# The impact of biopharmaceutical industrial parks on pharmaceutical innovation in China

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## Abstract

Pharmaceutical innovation plays a pivotal role in improving human health. While prior research has examined the effects of market demand on drug innovation, evidence on whether industrial policy can stimulate pharmaceutical innovation remains limited. This paper investigates the impact of biopharmaceutical industrial parks on drug innovation in China. We construct a staggered difference-in-differences framework, exploiting variation in the timing of park establishment across cities to estimate causal effects on innovation outcomes. The establishment of biopharmaceutical industrial parks significantly increases the number of invention patents for both biologic and chemical drugs. Regarding mechanisms, the establishment of biopharmaceutical industrial parks led to an increase in the number of innovative firms and expanded the incidence and volume of government-backed venture capital financing. Regarding aggregate innovation, it is associated with a reduction in the number of patents in non-drug fields within the same city, but no reduction in drug-related patents in other cities within the same province. Lastly, we find suggestive evidence that biopharmaceutical industrial parks significantly increased development activity for biologic drugs, but had no comparable effect on chemical drugs. These findings point to the mixed effectiveness of place-based industrial policy in fostering drug innovation.



Key words: industrial policy; drug innovation; government guidance funds.

## INTRODUCTION

Pharmaceutical innovation can play a critical role in enhancing human health and longevity. However, the process of developing new drugs is highly costly, inherently uncertain, characterized by irregular scientific breakthroughs and unpredictable timelines (Petrova, 2013; Chandra et al., 2024). A substantial body of theoretical and empirical research suggests that expansions in expected market size can stimulate private-sector innovation efforts in healthcare (Acemoglu and Linn, 2004; Blume-Kohout and Sood, 2013; Agha et al., 2022; Zhang and Nie, 2021; Clemens, 2013; Dranove et al., 2020, Finkelstein, 2004; Kalcheva et al., 2018). Yet in developing countries, where consumer purchasing power remains limited, market incentives alone may be insufficient to induce pharmaceutical firms to invest adequately in research and development (Kremer, 2002; Lichtenberg, 2005).

When innovation is inefficiently underprovided by private markets, there is a potential role for government intervention to enhance efficiency (Bryan et al., 2021). Conceptually, governments can intervene by either reducing the costs of research or increasing the expected revenues from innovation. Prior studies have demonstrated that policy instruments aimed at lowering the effective costs of R&D, such as tax credits (McCutchen, 1993; Oliver et al., 2024), tax deductions for R&D expenditures (Mansfield, 1986), and targeted incentives for clinical trials (Yin, 2008), are effective in promoting innovation. Public funding for basic scientific research has also been found to play a significant role in fostering innovation (Ward and Dranove, 1995; Toole, 2012; Blume-Kohout and Sood, 2013; Agarwal and Gaule, 2022).

Beyond targeted fiscal incentives, broader industrial strategies, such as place-based initiatives that provide land and infrastructure subsidies, tax credits, and government-backed venture capital, may also play a critical role in promoting pharmaceutical innovation, particularly in settings where market failures are pronounced. A growing body of empirical work has examined place-based policies in recent years (e.g. Lu et al., 2019; Devereux et al, 2007), evidence on their effectiveness in inducing high-cost, high-risk innovation activities, such as drug development, remains limited. The challenges of applying place-based policies to

pharmaceutical innovation are distinct from their application to traditional manufacturing sectors, which were the original focus of such strategies in early years of economic reform in China (Li and Branstetter, 2024). In highly uncertain fields such as pharmaceuticals, informational asymmetries between firms and policymakers can give rise to both moral hazard and adverse selection (Kremer, 2002). Moral hazard arises because policymakers cannot perfectly monitor recipients of policy support. Adverse selection occurs because researchers possess more information than policymakers about the true likelihood of success of their projects, while politicians often lack the expertise to evaluate which research proposals or disease targets are most promising (Kremer, 2002).

Hence, it remains unclear whether industrial policies such as place-based initiatives can effectively promote innovation. This paper examines the impact of biopharmaceutical industrial parks on pharmaceutical innovation in China. Biopharmaceutical industrial parks offer a bundle of explicit policy supports, including negotiated land and infrastructure subsidies, tax credits, and government-backed venture capital. In addition to these direct benefits, the concentration of firms and institutions within the parks facilitates the aggregation of skilled talent and the development of upstream and downstream supply chains. While many parks are established within existing national, provincial, and municipal industrial zones, some are created as entirely new developments (Zhao and Xu, 2021). Due to the absence of officially compiled records documenting the establishment year of biopharmaceutical industrial parks, we extract this information from city-level annual government work reports. Out of 286 cities in China, we identify 175 that established biopharmaceutical industrial parks between 2003 and 2020. We construct a multiple difference-in-differences framework, exploiting variation in the timing of biopharmaceutical park establishment across cities to estimate causal effects on innovation outcomes. Our specification includes city fixed effects to control for time-invariant differences across cities and province-by-year fixed effects to absorb unobserved shocks that vary across provinces over time, such as region-specific economic trends or policy shifts. We further control for a rich set of city-year level covariates to account for observable

time-varying characteristics that may influence both treatment assignment and innovation performance.

Using patent data, we find that the establishment of biopharmaceutical industrial parks led to an increase in the number of patents for both biologic and chemical drugs, while having no impact on the average number of citations those patents received. Second, to explore potential mechanisms, we find that industrial policies associated with the parks led to an increase in the number of newly established innovative firms and expanded both the incidence and volume of government guidance fund financing.

Third, we find that the establishment of biopharmaceutical industrial parks is associated with a reduction in the number of patents in non-drug fields within the same city—possibly because local resources and attention were redirected toward drug-related innovation. This suggests a new type of diversion effect not previously documented in the industrial policy literature. Importantly, this also implies that our results are unlikely to be driven by omitted variable bias, as we observe reallocation within cities rather than broad increases across all sectors of innovation. On the other hand, we do not observe a reduction in drug-related patents in other cities within the same province, indicating no evidence of geographic diversion effects within the biopharmaceutical sector.

Lastly, we find suggestive evidence that biopharmaceutical industrial parks significantly increased the development of new drug pipelines as measured by clinical trials for biologic drugs, but had no comparable effect on chemical drugs. In China, biologic drug firms appear to operate in a favorable demand and supply conditions: they face less generic competition, enjoy broader international market access, and are more often led by globally trained, research-oriented entrepreneurs. In contrast, chemical-drug firms tend to operate in saturated, cost-competitive markets and possess weaker R&D capabilities. These differential findings highlight the need for further research to identify market conditions that can enable place-based interventions to enable innovation in high-risk, high-investment sectors.

Overall, our findings reveal a nuanced and mixed picture of the impact of biopharmaceutical industrial parks on pharmaceutical innovation, characterized by

increases in patent quantity but not average citations per patent, trade-offs in innovation across sectors within cities, and heterogeneous effects by drug type. Together, these results help explain the recent surge in biologic drug pipelines in China and offer important lessons for other middle-income economies seeking to stimulate innovation in the life sciences.

This paper advances four strands of research. First, in developed countries, policy instruments aimed at lowering the effective costs of R&D—such as tax credits (McCutchen, 1993; Oliver et al., 2024), tax deductions for R&D expenditures (Mansfield, 1986), and tax incentives for clinical trial activities (Yin, 2008)—have been shown to significantly increase private-sector innovation. For example, Yin (2008) finds that the Orphan Drug Act (ODA), which provided tax incentives for rare disease drug development, led to a significant and sustained increase in new clinical trials, particularly for more prevalent rare diseases. In addition, public funding of basic scientific research has been demonstrated to spur downstream pharmaceutical innovation (Ward and Dranove, 1995; Kalcheva et al., 2018; Agarwal and Gaule, 2022). However, existing evidence primarily draws on advanced economies characterized by strong market incentives, robust intellectual property protection, and well-established regulatory institutions. Our paper extends this literature by focusing on place-based initiatives that bundle multiple forms of policy support and by providing new evidence from a middle-income country context characterized by weaker market incentives and price regulation.

Second, our study contributes to the growing literature on the efficacy of placed-based industrial policy (Lu et al., 2019; Wang, 2014; Zheng et al., 2017; Tian and Xu, 2022; Lu et al., 2023; Fang et al., 2024; Alder et al., 2016). By design, place-based policies can influence the amount of economic activity through agglomeration effects and human capital spillovers (Combes and Gobillon, 2015; Glaeser and Gottlieb, 2008). Existing research has primarily focused on outcomes such as foreign direct investment (Wang, 2014), firm productivity (Lu et al., 2019; Fang et al., 2024), total factor productivity growth (Alder et al., 2016; Wang, 2014; Zheng et al., 2017), output (Lu et al., 2019), wages (Lu et al., 2019; Wang, 2014), employment (Lu et al.,

2019; Zheng et al., 2017), and human capital (Lu et al., 2023). In contrast, relatively few studies examine the impact of industrial policy on innovation. Tian and Xu (2022) find that national high-tech zones positively affect local innovation output, as measured by patent counts, forward citations, and entrepreneurial activity. However, their paper do not distinguish between different types of innovation, and hence we still know relatively little about the effectiveness of industrial policy in promoting innovation in high-risk, capital-intensive sectors such as pharmaceuticals. In addition, our analysis highlights a key mechanism—government guidance fund investment—that has received limited attention in the existing literature on place-based industrial policy.

Third, this paper contributes to the broader literature on technological progress in emerging markets like China. Prior studies have explored China's innovation trajectory through various lenses, including rising wages and expanding domestic demand (Wei et al., 2017), international trade integration (Shu and Steinwender, 2019), human-capital accumulation (Kong et al., 2022), intellectual-property protection (Fang, 2017), institutional change (Rong, 2017), and wide-ranging industrial-policy instruments (Fang et al., 2025; Tian and Xu, 2022; König et al., 2022; Li et al., 2022). By contrast, the pharmaceutical sector has received surprisingly limited empirical attention, despite extensive media coverage and drug-review commentary on the sharp rise in global drug development activity involving Chinese firms (Li et al., 2022). Only recently have scholars begun to examine this domain. Jia (2023) shows that expedited drug-approval timelines stimulate innovation in drug development as measured by development pipelines, while Zhang and Nie (2021) find that the expansion of public health insurance boosts pharmaceutical patenting. Yet most existing work centers on regulatory reforms and other demand-side mechanisms. Our paper fills this gap by focusing on a supply-side institutional mechanism.

Fourth, this paper contributes to the broader literature on the mixed outcomes of industrial policy. Economic theory offers contrasting predictions regarding the effectiveness of such interventions. On the one hand, industrial policy can mitigate market failures or generate positive externalities through mechanisms such as

agglomeration economies (Kline and Moretti, 2014a). On the other hand, critics argue that it risks distorting resource allocation and supporting inefficient firms (Juhasz et al., 2023; Glaeser and Gottlieb, 2008), and therefore the success of industrial policies can be limited or mixed. Empirically, studies have documented that industrial policy often increases the quantity of innovation, but sometimes has limited impact on quality as measured by citations (Sun et al., 2021). Moreover, the literature highlights trade-offs: while targeted support can boost innovation in specific sectors or locations, it may also divert resources from other areas (Kline and Moretti, 2014b). The effectiveness of industrial policy also appears to be context-dependent, shaped by firm capabilities, market structures, and supply-side constraints (Barwick et al., 2019; Kalcheva et al., 2018). By systematically identifying and demonstrating these three interrelated patterns within a single empirical setting, our study advances the literature by offering a more nuanced understanding of the trade-offs, unintended consequences, and sectoral heterogeneity that condition the success or failure of innovation-focused industrial policy interventions.

## INSTITUTIONAL DETAILS

### China's Strategic Focus on Drug Industry

The Chinese government has identified the biopharmaceutical industry as one of the most strategically important sectors since the early 2000s (The State Council, 2015; The State Council, 2006). This recognition reflects the industry's multifaceted potential to advance critical national objectives. First, the development of a robust domestic pharmaceutical sector is essential for improving public health outcomes and ensuring equitable access to essential medicines. Second, it reduces China's reliance on imported drugs, which are often expensive and subject to supply chain risks. Third, the biopharmaceutical industry is characterized by high R&D intensity, substantial intellectual property content, making it a promising engine of high-value, innovation-driven economic growth. Promoting this industry therefore aligns with broader national goals of industrial upgrading, technological self-sufficiency, and long-run productivity growth (The State Council, 2006).

Recognizing its strategic value, the Chinese central government began actively promoting the development of the biopharmaceutical sector in the early 2000s, with significant policy signals articulated in the 11th Five-Year Plan (2006–2010) (The State Council, 2006). A key subdocument, the 11th Five-Year Plan for the Development of the Bioindustry, marked the first time that China formally designated the bioindustry as a strategic sector within its national economic and social development framework. Since then, a series of high-level policy documents—including the Made in China 2025 strategy and the Healthy China 2030 blueprint—have explicitly prioritized the biopharmaceutical sector as a key area for industrial upgrading, innovation, and national self-reliance (The State Council, 2015; The State Council, 2016).

In China's administrative system, formal policy documents serve as key mechanisms for articulating national priorities and triggering implementation at lower levels of government (Wang, 2024; Fang, 2025). Their issuance often shape resource allocation and bureaucratic incentives. Under China's "tournament-style" system of cadre evaluation, local officials are rewarded for initiatives that closely align with central policy priorities (Zhou, 2007). While industrial policies usually leave local governments ample room for discretion, after the biopharmaceutical industry was designated a strategic sector, local governments responded with tangible implementation efforts, although the timing and intensity of these responses varied by locality.

**Biopharmaceutical Industrial Parks**

One of the important vehicles through which local officials have implemented central directives is the establishment of dedicated industrial parks (Fang, 2025). These parks serve as institutional platforms for directing land, capital, and resources toward sector-specific development. These parks may be located within pre-existing zones to leverage shared infrastructure and administrative capacity, or may be developed in new areas when existing sites face land constraints. They offer both physical infrastructure and a policy environment conducive to innovation. They also provide the bureaucratic scaffolding necessary to implement targeted instruments

such as milestone-based subsidies, tax credits, and expedited regulatory approvals. Biopharmaceutical industrial parks that are within pre-existing zones include those in the Suzhou Industrial Park, Shanghai's Zhangjiang Hi-Tech Park, and Beijing's Zhongguancun Life Science Park. Independent biopharmaceutical industrial parks include Foshan Yundonghai Biopharmaceutical Industrial Park, the Jinan Qilu Pharmaceutical Biopharmaceutical Park, and the Chongqing International Biocity.

The creation of biopharmaceutical industrial parks is part of a broader utilization of place-based economic policy in China. Place-based policies are development strategies designed to stimulate growth in specific geographic areas by directing resources and administrative support to targeted localities (Neumark and Simpson, 2014; Austin et al., 2018). Since the beginning of the economic reform era, China has launched a series of place-based initiatives to accelerate regional development and industrial upgrading (Tian and Xu, 2022). These zones were initially designated with a specific industrial focus, such as advanced manufacturing, renewable energy, or digital technologies. However, their priorities often evolve over time in response to changes in national development strategy, industrial upgrading goals, or local comparative advantages. The industrial composition of national-level development zones in China has undergone significant restructuring over the past two decades. Initially dominated by labor-intensive manufacturing and traditional sectors, many of these zones have shifted toward high-tech, innovation-driven industries in response to evolving national strategies (Li and Branstetter, 2024; Wang, 2013; State Council, 2006).

Because many biopharmaceutical industrial parks are located within high-tech industrial development zones or economic and technological development zones (See Supplementary File A for explanations about these zones), it is useful to review the institutional features of these zones. They typically involve large-scale investments in land, infrastructure, and facilities designed to attract firms and foster local agglomeration economies (Wang, 2013). In addition to physical infrastructure, local governments offer a suite of policy supports. These include generous tax incentives (Wang, 2013; Alder et al., 2016), below-market land-use rights with flexible payment

terms (Zheng et al., 2017), and, in some cases, direct discounts of 25–35% on land-use fees (Lu, Wang & Zhu, 2019). Access to finance is also improved through collaboration with state-owned banks, which provide preferential loan terms and simplified approval processes (Wang, 2013; Alder et al., 2016). Many cities have also established government-backed venture capital and industrial development funds to support early-stage, high-potential firms, particularly those engaged in R&D (Tian & Xu, 2022). Administrative efficiency is another distinguishing feature. For example, in national high-tech zones, administrative staffing levels are significantly lower than in comparable districts, resulting in faster and more predictable approval processes. These streamlined procedures help reduce regulatory burdens and lower transaction costs for firms (Tian & Xu, 2022; Zheng et al., 2017).

Compared to traditional industrial parks, biopharmaceutical parks benefit from additional subsidies and policy instruments tailored to the sector's unique needs (Zhao and Xu, 2021). For example, some of the local governments provide milestone-based grants to firms that enter clinical trials, obtain FDA or EMA certification, or achieve key commercialization outcomes. Other targeted support includes one-time subsidies for technological breakthroughs, expedited approval processes for importing innovative drugs and medical devices, and prioritized access to pilot programs for medical innovation. Informed by an understanding of upstream and downstream supply chains, local governments also actively promote industrial clustering by attracting firms across the biopharmaceutical value chain.

**Differences in Chemical versus Biologic Drugs**

We distinguish between chemical and biologic drug patents, along with their corresponding development pipelines, due to several differences between these two drug types. First, the discovery process differs by these two types of drugs and hence the inherent risk differ (Lakdawalla, 2018; Petrova, 2013). The discovery processes for chemical (small-molecule) and biologic (large-molecule) drugs share a common staged structure but differ significantly in technological complexity, risk profile, and R&D investment intensity. Small-molecule drug discovery typically begins with identifying a disease-related biological mechanism, followed by screening and

optimizing chemical compounds to modulate that mechanism. These drugs are chemically synthesized, allowing for more standardized production and lower marginal costs once developed. In contrast, biologic drug discovery involves engineering molecules to interact with biological targets such as proteins or genes, using advanced biotechnological methods. Biologics are inherently more complex, resulting in higher production costs, greater regulatory uncertainty, and higher attrition rates throughout the R&D pipeline (Lakdawalla, 2018; Petrova, 2013).

Second, market opportunities differ significantly between these two types of drugs. In international markets, chemical drugs face intense competition. Mature regulatory frameworks, low production costs, and long-established multinational firms have created highly competitive markets for chemical drugs (Yina et al., 2023). By contrast, biologic drugs encounter relatively less competition globally. Many biologic therapies target emerging or specialized therapeutic areas, such as oncology and autoimmune diseases, where competition remains less saturated (Li et al., 2022). As a result, biologic drugs offer firms better market opportunities and possibility of premium pricing both domestically and internationally.

Firm characteristics differ substantially between the chemical and biologic drug sectors in China. Chemical drug firms are generally older, having grown during earlier phases of China's pharmaceutical industry expansion focused on generic production and chemical synthesis (Shen et al., 2025). Many of these firms have limited R&D capabilities and historically prioritized manufacturing efficiency and cost competitiveness over innovation. In contrast, firms specializing in biologic drugs are often newer entrants founded during the 2000s and 2010s, many led by entrepreneurs with many years of scientific and industry experience (Han et al., 2021; Xu et al., 2024). These biologic firms tend to emphasize research and development and often adopt business models geared toward international regulatory approval and global market participation.

## DATA AND RESEARCH DESIGN

### Establishment of Biopharmaceutical Industrial Parks

This paper leverages city-level government work reports from 2003 to 2020 to measure whether municipal governments announced the establishment of biopharmaceutical industrial parks in a given year. Government work reports are among the most authoritative and standardized official documents at the municipal level in China. Typically delivered in the first quarter of each year by the mayor to the local People's Congress and the Chinese People's Political Consultative Conference, these reports summarize the city's major socio-economic achievements over the past year and outline key policy priorities and development targets for the year ahead. Extracted policy commitments and development targets from these reports have been widely used in prior research to examine the effects of local policy priorities and targets on economic and social outcomes (Chen et al., 2018; Yu et al., 2019). Prior research has used policy documents issued governmental agencies to quantify the intensity and target of industrial policy (Mao et al., 2021; Juhasz et al., 2023; Fang et al., 2025). Government work reports are available for most cities from 2003 onward, enabling consistent tracking of policy announcements over time.

We intend to identify the establishment of biopharmaceutical industrial parks which would involve the planning, construction, or expansion of dedicated zones for pharmaceutical innovation and production. To systematically identify these policy announcements, we employed a multi-step approach. First, we used ChatGPT 4.0 and DeepSeek to generate a comprehensive list of keywords related to pharmaceuticals and industrial parks (see Supplementary File C Table 1 for details). Second, we extracted all municipal government work reports containing these keywords. Third, our team of co-authors and research assistants manually interpret and filter the relevant passages, distinguishing substantive policy actions—such as the establishment of biopharmaceutical industrial parks—from rhetorical references. Common phrases identified include statements such as "this year we will finish building a biopharmaceutical industrial park," "the construction of the biopharmaceutical industrial park will soon be completed," or "we will accelerate the development of the biopharmaceutical industrial park this year." All outputs are then

manually reviewed and verified by co-authors to ensure accuracy and consistency in coding.

We then aggregate the extracted information to the city-year level. A city is coded as treated (i.e., assigned a value of one) starting from the first year the establishment of a biopharmaceutical industrial park is mentioned in the report; all subsequent years are also coded as one, following a standard treatment-onset convention in difference-in-differences designs.

While it is possible that some municipal governments established biopharmaceutical industrial parks prior to 2003, such early cases are not captured in our dataset due to the lack of systematically archived reports before that year. However, it is more likely that most cities initiated these efforts after 2003, driven by shifts in national development strategy, particularly the increased emphasis on science and innovation-led growth outlined in the country's 11th Five-Year Plan (2006–2010). Earlier efforts had primarily focused on positioning China as a global manufacturing hub with a comparative advantage in the production of inexpensive commodity goods, rather than on innovation-driven production of technologically sophisticated products (Li and Branstetter, 2023).

We measure the establishment of biopharmaceutical industrial parks using city-level government work reports because there is no publicly available, centralized dataset that documents the exact timing and nature of these park establishments. While records on special economic zones (SEZs) indicates the year of establishment, the designated zone type, and the target industries—relying on these records presents significant limitations in our context. First, the industry focus listed in SEZ documentation covers multiple sectors simultaneously. For example, many of the tech including electronics, manufacturing, logistics, materials, and pharmaceuticals. As a result, it is difficult to determine whether the biopharmaceutical sector was prioritized in practice or merely mentioned as part of a general development agenda. Second, many national and provincial-level SEZs were designated in the 1990s or early 2000s, during a period when industrial policy primarily targeted manufacturing, export-oriented production, and traditional sectors. As such, even when pharmaceuticals

were included in SEZ mandates, most of the focus was on the production of generic drugs rather than on high-risk, innovation-intensive R&D. China shifted toward an innovation-driven development strategy under the 11th Five-Year Plan. Thus, during this period, biopharmaceutical industrial parks were developed to explicitly support novel drug development and were often accompanied by tailored policy instruments. Therefore, relying solely on SEZ records would introduce substantial measurement error. Lastly, commonly used SEZ datasets typically cover only national and provincial-level zones. However, a number of biopharmaceutical industrial parks have been launched at the municipal level. Relying solely on SEZ records would therefore result in incomplete coverage and would systematically omit an important subset of relevant policy interventions. By drawing from city-level government work reports, we are able to identify a more comprehensive and policy-relevant sample of biopharmaceutical park establishments.

**Measurement of Outcome Variables**

We conduct our analysis at the municipal-year level. Our main outcome of interest is the number of approved invention patent at the city level. Pharmaceutical R&D follows a structured but highly uncertain pipeline. After the discovery of a new compound, firms typically file for a patent well before clinical validation or market approval. Hence, patents have often been used in the literature as an early and observable indicator of innovative activity. While not all patents lead to commercially viable products, the decision to file a patent reflects a firm's intention to protect novel intellectual property and signals a commitment to further development (Gadiya, 2023).

Our patent record is obtained from the State Intellectual Property Office (SIPO). For each patent, we extract essential information including the patent title, application date, applicant name and address, and legal status indicators such as grant, renewal, and expiration dates. We restrict our sample to patents related to drugs and granted to firms, excluding those filed exclusively by individuals or academic institutions. Each granted patent is assigned to the municipality of the first-listed applicant. Furthermore, we limit the analysis to invention patents, excluding utility models and

design patents, which typically reflect lower levels of technological novelty. The final dataset spans the years 2003 to 2020.

To distinguish between biologic and chemical drugs, we classify patents using a combination of International Patent Classification (IPC) codes, keyword-based filters, and manual validation. We supplement the SIPO dataset with forward citation data obtained via web scraping from Google Patents. Forward citations are widely used in the innovation literature as a proxy for patent quality and technological impact.

**Control Variables**

We obtained information on GDP, population, employment, the ratio of government expenditure to revenue, GDP growth rate, the share of employment in agriculture and manufacturing, land area, and the shares of secondary and tertiary industries from the China City Statistical Yearbook, published by the National Bureau of Statistics of China. In addition, we extract information on the establishment year of the national or provincial special economic zones and information on whether the zone is a high-tech industrial development zones or economic and technological development zones and whether they are established at national or provincial level from the Bulletin List for the Official Boundaries of Chinese Industrial Parks published by Ministry of Land and Resources in China.

**Multiple Differences-in-differences Specification**

To understand the impact of the establishment of biopharmaceutical industrial parks on innovation activity, we construct a multiple differences-in-differences specification using the following specification, where

$$Outcomes_{it} = \beta_0 + \beta_t Treatment_{it} + X_{it} + \gamma_i + \omega_{jt} + e_{it} \quad (1)$$

where $Outcomes_{it}$ is the sum of patents measured at the city level at time t. To accommodate zero values in patent applications and citation counts, we apply a log transformation after adding one to each count. $Treatment_{it}$ equals one if the city announced the establishment of a new industrial park for the first time (and remains one thereafter), and zero otherwise.

Our identifying assumption is that the timing of biopharmaceutical industrial park establishment is uncorrelated with unobserved factors that simultaneously affect our

outcomes of interest. First, Figure 1 depicts the geographic rollout of biopharmaceutical industrial parks across Chinese cities from 2003 to 2020. Each shaded area in the figure corresponds to a city where a new park was established during a two to three year period. This temporal and spatial visualization illustrates both the progressive expansion of the program and the breadth of geographic coverage it achieved. A key feature revealed by Figure 1 is the relatively even distribution of parks across coastal and inland areas in each wave of implementation. Second, we control for a set of city-year level characteristics, including GDP, population, employment, the ratio of government expenditure to revenue, GDP growth rate, share of employment in agriculture, share of employment in manufacturing, land area, shares of secondary and tertiary industries. Third, we include city fixed effects to absorb time-invariant unobserved heterogeneity across cities. We incorporate province-by-year fixed effects, which allow us to control for all time-varying shocks at the provincial level. This approach ensures that identification is based solely on within-province, across-city variation in the timing of park establishment. Moreover, we explicitly control for the establishment of other industrial policy instruments, including the creation of national or provincial industrial zones and the types of zones, to isolate the independent contribution of biopharmaceutical park policies. Additionally, we conduct event-study analyses to test for pre-treatment trends in outcomes, providing a direct assessment of the parallel trends assumption and further reinforcing the credibility of our identification strategy.

## RESULTS

### Main Results

Table 1 presents a set of baseline covariates used as controls in the empirical analysis. These variables allow us to control for key dimensions of local development that may influence both the likelihood of park establishment and innovation outcomes.

Figure 2 presents event-study estimates of patenting outcomes disaggregated by drug type. The results show no discernible pre-treatment trends prior to the establishment of biopharmaceutical industrial parks, lending support to the validity of

the parallel trends assumption. Beginning approximately two to three years after park establishment, we observe a statistically significant increase in the number of overall patents, as well as in patents for both biologic and chemical drugs. This upward trajectory persists for at least a decade following the park's inception.

We address recent econometric concerns with staggered difference-in-differences research designs by showing robustness to the use of a variety of alternative estimators. We report OLS estimates under the homogeneous treatment effect assumption, as well as adjusted event study estimators that are robust to heterogeneous treatment effects over time or across groups in Figure 2 and Supplementary File C Table 4 (Borusyak et al., 2022; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; De Chaisemartin & D'Haultfoeuille).

Table 2 presents the corresponding regression estimates, quantifying the effects illustrated in Figure 2. Specifically, the establishment of a biopharmaceutical industrial park is associated with a 26.1% increase in total drug patents, a 24.7% increase in biologic drug patents, and a 26.8% increase in chemical drug patents, controlling for city fixed effects and province-year fixed effects. We added additional city-level covariates in Column 2. In Column 3, we further control for the timing of Special Economic Zones (SEZs), distinguishing by SEZ level (national versus provincial) and SEZ type (whether the zone is a high-tech industrial development zones or economic and technological development zones), to ensure that the observed effects are not confounded by broader industrial policy trends or earlier waves of spatial economic planning. The treatment effects remain stable and statistically significant across these specifications. The corresponding estimated effects are 25.4%, 23.9%, and 26.2%, respectively. In Supplementary Table 2, we examine patent outcomes using total patent applications. The results are consistent with those obtained using the number of approved patents.

Table 3 presents the regression results for average forward citations, a commonly used proxy for the quality and impact of innovation. We do not find any statistically significant effect of biopharmaceutical industrial park establishment on the average number of citations per patent. This suggests that while the parks stimulate an

increase in the quantity of patenting activity, they do not appear to influence the average technological significance or scientific impact of those patents as measured by citation counts. This result is consistent with previous findings that industrial policy interventions often increase the quantity of innovation outputs but have limited impact on innovation quality (Sun et al., 2021). One possible explanation is that parks may incentivize strategic patenting without necessarily fostering substantive technological breakthroughs. Alternatively, the support provided by parks may encourage marginal or incremental innovations and follow-on improvements, rather than enabling truly groundbreaking discoveries. It is also possible that in the pharmaceutical sector, many patents are often filed for strategic or regulatory purposes (Gurgula, 2020). In such cases, citation counts may not fully capture the economic or clinical significance of the underlying innovation.

In Supplementary File C Table 2, we examine total citations and find that park establishment increases total citations. This result aligns with our earlier findings: while there is an increase in the total number of patents, the average citation per patent remains unchanged.

**Robustness Tests**

To ensure the validity of our findings, we conduct a series of robustness checks. First, we estimate Poisson regressions to account for the count nature and skewed distribution of our dependent variables. As shown in Supplementary File C Table 3, the positive treatment effect on patent outcomes remains statistically significant under this specification.

Second, we assess the sensitivity of our results to variable selection procedures. To this end, we employ the post-double selection LASSO method (Belloni et al., 2014), which leverages machine learning to identify the most relevant control variables while mitigating the risk of overfitting. As reported in Supplementary File C Table 5, we include the original control variables along with their square and third polynomial terms. The estimated treatment effects remain robust after adjusting for the covariates selected through this procedure.

Third, we assess the robustness of our findings to sample composition by excluding municipalities directly administered by the central government—Beijing, Shanghai, Tianjin, and Chongqing—which may possess disproportionately large innovation systems or administrative privileges. In addition, we also conducted an analysis excluding Guangzhou and Suzhou which are known for their innovation capacity in drugs. Supplementary File C Table 6 shows that the treatment effects remain stable and statistically significant, suggesting that our results are not driven by these outlier cities.

Fourth, we control for concurrent innovation-related policies, the establishment of public service platforms. The establishment of public service platforms refers to the creation of shared facilities by the government or relevant agencies to support the development of the biopharmaceutical industry. These platforms provide services such as technology R&D, testing, and information consulting. Examples include large-scale biopharmaceutical testing centers, public laboratories, and similar facilities. As shown in Supplementary File C Table 7, our main findings remain robust. The coefficient on park establishment remains positive and significant, while the additional policy variables are generally insignificant or imprecisely estimated.

Fifth, we test the robustness of our results using an alternative outcome measure—per capita patenting. As shown in Supplementary File C Table 8, per capita invention patents also increase significantly after park establishment.

Lastly, in Supplementary File B Figure 1, we randomly assigned treatment years to cities and found that the resulting placebo estimates were centered around zero and statistically insignificant.

**Possible Mechanisms**

To better understand the mechanisms through which biopharmaceutical industrial parks influence innovation outcomes, we focus on two key channels: the entry of innovative firms and changes in venture capital investment. Drug R&D requires substantial upfront financing and is highly dependent on the availability of skilled human capital. Thus, an enabling environment that lowers barriers to entry and

mobilizes financial resources is likely to be critical in translating policy intent into measurable innovation outputs.

Table 4 presents evidence on firm dynamics, showing that the number of innovative firms—measured by the count of drug firms that have ever filed for patents—increases significantly following the establishment of a biopharmaceutical industrial park. We created this variable based on the patent dataset. This finding suggests that the parks may serve as effective incubators for innovative firms.

We use data from Zero2IPO, a leading venture capital and private equity service provider in China. Founded in 2000, Zero2IPO offers one of the most comprehensive commercial datasets on venture capital and private equity activity in the country (Beraja et al., 2024). While total VC investment does not show a statistically significant change following park establishment, we find a robust increase in government guidance fund capital, both in the number of investments and in total capital deployed. Government guidance funds are established by central and local governments in collaboration with private venture capital, aiming to invest in sectors prioritized by the state (Wei et al, 2023). Specifically, the number of government guidance fund deals increases by 4.5%, and investment funding grows by 11.5%. In contrast, there is no significant change in private-sector VC activity, suggesting that public capital is playing a central role in financing early-stage drug development, likely due to the high-risk, long-horizon nature of pharmaceutical R&D that private investors are more hesitant to fund.

**Aggregate Innovation: Effects on Other Innovation**

Because the city has to allocate substantial fiscal and policy resources to support the biopharmaceutical park—including land, infrastructure investment, subsidies, and administrative capacity—it may divert attention and funding away from other types of innovation. We examine this empirically in Supplemental File C Table 9 and find that the establishment of the park is correlated with a statistically significant reduction in other innovation activities, as measured by non-drug invention patents. This result helps rule out the possibility that our findings are driven by general upward trends in innovation or by omitted variables affecting all sectors equally.

In addition, it suggests that cities may face an innovation trade-off when adopting targeted industrial policies. This crowding-out effect underscores the importance of considering opportunity costs in the design and evaluation of place-based innovation policies.

**Aggregate Innovation: Creation versus Diversion Effects?**

It is possible that part of the observed increase in pharmaceutical innovation reflects firm relocation rather than net new firm creation (Glaeser and Gottlieb, 2008). To test this possibility, we follow the approach of Zhang (2014) and examine whether a city's pharmaceutical innovation outcomes are affected by the presence of a neighboring city that establishes a biopharmaceutical park. Specifically, we estimate a specification that includes an indicator for whether any city within the province initiated a park policy during the observation window. We find no statistically significant decline in pharmaceutical patenting in cities within the same province, suggesting that the observed innovation gains in treated cities are not merely the result of displacement from nearby locations (Supplementary File C Table 10). This finding supports the interpretation that the biopharmaceutical industrial parks generate net positive effects on innovation, rather than simply redistributing existing activity within a region.

**Additional Outcomes**

In addition to patent data, we collect information on clinical trials from the registry maintained by the National Medical Products Administration (NMPA). This registry includes detailed clinical trial application information on applicant names, application dates, purpose of clinical trials, drug types with all applications classified as either biologic or chemical drugs, and locations of application. We measure development activity using the aggregate number of clinical trials at the level.

A key limitation is that systematic drug development data on clinical trials are only available beginning in 2012. This creates a potential source of bias: a number of cities (66 out of the full sample) had already established biopharmaceutical industrial parks prior to 2012 and thus appear as treated throughout our entire sample window. These "always-treated" cities would cause bias because always-treated units lack a

pre-treatment period, so their observed outcomes cannot be cleanly used to estimate counterfactual trends. In addition, if their treatment effects evolve over time, they contaminate the control comparisons used to estimate effects for later-treated groups (Goodman-Bacon, 2021). To mitigate this concern, following Braghieri et al. (2022), we conduct our analysis on a restricted sample that excludes early-treated cities and includes only those cities that established biopharmaceutical industrial park in or after 2011. This approach ensures a valid comparison group and sufficient pre-treatment periods for identification. The corresponding results are presented in Supplemental File C Table 11. We find no statistically significant effect of biopharmaceutical industrial park establishment on total development activity. However, the estimated effect on biologic drug development activity is positive and statistically significant. The coefficient of 0.412 suggests that park establishment is associated with an average increase of 0.412 biologic development activity per city-year. In contrast, the effect on chemical drug development pipeline is positive but statistically insignificant, suggesting that the treatment effect is concentrated in biologics.

This progression along the R&D pipeline highlights that the parks not only stimulate early discovery (as reflected in patenting) but also facilitate clinical development for biologic drugs. In contrast, we do not observe statistically significant effects on chemical drug trials.

By separately analyzing biologic and chemical drugs, we find that industrial policy efforts are more effective in promoting innovation in the biologics sector. These additional findings provide a more nuanced understanding of the conditions under which policy interventions yield differential impacts. Kalcheva et al. (2018) emphasized the dual importance of demand-side triggers and a conducive supply-side environment. Chinese biologics firms appear to benefit from both dimensions. On the demand side, they face limited generic competition and enjoy broader global commercialization opportunities—such as licensing products to advanced markets like the United States. On the supply side, many biologics firms are younger, research-intensive ventures led by returnee scientists and internationally trained entrepreneurs. In contrast, chemical-drug firms operate in more mature and price-

competitive markets and often face constraints in global talent acquisition and innovation capacity.

## DISCUSSION AND CONCLUSION

China has made remarkable strides in biologics drug innovation in recent years. Major international outlets such as The Wall Street Journal and CNN have referred to these developments as "Deepseek moments" for China"s pharmaceutical sector, underscoring the industry's progress in drug innovation (Wainer, 2025; Chang, 2025). The findings of this paper help illuminate some of the institutional underpinnings of this growth.

Overall, we present a mixed assessment of industrial policy effects in the context of pharmaceutical innovation. Exploiting variation in the timing of park establishment across cities and drawing on a city-year panel, we estimate the causal impact of these place-based industrial policies on a range of pharmaceutical innovation outcomes. We find that park establishment leads to significant increases in invention patenting for overall drugs and for both biologic and chemical drugs, but have no impact on the number of forward citations of the patents.

Second, we find a significant reduction in non-pharmaceutical patenting within treated cities. This intra-jurisdictional reallocation may have resulted from the diversion of public resources, land allocation, and administrative capacity away from broader innovation efforts and toward the prioritized sector.

Third, we also explored the effects on new drug development activity clinical trials and found that the effects are concentrated in biologics, suggesting that the parks not only boost early-stage idea generation but also help translate promising discoveries into more advanced pipeline development in the biologic domain. This differential impact likely reflects the specific scientific, market, and institutional conditions under which such policies are implemented.

The mixed findings of industrial policy effects have important policy implications for middle-income countries seeking to stimulate innovation in the life sciences. Because biopharmaceutical industrial parks are predominantly subnational initiatives, they offer a transferable model for other countries facing similar challenges of

underinvestment in high-risk, capital-intensive R&D sectors. The findings also highlight the need for careful policy design: interventions should consider balance support for targeted sectors with the potential crowding-out of other innovative activities, and should account for sector-specific factors, such as market structures, to ensure that public investments translate into meaningful innovation gains.

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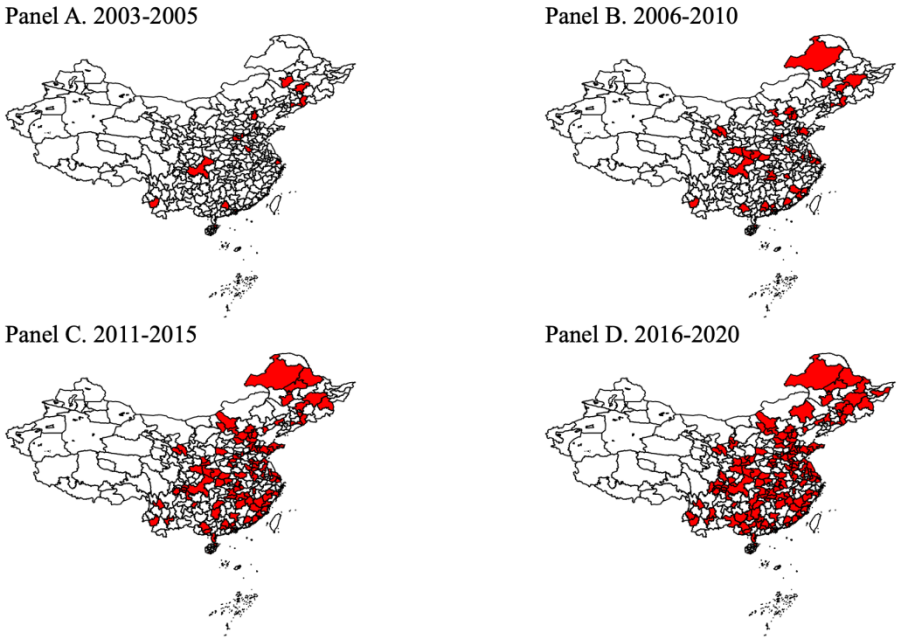
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## Figures and Tables

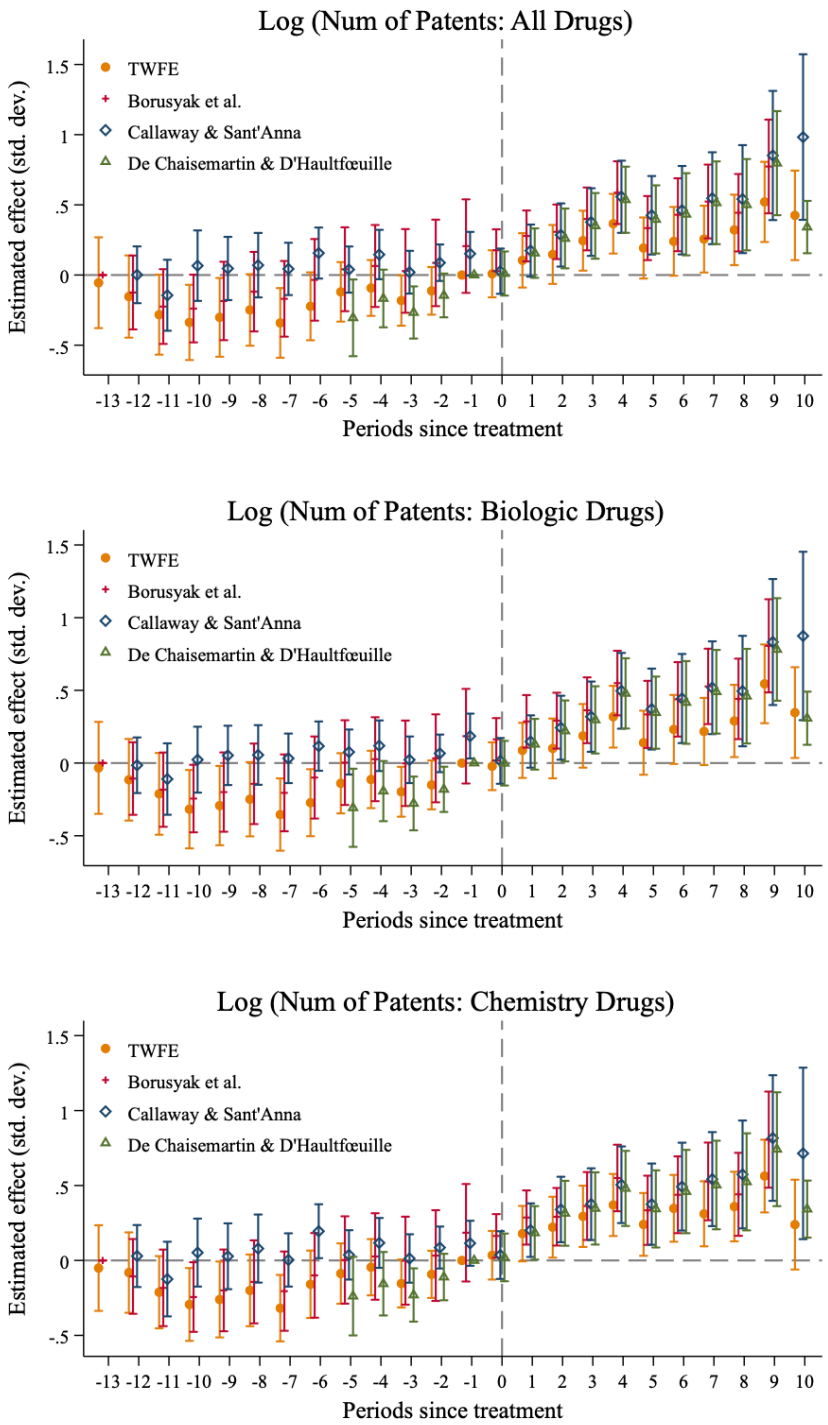
### Figures

**Figure 1. Spatial distribution of biopharmaceutical industrial parks**




*Notes:* The figure shows China's biopharmaceutical industrial parks established in the period of 2003–2005, 2006–2010, 2011–2015, and 2016–2020. Cities where new parks were established are highlighted in red.

**Figure 2. Event study analysis of patents**




*Note*: This figure presents event-study estimates for the drug patents using four different estimators: TWFE OLS (orange circles), Borusyak, Jaravel, and Spiess (2021) (red crosses), Callaway and Sant'Anna (2021) (blue diamonds), and De Chaisemartin and D'Haultfœuille (2020) (green triangles). The coefficients are plotted along with their corresponding 95% confidence intervals.

**Tables**

**Table 1. Descriptive Statistics**

| Variable Names | Mean | SD |
|---|---|---|
| Log GDP | 6.983 | 1.039 |
| Log population | 5.881 | 0.689 |
| Log employment | 3.480 | 0.783 |
| Ratio of government expenditure to revenue | 2.847 | 1.895 |
| GDP growth rate | 10.560 | 4.532 |
| Share of employment in agriculture | 2.877 | 6.729 |
| Share of employment in manufacturing | 43.375 | 14.194 |
| Log land area | 9.347 | 0.803 |
| Share of secondary industries | 0.467 | 0.111 |
| Share of tertiary industries | 0.400 | 0.099 |
| National economic and technological development zones | 0.353 | 0.478 |
| National high-tech industrial development zones | 0.333 | 0.471 |
| Provincial economic and technological development zones | 0.966 | 0.182 |
| Provincial high-tech industrial development zones | 0.271 | 0.444 |

*Note*: Information on GDP, population, employment, the ratio of government expenditure to revenue, GDP growth rate, the share of employment in agriculture and manufacturing, land area, and the shares of secondary and tertiary industries from the China City Statistical Yearbook are published by the National Bureau of Statistics of China. Development zones information are sourced from the Bulletin List for the Official Boundaries of Chinese Industrial Parks published by Ministry of Land and Resources in China. N=4365

**Table 2. Impact of biopharmaceutical industrial parks on patents**

| | **Panel A. Log (Num of Patents: All Drugs)** | | |
|---|---|---|---|
| Biopharmaceutical industrial parks | 0.261*** | 0.252*** | 0.254*** |
| | (0.071) | (0.062) | (0.061) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |
| | **Panel B. Log (Num of Patents: Biologic Drugs)** | | |
| Biopharmaceutical industrial parks | 0.247*** | 0.238*** | 0.239*** |
| | (0.070) | (0.061) | (0.060) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |
| | **Panel C. Log (Num of Patents: Chemical Drugs)** | | |
| Biopharmaceutical industrial parks | 0.268*** | 0.262*** | 0.262*** |
| | (0.062) | (0.055) | (0.053) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |

*Note*: All observations are at the city-year level. In Column 1, we included city fixed effects and province-year fixed effects. In Column 2, we added a set of rich city-year level covariates which include GDP, population, employment, the ratio of government expenditure to revenue, GDP growth rate, the share of employment in agriculture and manufacturing, land area, and the shares of secondary and tertiary industries. In Column 3, we additionally add dummies that indicated whether the zone is a high-tech industrial development zones or economic and technological development zones and whether they are established at national or provincial level. Robust standard errors clustered at the city level are reported in parenthesis. *$p < .10$; **$p < .05$; ***$p < .01$.

**Table 3. Impact of biopharmaceutical industrial parks on patent citations**

| | **Panel A. Log (Average Citations Per Patent: All Drugs)** | | |
|---|---|---|---|
| Biopharmaceutical industrial parks | -0.044 | -0.036 | -0.024 |
| | (0.042) | (0.042) | (0.041) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |
| | **Panel B. Log (Average Citations Per Patent: Biologic Drugs)** | | |
| Biopharmaceutical industrial parks | -0.045 | -0.036 | -0.026 |
| | (0.042) | (0.042) | (0.041) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |
| | **Panel C. Log (Average Citations Per Patent: Chemical Drugs)** | | |
| Biopharmaceutical industrial parks | 0.011 | 0.017 | 0.028 |
| | (0.041) | (0.041) | (0.040) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | N | Y | Y |
| SEZ controls | N | N | Y |
| *N* | 4,289 | 4,289 | 4,289 |

*Note*: All observations are at the city-year level. In Column 1, we included city fixed effects and province-year fixed effects. In Column 2, we added a set of rich city-year level covariates which include GDP, population, employment, the ratio of government expenditure to revenue, GDP growth rate, the share of employment in agriculture and manufacturing, land area, and the shares of secondary and tertiary industries. In Column 3, we additionally dummies that indicated whether the zone is a high-tech industrial development zones or economic and technological development zones and whether they are established at national or provincial level. Robust standard errors clustered at the city level are reported in parenthesis. *$p < .10$; **$p < .05$; ***$p < .01$.

**Table 4. Test for the mechanism: innovative firms**

| | Log (Number of Innovative Firms) | | |
|---|---|---|---|
| | **Innovative firms measured by patents related to biologic or chemical drugs** | **Innovative firms measured by patents related to biologic drugs** | **Innovative firms measured by patents related to chemical drugs** |
| Biopharmaceutical | 0.344*** | 0.330*** | 0.330*** |
| industrial parks | (0.079) | (0.076) | (0.071) |
| City FEs | Y | Y | Y |
| Province-year FEs | Y | Y | Y |
| City controls | Y | Y | Y |
| SEZ controls | Y | Y | Y |
| *N* | 4,289 | 4,289 | 4,289 |

*Note*: All observations are at the city-year level. In all regressions, we included the same set of controls used for Table 2 Column 3. Robust standard errors clustered at the city level are reported in parenthesis. *$p < .10$; **$p < .05$; ***$p < .01$.

**Table 5. Test for the mechanism: venture capital**

| | All Venture Capital | Government Guidance Fund | Private Venture Capital |
|---|---|---|---|
| | **Panel A. Log (Counts of VC investment)** | | |
| Biopharmaceutical industrial parks | 0.034 | 0.045*** | 0.006 |
| | (0.031) | (0.017) | (0.027) |
| Mean of dependent variables | 0.780 | 0.149 | 0.650 |
| City FEs | Y | Y | Y |
| Year FEs | Y | Y | Y |
| City controls | Y | Y | Y |
| SEZ controls | Y | Y | Y |
| *N* | 4,289 | 4,289 | 4,289 |
| | **Panel B. Log (Total amount of VC investment)** | | |
| Biopharmaceutical industrial parks | 0.077 | 0.115** | 0.034 |
| | (0.081) | (0.053) | (0.073) |
| Mean of dependent variables | 17.196 | 2.868 | 14.329 |
| City FEs | Y | Y | Y |
| Year FEs | Y | Y | Y |
| City controls | Y | Y | Y |
| SEZ controls | Y | Y | Y |
| *N* | 4,289 | 4,289 | 4,289 |

*Note*: All observations are at the city-year level. In all regressions, we included the same set of controls used for Table 2 Column 3. Robust standard errors clustered at the city level are reported in parenthesis. *$p < .10$; **$p < .05$; ***$p < .01$.