

REVIEW

State Restructuring and Urban Innovation Development in Post-reform China: Shanghai's Innovation Action in Review

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ABSTRACT

Given the ample evidences from present studies on national-level innovation policies evolution and mechanisms, this paper contributes to a city-level understanding towards innovation-related state restructuring, the consequent innovation policy change and its relational performance with urban development in post-reform Shanghai, China from an input-output perspective. It unfolds that state restructuring relinquishing state power to the market has revived non-government innovation activities and a synchronous, though a bit backward, firms-oriented transition towards innovation development in Shanghai throughout 1990s has been observed. Though scholars are reluctant to label the party-state in post-reform China as a developmental state due to dysfunctionality of state intervention in corporate sectors, in the field of technological upgrading, such top-down, elite driven and state-sponsored mode giving priority to innovation competitiveness well captures the developmental state model at local level, thus exhibits elements of local developmental state. Impacts of this restructuring and policy change are substantial, which can be observed in the soaring increase of science and technology expenditures and patents applications in Shanghai. Additional analysis further unveils that in most circumstances, innovation growth kept paces with urban development, yet its synergy with economic development and permanent residents is more significant than with other aspects.

1. Introduction

State restructuring, referring to the decentralization of state power to the local and the market in post-reform China, profoundly remolds the geography of institutions and induces multi-scalar reorganization of state power at both the central and local level^[1-3]. Interpreted in the

work written by Brenner, state restructuring is inseparable from space of neoliberalism wherein the organization of state is not pre-given^[4]. In other words, the state must cope with diverse array of mixed forces that technological progress is a significant one. Thus, it is not a surprise that the worldwide innovation fever resulting from state restructuring has witnessed an increasing state intervention

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at different geographical scales. While much literature on China's state restructuring has been preoccupied by its powerful effects on economic growth and urban transformation^[5-8], less is noted on how this profound reform steers and reshapes innovation development, development that has increasingly become the key force for economic transition and upgrading. In few studies touched upon this topic, their primary focus is at the macroscopic national or regional level, interrogating how policies and spaces have evolved under the innovation related restructuring^[1,9-11], whether innovation policies and its outputs in the cities synchronize those at the macro level and how they perform is less clear. We can simplify the urban-level innovation process as resulted from inno-state restructuring by which innovative activities are spatially evolved and resonant with local urban development. To enrich a city-level understanding towards innovation process against the backdrop of national state restructuring, this research interrogates how marketization of state power reshaped innovation landscapes and how related policy actions and urban development factors relate to urban innovation efficiency.

Shanghai has long been a progressive city as China's new, handy growth model^[12] and illustrates central state's intentions for "molded, managed" capitalism with its emerging planned-market. Being a trading port since Qing Dynasty, Shanghai developed alongside the rise of modern China and has gradually evolved to a solid industrial base epitomizing China's modern industrialization, with intense intervention and power struggle from upper level governments. In most up-to-date orientation from the central state, Shanghai, alongside Beijing and Shenzhen, is shouldered to lead innovation development in the coming years, and serves an ideal case to illustrate urban innovation development and efficiency under the macro technological policy transition.

2. Innovation Policy and State Restructuring in Post-reform China

In China, science and technology (S&T) development has long been a commitment from the top design. Before the well-known market-oriented reform, public research organizations (PROs) stood by government and state-owned enterprises (SOEs) exempted from market competition were the principal executors for R&D^[13]. A market-leaning innovative atmosphere arose in the 1978 National S&T Conference and was further ignited in 1985 that non-government R&D funding and technology activities appeared. In 1990s, the original PRO-centered innovation system had evolved firms-oriented, a shift fostering

firms' innovation capabilities, commercializing technology, and enhancing efficiency of the innovation system^[14,15]. Marketization pace has reached a peak during Zhu Rongji's premiership (1998-2003). Policy over S&T has been dissociated from heavy industry while natural and human scientific research was reiterated. Relaxation of state power to market has brought evidently less government intervention in high-tech sectors such as integrated circuit fabrication, nuclear power technology and civilian aircraft. But this doesn't mean that state support was no longer important. Instead, state has played a great role in launching and implementing key national innovation strategies. For instance, to implement the strategy of "revitalizing the Nation through Science and Education [*keji-ao xingguo*]", the state raised budgetary allocation for the Chinese Academy of Science, increased grants approved by the National Natural Science Foundation of China, and invested large amount of funds to higher education institutions^[9]. The state also insists on the open-door policy to allow foreign direct investment as a crucial channel for technology transfer and upgrading. To further integrate into the international market, the state paid more attention to intellectual property rights especially agreement on Trade-Related Aspects of Intellectual Property Rights^[10].

Unleashing the power to facilitate innovation development in China has boomed the debates on whether post-socialist Chinese state can be characterized as developmental state (DS) as technological upgrading and innovative capabilities are key to the DS model^[16-18]. Scholars working on DS point out that this model serves two main purposes: (1) to look beyond the American-Soviet comparison and (2) to connect interventionism with rapid economic growth happening anywhere in the world^[19]. In general, theory of capitalist developmental state was earliest originated from explaining the East Asia industrialization (particularly Japan and the Four Dragons) under an ideal type of an interventionist state that was neither socialist nor free-market in nature^[20]. In a capitalist developmental state, an "embedded autonomy" secures a social embeddedness to bureaucratic economic growth^[21]. As Ronald Dore noted, the Japanese don't believe in the invisible hand, so that state-guidance and intervention are placed in the centerpieces of the DS model^[22]. As a nationalist ideology prioritizing economic growth at the top of all the national affairs, the DS model also places the interests of the state over those of the individual, blurs the sphere between the public and private, pulses-on development as the most important legitimizing principle of the state, embraces plan rationality as opposed to market rationality, and selects autonomous technocratic, economic bureaucratic elites to serve the national interest^[23].

Noteworthy, as proclaims by Johnson, this plan-rational growth model does not mean to exclude any private forces. Instead, they are allied with the state technocracies to serve the national goals, especially the development of competitive industrial sectors.

Indeed, scholars comparing China's growth pathway to that of the capitalist developmental states in the named East Asian countries are reluctant to label the Chinese post-socialist party-state as a developmental state, especially before 2000s^[20]. In most cases, they tend to acknowledge that the operation of Chinese state, recognized by Castells as "state capitalism" or the "socialist market economy"^[24], exhibits similar characteristics to that of DS (e.g. intentionally steer economy towards innovation) but is not identical to its archetype^[25]. In innovation-related fields, China's main difference from the DS was found in the dysfunctionality, sometimes negative effects, of state intervention in the corporate sectors in the early days of reform^[18,26]. In other words, the early destatization was not contributing much to China's entrepreneurship, it is the spontaneously developed town and village enterprises that went across the rivers by feeling the stones did^[27,28]. This challenges the role and functions of the party-state in China's economic development. To many scholars, China's state restructuring characterized by dismantling of state power and fiscal decentralization had transformed local governments with strong developmental interest, formulating plans, attracting investment, and financing infrastructure to create economic miracles. Such developmental behaviors of local states were akin to those of its East Asian counterparts, and thus local developmental state (LDS). But as Zhu acknowledged, China's local state is a developmental state of its own kind^[29], which is empowered by central government with economic autonomy and bear more liability for local prosperity but remains politically at the command of upper level government^[28]. This can be verified in the strong control force of local government in the growth coalition formed by foreign, private and government sectors in urban redevelopment^[30], as well as efficient execution of upper level command during the COVID-19 pandemic^[31]. Yet, scholars also noticed that such developmental ideology did not always benefit the local. For instance, weak leverage of local government in guiding the market forces leads to the inferior and suboptimal built environment^[29]. Policy coordination thus is necessary to better serve local sustainable development.

In view of the previous research findings, this paper assumes that in the field of innovation development, local governments in Chinese city reflect elements of the DS model, thus LDS in nature. And, through the perspective

of policy evolution, this research further interrogates to what extent and in what aspect the LDS model capture the innovation evolution alongside the elapse of time, and how innovation outputs, under this evolution, relates to pros and cons of urban development in different time period. Shanghai pioneering in China's innovation strategy is selected as the case for a longitude study throughout 1985 to 2015 to generate insights for other cities. Diverse range of data such as patent records, archives, research such as published articles, statistical yearbooks, government working reports, local newspapers, and urban planning documents are broadly consulted.

3. Shanghai's Innovation in Action

3.1 Inputs from Local Government

"Shanghai has been the center of a vortex of economic change spreading from the city to engulf the rest of China, and the pattern of its development during the past century has been modern China in microcosm"^[32]

Shanghai's policy and inputs on innovation development generally synchronize those at the macro level and represent another microcosm of innovative China. The local's innovative boom not only demonstrates a competent government action towards innovation but also reveals an efficient allocation of central state's vision for a powerful nation of science and technology.

3.1.1 Policy Inputs on Innovation: Evolved Firm-centered, Open Sharing and State-market Hybrid

Since the first national S&T conference held in 1978, the role of Shanghai municipal government to foster innovation development has transited from a passive gatekeeper approving research projects and funding to an active planner making pro-innovation policies, organizing and coordinating macroscopic technological development. It showcases strong impetus to articulate the nation's marketization reform and visions for innovation and exhibits features of LDS in innovation policy making mainly in three aspects.

First, the government has made great efforts to steer non-state actors to be innovative and to release their innovation motives through policy initiatives and guidance for the national goals of innovative economy. In this regard, investment of science and technology is no longer purely government funded, but comes from diverse channels include NGOs, individuals and firms etc., in which firms evolved increasingly important in the local innovative boom. Specific measures include the effort to incent vitality of scientific and technical personnel, allows scientific

and technical staffs in the non-profit state supported R&D institutions to run their own companies for profit-making. Also, the main forces and preferential policies for technological progress have shifted from R&D institutions and universities to firms. By doing so, the government has opened up the enclosed innovation system and shaped it as market-oriented, firm-centered and political/industrial/academic/research-integrated. Second, the government has transited from providers of cheap labor and land absorbing foreign capital and technology, exemplified in the early established development zones (e.g. Minhang, Hongqiao, Caohejing), to pathfinders encouraging open sharing and nurturing local core- and high-tech firms, fundamentally practicing LDS that emphasizes indigenous impetus. At the national level, open door policy over S&T is amplified from usual communications, ordinary cooperation to joint development. Ideas of sharing are prioritized to chase the upper chain of R&D. In Shanghai, sharing part of the core technology should be a must when negotiating with foreign investors to settle. Also, in contrast to the traditional platform committed to serve narrow, specialized scientific research, technological service system has become more open sharing to foster high-technological clusters and new pillar industries, rather than merely focus on identifying technological potentials and transforming traditional industries. In such sense, Shanghai has been upgraded from a place transplanting advanced technologies from developed areas to an eco-system incubating up-to-date innovative ideas and nurturing new inventions. Third, innovation clusters are intentionally fostered and incorporated into urban spatial plans that are the regulatory product under a market economy. As the dragonhead in Yangtze River Delta, Shanghai got substantial policy supports from central government and formulated numerous planned for nurturing innovation activities. For instance, in the “22 opinions to promote Shanghai technology and innovation center”, six innovation clusters including Zhangjiang, Zizhu, Yangpu, Caohejing, Jiading and Lingang are spe-

cially proposed. In the newly approved Shanghai master plan (2017-2035), a stratified innovation spatial system is planned. There are also knowledge-intensive universities and research institutes (e.g. Tongji knowledge economic industrial circle in Yangpu) contributing to the basic R&D and incorporated into these plans. All these initiatives represent a hybrid approach involving state-market interactions.

3.1.2 Investment Inputs on Innovation: Diverse Funds Dominated by Local Finance

Innovation inputs comprised of R&D investment, financial expenditure, infrastructural initiatives, and government service supports etc. are revealed in this section and related to broader institutional and policy changes. It is found that local finance dominates the innovation investment, with main sources come from firms since 2000. In the meanwhile, foreign investments are minimum and decreasing whereas funds from the governments are considerable and grow. Among the three types of innovation research, basic research receives the least funding support and the most money goes to experimental development. Firms still are the main executive departments and very few executions are from universities. In general, R&D investment and its ratio to GDP have increased yearly since mid-1980s, from 462 million RMB, 0.99% in 1985, 767.3 million RMB, 1.6% in 2000, to 104.9 billion RMB, 3.7% in 2016. S&T expenditure of local financial increases from 2.49 million RMB in 1985, 10.08 million RMB in 2000, to 341.71 million RMB in 2016, but its ratio to the total fluctuated in recent years, decreasing to a low ebb of 4.59% in 2008, arriving at a peak 7.2% in 2009 and declining thereafter.

Infrastructural initiatives to buttress innovative activities are primarily natural science-based, investment in social and humanity is nil in most years and has been very few until recently. The most dazzling infrastructural initiative is the large-scale scientific facility which contrib-

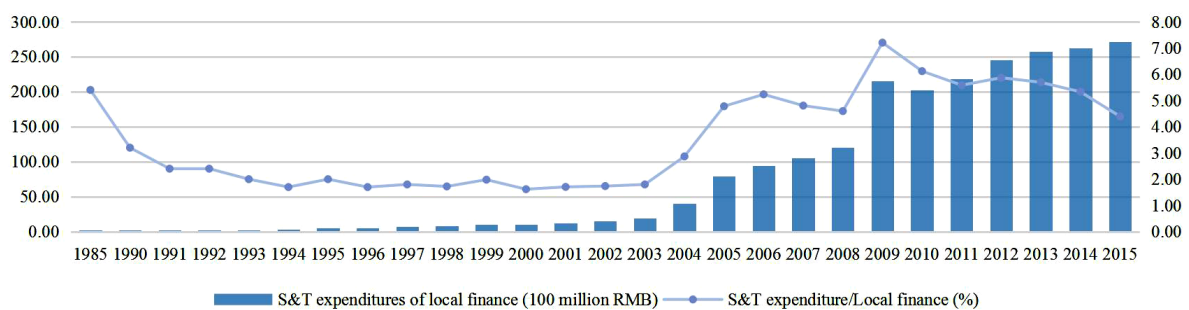


Figure 1. Financial expenditure on R&D and its ratio to local revenue

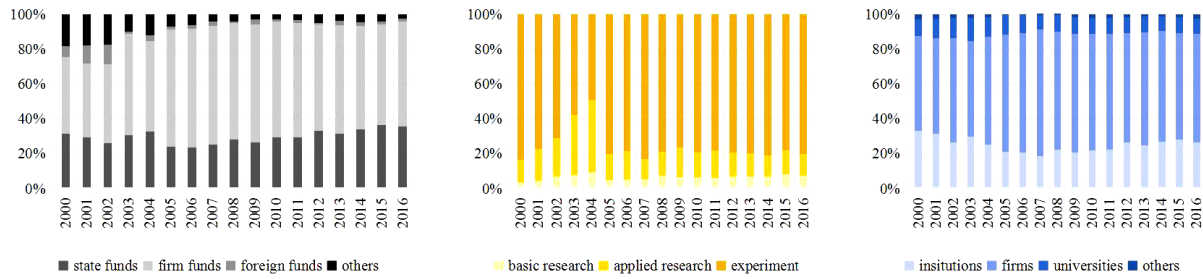


Figure 2. Sources of funds, types of innovation research and executive departments

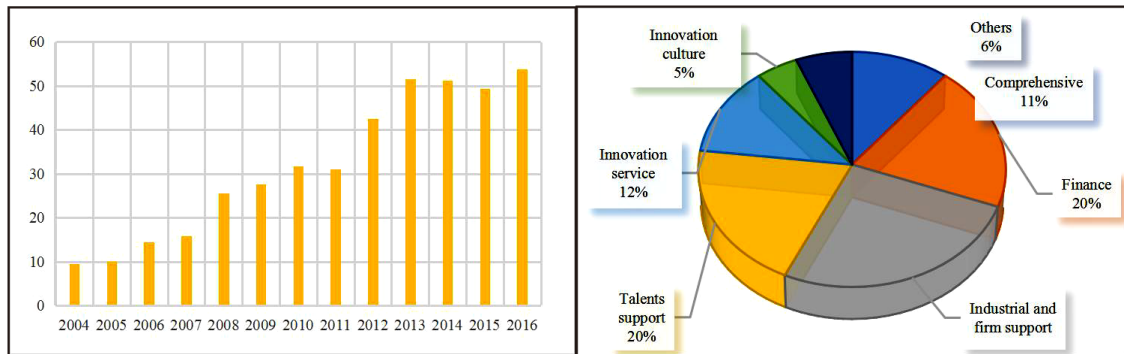


Figure 3. Natural science infrastructural investment and diverse government service supports

utes greatly to major innovations in Shanghai. Shanghai Synchrotron Radiation Facility (SSRF), National Center for Protein Science Shanghai and Submarine observation project are three topmost important large scale scientific facilities where most patents, scientific publications and new inventions come from. All these achievements are inseparable from government service support for innovation, which has undergone several stages for the past decades. From early to mid-2000s, advance intellectual property protection, commercialization of S&T, and financial investment rules on S&T enterprises were the main area of service support, protecting original innovation. Then, government had evolved to promote S&T finance and business service from mid to late 2000s, with the maturity of innovation policy system (marked by industrialization of high-tech) from late 2000s to mid-2010s, promoting commercial synergy with R&D. Since 2015 onwards, Shanghai’s innovation has entered a new stage with many of the policy and institutional designs implemented to help a sustained, self-innovated development pathway. For instance, the “Opinion of Shanghai Municipal Party Committee and Shanghai Municipal People’s Government on Accelerating the Construction of Globally Influential Science and Technology Center” and “Supporting Policies on Increasing Revenue Support to Accelerate the Construction of Globally Influential Science and Technology Center” were all promoted in 2015.

3.2 Outputs and Relational Aspects with Urban Development

3.2.1 Innovation Outputs: Evolved to Firm-dominated Pattern

Among the ways of measuring innovation outputs, this research deploys patent data which strongly correlated to R&D spending to showcase innovation intensity and knowledge production in Shanghai. Over 819,000 patent records applied from Shanghai since 1985 were identified from National Intellectual Property Administration. Each application records detailed information of patent type, application date, patent number, patent title, patent abstract, applicant, and applicant address with postcode. Though the initial 730 applications in 1985 were almost negligible, it signified a startup of Shanghai’s innovation development. And, the increase of absolute number of patent applications has been up to 12 times in the past 17 years, surging from around 9,000 in 2000 to around 110,000 in 2016. Classifying patent records by the nature of the applicant (individual, firm, university and research institute, and authority), it is identified that individuals had been dominated the applications in early times, accounting 40%-50% before 1998 and reaching the peak of 52.1% in 1993. In all the 28,000 records between 1985 and 1999, 42% were from the individuals. Applications from universities were not negligible, with average 15% in 1980s and

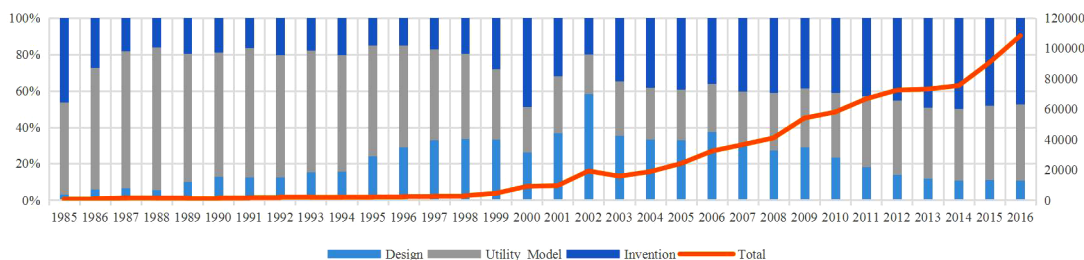


Figure 4. Three types of patents and growth trend by years (1985-2016)

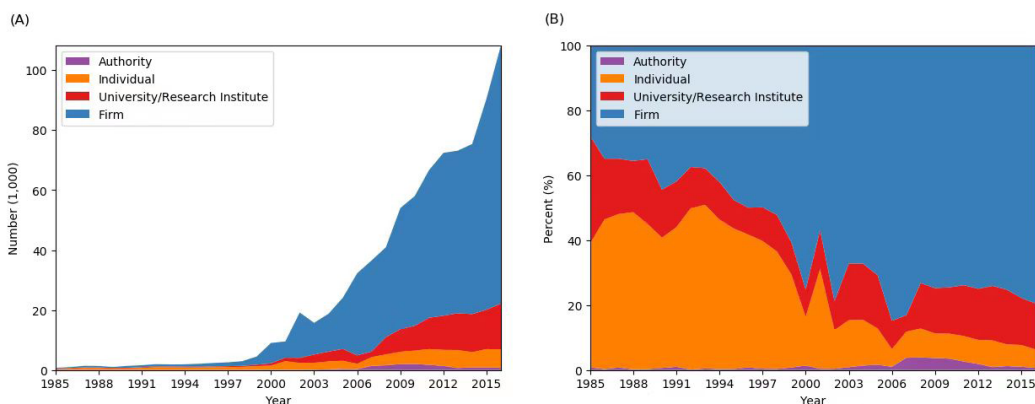


Figure 5. Patent applications by authorities, individuals, universities and research institutes, and firms (1985-2016)

1990s. Yet, ratio of records from both individuals and universities has diminished quickly though there has been an apparent upsurge of annual patent applications since 2000. The record shows that firms, contributing more than 60% of the total number, are the main sources of patent applications while university and research institutes contribute 10% to 20%. In contrast, individuals contribute much less and the share of it decreased from over 15% in 2000 to less than 5% in 2015. This has been in line with the policy supports to high-tech firms since 2000. Authorities refer to public entities that are not research oriented such as government sectors, primary and secondary schools, and armies. Their applications are minimal and kept dropping in recent years. Among the three types of patents, utility model led the growth before 2000 but invention has been increasing fast in recent years. Proportion of design reached the peak 58.4% in 2002 but has decreased rapidly since then.

Shanghai’s booming innovation activities of firms accord against the general shift towards a firm-centered S&T model in China^[33]. Before 2000, individuals, universities and research institutes were critical to China’s innovation. Ratio of patent applications from firms were even lower than that from individuals during 1980s and 1990s^[1]. Yet by late 1990s, innovation policies committed to developing high-tech industrial firms became prevalent, alongside a surge of new inventions from business^[34].

Shanghai pioneered carrying out this policy transition and proposed policy packages to advance intellectual property protection, commercialization of S&T achievements, and financial investment on S&T enterprises^①. The result is a gradual increased proportion of patent applications from firms after 2000. Sprawling of innovation activities also conformed with suburban development in Shanghai, in particular complied with its industrial suburbanization. Since 2000, Shanghai fostered a “1+3+9” spatial structure of industrial parks wherein “1” is Pudong New Area, “3” represents Caohejing Hi-Tech Industrial Park, Minhang Economic and Technology Development Zone, and Shanghai Chemical Industry Park, and “9” refer to Chongming, Jiading, Baoshan, Qingpu, Songjiang, Fengxian, Jinshan, Xinzhuang, and Kangqiao Industrial Development Zones. These industrial zones have nurtured a large number of firms investing and operating innovation production in outskirts. As part of the optimization strategy of Shanghai’s metropolis structure, this industrial urbanization and its incubated innovation firms have re-shaped the spatial layout of innovation-oriented capital accumulation^[35].

① For instance, the “Notice of the Shanghai Municipality on Promoting the Transformation of New and High-tech Achievements” formulated in 2004, the “Shanghai Rising-Star Program” started in 2003, and the “Opinion of the Shanghai Municipality on Increasing Financial Service and Support for Technology-based SMEs” issued in 2009.

As patent applications before 2000 are negligible, this research has geocoded and mapped the patent records to reveal the spatial evolution of innovation activities after 2000 (Figure 6). Previous studies suggest that innovation activities tend to cluster spatially at the national or regional level [36-38]. Our analysis indicates that within the city, innovation activities are clustered in downtown and several major planned industrial base such as Zhangjiang, Zizui, and Caohejing. Innovation outputs along the expressway is eminent, from which we may assume that most of the innovation activities are related to manufacturing industries, which show high sensitivity of accessibility. Spatial growth of patent applications is a dual process: intensity of innovation activities kept concentrating in central city particularly in Puxi whereas innovation expansion towards suburb also persisted, moving towards south and north in the initial and diffusing across the metropolitan area after 2007. Innovation policy has profoundly influenced this process since 2000: improvement of innovative soft environment has further consolidated and optimized the innovation edge of central city as innovation infrastructure such as human resources, transportation, cultures and public services are enhanced. Alongside the “Opinion of Shanghai Municipal Party Committee and Shanghai Municipal People’s Government on Accelerating the Construction of Globally Influential Science and Technology Center” and “Supporting Policies on Increasing Revenue Support to Accelerate the Construction of Globally Influential Science and Technology Center” promoted in 2015, Shanghai’s innovation has entered a new stage with many of the policy and institutional designs implemented. Coping with the suburban policies, industrial parks as significant carriers for innovation activities thrived and facilitated expansion of innovation to outskirts where new industrial space takes shape and disperses.

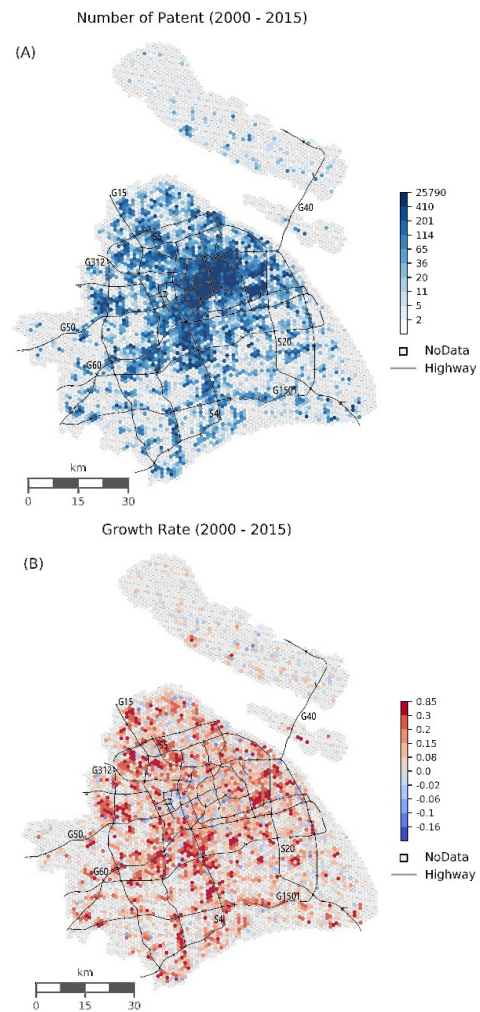


Figure 6. Cumulative spatial distribution of innovation activities in Shanghai (2000-2015)

3.2.2 Relational Aspects of Innovation Outputs with Urban Development

This research further inquiries into how innovation

Table 1. Compare indices of urban innovation and urban development

Urban innovation index abbreviation	Equation	Positive/negative index
IAGDP _s	$= ((GDP_{t_2} - GDP_{t_1}) / GDP_{t_1}) / ((IA_{t_2} - IA_{t_1}) / IA_{t_1})$	Positive
IAEngel	$= (Engel_{t_2} - Engel_{t_1}) / (IA_{t_2} - IA_{t_1})$	Negative
IAPER _s	$= ((PER_{t_2} - PER_{t_1}) / PER_{t_1}) / ((IA_{t_2} - IA_{t_1}) / IA_{t_1})$	Positive
IACC _s	$= ((CC_{t_2} - CC_{t_1}) / CC_{t_1}) / ((IA_{t_2} - IA_{t_1}) / IA_{t_1})$	Negative
IAAQ _s	$= ((AQ_{t_2} - AQ_{t_1}) / AQ_{t_1}) / ((IA_{t_2} - IA_{t_1}) / IA_{t_1})$	Positive

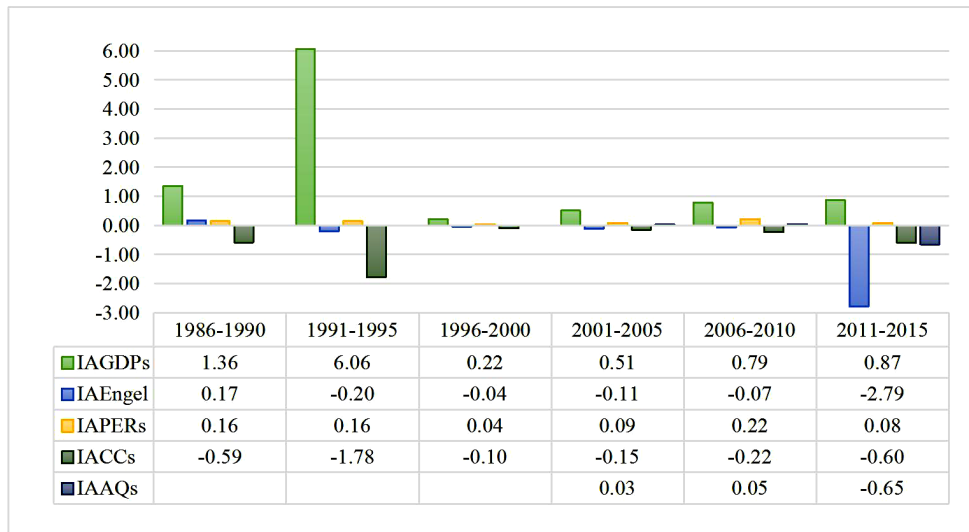


Figure 7. Comparison of innovation growth and the improvement of urban development level in Shanghai during six five-year plans (1986–2015)

relates to Shanghai’s urban development of different dimensions by consulting the effects of innovation by years. A set of indices are developed to compare the growth rate of innovation and the level of urban development (Table 1). A five-dimensional indices representing urban development level are consulted. IAGDPs is the standard effect of urban innovation related to economic growth measured through growth rate of GDP divided by the growth rate of innovative activities. It is an economic index reflecting how innovation relates to economic performance and development level of the city. IAPERs, IACCs and IAAQs are standard effect of urban innovation related to permanent residents, Coal Consumption per GDP (kg/10,000 RMB) and air quality measured by a similar method. They reflect how innovation relates to the improvement of social development level, energy efficiency, and environment quality respectively. IAEngel is effect of urban innovation related to living standard improvement measured through growth rate of Engel coefficient divided by the growth rate of innovative activities. IAGDPs, IAPERs, and IAAQs are positive indices, meaning that the higher value the index is, the more innovation synchronizes with the particular dimension of urban development in this period. IAEngel and IACCs are negative indices manifesting the opposite meaning.

Most value fell between -1 and 1, implying that almost all the five dimensions of urban development level keep pace with the innovation development. Yet, differences remain visible. Almost in all the five-year intervals, growth of GDP and permanent residents positively related to innovation growth. However, only in the first two five-year periods, growth of GDP outpaced that of innovation.

Since 1996, IAGDPs has been below 1, implying that the growth rate of GDP fell behind that of innovative activities, but this phenomenon has been mitigated with the increase of the value recently. Performance of living standard is unstable. Result of IAEngel was unsatisfactory at the initial, with coefficient increase alongside innovation increase. Situation gets better in early 1990s but worse again since 1996 as reduction rate of Engel coefficient became slower than increase rate of innovation growth. Yet a surprising trend emerges recently that IAEngel was lower than -2.5 from 2011 to 2015, meaning that improvement of living standard goes far beyond the innovation development. IAPERs value is positive but only has a small amount, meaning that permanent residents do not increase significantly when city has better performance in innovation. As long as Shanghai municipal government sticks to population control in the coming years, this trend may keep. From another perspective, this also means that innovation outputs per capita increase and that innovation density improves. Results of IACCs show a similar trend as IAGDPs. Decrease rate of coal consumption per GDP surpassed growth rate of innovation only in early 1990s, this trend has become much slower since mid-1990s but getting better recently (2011-2015). Air quality seems the most unsatisfactory dimension among all the five. Value of IAAQs decreases to minus 0.65, meaning that days with good air quality reduced and the reduction rate is non-negligible compared with the growth rate of innovation.

4. Conclusions

This research enriches the city-level understanding of

state restructuring and the consequent urban innovation development, from an input-output perspective. Starting from a country-level review of state restructuring and the subsequent policy change of innovation, an increasingly active participation of non-state actors in innovation development with the elapse of time is identified. Though there have been divergent views towards whether the party-state in post-reform China can be label as a developmental state at the national level due to the initial dysfunctionality of state intervention in corporate sectors, findings of this research suggest that local government exhibits elements of LDS in innovation development, mainly from three aspects. First, the top-down, elite driven and state-sponsored growth mode giving priority to technological upgrading for innovation competitiveness in Shanghai case is considered the key to the developmental state model. Second, not only the state but also the non-state actors are motivated, collectively serving innovative economy to articulate the national goals. This is well illustrated in the synchronous, though a bit backward, policy transition towards firms-oriented innovation development in Shanghai throughout 1990s and the concomitant firm-dominated spatio-temporal patterns of innovation clusters development. Third, professional technocracies are widely involved to contribute their wisdom to this innovation boom, which is well exemplified in the policies, plans, regulations made to nurture innovation.

This research also draws some policy implications for innovation development in counterpart cities. First, stimulating market vitality can greatly improve innovative capability and outputs, which can be observed in the soaring increase of science and technology expenditures and patents applications in Shanghai since 2000s after the policy orientation evolved more marketized and firm-centered. In Shanghai, policy and spatial responses to state restructuring demonstrate an enhanced role of firms in innovation development. Under a pro-market ideology, policy support for firms overwhelms other type of innovation entities and firm innovation determines the spatial patterns and evolutionary trajectory of innovation in Shanghai. Second, the balance between innovation and urban development especially its potential negative effects on environment and social development shall be paid special attention to, as indicated in the fluctuated, unsatisfactory relational results of innovation and air quality as well as Engel coefficient. Third, a well infrastructural support especially rapid transportation system remains crucial for innovation development in cities like Shanghai where innovative activities concentrate alongside the expressway and show high sensitivity of accessibility. But policy makers should bear in mind that the chase to cutting-edge technology still has

a long way to go as current innovation outputs, implied in the Shanghai case, remain at the stage of mass production technology upgrading with many invalid and revoked patents.

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References

- [1] Prodi, G., F. Nicolli, and F. Frattini, State restructuring and subnational innovation spaces across Chinese prefectures. *Environment & Planning C*, 2017. 35(1): p. 94-112.
- [2] Li, Z., J. Xu, and A.G.O. Yeh, State rescaling and the making of city-regions in the Pearl River Delta, China. *Environment and Planning C: Government and Policy*, 2014. 32(1): p. 129-143.
- [3] Cartier, C., Urban Growth, Rescaling, and the Spatial Administrative Hierarchy. *Provincial China*, 2011. 3(1).
- [4] Brenner, N., *New State Spaces: Urban Restructuring and State Rescaling in Western Europe*. 2004, Oxford: Oxford University Press.
- [5] Laurence, J.C. and F. Wu, *Restructuring the Chinese city: diverse processes and reconstituted spaces*. 2005.
- [6] Tosics, I., Spatial restructuring in post-socialist Budapest, in *The Urban Mosaic of Post-Socialist Europe*. 2006, Springer. p. 131-150.
- [7] Wei, Y.H.D., *Restructuring for growth in urban China: transitional institutions, urban development, and spatial transformation*. *Habitat international*, 2012. 36(3): p. 396-405.
- [8] Wu, F., Urban restructuring in China's emerging market economy: towards a framework for analysis. *International Journal of Urban and Regional Research*, 1997. 21(4): p. 640-663.
- [9] Chen, L. and B. Naughton, An institutionalized policy-making mechanism: China's return to techno-industrial policy. *Research Policy*, 2016. 45(10): p. 2138-2152.
- [10] Liu, F.C., et al., China's innovation policies: Evolution, institutional structure, and trajectory. *Research Policy*, 2011. 40(7): p. 917-931.
- [11] Hassink, R., *Regional Innovation Policies Compared*. *Urban Studies*, 1993. 30(6): p. 1009-1024.
- [12] Ramo, J.C., *The Shanghai Bubble*. 1998: Foreign Policy, Summer.
- [13] Brockhoff, K. and J. Guan, Innovation via new ventures as a conversion strategy for the Chinese defense

- industry. *R & D Management*, 2010. 26(1): p. 49-56.
- [14] Chen, K. and J. Guan, Mapping the functionality of China's regional innovation systems: A structural approach. *China Economic Review*, 2011. 22(1): p. 11-27.
- [15] Guan, J., Measuring the Efficiency of China's Regional Innovation Systems: Application of Network Data Envelopment Analysis (DEA). *Regional Studies*, 2012. 46(3): p. 355-377.
- [16] Bolesta, A., China as a developmental state. *Montenegrin Journal of Economics*, 2007. 3(5): p. 105-111.
- [17] Castells, M., The rise of the network society. The information Age: Economy, society and culture, ed. M. Castells. Vol. I. 1996, Malden and Oxford: Blackwell publishers.
- [18] Breslin, S.G., China: developmental state or dysfunctional development? *Third World Quarterly*, 1996. 17(4): p. 689-706.
- [19] Johnson, C., The developmental state: Odyssey of a concept. *The developmental state*, 1999: p. 32-60.
- [20] Woo-Cumings, M., *The Developmental State*, ed. M. Woo-Cumings. 1999: Cornell University Press.
- [21] Evans, P.B., *Embedded autonomy: states and industrial transformation*. 1995: Cambridge Univ Press.
- [22] Dore, R.P., *Flexible rigidities: Industrial policy and structural adjustment in the Japanese economy, 1970-80*. 1986: Stanford University Press.
- [23] Saito, A., Global city formation in a capitalist developmental state: Tokyo and the waterfront sub-centre project. *Urban Studies*, 2003. 40(2): p. 283-308.
- [24] Castells, M., *The Rise of the Network Society*. 2009, Cambridge, MA/Oxford, UK: Blackwell.
- [25] So, A.Y., The post-socialist path of the developmental state in China, in *The Asian Developmental State: Reexaminations and New Departures*, Y.-w. Chu, Editor. 2016, Palgrave Macmillan, New York: London.
- [26] Nee, V., S. Opper, and S. Wong, Developmental state and corporate governance in China. *Management and organization review*, 2007. 3(1): p. 19-53.
- [27] Jiang, X. and J.J. Wang, Reassembling the state in urban China. *Asia Pacific Viewpoint*, 2012. 53(1): p. 7-20.
- [28] Li, L. and R.C.K. Chan, Contesting China's engagement with neoliberal urbanism: An overview of the evolving policy and mismatches in urban China. *Asian Education & Development Studies*, 2012. 6(1): p. 44-56.
- [29] Zhu, J., Local developmental state and order in China's urban development during transition. *International Journal of Urban and Regional Research*, 2004. 28(2): p. 424-447.
- [30] He, S. and F. Wu, Property-Led Redevelopment in Post-Reform China: A Case Study of Xintiandi Redevelopment Project in Shanghai. *Journal of Urban Affairs*, 2005. 27(1): p. 1-23.
- [31] Sharifi, A. and A.R. Khavarian-Garmsir, The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Science of The Total Environment*, 2020. 749: p. 142391.
- [32] Murphey, R., *Shanghai : key to modern China*. 1953, Cambridge: Harvard University Press.
- [33] (OECD), *O.f.E.C.-o.a.D., OECD Reviews of Innovation Policy: China 2008*. 2008, Paris: OECD Publishing.
- [34] Li, X., China's regional innovation capacity in transition: An empirical approach. *Research Policy*, 2009. 38(2): p. 338-357.
- [35] Chan, R.C.K. and L. Li, Entrepreneurial city and the restructuring of urban space in Shanghai Expo. *Urban Geography*, 2017. 38(5): p. 666-686.
- [36] Feldman, M.P. and R. Florida, The geographic sources of innovation: technological infrastructure and product innovation in the United States. *Annals of the association of American Geographers*, 1994. 84(2): p. 210-229.
- [37] Audretsch, D.B. and M.P. Feldman, R&D spillovers and the geography of innovation and production. *The American economic review*, 1996. 86(3): p. 630-640.
- [38] Van Oort, F.G., *Urban growth and innovation: Spatially bounded externalities in the Netherlands*. 2017: Routledge.