Central-Local Government Interactive Learning and the Rise of Innovative Industries: Reconsidering the Chinese National Innovation System

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Abstract Chinese innovative capability has gone beyond the traditional explanations based on catch up, as today in a number of industries Chinese firms compete technologically with leading developed country firms. We explore that the institutional learning between the central and local governments in China's National Innovation System (CNIS) and how it has been a critical component for building its global-class innovative industries. Motivating local agency is inherent in the design of Chinese central planning and makes local governments core actors in the CNIS. In the context of uncharted technological paths and emerging business models, there is an increasing emphasis on bottom-up experiments and mutual learning between China's central and local governments, with empowering local agencies being essential for success. We demonstrate this through case studies of two significant innovative industries, the online platforms and battery-powered electric vehicle (BEVs) industries -- in both of which China has become a global leader. We contribute to understanding the sources of China's success in developing global-class industries.

Keywords: National innovation system; Regional innovation systems; China; Local governments; Innovative industries

1 Introduction

The Chinese economy has experienced a remarkable evolution from one dependent upon technology transfer from abroad and catch-up strategies to becoming a global-class competitor in

a number of emerging industry technologies ranging from batteries and battery-powered electric vehicles (BEV) to AI, online platform software, and 5G and beyond wireless communication technologies (Kim et al., 2020; Lundvall & Rikap, 2022; Yu et al., 2022). The development of a powerful position in these technologies suggests that the contemporary Chinese national innovation system (CNIS) is no longer a follower or in a simple catch-up mode. This CNIS is the result of a series of reforms, including "Revitalize the Nation through Science and Education" (1985), "Indigenous Innovation Strategy" (2006), "Innovation-driven Development Strategy" (2012) that led to massive increases in science and technology research and development funding and technology-based innovation and entrepreneurship.

While the National Innovation System (NIS) literature focuses almost entirely on the interrelationships between national governments, firms, universities, research institutes etc. (Etzkowitz & Leydesdorff, 2000; Lundvall, 1992; Nelson ed., 1993), to understand the CNIS it is necessary to appreciate the vital role of local governments. In one respect, our perspective comports with research on industrial clusters, which found that much innovation actually occurs in regions and that the way regional institutions were organized for innovation varied dramatically within nations (Malerba, 1993; Li et al., 2022). This is particularly true for enormous economies such as the US, where there does not appear to be a single recipe applicable across all regions in the same nation. Perhaps, for the experience of developed nations, it may be that lack of attention to local governments and the relationship between the NIS and regional innovation systems (RIS) may be justified. However, we show that in the CNIS local governments play a crucial role in facilitating institutional learning for the central government from local entrepreneurs and innovation practices.

This paper also contributes to understand the differences in governmental learning patterns and knowledge sources within the CNIS between the catch-up and emerging industries. Although

the essential roles and autonomy of China's local governments in developing catch-up industries have been widely acknowledged (Breznitz & Murphree, 2011; Lee, 2021), the knowledge creating and spreading function of local governments and the mutual learning between the central-local governments have not been theorized. This is because learning from bottom-up innovation in navigating uncharted technological paths and business models become increasingly significant in developing emerging industries. The interactive learning relationships between local governments and local industry and the central and local governments has become the centerpiece of the CNIS. Paradoxically, to innovate and build cutting-edge industries in a centrally planned economy like China, empowering and motivating local agency is central to success.

This paper proceeds as follows. We first review the literature on NIS and clarify the theoretical gap with relationship to explaining the CNIS. We then present our CNIS model of developing innovative industries. The research methods are provided in Section 3. This is followed by case studies of China's online platform and the EV industries in Section 4 and 5. The final two sections summarize our findings and reflect upon the strengths and weaknesses of CNIS, and speculate how the Chinese experience regarding the institutional learning between central-local governments to support innovative firms may be applicable to other countries.

2 Literature Review and Theoretical Framework

2.1 NISs, RISs and the CNIS

The National Innovation System (NIS) is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987). A consensus emerged that: (1) innovation is an interactive rather than a linear process, (2) knowledge and learning are the most fundamental resource and process in the

modern economy, and (3) innovation systems are complex and characterized by co-evolution and self-organization (Lundvall, 1992; Lundvall, 2007; Nelson ed., 1993). As the name implies, the original intuition was that national industrial structures and institutional interactions structured the type and trajectory of innovation (Dosi, 1982; Lundvall, 2007).

Driven by a recognition that the nation-state was often too aggregated in scale and that regions could develop their own innovation recipes (Breznitz, 2021), the concept of Regional Innovation Systems (RIS) was introduced, as scholars found that sub-national regions had different institutional configurations for supporting innovative activities (Braczyk et al., 2003; Cooke et al., 1997). The key factors identified as differentiating RISs and determining their innovative performance include the regional knowledge base, labor market, access to capital, and the existing material and financial infrastructure (Asheim et al., 2011; Tödtling & Trippl, 2005).

The innovation system literature less effectively theorized the linkages between the RIS and NIS. NIS scholars have acknowledged a need to study networks at the local and regional level, however, subnational networks research has been mainly regarded as an operational method or a focusing device for understanding the dynamics at the national level (Lundvall, 2007; Miettinen, 2002). In effect, the RIS was conceptualized as a separate system or a simple "subset" rather than an organic part of the NIS. And yet, the literature has seen the RIS and NIS concepts as either contradictory or left the connections between them vague (Asheim et al., 2011). We argue that China has successfully developed institutions to motivate and harness RISs in such a way as to make them an integral part of NIS – and, more importantly, in China's central planned economy this system is effective at generating global-class, new-to-the-world innovations and industries, i.e., those that have no existing technological routines and business models to be copied.

The starting point for understanding the current CNIS are the transition in the late 1970s from top-down central planning to greater market coordination and a conscious decision to

decentralize much of the decision-making (Liu & White, 2001). This meant the conscious creation of a contradiction.

First, government, especially the central government, continues to have a central role in CNIS (Sun & Liu, 2010). In China many production factors such as land, labor and capital continue to be controlled or managed by the government. For some, it was expected that China would evolve towards a "lighter touch" government innovation policy such as occurred in Japan or South Korea (Chen & Naughton, 2016). And yet, even though private firms rapidly increased their R&D expenditures and became major R&D funders, the government continues to shape the innovation incentive structures and activities through strategic plans, industrial policies, and massive increases in R&D investments (Gu et al., 2009; Schmid & Wang, 2017). In this way, the central government continues to be the core institutional actor in CNIS (Băzăvan, 2019).

Second, traditional wisdom has suggested that Chinese innovation is largely incremental rather than based on original breakthroughs. Further, it was accepted that one of the most important knowledge sources is foreign investment or multi-national enterprises (MNCs) (Schmid & Wang, 2017). Most work on the CNIS conceptualizes China, as a latecomer that is catching-up or leapfrogging developed countries in mature industries (Li et al., 2020; Mu & Lee, 2005). Innovation, in this context, largely relates to how Chinese firms learn to employ technology that has been developed in the developed economies (Breznitz & Murphree, 2011; Nelson ed., 1993). For example, learning to manufacture internal combustion engine automobiles or producing computational equipment for foreign original equipment manufacturers (OEMs). This learning from abroad takes place mainly through FDI joint ventures, systematic reverse engineering, or even purchasing foreign firms (Mu & Lee, 2005; Liu & White, 2001). More recently, some scholars have begun to recognize that China is becoming an innovator in its own right (Chen et al. 2021), while others have a less sanguine view of Chinese capability (Ding

2023).

Chinese RIS studies usually focus on single clusters and normally focus on mature industries and, most often, FDI-driven regional development. The most important of which, Beijing, Yangtze River Delta Region (Shanghai-Suzhou-Hangzhou-Nanjing) and Pearl River Delta Region (Shenzhen-Guangzhou-Dongguan) have been the subject of multiple studies (Chen & Kenney, 2007; Wang et al., 2021; Yang, 2015). Similar to studies on CNIS, most of the RIS studies of China have focused on mature industries where incremental innovation takes place rather than emerging industries where novel product innovation emerges (Murphree et al., 2016). While previous research has been shown that local governments are important actors that control significant resources, it has focused more on how the government supports building local absorptive capacity and low-end manufacturing clusters. In addition, most discussions have focused on Chinese regions where multinational firms are the central actors rather than innovative clusters driven by domestic firms (Li et al., 2021). ~~The most important exception to this is the now voluminous literature on the Beijing Zhongguancun (ZGC) district (Ning et al., 2023; Zhou, 2008).~~

China's competitiveness in global-class technologies has only recently become the object of study. Even when such studies recognize that the CNIS is producing global-class innovative firms, the studies focus on China, as a whole. These studies attribute China's success in emerging industries such as AI and electric vehicles to a strong, top-down, centrally coordinated national innovation system led by the central government (Lundvall & Rikap, 2022), while overlooking China's multi-layered institutional arrangements and the region-specific industrial development pathways (Sun & Liu, 2010). ~~For example, Lundvall and Rikap (2022) attribute China's emergence as a leader in AI to the co-evolution of its corporate and national innovation systems. Wang and Kimble (2011) and Rong et al (2017) discuss how central government policy drove~~

~~China's success in developing BEV technology.~~ Additionally, t~~T~~he extant literature on Chinese innovative industries focuses on national-level institutions and explains Chinese advances using the concept of "catch-up/leapfrogging" (Wang & Kimble, 2011). Leap-frogging~~, as a concept,~~ certainly explains the entry dynamics in technologies that already have a dominant design and technological trajectory such as, for example, semiconductors (Rho et al. 2015). However, its applicability diminishes in the context of emerging innovative industries where the technological trajectory is uncertain and no country or region can copy technological and policy experiences from others (Bonnín Roca et al., 2017). Moreover, considering that China's economic growth is transforming from the FDI-driven or export-oriented economy to a more endogenously innovation-driven one (Zhang et al., 2022), the dynamics of the CNIS should be revisited.

The existing research has not considered how RISs have become an integral part of the CNIS and, in particular, the relationship between central-local governments for supporting new innovative industries. ~~Sun and Liu (2010) suggested that China developed a multi-level system of innovation within which the RISs are integral to the NIS.~~ Interestingly, some have suggested that the relationships between the central and local governments are conflictual and have resulted in the weak growth of private firms (Lee, 2021). Others have found that the relationship between China's NIS and its RISs are two parallel systems that facilitated China in catch-up and incremental innovation but stymied novel-product innovation (Breznitz & Murphree, 2011).

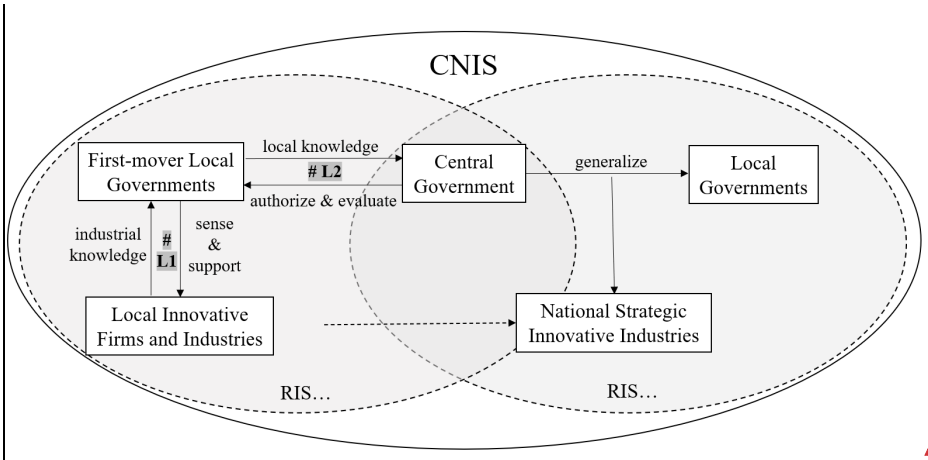
Although it is widely acknowledged that good innovation performance in a nation is enhanced by the close cooperation between the central and regional governments (Chung, 2002), the relationship between NIS and RIS still remains unclear. China is an important case study because, as we will demonstrate, the RISs are critical constituents of the CNIS. The role of local governments and the interactions between the central-local governments in the CNIS is largely overlooked in terms for the development of cutting-edge innovative industries. ~~A critical variable~~

~~in the success of China in becoming a leader in a number of new-to-world technologies is the central-local mutual learning in sensing and supporting local innovative entrepreneurs and industries.~~

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2.2 The CNIS Model for Developing Innovative Industries

The core of a NIS is creating institutions and developing knowledge infrastructure that support interactive learning and build innovation capabilities (Lundvall, 2007). Accordingly, we synthesize two strands of literature, China's macro governance structure at the national level and the micro innovation processes at local level, and develop a model for how innovative industries/firms develop in interaction with their local governments within the CNIS (Figure 1). Our model provides a stylized depiction of the connection between RISs and NIS, predominantly driven by interactive learning at both regional and national levels, especially involving local and central governments. Of course, this is a simplified model describing CNIS for developing innovative industries, and we have omitted other vital actors such as the educational and public research organizations, and consumers. These omissions are meant to highlight the central-local interactions that encourage bottom-up initiatives and local knowledge of emerging industries feeding into the national policy process.



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Figure 1: Stylized Model for How the CNIS Supports Innovative Industries

CNIS is shaped by China's fundamental governance structure, which has been termed a "regional decentralized authoritarian (RDA) regime", combining political centralization (top-down control, which, in many respects, operates in terms of directing attention in certain directions), economic regional decentralization (local autonomy) and inter-regional competition (Chen & Naughton, 2017; Xu, 2011). The central government is the supreme political and economic authority through its control of national-level strategic planning and the promotion of local officials (Naughton, 1990). Because local officials are constantly evaluated on the basis of their economic performance they actively search for technological innovations and industrial development opportunities (Guo, 2020).[1] This rigorous evaluation system fosters inter-regional competition for economic growth, attempts to encourage in-flows of qualified labor, capital and enterprises, which, in turn, encourages local government experimentations and searching for new economic opportunities (Montinola et al., 1995; Yang, 2009).

Second, after the central government institutionally decentralized the economic decision-making power in the 1980s, Chinese local governments received a high degree of independence and ample resources for formulating and implementing place-based industry policies and initiatives (Breznitz & Murphree, 2011; Walder, 1995). These local governments are the de facto owners of urban land, which provides them enormous lease revenue that can be used to build science parks and even to fund local S&T activities. Moreover, local governments can attract highly skilled Chinese workers through their control of the local household registration system (*hukou*) and its attendant benefits (Au & Henderson, 2006). These are just a few of resources that

[1] Of course, it is important to recognize that while the evaluations are rigorous, there is a long history of local officials inflating statistics and gaming the system.

local governments have in their portfolio. For example, because of China's regionally decentralized judicial system, local governments can make and enforce laws within their jurisdiction, as well as influence local judicial decisions (Xu, 2011).

After 2000s, the uncertainties of new-to-world emerging industries made the autonomy and capabilities of local governments increasingly important. For catch-up industries, most technologies and business models have long been used in the developed economies and have clear technological trajectories and performance standards, consequently, industrialization is on the basis of duplicative imitation rather than of invention or innovation (Amsden, 1989; Kim, 1997). China introduced these mature technologies and policy experiences, and promoted top-down catch-up industrial policies from central governments to local governments (Breznitz & Murphree, 2011; Murphree et al., 2016). In contrast, for emerging industries, most of technologies are new-to-world and do not yet have dominant technological trajectories and business models, thus all actors face deep uncertainties and risks (Wong, 2011; Bonnín Roca et al., 2017). Consequently, the Chinese government must discover and learn from indigenous innovations and innovators and formulate innovation policies from bottom-up. Due to their embeddedness in local entrepreneurial ecosystems, local governments have the advantage to recognize and support emerging innovative firms and industries, while the central government is responsible for scaling up and disseminating local innovations, as well as providing coordination between various RISs (Heilmann, 2008).

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Under the RDA structure and the new context of developing emerging industries, local governments resemble institutional investors assisting innovators instrategic building their businesses. The Chinese government developed a strategy of encouraging decentralized action in various RISs that could be monitored by the central government for possible generalization. In Figure One, we argue that there are two location-based learning~~/action~~ mechanisms in the CNIS

(Figure 1). ~~We term these "quasi-experiments". Some are initiated by local governments, while others are launched by the central government. These experiments are implemented in collaboration between local officials and entrepreneurs. Due to their embeddedness in local entrepreneurial ecosystems, the central government expects that local governments will recognize and support emerging innovative firms and industries, while the central government is responsible for scaling up and disseminating local innovations, as well as providing coordination between various RISs (Heilmann, 2008).~~

Learning mechanism~~Relationship~~ L1 depicts how first-mover local governments learn from and support ~~and interact with~~ local entrepreneurs, during which local governments develop knowledge about the operations and needs of local innovative industries. As we mentioned above, local government and its officials have the motivation, resources, and autonomy to enable them to sense and support private entrepreneurial initiatives. Given that the central government is unable to issue clear directives for local governments to follow in emerging industries~~Local governments are not merely followers simply responding to central government directives, but~~, local governments can actively design locality-tailored development schemes such as mobilizing resources and establishing investment operations for local entrepreneurs, and acting as an organizer by orchestrating supply chain ~~?~~diverse actors (Zhang et al., 2022). Additionally, they often act as lead users or early customers for innovations by local entrepreneurs, thereby providing a niche marker early in the innovation life-cycle (Yu et al., 2022). Conversely, ~~,~~ by interacting with local entrepreneurs, local governments gradually ~~improve their ability to recognize and support emerging industries, thus~~ build~~ing~~ the local industrial knowledge base of recognizing and supporting emerging industries, thus~~and~~ driving China's entry into these industries.

Learning mechanism~~Relationship~~ L2 is an interactive learning process whereby the local

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Commented [JS4R3]: It's not an "either···or···" question, success in particular industry may be transferred to a general capability.

But considering we are not trying to prove the dynamic capability of local governments, so we can delete this to reduce confusion

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knowledge generated by the interaction with local entrepreneurs is communicated to the central government. As some nascent firms grow and demonstrate stronger market influence, the central government recognizes the strategic significance of certain emerging industries for the national economy. The local industrial knowledge and policy experiences accumulated in pioneering regions are captured by the central government through various channels, with pilot projects being the most institutionalized. We term these "quasi-experiments". Some are initiated by local governments, while others are launched by the central government. These experiments are implemented in collaboration between local officials and entrepreneurs. And the central government encourages local governments to explore innovative pathways for the development of innovative industries in pilot projects. By authorizing pioneering regions to undertake pilot projects, the policy experiences of these regions can be systematically documented and reported back to the central government (Heilmann et al., 2013). For local officials, successfully carrying out these vague mandates improves their prospects for promotion and securing future access to resources (Chen & Naughton, 2016). Therefore, some local governments cooperate with local entrepreneurs to initiate innovative projects, or seek authorization from the central government for pilot projects.

~~Certainly, Tthe central government through the Five-Year Plans (FYPs) and various incentives also identifies strategic industries that it encourages local governments to support. But, critically the central government allows the local governments significant discretion in choosing the policy instruments to encourage the development of these industries (Heilmann et al., 2013). For local officials, successfully carrying out these vague mandates improves their prospects for promotion and securing future access to resources (Chen & Naughton, 2016). Therefore, some local governments cooperate with local entrepreneurs to initiate innovative projects, or seek authorization from the central government for pilot projects.~~

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This is changing the message

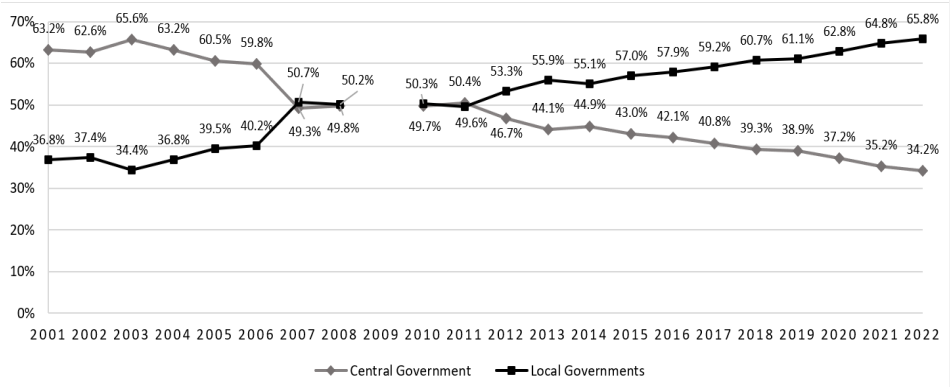
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Commented [MFK7]: Here again, this has contradictions. Now the central government is driving local decisions and locals just have discretion in using policy instruments. This argues for top-down in fact with some discretion···.not bottom up.
This is changing the message

After the central government evaluates the outcomes of the early local experiments, the successful ones are propagated from a few pioneering regions to other regions (Heilmann, 2008). As a result, almost every strategic emerging industry identified by the central and local governments has experienced trials in RISs prior to becoming a national strategic industry.

In sum, L1 and L2 are the core learning mechanisms in the CNIS -- the former representing the generation and exploitation of knowledge at the local level and the latter representing general direction setting and the transmission of knowledge from various RISs to the NIS.

The above two interactive learning relationships contribute to the embeddedness of RISs within CNIS. This was explicitly recognized in *China's Outline of the National Medium- and Long-Term Science and Technology Development Plan (2006-2020)*. In this plan, the central government decided to build a NIS with Chinese characteristics, and one aspect of this was "building RISs with different characteristics and advantages" in a coordinated manner, and "promoting the organic combination of central and local S&T forces." The central government also made it mandatory for local governments at all levels to increase their investment in S&T activities. As a result, as shown in Figure 2, China's local government S&T investment increased dramatically after 2006 and surpassed that of the central government for the first time in 2007.



Commented [MFK8]: What does this mean? In EVs that everywhere should build EV factories or start platform firms? This does not make sense does it?

Commented [JS9R8]: It doesn't have to be everywhere, but only 3-5 first mover cities are not enough, China has over 300 cities. The central governments encourgaes other regions to develop platform industries or EV industries.

For example, encouraging other regions to learn from Hangzhou to collaborate with leading internet companies on Internet+ initiatives, and to learn from Shenzhen by pioneering the use of electric vehicles in public transportation.

Figure 2. Proportion of central and local governments expenditure on science and technology in China

Data source: China's National Bureau of Statistics, National Statistical Bulletin on Investment in Science and Technology, 2002-2023

Note: the data of 2009 is not available in China's official statistics.

The division of the responsibilities between the central and local governments was further clarified in the *National Science and Technology Innovation Plan for the 13th Five Year Plan (2016-2020)*, which shows "the functions of the central government focus on overall, fundamental and long-term work, while the functions of local government focus on the promotion of technology development and transformation and application". In order to track and coordinate local S&T activities, the central government also mandated a national innovation survey system, which monitors and evaluates the regional innovation capacity and publishes annual reports. In sum, the agency of local governments in CNIS has been intentionally mobilized by the central government, and the central-local mutual learning in sensing and supporting local innovative industries has been . A a critical variable in the China's success of China in becoming a leader in a number of new-to-world industritechnologics is the central-local mutual learning in sensing and supporting local innovative entrepreneurs and industries.

3 Research Methods

We adopt a deductive analytical approach that begins methodology , commencing with the formulation of the stylized model offor how the CNIS supports emerging innovative industries and. -thenConsequently, test empirical validation of this modelframework by examiningis undertaken through the examination of specific cases. ASpecifically, a qualitative replicative

case study ~~approac~~method~~h~~ is employed to examine how the relationship between national and local governments has played an important role in the rise and success of China's global-class innovative industries.

We chose the online platform (and now artificial intelligence leaders) and BEV industries due to their ~~cutting edge,~~ global technological frontier status and economic significance, and conducted process tracing and in-depth descriptions of both cases from 1996 to present. The two industries differ significantly in terms of their business models (online versus offline), industrial sectors (digital services versus manufacturing), and market (winner-take-most versus oligopolistic competition). Among the top 10 global online platform companies, four are Chinese – the other six are US (citation). Chinese firms (and Tesla) are the global leaders in the BEV industry as its production and sales have led the world for the last eight years. Today, China is the home to three of the ten largest BEV producers and six of the top ten EV battery producers.[2] Given their global economic importance, these two industries provide excellent cases for examining the role of local governments in developing innovative local industries and how the interactive learning ~~relationship~~ between the local and central governments can inform national industrial policy about new innovative directions.

The arguments in this paper are supported by multiple sources of evidence, including both English and Chinese sources from the 1990s to present. Primary source material included 70 semi-structured interviews, 34 central government policy documents, 58 local government policy documents, and over 20 government and enterprises projects, etc.

Firstly, we conducted 70 semi-structured interviews with China's central government, local authorities, entrepreneurs, and research institutes ~~and university researchers~~, totaling nearly 90

[2] IEA (2023), Global EV Outlook 2023, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2023, License: CC BY 4.0; People's Daily, China's new energy vehicle production and sales for 8 consecutive years the world's first, https://www.gov.cn/xinwen/2023-01/24/content_5738622.htm

hours between December 2023 and August 2024 (as shown in Table 1, for a full interview list, see Appendix 1). Interviewees were reached by employing a snowball technique, where previous interviewees referred future interviewees. These interviews cover four topics designed to address our research objectives: (1) What factors drive the development of China's online platform and BEV industry? (2) What core resources do platform and BEV enterprises need from central and local governments at different stages of their development? (3) How central and local governments perceive and identify emerging sectors and potential enterprises? (4) How do central and local governments interact in the development of the platform and BEV economy? In most of our interviews, we were able to speak with government officials directly responsible for the development of platform and BEV industries, as well as with senior corporate executives. In our case presentations, interviewees were anonymized and numbered based on their organization type and interview sequence. For example: central government (C-GV01, C-GV02), local governments of Beijing (BJ-GV), Hangzhou (HZ-GV), Shenzhen (SZ-GV), Chengdu (CD-GV), and Hefei (HF-GV), as well as ~~local governments (BJ-GV), Hangzhou local governments (HZ-GV), Shenzhen local governments (SZ-GV), Chengdu local governments (CD-GV), Hefei local governments (HF-GV),~~ enterprises (ET)~~,~~ and research institutes (RI).

Table 1. Summary of Interview by Location and Organizational Type

City	Governments (GV)	Enterprises (ET)	Research Institutes (RI)	Total
Beijing (Central Government)	3	-	-	3
Beijing	5	9	9	23
Hangzhou	3	4	0	7
Shenzhen	3	4	0	7
Shanghai	7	10	3	20
Chengdu	4	0	0	4
Hefei	1	2	0	3
Guangzhou	0	2	1	3
Total	26	31	13	70

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Note: please see the full list of interviews in the Appendix 1.

Secondly, we collect secondary data from websites of governments and firms, the news

media, and academic publications. Among many policy documents, we use China's Five-Year Plans (FYPs) as snapshots to trace the learning dynamics between local government-entrepreneurial firms and the central-local ~~central~~ governments in two industries. The FYPs are released every five years and are the most important and systematic strategic guidelines for industrial policies (Chen et al., 2017). During every FYP period, the national and local governments identify and prioritize several strategic industries and channel preferential resources to firms in these industries (Xie et al., 2021). Accordingly, the central-local governments interactions and their industrial initiatives can be identified in different FYP periods. In addition, to triangulate the above data and gain broader theoretical insights, we extensively reviewed literature and news reports on innovation dynamics in China, China's platform industry and EV industry, directly citing 10 academic works and 14 news reports in our case analysis.

4 Case One: Online Platform Industry

The entry of Chinese firms into the online platform industry was slightly later than in the US, but, more recently, it has made globally original innovations in, for example, payment systems (Alipay and WeChat Pay), super apps (WeChat), online fast fashion (Shein) and short-form video (Douyin and TikTok) that have outstripped the US. This is more than simple catch-up or even "leap-frogging" in the same industry such as, for example, Samsung becoming a leader in the existing semiconductor industry's technological trajectory. Chinese platform firms have introduced new-to-the-world innovations that emerged in its closed domestic market and, a few of which, such as TikTok, Shein, and Temu are now leading global applications.

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4.1 The birth of online websites (1996-2010)

The central government first recognized and emphasized the electronic information

industry in the 9th FYP released in 1996 (just as the internet was being privatized in the US). Although most local governments simply mirrored the national FYP by including the general electronic information industry into their FYP, Beijing, Shenzhen and Hangzhou municipal governments emphasized developing software-based industrial clusters. Due to the concentration of R&D capabilities and the proximity to the central government, Beijing became the first region to establish a domestic electronics-centric RIS, i.e., the ZGC Science Park, that facilitated the emergence of entrepreneurial firms and led Internet commercialization in the late 1990s (BJ-GV02, 03; BJ-ET03). In the 1980s, ZGC had already become known as the "Electronic Street" because the agglomerations of companies selling computer hardware and software, most of which were spin-offs from nearby universities and national research institutes (Zhou, 2008). Both the central and local government recognized this burgeoning information industry area, and designated ZGC as the testing ground for China's electronics industry. Further, it was the first national-level high-tech industrial development zone, national indigenous innovation demonstration zone, and a national-level talent zone in China. As an incentive, Beijing local governments not only provide high-tech enterprises registered in ZGC with tax reductions, land use permits, and also introduced pioneering legislative guarantees in terms of IP protection, foreign joint venture legislation, venture capital, and talent attraction (BJ-GV01, 03; BJ-ET03).[3] This motivated both local entrepreneurs and Chinese returnees to start internet firms (BJ-ET02, 03). The overseas returnees included the founders of two key early internet firms, Baidu and Sohu (BJ-ET02, 03).

Although they did not have the same R&D resources and central government attention as Beijing, the Shenzhen and Hangzhou local governments also recognized the growth of

[3]Beijing Municipal Bureau of Justice, Zhongguancun Science and Technology Park Regulations, http://sfj.beijing.gov.cn/sfj/index/fzzfjs/fzzfjspdfzw/488349/index.html

local start-ups and began trying to promote their own Internet industries (HZ-GV02; SZ-GV01). For example, in the 10th FYP, Shenzhen stated that it aimed to be "China's information center" and prioritize computers and software as "pillar" industries. Shenzhen employed policy instruments such as building the public broadband information infrastructure, as well as establishing a technology-oriented venture capital fund and the Shenzhen Virtual University Park (SZ-GV01, 03) (Breznitz & Murphree, 2011).

The Hangzhou government also prioritized the electronic information industry. Through interactions with Alibaba, an e-commerce company established in 1999 which grew to become China's largest e-commerce platform company, it sensed the potential of the emerging e-commerce industry (HZ-GV02; RI05). In 2000, the Hangzhou Municipal Government specifically emphasized the development of e-commerce and Alibaba in their *Outline of Hangzhou Economic and Social Informatization Development Plan*.

During the 10th and 11th FYP (2001-2005 and 2006-2010), the central government came to believe that IT and Internet commercialization could be the main driving force for technological advancement and economic growth (C-GV02). It proposed "to drive industrialization by IT" (10th FYP). This fit with the decision in 2006 to implement an "indigenous innovation strategy" and promote e-commerce (11th FYP). During this period, the central government introduced exclusive licenses, import restrictions, supportive and steering industrial policies to protect the home market and encourage industrial growth (C-GV01, 02) (McKnight et al., 2023). [4] One of the most important policies was promulgated in 2001 forbidding foreign firms from direct ownership of firms in the communications infrastructure, and this included internet-related firms. This provided the space within which

[4] Central Government of China, Regulations on the Administration of Foreign Invested Telecommunications Enterprises, https://www.gov.cn/gongbao/content/2002/content_61770.htm

Chinese entrepreneurs could form firms and not face far larger and better-funded foreign competitors (HZ-ET01; RI02, 05).

Clusters of internet firms emerged and received support from local governments. In Beijing internet companies and entrepreneurs were located within the ZGC Science Park (BJ-GV02, 03); Hangzhou aimed to become China's Silicon Valley and e-commerce center (HZ-GV01, 02); Shenzhen aimed to be the model city for informatization and the network economy (SZ-GV01, 03). In each case, the local governments provided a mix of incentives and subsidies including providing IP protection, venture capital, internet infrastructure services such as data centers, and cloud computing.

In Hangzhou and Shenzhen, the municipal governments specifically incorporated the growth of their giants, Alibaba, NetEase, and Tencent, and the cooperative projects with them into their 11th FYP (HZ-GV02; SZ-GV01). Accordingly, these local governments continued channeling preferential resources such as data access, government procurement, tax rebates, discounted land use, etc. to support local giants (HZ-GV01, 03; SZ-GV01, 02). As a result, the successful local giants became nationally influential leaders and expanded into new businesses such as online banking and online gaming.

4.2 The rise of mobile applications and the platformization of Chinese society (2011-present)

In the early 2010s, China transitioned, far more quickly than the US, from the PC-based to the mobile Internet -- the proportion of smartphone users as a percentage of the overall number of internet users exceeded 50% already in 2009. The rise of mobile internet and the simultaneous increase in internet penetration created opportunities for platform firms to introduce mobile applications.

The Chinese economy and society experienced rapid platformization during the 12th and 13th FYP (2011-2015 and 2016-2020). In the national 12th FYP, the new-generation mobile communications and next-generation Internet were identified by the central government as a strategic emerging industry (C-GV02). One of the central government policy instruments was to build regional innovation centers, in particular, "building ZGC in Beijing into global influential S&T innovation center" was declared as a national policy goal. In the national 13th FYP, for the first time, the central government included Internet penetration in its national planning targets, and launched the "Broadband China" project, aiming at improving Internet access in less developing regions by deploying fourth-generation (4G) mobile communications technology. It also launched the "Internet Plus" Action to encourage the integration of the Internet as infrastructure into all facets of society including manufacturing, education, transportation, government, etc. (C-GV03). This initiative both recognized and encouraged the rapid expansion of platform businesses and the rapid adoption of platform services (BJ-ET02, 08) (de Kloet et al., 2019; McKnight et al., 2023).

Since 2011, to accelerate the development of China's informatization, the central government conducted several major pilot projects in various regions. As shown in Table 2, the pilot policies include both specialized policies such as encouraging (cross-border) e-commerce, smart cities, e-government, and broadband adoption, as well as comprehensive polices to encourage adoption of next-generation Internet services. The pilot regions were selected either by direct assignment from the central government or by competitive applications from local governments (RI01).

For example, the central government commissioned Hangzhou to build the first comprehensive pilot zone for cross-border e-commerce in 2015 given its already dominant position (driven by Alibaba's Taobao and AliExpress success) in the domestic and early

penetration of the global e-commerce market (C-GV01, 02; HZ-GV01). After gaining the knowledge from Hangzhou's experimentation, the central government decided to generalize the cross-border e-commerce policy nationally (C-GV02; HZ-GV02). From 2016 to 2022, the central government sequentially authorized six batches of a total of 164 cities and regions to set up Comprehensive Pilot Zone for Cross-border E-commerce extending the policy from the most developed central cities to the second- and third-tier cities. Further, as industry knowledge and experience increased due to local experimentation, that knowledge was subsequently integrated into national policies to be replicated in other regions (C-GV01, 02).

Table 2. Internet and Platform Related Regional Pilot Projects of China

Time	Pilot Theme	Pilot Regions
2010	Cloud Computing Service Innovation Development Pilot Demonstration	5 cities
2011-2014	E-commerce Demonstration Cities	52 cities: 22 +30
2013	Smart City Pilot Cities	193 cities or districts: 90 + 103
2013	Pilot Construction and Application of Public Platforms For E-Government	65 cities
2013	National Next Generation Internet Demonstration Cities	18 cities
2013-2014	Information Consumption Pilot Cities	104 cities or districts: 68 + 36
2014	Information Beneficiary Pilot Cities	80 cities
2014	Broadband China Demonstration Cities	41 cities
2015-2022	Comprehensive Pilot Zone for Cross-border E-commerce	165 cities and territories: 1 +12 + 22 + 24 + 46 +27 + 33
2019	National Pilot Zone for Innovative Development of Digital Economy	6 provinces

Data sources: Author's compilations.

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The three cities, Beijing, Hangzhou, Shenzhen, leveraged a variety of innovative policy tools to support local Internet entrepreneurship. They launched talent attraction programs, established Internet industrial parks, and committed funds to support firm growth (BJ-GV03; HZ-GV02; SZ-GV02; RI05). Importantly, their initiatives led national policy, as can be seen in the policies and innovative business areas they emphasized in their FYPs (C-GV02; RI01).

For example, although the central government used the term “Internet economy” and “sharing economy” in its 13th FYP, Hangzhou and Shenzhen local governments had already shifted their terminology for the internet-based economy as a “platform economy”, and Beijing emphasized platform-based businesses. Only in the 14th FYP, did the term “platform economy”, used by the local governments in the previous FYP, appear in the national FYP. Another example is the development of online financial services in China. It was the Hangzhou and Shenzhen local governments that first recognized the potential of mobile payments and other online financial services – once again, prior to the central government, as shown in their respective 11th FYPs. Hangzhou and Shenzhen helped accelerate adoption by allowing their local firms (in particular, Alibaba and Tencent) to introduce online payment applications for public transportation and government services (HZ-ET03; SZ-ET01). They also allowed the use of consumer credit data to facilitate their local firms’ online banking businesses (HZ-ET03; SZ-ET02).[5]

It was only in the most recent, 14th FYP (2021-2025), that the central government proposed to “accelerate the development of digitization and build the Digital China”. Specifically, the central government set a target of increasing the value added of the core industries of the digital economy from 7.8% of GDP in 2020 to 10% in 2025~~. To achieve this, the central government was deploying new information infrastructures such as 5G and IPv6~~ (C-GV03). The leading three cities all declared policies to actively develop the digital economy, Beijing is “building a benchmark city for the global digital economy” (BJ-GV01, 05), and Hangzhou and Shenzhen each aim to “become the global Fintech hub and digital pioneer city” (HZ-GV01; SZ-GV02).

[5] Nanfang Daily. (2022, December 13). Shenzhen Credit joins hands with WeBank to enhance the efficiency of financing for small and micro enterprises. Sohu. https://www.sohu.com/a/616908142_100116740

In sum, as a result of the central-local interactions since the 1990s, China has developed globally competitive platform firms and formed a number of RISs led by Beijing, Hangzhou, and Shenzhen, but also includes Shanghai. In the leading RISs, local governments developed capabilities to sense emerging local platform opportunities and deploy a wide range of policies tailored to incentivize the creation and expansion of local innovations. The most advanced local governments, not only led the policy framing at the national level, but also enabled the central government to recognize the opportunities (and risks) the China's emerging platform economy was creating.

5 Case Two: Battery-Powered Electrical Vehicle Industry

In 2009, China became the world's largest auto market.[6] Today, China is the global leader in producing and selling BEVs. This transition to BEVs is resulting in the loss of market share of foreign brands, almost all of which, with the exception of Tesla, sell internal combustion-powered vehicles (ICE).[7] To illustrate, in 2023, for the first time, the annual market share of domestic auto brands in China surpassed 50%, with domestic brands accounting for 80.6% of the total new energy vehicles (include BEV, HEV, FCV) produced in China.[8] Moreover, on the strength of BEVs, in 2023, China became the world's largest automobile exporter. Here again, success was the result of the efforts of entrepreneurs assisted by the innovation and industrial policies of central and local governments.

[6] China Central Government. (2010, January 8). China's auto production and sales exceeded 13.5 million in 2009, making it the world's largest producer and seller. https://www.gov.cn/jrzg/2010-01/08/content_1506088.htm
[7] The Wall Street Journal. (2023, July 10). In China, the era of Western carmakers is over. https://www.wsj.com/articles/rise-of-chinas-ev-makers-puts-end-to-wests-local-dominance-775d0811
[8] Xinhua News. (2024, February 2). Annual review of the automotive industry: Domestic brands accelerate their leap and reshape the automotive industry landscape. http://www.news.cn/auto/20240202/50bdabc1922a44b49f3f3b3ccf2cdd41/c.html

5.1 R&D and government-led demonstration projects (2001-2013)

Historically, the Chinese ICE-powered auto industry was dominated by Chinese-foreign joint ventures. Given this dependence, government officials came to believe that alternative fuel technologies could address China's serious air pollution and dependence upon fossil fuel imports (C-GV03; RI09). In response, in 2001 beginning with the 10th FYP, the central government launched national-level R&D into a broad portfolio of alternative power sources including but not limited to BEVs.

The centerpiece of this initiative was the National "863" EV Project Program (RI08, 09) that was jointly funded by national and local governments and enterprises. It successfully developed several prototypes and introduced three potential technological roadmaps -- battery-powered electric vehicle (BEV), plug-in hybrid electric vehicles (HEV), and fuel cell-powered vehicles (FCV). It further identified three component areas (batteries, electric motors, and electric control systems). However, this program did not result in commercialization of alternative-powered vehicles and the central government was unsure about which technology was the most promising (C-GV03; RI02).

Remarkably, in 1997, prior to the national S&T project, Shenzhen government had already established a local S&T project studying nickel-metal hydride batteries for propulsion with a small battery manufacturer, BYD, that is now China's largest BEV manufacturer (SZ-GV01).[9] These locally-funded S&T projects helped BYD accumulate battery technology and manufacturing experience that allowed it to enter the BEV business in 2003 (SZ-ET04; RI08). The interactions with local entrepreneurs also enabled Shenzhen government to sense the transformational opportunity of BEVs (SZ-GV01). For example, in 2010, BYD launched the "Green Solution Initiative of Urban Public Transportation Electrification". To assist BYD,

[9] Shenzhen Economic Daily. (2020, September 9). The story of BYD and Shenzhen. https://digi.shenchuang.com/20200909/1561337.shtml

Shenzhen government launched demonstration projects and began procuring electrified buses even before the central government in 2023 required localities to launch such pilot projects "the full electrification of public transportation" (C-GV03).

As was the case with the platform industry, the central government gained BEV industrial knowledge and refined policy instruments by interacting with and observing local governments that were initiating local projects (C-GV03; RI09). For example, in 2009, inspired by Shenzhen's electric bus R&D activities, the central government initiated a national demonstration project named the "Ten Cities and Thousands of EVs"[10], which was meant to promote demonstration of 1,000 new energy vehicles in the public transportation sectors in ten cities each per year. As shown in Table 3 ~~I~~In this program, three batches of 25 demonstration cities were finally selected by the central government (including Shanghai, Shenzhen, Guangzhou, etc.). The central government established specific targets for each demonstration city. However, in order to gain the central government's recognition and a head start in the market, leading local governments competitively set more ambitious goals than did the central planners (SH-GV02, 03; SZ-GV01) (Gong et al., 2013).

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Table 3. BEV Related Regional Pilot Projects of China

Time	Pilot Theme	Pilot Regions
2009-2012	"Ten Cities and Thousands of EVs" Demonstration Project	25 cities: 13+7+5
2013-2014	Promotion and Application of New Energy Vehicles in Cities	88 cities
2021	Coordinated Development of Smart City Infrastructure and Intelligent Connected Vehicles in Cities	6 cities +10 cities
2021	Pilot of New Energy Vehicle Battery Swapping Mode Application	11 cities
2023	Pilot Zone for Full Electrification of Public Sector Vehicles	15 cities

Source: Author's compilations.

[10] Hong Kong Wen Wei Po. (2010, August 18). Key events impacting the development of new energy vehicles in China. Retrieved from http://pdf.wenweipo.com/2011/08/18/b03-0818.pdf

In 2010, the central government selected a further five cities (Shanghai, Changchun, Hangzhou, Shenzhen, and Hefei) to become the first batch of pilot cities to subsidize the purchase of EVs by citizens, and also for infrastructure standardization of batteries and charging stations. In return, the pilot cities were required to provide financial subsidies, preferential electricity prices, infrastructure and other supporting policies and measures (SH-GV06, 07; HF-ET02).[11] The fledgling domestic firms benefited from collaborating with local governments (SZ-GV01; BJ-ET09; SH-ET02, 05). For example, in 2010 BYD and Shenzhen's state-owned bus company established a joint-venture taxi company that used only electric vehicles.[12] In 2010, the success of these quasi-experiments motivated the State Council to identify new energy vehicles as one of the seven national strategic emerging industries (RI02, 09).

The joint efforts of the central and local governments in the pilot program resulted in a public sector BEV market. And yet, the industry was at an early stage and the private market remained weak (Wu et al., 2021). Technological immaturity, the inadequate charging infrastructure, and high prices retarded adoption (BJ-ET09; RI09) (Zheng et al., 2012).

During the 12th and 13th FYPs (2011-2020), the central government planning and local policies were introduced to speed adoption. In the 12th FYP, the central government supported all three possible technical roadmaps, which meant there was no clear central government decision on which propulsion technology would be successful (BJ-ET09; SH-ET10; RI02, 08). It was certain local governments that in their 12th FYPs prioritized BEV technology and adopted policy instruments that were more aggressive than those of the national plan (SH-GV01; SH-ET05; RI09). In 2011, Shanghai established China's first

[11] National Development and Reform Commission of China, (2010, May 31). Notice on pilot subsidies for private purchases of new energy vehicles, https://www.ndrc.gov.cn/fggz/hjyzy/jnhnx/201006/t20100603_1134366.html
[12] National Energy Administration of China. (2012, September 5). The Shenzhen model empowers the development of pure electric vehicles. https://www.nea.gov.cn/2012-09/05/c_131828199.htm

international demonstration zone for BEVs. During the demonstration process, Shanghai local governments directly provided or sponsored various public technical services for BEVs, such as vehicle testing and certification services, as well as local standards (SH-GV05; SH-GV07; SH-ET04; SH-ET05; SH-ET06). This environment fostered the growth of startups like NIO, a company focused on pure electric vehicles (SH-GV05; SH-ET02). Guangzhou explicitly stated a "focus on developing pure electric vehicles", with a set of specialized policies of supporting public technological ~~innovation,~~ testing and experimental equipments~~platforms~~, forming EV technical specifications and standard systems, building EV demonstration projects and areas and using government purchases (GZ-ET02). Shanghai and Shenzhen further put forward ambitious policy goals in their 12th FYP respectively. Shanghai aimed to "become China's leading technology, industrial agglomeration and mass application of new energy vehicles", while Shenzhen optimistically stated that "by 2015, the new energy industry will reach 250 billion dollars."

5.2 Large-scale industrialization (2014-present)

It was only in 2012, that the central government issued *The Planning for the Development of the Energy-Saving and New Energy Automobile Industry (2012-2020)*, in which the BEV was chosen as the main technological direction. In 2013, a new pilot project, *The Promotion and Application of New Energy Vehicles in Cities,* was initiated by the central government and pilot cities were expanded to 88 (Table 3). During this period, city-level incentive policies became the main driving force for the BEV industry.

In 2013, 2014 and 2015, to stimulate private BEV purchases, the central government issued three nationwide subsidy policies. The central government's financial subsidies were premised on encouraging the growth of domestic technologies and enterprises (C-GV03). In 2014, China announced the first group of new energy vehicles that would be exempted from

purchase tax -- imported BEVs were not included on the tax-free list -- BYD and CATL, the Chinese battery producers, were the main beneficiaries (C-GV03).[13] Local governments of Shanghai, Shenzhen, and Guangzhou, in addition to the national subsidies, also introduced more incentives such as license fee exemptions, exemption of BEV owners from driving restrictions, and priority access to land for building charging stations, etc. (SH-GV02, 05, 07) (Wang et al., 2019). In these huge cities, where both automobile purchases and registration were limited due to congestion, EV purchasers were exempted. As a result of these incentives from both of the central and local governments, sales of new energy vehicles (include BEV, HEV, FCV) exceeded 330,000 units in 2015, accounting for nearly 60% of the global market.[14] Further, in 2015, the State Council released *Made in China 2025*, within which the new energy vehicles industry was listed as one of the ten key development areas.

And yet, in 2015 in response to several subsidy frauds the governments reduced its financial subsidies (C-GV03) and implemented other measures.[15] For example, the government began using technical indicators, such as, range, energy efficiency, battery energy density, and power output to qualify for the subsidies (C-GV03; RI09). This allowed the government to test and verify vehicles, thereby driving out inferior producers and accelerating technological evolution (C-GV03; RI09) (Wu et al., 2021).

In 2014 and 2015, the central government issued three national policies outlining a comprehensive roadmap for accelerating the construction of charging infrastructure. It explicitly required local governments to incorporate charging facilities as part of the urban

[13] Ministry of Industry and Information Technology of China, & State Taxation Administration of China. (2014, August 27). Catalogue of new energy vehicle models exempt from vehicle purchase tax (First batch). https://www.miit.gov.cn/zwgk/zcwj/wjfb/gg/art/2020/art_f7e3cc5fb65447b1b429d0afe7d7b958.html

[14] National Development and Reform Commission of China. (2017, December 21). Review of the development of the new energy vehicle industry during the 12th Five-Year Plan period. https://www.ndrc.gov.cn/xwdt/gdzt/xyqqd/201712/t20171221_1197831.html?code=&state=123

[15] Ministry of Industry and Information Technology of China. (2016, December 20). Severe punishment for fraudulent subsidies in the new energy vehicle sector and regulation of industry development order. https://www.miit.gov.cn/jgsj/zbes/gzdt/art/2020/art_dd6367cc50e64368906fd3347f367815.html

planning ~~process for urban public infrastructure~~ and provide support in terms of land use and financial subsidies. Cities were eligible for annual central government financial support for the construction of a charging infrastructure (SH-GV01, 07; HF-ET01, 02).[16] Then in 2021 two new central government pilot projects were introduced to encourage local governments to invest in BEV infrastructure (Table 3).

Due to an increasing confidence in domestic technology, China reduced tariffs and other barriers to foreign firms thereby opening the domestic BEV market to global competition (C-GV03; SH-GV02; RI09). Most important, was the 2018 announcement that restrictions on foreign ownership in the automotive manufacturing would be gradually lifted, especially for the production of BEV (C-GV03; RI09).[17] Foreign BEV manufactures were no longer required to establish joint ventures with Chinese companies. Just one month after the release of this new regulation, Tesla announced the construction of a Gigafactory in Shanghai. It was the first and currently the only foreign automaker permitted to operate without a joint venture with a Chinese company. The Shanghai government negotiated with national ministries multiple times to secure the sole ownership right and tax incentives for Tesla (RI09; SH-GV02; SH-GV04). Further, European and Japanese ICE manufacturers such as Volkswagen, Mercedes, and Toyota built huge BEV manufacturing joint-venture operations in China (BJ-ET07; HF-GV01).[18]

At least three major BEV RISs emerged in China ~~(Table 4)~~. The first is Shanghai with leading manufacturers Tesla Gigafactory, SAIC Motor, and NIO. Tesla's entry into the market

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[16] Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, National Development and Reform Commission, & National Energy Administration. (2016, January 11). Notice on the "13th Five-Year" new energy vehicle charging infrastructure incentive policy and strengthening the promotion and application of new energy vehicles. https://www.mof.gov.cn/gkml/caizhengwengao/wg2016/wg201603/201607/t20160705_2344732.htm
[17] Central Government of China. (2018, April 17). China will gradually eliminate the foreign ownership limit in the automotive industry over a 5-year transition period. https://www.gov.cn/xinwen/2018-04/17/content_5283413.htm
[18] China Economic Weekly. (2022, December 30). Why are multinational car companies increasing their investments in China? http://paper.people.com.cn/zgjjzk/html/2022-12/30/nw.zgjjzk_20221230_7-06.htm

was prompted not only by the large market but also because it could take advantage of the powerful BEV supplier base and China's increasing leadership in battery technologies (SH-GV02; SH-GV04; SH-ET07). The second RIS is Shenzhen centered on BYD, which received support from both the central and local governments to implement EV pilot projects (SZ-ET04) (Rong et al., 2017). Also, the Shenzhen local governments invested heavily in infrastructure, with the highest density of public charging stations in China (SZ-GV01; RI09) ~~(Table 4)~~. With the BEV industry as a new pillar of the economic growth, in 2023 Shenzhen proposed to build a "new-generation, world-class automobile city".[19] Guangzhou, which hosts two leading BEV manufacturers and approximately 16,600 BEV-related firms is the third RIS. Similar to Shanghai and Shenzhen, the Guangzhou local government launched a number of initiatives to foster the local clustering of BEV enterprises (GZ-ET01,02).[20] Local governments not only tailored policies for leading local companies but also actively worked to orchestrate other supply chain actors (SH-ET04, 05; GZ-ET01,02). Most importantly, local governments introduced complementary policies, such as standards-setting, introducing laws to increase BEV purchases, and investing in education and research at local universities (SZ-GV01; SH-GV05; HD-GV01; SH-ET02; BJ-ET02; SZ-ET04).

~~Table 4. Three Major RISs of EVs in China (2022)~~

	~~Leading EV manufacturer~~	~~EV related firms (10,000 units)~~	~~EV Production (10,000 units)~~	~~EV Sale (10,000 units)~~	~~Urban Public Charging Station Density (Units /Km^2)~~
~~National~~	~~BYD, Tesla, Aiono~~	~~60.58~~	~~705.8~~	~~688.7~~	~~26.5~~
~~Shanghai~~	~~Tesla Gigafactory, SAIC Motor, NIO~~	~~2.15~~	~~98.86~~	~~33.25~~	~~56.7~~

[19] Shenzhen Bureau of Industry and Information Technology. (2023, August 3). Shenzhen three-year action plan for accelerating the creation of a new generation of world-class automobile city (2023-2025). http://www.sz.gov.cn/cn/xxgk/zfxxgj/zcfg/content/post_10764131.html

[20] People.cn. (2023, February 18). Industrial agglomeration effect boosts the high-quality development of Guangzhou's automobile industry. http://finance.people.com.cn/n1/2023/0218/c1004-32626490.html

Shenzhen	BYD	1.77	55	21.15	154.9
Guangzhou	Peng Motor, Aion	1.66	31.37	17.34	45.0

Data sources: China Academy of Urban Planning and Design; China Automobile industry Yearbook; QCC Technology Co., Ltd.

The interactions between local governments and entrepreneurs and between the local and central governments were vital for the success of China's BEV industry. The combination of central planning and local initiatives allowed a transition from government purchases to global commercial leadership. Central planning, represented by FYPs and medium- to long-term industry plans did motivate local governments to invest in local BEV entrepreneurship. In turn, local initiatives, along with substantial investments, helped the central government accumulate industry knowledge and market information that were vital in defining the dominant technological path. This underlies two connected collective learning processes between local government and entrepreneurs and between the local and central governments. The result is that China is now the global center of the BEV industry – but is also geographically dispersed – in contrast to the US where domestic ICE leadership remains concentrated in Detroit and, of course, Tesla, which is a Silicon Valley firm.

6 Discussion

China is a global leader in both online platforms and BEVs. This demonstrates that CNIS is capable of generating global-class, cutting-edge innovations. The Chinese innovation process is no longer only one of either catch-up or classical leap-frogging. The CNIS explicitly incorporates and learns from RISs, which are integral to the interactive learning relationship between the local and central governments. The local government leadership is incentivized to be entrepreneurial and engage in initiatives that result in learning and increased innovative

performance for the region and, by extension, the nation.

RISs are integrally embedded within the CNIS, with interactive learning between central and local governments serving as a key methodology for China to address uncertainties in emerging industries and foster new-to-world innovations. ~~By combining the central planning and local initiative, the role of China's central government in its NIS also goes beyond the stereotype of top-down direct intervention in catch-up industries to encouraging bottom-up, inter-level dialogue and learning in emerging industries.~~ The central-local relationship in CNIS exhibits different characteristics in the catching-up and innovation stages (as shown in Table 4~~5~~). While local autonomy existed in both stages, it was during the innovation phase that the central government shifted from a top-down approach of formulating industrial policies to learning from local experiments, recognizing the importance of bottom-up innovation in navigating uncharted technological paths. In catch-up industries, technological paradigms are well-defined, and the central government adopted a control-oriented approach, setting industrial policies and standards while delegating implementation to local governments. These industries primarily relied on the transfer or imitation of foreign technologies. Conversely, high levels of technological and industrial uncertainty are evident in emerging industries, with no established performance standards. Here, local enterprises drive innovation through R&D, and the relationship between central and local governments shifts to one of interactive learning. Leading local governments proactively support startups and pilot projects, while the central government plays a coordinating role, generalizing successful local experiments and developing strategic innovation policies. Thus ~~By combining the central planning and local initiative,~~ the role of China's central government in its NIS also goes beyond the stereotype of top-down direct intervention in catch-up industries to encouraging bottom-up, inter-level dialogue and learning in emerging industries.

Table 4~~5~~. Comparison of Central-local Relations between Catch-up and Emerging Industries in China

Type of Industry	Catch-up Industries	Emerging Industries

Policy Period	1980s-2000s	2000s-2020s
Technological and Industrial Uncertainty	Low: clear dominant technological paradigms, business models and performance standards	High: competition among multiple technological paradigms and business models, with no established performance standards
Knowledge Source	Introduction or imitation of existing foreign technologies	Local enterprises' research and development (R&D).
Central-local Governments Relationships	Control-oriented principal-agent relationship.	Interactive learning relationship.
Typical Cases	Combustion engine automobiles; low-end electric manufacturing.	Electric vehicles industry; online platform industry.

China's successes provide valuable case studies of how a non-OECD or a late-industrializing nation can harness local entrepreneurship and innovation to build successful cutting-edge industries.

In contrast to the structured relationships between local entrepreneurs and government and between the local and central government, in the United States the RIS and NIS is more disconnected due to a different legal structure its incentives. For example, in the US, the federal government plays the predominant role in government funding and procurement of technological innovation and launching industrial policies in emerging economic sectors (e.g., DARPA and the Internet, NASA and commercial satellites, etc.). State and local governments have far less resources to invest in technological innovation and, in particular, commercial firms. In many RIS private capital ranging from angels to formal venture capital provide capital for firms. Local governments can provide favorable zoning and tax breaks but rarely undertake procurement policies.

More recently, the US federal government has begun investing in regional technological capacity by designating and funding regional technology hubs, though these are usually relatively small.[21] Further, they do not drive the intensive interaction and customized

[21] Regional Technology and Innovation Hubs (Tech Hubs) | U.S. Economic Development Administration. Retrieved November 28, 2023, from https://www.eda.gov/funding/programs/regional-technology-and-innovation-hubs

incentives that the Chinese local governments introduce to support their entrepreneurs. Moreover, the US federal government has no structured channels for learning from local governments. Most important, US officials/politicians are not directly judged on their success in facilitating local economic development – US elections are decided by a far greater variety of issues. Similarly, the regional innovation strengths within the European innovation system are often robust, but given the diversity of European nations, it is difficult to generalize.

~~issues.~~

~~When compared to Chinese local governments, those in the US (and most other Western European nations) have far fewer resources to invest in innovative technologies making it difficult for them to make significant investments in local entrepreneurial firms. In the US, in many RIS private capital ranging from angels to formal venture capital provide capital for firms. Local governments can provide favorable zoning and tax breaks but rarely undertake procurement policies.[22] Similarly, the regional innovation strengths within the European innovation system are often robust, but given the diversity of European nations, it is difficult to generalize.~~

7 Conclusions

The Chinese online platform and EV industries show that local government initiatives in developing industries with new-to-the-world innovations is an integral part of the CNIS. The CNIS deliberately encourages and incorporates RISs by mobilizing local governments proactively to sense and ~~then~~ support innovative local firms. This is accompanied by active interaction with the central government. Importantly, while most observers suggest that Chinese

~~[22] The federal government and, in particular, the military have a long history of using procurement to support entrepreneurial firms.~~

technological directions are set centrally in a top-down fashion, which was true in most catch-up industries, we show that in both emerging industries there were local governments learning from local entrepreneurs that preceded or ran contemporaneously with central government initiatives or decisions.

We extend existing theories in two aspects: First, the theoretical framework and cases in this study address the gap in understanding how connections between RIS and NIS are structured in China. By focusing on the CNIS model of developing innovative industries, we underscore the critical significance of RISs as integral components of the China's ability to move to the cutting edge in a number of technologies, including online payment, drones, maglev rail, artificial intelligence, etc. Second, this study contributes to explaining the CNIS success in nurturing cutting-edge industries. China has two institutional learning mechanisms for emerging industries. On one hand, by encouraging the interaction between the local governments and entrepreneurial firms, while, on the other hand, creating a learning dialectic between local government-industry knowledge creation and central government industrial planning/direction setting. The now proven success of this model challenges the notion that the US relatively delinked NIS and RIS are necessarily the best emerging technology development model.

The CNIS with its delegation of significant agency to local governments can have significant costs. The non-market-oriented policy arbitrage space created by these firm-specific and industry-specific policies can encourage over-investment and long-term investment inefficiencies. For example, in the BEV sector, US and European government officials have claimed that such over-investment is a problem. In addition, the proliferation of local initiatives can result in local protectionism and market fragmentation that lead to duplication and vitiating the benefits of economies of scale and scope and network effects. These drawbacks thus far these

do not appear to have frustrated China's further development.

All NISs and their relationship with RISs are unique and emerged from the path-dependent development of the particular polity -- and, certainly, the CNIS is unique. However, learning from the CNIS is possible. For example, many countries have bureaucrats that rotate through local governments and are presumably judged by their success in their local postings. For example, India has central government civil servants that rotate throughout the country. Should their evaluation be more weighted towards their role in increasing the local economic development in the regions they serve? In other developing countries, could resources for technological (not scientific) development be transferred to local governments for them to invest and then be evaluated by economic development outcomes?

Decentralization, combined with evaluations of local government initiatives in recognizing and using their resources to support entrepreneurs developing seizing innovative technology has become an integral component of the CNIS. The deliberate integration of local government initiative in supporting emergent industries and local entrepreneurs allows a diversity of policies tailored to local conditions to be implemented, thereby creating a plethora of home-grown initiatives that the central government can monitor to learn "from the grass roots".

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