TC = \frac{\sum_{i=1}^{s} n_i * c_i}{N} \quad (2)$$

where TC represents the technological complexity of innovation activities in core or peripheral innovation centers, s is the number of patent classifications, n_i represents the number of patents belonging to classification i, c_i is the complexity of patent classification i, and N is the total number of patents in core or peripheral innovation centers. By definition, TC is essentially the weighted average of the technological complexity of different patent classifications. A higher value of TC suggests a higher level of technological complexity.

Table 6 shows the mean values of TC of innovation activities by location and year, each of which is calculated at the three-digit and four-digit levels, respectively. Overall, we can see that the technological complexity of innovation activities in core innovation centers is higher on average than that in peripheral innovation centers. Moreover, the paired t tests for the differences in the mean values of technological complexity between core and peripheral innovation centers are statistically significant at the 10 percent level most of the time except for 2010. Suppose we regard technologies with higher levels of complexity as more original and radical. In that case, this result supports the argument that innovation activities in urban cores are generally more

Table 6. The differences in technological complexity of innovation activities between core and peripheral innovation centers, 2010 through 2018

Year	Mean values of technological complexity at the three-digit level			Median values of technological complexity at the four-digit level		
	Core	Periphery	Difference	Core	Periphery	Difference
2010	42.602	40.922	1.680	53.128	51.927	1.201
2012	40.647	38.234	2.413*	51.824	50.109	1.715**
2014	39.081	35.245	3.836***	50.636	48.118	2.518***
2016	37.718	35.021	2.696***	49.724	48.093	1.631***
2018	37.975	35.714	2.261***	49.919	48.455	1.464***

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

inclined to create entirely new innovations because of related variety and diversification externalities in the context of urban cores (Boschma, Eriksson, and Lindgren 2009). Shearmur and Doloreux (2016) also argued that adaptive or imitative (i.e., less radical) innovations usually occur in peripheral areas where smaller and early-stage firms are overrepresented.

Finally, we investigate the connectivity differences in innovation activities between core and peripheral centers. Here, the connectivity of innovation activities is defined as the extent to which innovations are achieved through external collaboration. Because copatents can partly reflect such collaboration, we first count the number of copatents in each city's core and peripheral innovation centers, respectively. Furthermore, we distinguish whether these copatents are achieved through within-city or intercity collaboration. To this end, we use the fractional counting method to aggregate the times of connectivity at the city level (Y. Li and Phelps 2018). Specifically, each cooccurrence of a pair of applicants is divided by the total number of applicant pairs for each copatent. To calculate the within-city and intercity connectivity, each cooccurrence is aggregated to the city level by judging whether two applicants are from the same city. In doing so, the sum of within-city and intercity connectivity is the total number of copatents for each city. Because patents only contain the address information of their first applicants, we need to search the address information of 98,738 applicants for a total of 383,849 copatents. Of course, we can directly obtain the address information of those applicants who have applied for patents as the first or sole applicant. The number of this type of applicant is 40,126, accounting for 40.6 percent of the total applicants without address information contained in patents. We manually search address information for the remaining 58,612 applicants, ensuring the identification of different collaboration types as often as possible. After excluding copatents associated with applicants whose addresses cannot be identified, we finally obtained collaboration information for 347,776 copatents, accounting for 90.6 percent of all the copatents.

For each Chinese city's core and peripheral innovation centers, we calculate two indicators based on the detailed information of copatents. One is the share of copatents to all patents, and the other is the share of within-city copatents to all copatents. Whereas the former indicator reflects the extent to which innovation activities are involved with collaboration, the latter indicates the extent to which within-city collaboration accounts for all collaboration. Table 7 compares the differences in the mean values of the two indicators between core and peripheral innovation centers. Obviously, the mean values of the share of copatents to all patents are between 4 percent and 10 percent, suggesting that innovation activities in these innovation centers on average rely to some extent on external collaboration. The differences between core and peripheral innovation centers have fluctuated signs, however, and are only weakly significant in 2010 and 2018. In contrast, the paired *t* tests for the differences in the mean values of the share of within-city copatents to all copatents over the years are all statistically significant at the 10 percent level, suggesting that innovation activities in core centers are more inclined to involve within-city collaboration than those in peripheral centers. In other words, innovation

Table 7. The differences in connectivity of innovation activities between core and peripheral innovation centers, 2010 through 2018

Year	Mean values of the share of copatents to all patents			Mean values of the share of within-city copatents to all copatents		
	Core	Periphery	Difference	Core	Periphery	Difference
2010	0.059	0.103	−0.044*	0.520	0.389	0.131**
2012	0.060	0.075	−0.015	0.446	0.309	0.137***
2014	0.049	0.044	0.005	0.407	0.341	0.067*
2016	0.049	0.050	−0.001	0.331	0.283	0.048*
2018	0.054	0.038	0.016**	0.364	0.308	0.056**

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

activities in peripheral innovation centers could rely more on intercity collaboration. Overall, the result partly corroborates the findings of some existing studies (Fitjar and Rodríguez-Pose 2011; Glückler 2014; Grillitsch and Nilsson 2015; Martinus 2018). For instance, Fitjar and Rodríguez-Pose (2011) showed that the success of southwest Norway as a remote but innovative region in Norway mainly lies in the strong connections of its firms to international innovation networks.

Conclusions

Although existing studies have examined patterns and processes of geographically peripheral innovation at the interregional and interurban scales, there remains a dearth of empirical findings and analysis of peripheral innovation at the intraurban scale. This article provides extensive and robust empirical evidence of the rise of peripheral innovation across Chinese urban areas, highlighted by an increasing number of cities in China with at least one peripheral innovation center and a growing share of innovation activities occurring in these areas. These findings are striking given the built-in urban bias of the patent data used here to uncover these patterns. Furthermore, our empirical findings suggest that four critical aspects of governmental intervention—planning for polycentric urban spatial structures, establishing development zones, constructing high-speed railway stations, and creating college towns—play significant roles in promoting innovation in urban peripheries. Finally, compared to innovation activities in urban cores, those in urban peripheries are found to be more specialized, less technologically complex, and more reliant on intercity collaboration.

As some of the first comprehensive evidence that the "Promethean fire" of innovation burns in the peripheries of urban areas, this article has significant implications for urban-economic theory. Commentary has long emphasized that the cores of the largest and most diverse urban economies incubate new but then shed mature industries or sterile divisions of labor to urban peripheries or smaller free-standing cities (Jacobs 1969). As a consequence, though, urban peripheries have rarely been considered to offer the sorts of agglomeration economies that are said to drive innovation. Our findings suggest that urban economic and economic geographical theory should take this possibility more seriously and respond to urban peripheries as homes to distinct segments of the creative class and diverse innovation processes. To the extent that individual urban areas are microcosms of national economies, they could host diverse intraurban zones—including peripheral intraurban zones—where both Marshallian and Jacobian externalities along with associated knowledge production processes flourish. This perspective opens new avenues for urban planning and other policies to effectively support these innovation dynamics.

In the broadest terms, our findings indicate the valuable contribution that economic geographical analysis can make to adjacent (sub)disciplines such as urban geography, urban planning, and urban sociology. Notable are debates regarding the need for urban theory to move beyond "methodological cityism" (Brenner 2014) and to rethink urban theory from the "outside in" (Keil 2014). The independence and national connectivity of outer suburban economies, as concentrations of corporate head offices, research and development facilities, and locales for new enterprise formation, have been apparent for some time (Muller 1997; Renski 2008). The evidence presented in this article of the extent of urban peripheral knowledge production, but also its lower technological complexity and different geographical sources of knowledge, paint a picture not of homogeneous urban peripheral sprawl but of intraurban differentiation involving not only the presence of "specialized-trading places" (Bogart 2006) but also variety in their social, political, and economic trajectories of development (Phelps and Wood 2011; Ohashi and Phelps 2021).

Our findings also point toward future avenues of related conceptual and empirical research regarding the social composition and physical form and amenity of these intraurban homes of innovation. First, further investigation is needed to ascertain the (ir)relevance of traditional infrastructural investments to the promotion of urban creativity and innovation (Florida 2014). Our findings indicate they remain important in the Chinese context and extend into questions of how housing provision and affordability plays into intraurban patterns of knowledge economy labor market formation and associated innovation (Miao 2017). Second, an understanding of how innovation differs from urban core to periphery and its basis in physical form could greatly aid an understanding not only of the drivers of innovation but also the development of improved (sub)urban planning, design, and development models. The present and future challenges of the physical retrofit of suburbs internationally (Dunham-Jones and Williamson 2011) are also important for understanding the economic potential of urban peripheries. The microfoundations of agglomeration (Duranton and Puga 2004) are related to intraurban variations in (sub)urban morphology—density of development, street networks and accessibility, land-use mix, and the like. It is unclear, though, whether and to what extent urban peripheral innovation is associated with those suburban employment nodes most amenable to retrofit (Day et al. 2022) or is dispersed more broadly in ways that might elude policy pertaining to urban form. In this regard, underlying local economic labor market fundamentals could yet prove more important levers for policy to operate on than architectural design or urban planning.

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Note

1. Spatial units are considered neighbors if they share a common border under the criterion of Rook contiguity or if they share a border or a vertex under the criterion of Queen contiguity.

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