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EXPERIMENTING WITH ENTREPRENEURSHIP: GOVERNMENT, GLOBALIZATION, AND THE RISE OF TECH STARTUPS IN CHINA

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To My Family

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List of Abbreviations

CAS: Chinese Academy of Sciences
CCP: Chinese Communist Party
CICF: China Integrated Circuit Industry Investment Fund
CPU: central processing unit
CRO: contract research organization
FDI: foreign direct investment
HTZ: high-tech industrial development zone
IC: integrated circuit
IDM: integrated device manufacturer
IPO: initial public offering
MEI: Ministry of Electronics Industry
MII: Ministry of Information Industry
MIIT: Ministry of Industry and Information Technology
MNC: multinational corporation
MOST: Ministry of Science and Technology
NDRC: National Development and Reform Commission
NYSE: New York Stock Exchange
PE: private equity
R&D: research and development
S&T: science and technology
SEHK: Stock Exchange of Hong Kong
SME: small and medium-sized enterprise
SOE: state-owned enterprise
SSE: Shanghai Stock Exchange
SSTC: State Science and Technology Commission
SZSE: Shenzhen Stock Exchange
USFDA: United States Food and Drug Administration
VC: venture capital
VIE: variable interest entity

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Abstract

This dissertation examines the institutional origins of China's recent boom in technology startups and its contribution to the country's advance in high-tech. The past few decades witnessed a major transformation of China's political economy—from one that was hostile to entrepreneurship to one that actively supports and harnesses it, particularly that in technology. China's tech startup sector—now the world's second largest, just behind that of the U.S.—has become an important source of economic dynamism and played a key role in China's advance in many cutting-edge technologies. These developments cannot be satisfactorily accounted for by theories in comparative political economy that consider the state and the market as being mutually exclusive or those that prescribe certain state structures as necessary conditions for economic development.

To understand the rise of tech entrepreneurship and its impact on technological development in China, this dissertation draws from almost 100 field interviews in China and a variety of materials such as local gazetteers, memoirs, and listed company documents. I make three main claims in this dissertation. First, I argue that local tinkering of existing institutions and the embrace of transnational venture finance helped to foster entrepreneurship and forge new interests. This not only resulted in the removal of restrictive rules but also led to the creation of arrangements that combine the state and the market in new ways and render vibrant tech entrepreneurship and active state involvement mutually supportive. This finding contributes to the literatures on gradual institutional change and capitalist diversity and challenges works in comparative political economy that associate vibrant entrepreneurship with free market economies.

Second, through detailed case studies of the integrated circuit and pharmaceutical sectors, I show how the Chinese state through experimentation increasingly relied on

entrepreneurs—especially returnees—and became embedded in entrepreneurial networks, which helped to transform both sectors such that bottom-up discovery, specialization, and integration in global networks play a more prominent role. Leveraging local advantages and the opportunities created by globalization, entrepreneurs experimented with new products and business models and formed various kinds of relations with multinationals that transcended the hierarchical relations in the existing global production literature. I move beyond existing theories on development that stress state structures and strategies and show that the Chinese state's embeddedness in entrepreneurial networks was created in the process of high-tech growth and that the sectors have often developed in ways unanticipated by the state's industrial policies.

Third, I argue the potential of tech entrepreneurship has been limited by the Chinese state's continued pursuit of self-sufficiency and its inadequacies, particularly in market creation, regulatory capacity, and investment in basic research. By showing how concerns over the reliance on foreign technologies led to inefficient allocation of resources, I highlight the dilemma of pursuing high-tech development through participation in global networks of which a strategic competitor rests at the center. This argument also suggests that the demands on the state placed by high-tech are more arduous and comprehensive, especially for countries that strive for high degrees of autonomy.

Chapter 1 Introduction

China's sustained economic growth has been the subject of many social science inquiries. Earlier works have focused on rural industries in the 1980s and export-oriented foreign investment in the 1990s. More recently, entrepreneurship in technology has become an increasingly important source of growth and technological advance in the Chinese economy. The most successful tech startups, such as Alibaba and Tencent, have expanded at a remarkable speed and are now among China's largest companies. Many more have become publicly listed tech companies or the so-called "unicorns."[1] China's tech startup boom can be also seen in its venture capital market, which has grown from virtually nothing in the 1990s to $38 billion in 2017, making it the world's second largest, only behind that of the U.S.[2] Tech entrepreneurship is also playing a vital role in shifting China's economy from low value-added manufacturing and export toward domestic consumption and research and development (R&D). In the internet-based new economy, entrepreneurial firms have been actively creating new platforms and business models and have greatly transformed social life.[3] In cutting-edge industries such as artificial intelligence and electric vehicles, tech startups are key players driving China's advance.

Behind this tech startup boom is a gradual evolution of institutions that govern tech entrepreneurship in China. Whereas in the early stages of China's economic transition those hoping to start new businesses in technology faced numerous restrictions on and discrimination against private business, now the state actively supports and harnesses tech

[1] "Unicorns" are startups valued at over $1 billion but have not been listed on a stock exchange. According to CB Insights, by November 2020 there were 500 unicorns globally, of which 242 are based in the U.S. and 119 in China. Kazuyuki Okudaira, "Unicorns surge to 500 in number as US and China account for 70%," *Nikkei Asia*, November 26, 2020.
[2] Phred Dvorak and Yasufumi Saito, "Silicon Valley Powered American Tech Dominance—Now It Has a Challenger," *The Wall Street Journal*, April 12, 2018.
[3] This transformation is no longer limited within China, as demonstrated by the global expansion of TikTok.

entrepreneurship. Not only has the state removed various institutional obstacles faced by tech entrepreneurs and tried to improve their access to finance, but it also increasingly tries to leverage entrepreneurial initiatives for policy objectives, as can be seen in the recently launched Mass Entrepreneurship and Innovation campaign, which seeks to encourage entrepreneurship to promote economic growth, create jobs, and spur innovation. In addition, entrepreneurship and venture capital are now given important roles in the government's industrial policies, such as those targeting semiconductors and advanced manufacturing.

From prevailing social science perspectives, China's tech startup boom came as a surprise. In the liberal view, economic and political freedom are mutually dependent, with the former guaranteed by a limited government whose main function is protecting property rights and enforcing contracts. Closed political systems are often associated with the repression of economic opportunities and long-run stagnation. In the comparative political economy literature, vibrant tech entrepreneurship is seen as a unique strength of liberal market economies, whose institutions support unfettered movement of factors, particularly finance, which is regarded crucial for the rapid growth of new ventures. While China's political economy was not long ago considered rather hostile to entrepreneurship, remains under single-party rule today, and is often characterized as "state capitalist" and contrasted against free-market economies, the country has nonetheless fostered a vibrant tech startup sector in which the state plays an active role.

How was a political economy originally hostile toward private business gradually transformed into one that both supports and actively harnesses tech entrepreneurship? How has the rise of entrepreneurship contributed to China's advance in key high-tech sectors? Drawing upon months of fieldwork and a variety of materials, this dissertation examines the origins of China's tech startup boom and its effect on China's technological advance. In tracing the evolution of legal, administrative, and financial institutions that govern tech

startups in China, I highlight the role of local tinkering of existing institutions and China's embrace of transnational venture finance in fostering new activities and forging new interests that pave the way for institutional change. I show that not only have institutions restricting new ventures and their access to resources been removed or relaxed, but also new arrangements that combine public and private capital and initiatives have been created to harness tech entrepreneurship. In addition, through detailed sectoral case studies, I show how the Chinese state through experimentation increasingly relied on entrepreneurs—especially returnees, or what Saxenian (2006) calls the "new Argonauts"—and became embedded in entrepreneurial networks, which helped to transform these sectors such that bottom-up discovery, specialization, and integration in global networks played a more important role. Leveraging various local advantages, entrepreneurs experimented with new products and business models and formed various kinds of relations with multinationals that transcend the hierarchical relations in the existing global production literature. Moreover, I assess how the potential of tech entrepreneurship has been limited by the state's continued pursuit of self-sufficiency and its inadequacies, particularly in market creation, regulatory capacity, and investment in basic research. By tackling these questions, this dissertation contributes to the understanding of institutional change under politically closed regimes and shows how the state and the market can be creatively recombined to foster tech entrepreneurship under government guidance. It also enhances understanding of the state's role in high-tech with the rise of global networks of production, talents, and capital and sheds light on the opportunities and dilemmas of pursuing high-tech development in a globalized world.

Literature Review

Tech Entrepreneurship and Comparative Political Economy

In comparative political economy, vibrant entrepreneurship in technology is often associated with liberal market economies (LMEs), because they encourage risk-taking and unencumbered movement of factors, particularly finance. In *Varieties of Capitalism* (VoC) Hall and Soskice (2001) note the availability of venture capital in liberal market economies enables scientists and engineers to start new businesses to take their ideas to market. Though venture capital is considered as an exception to the pattern of allocating capital based on publicly available information in LMEs, it tends to be more amply supplied in countries with developed stock markets (Lerner and Tåg 2013), which are often LMEs, as opposed to other types of political economies whose financial structure is bank-centered (Black and Gilson 1998; Rajan and Zingales 2003). Apart from the provision of high-risk finance, a developed capital market also facilitates the creation of high-powered incentives, that is, the use of stock options by startups as a key form of compensation (Casper 2007). Due to institutional complementarities, these differences between LMEs and non-liberal political economies are considered stable and entrenched (Hall and Soskice 2001).

While LMEs are usually set against coordinated market economies (CMEs), oftentimes they also serve as the point of reference for the literature on "state capitalism." Kurlantzick (2016, 227), for instance, contrasts state capitalism with "free-market capitalism" and notes the former's lack of venture capital and inability to foster tech startups. In research on China's political economy, a similar critique that a powerful state has hampered entrepreneurship is often made. For instance, Yasheng Huang (2008) attributes China's phenomenal growth in the 1980s to the state's improving entrepreneurs' access to capital and providing them political reassurance, particularly in the rural area, and criticizes the shift to the state-controlled urban sector in the 1990s for creating massive distortion in the economy

and giving rise to what he calls "two Chinas"—an entrepreneurial, rural one and a state-dominated, urban one. Recent works that draw more heavily from the VoC literature to delineate the institutional characteristics of China's economy also stress the state/private duality (McNally 2012; Naughton and Tsai 2015), though they stop short of claiming private entrepreneurship has been inhibited by the state's active role in the economy. Rather, they stress how the latter coexists with the private sector, where entrepreneurs often rely on informal networks to access finance. Importantly, they see this duality as a stable—or at least stabilizing—arrangement, with the state-guided realm and the entrepreneurial realm each having "its own inner logic and internally reinforcing incentives" (McNally 2012). Naughton and Tsai (2015, 1) also conclude that China's "state capitalism" represents the emergence of "a reasonably stable and mutually reinforcing arrangement of political and economic institutions."

The VoC literature and the state capitalism literature that it inspires offer a valuable framework for studying capitalist diversity, but they provide little purchase for understanding China's tech startup boom. First, by privileging institutional stability and complementarity at the expense of change, they provide little analytical space for explaining the evolution of China's political economy from being inhospitable toward entrepreneurship to being supportive. In addition, they are often undergirded by an implicit liberal view that regards the public and private as antagonist or at least mutually exclusive. This view obscures the fact that private sector growth is often sustained by an active state, even in places such as Silicon Valley, and precludes the possibility that the state and market can be creatively recombined in various kinds of hybrid arrangements. Third, they assume the existence of a coherent national political economic system and tend to overlook the ways in which domestic institutions can be conditioned by cross-border forces such as the internationalization of entrepreneurial networks and venture capital. Of particular concern is cross-border flow of

capital, which, as Ching Kwan Lee (2018, xiii) puts it, "is too globally mobile and politically contested to be contained within national frameworks of institutional complementarity."

To be sure, comparative political economy scholars have begun to address some of these issues. An influential strand of literature has for instance examined the sources of incremental institutional change, highlighting the ambiguities around formal rules and their enactment (Streeck and Thelen 2005; Mahoney and Thelen 2010). This literature provides a much-needed correction to the static VoC paradigm, but it focuses primarily on the realm of rulemaking in pluralist polities and tends to presume well-defined and stable identities and interests. This limits its ability to explain instances of change in closed regimes where groups advocating for change were initially weak, such as the evolution of startup-governing institutions in China. Instead, I draw from works of the constructivist, pragmatist tradition, which sees actors and their practices as drivers of change, stresses that institutions are always indeterminate and can be creatively recombined, and calls for attention to how institutions are lived and the relational processes it sets off (Berk and Galvan 2009; Herrigel 2010; Berk, Galvan, and Hattam 2013). Understanding institutions and institutional change through this lens allows for the possibility that actors can creatively tweak existing institutions locally, forge new interests, and shift preferences of other actors.

In addition, the comparative political economy literature is paying more attention to how domestic institutions may be altered by transnational forces (e.g., Farrell and Newman 2014). In the realm of venture finance, Posner (2005) has shown how supranational bureaucrats at the European Commission played a key role in the creation of Nasdaq-style stock markets in various European countries. In this thesis, special attention is given to China's integration into transnational entrepreneurial and venture finance networks, which played a crucial role in strengthening the coalition for institutional change. At the same time, I stress that China's integration in transnational networks has not led to full convergence to the U.S. model of

venture finance but a mixture of state guidance and market allocation, as officials have actively sought to shape the VC market to harness tech entrepreneurship. Thus, China's embrace of foreign institutions goes beyond "institutional outsourcing" (Steinfeld 2010), that is, the acceptance of certain activities being governed by foreign institutions. Apart from embracing transnational capital, Chinese officials have created new arrangements in which state capital not only coexists but also *combines* with private capital. In other words, institutional evolution in this case involved innovation and hybridization rather than replication. By highlighting the role of the state and foreign capital in supporting China's tech startups and the unique institutional arrangements created to support and harness tech entrepreneurship, this project complements earlier works that emphasize how informal borrowing facilitated the rise of capitalist enterprises in China (Tsai 2007; Nee and Opper 2012).

The Politics of High-Tech Growth

The rapid industrialization of several East Asian economies in the second half of the 20th century led to numerous studies that tried to decipher the "East Asian Miracle." An influential literature stressed the central role of the state in masterminding these countries' late development. At the center of these developmental states were elite bureaucracies that were filled by some of the nations' best talents and governed by meritocratic rules (Johnson 1982; Wade 1990).[4] These bureaucracies implemented industrial policies to mobilize resources for targeted sectors and to protect the domestic market to nurture national champions. The effectiveness of these measures was predicated on the ability of the state to

[4] See also, Amsden (1989) and Kohli (2004). For a recent and comprehensive overview of the developmental state literature, see Haggard (2018). For origins of the developmental states, see Waldner (1999) and Doner, Ritchie, and Slater (2005).

discipline the private sector, i.e., state resources and protection were conditional on firms' satisfactory performance (Amsden 1989; Chibber 2003).[5]

While the developmental states proved highly effective in industrial catchup, later works suggest that their top-down mode of involvement is too rigid for rapidly evolving technologies. In an important contribution, Evans (1995) complements the early emphasis on the quality of bureaucracy with attention to the state's ties to the private sector. Conceiving industrial transformation as a shared project between state and society, he highlights the crucial role of the private sector in providing intelligence and decentralized implementation, which are especially important for sectors such as information technology. Similarly, Ó Riain (2004) points to the outstanding performances in high-tech of "developmental network states," which are more decentralized and preoccupied with nurturing post-Fordist networks compared to the bureaucratic developmental states that focused on creating vertically integrated national champions. Some of the bureaucratic developmental states have recognized their own limits and the need to work with actors with specialized knowledge and expertise and have reorganized knowledge-intensive industries such as biotech to share risks and deal with uncertainty with other stakeholders (Wong 2011).

Recent works on the state's role in rapidly evolving technologies also differ from the early one in its more positive take on globalization. The original developmental state literature has a strong nationalist bent, which is manifest in its emphasis on protection of domestic industry from foreign competition and the suspicion toward foreign capital. With globalization of production and R&D, there is increasing recognition of the benefits of various kinds of transnational connections, especially with countries with advanced technologies and abundant capital. A crucial task for the developmental network states is to foster beneficial global connections with other high-tech regions of the world (Ó Riain 2004).

[5] Maggor (2020) has extended this argument from industrial catchup to innovation.

Other works on the state's role in innovation also emphasize international networks of knowledge, production, and finance (Breznitz 2007; Taylor 2016; Ibata-Arens 2019).

This recent literature on the state's role in high-tech is helpful in highlighting the importance of decentralized networks and the potential benefits associated with deeper integration in the world economy. Importantly, it rejects the neoliberal prescription that with globalization and rapid technological change states should sit back but argues that states are still quite relevant, though to be effective they need to be active in more agile and flexible ways. Still, a few gaps exist in this literature. First, it tends to confer explanatory power on the state's structural features, especially its relations with domestic and international actors. This leaves unanswered the question of how a relatively top-down governed political economy with a weak private sector could nurture transnationally connected entrepreneurs and foster cross-border and decentralized networks. In the Chinese case, embeddedness was largely absent in the late twentieth century and could hardly explain the subsequent development in high-tech. Rather, it was gradually nurtured in the process of development as officials looked for new partners and increasingly relied on entrepreneurs. Second, the role of entrepreneurship is often shortchanged. To be sure, this literature considers the state and entrepreneurs as equal partners and emphasizes the state's role in fostering entrepreneurial networks and addressing network failures, yet in many accounts entrepreneurs do not seem to have much impact on industrial outcomes. This is most apparent in works that attribute patterns of high-tech growth to state choices (e.g. Breznitz 2007), which risk neglecting entrepreneurs' contribution in exploring new ways to organize production and connect to the global economy. To stay true to the idea that successful states are private sectors' collaborators rather than commanders and to better account for patterns of industrial development, we need to incorporate entrepreneurs' experimentations and innovations. Third, this literature has focused mostly on allies or strategic partners of the U.S., who have better

access to and are willing to rely upon American technologies and capital. The countries that have received the most attention—Ireland, Israel, Singapore, and Taiwan—have thrived in high-tech by specializing in certain products or production stages while being dependent on input and investment from American firms. In other words, their emergence as important players in global high-tech production rested on "careful economic and political negotiation of relations to the United States" (Ó Riain 2006, 79). Expanding the discussion to countries that are sensitive about vulnerabilities associated with dependence on the U.S. would help reveal some of the dilemmas and tradeoffs of developing high-tech by integrating in networks in which the U.S. holds the central position.

Research on industrial and technological development in China has been more cautious about the impact of global integration, mainly because China's participation in international networks relied heavily upon foreign direct investment (FDI), which initially focused on locating labor-intensive, low value-added phases of production to China. While this strategy attracted alternative sources of investment and created jobs, it is often argued that an ineffective state has hampered subsequent upgrading. For instance, Steinfeld (2004) points to how self-contradictory industrial policies combine with the rise of modularity in global production networks to lead to "shadow integration," or the lack of ability to move beyond the manufacturing of undifferentiated products. Others concur that uncertainties regarding policies has been an issue but suggest that China has managed to obtain considerable benefits from integration into global production thanks to local firms' efforts to innovate at the process level (Breznitz and Murphree 2011). While this debate is ongoing among scholars, the Chinese government was spurred to take a more active role in technology and innovation in the late 2000s, partly due to the concern that China might stay in the trap of low-end manufacturing. Recent research suggests that the implementation of this initiative has been

uneven, due to the coalitional constellations created by different types of foreign investment (L. Chen 2018).

While this literature has helped to identify the challenges of the foreign firm-centered, export-processing strategy, it is limited by its tendency to reduce the relations between indigenous and foreign firms to a few possibilities, whereas in reality these relations are varied and dynamic (Herrigel, Wittke, and Voskamp 2013). Research on China's clean energy sector, for instance, has shown that instead of unidirectional technology transfer Chinese firms and their foreign partners engage in collaboration and mutual learning (Nahm and Steinfeld 2014). In addition, the attention to policy uncertainties and the gap between central policy and local implementation seems to be misplaced. Much of the uncertainty regarding China's economic policies stems from the extensive experimentation and "maximum tinkering" in the policymaking process, which, as Sebastian Heilmann (2008; 2018) have argued, reflects a pragmatist approach and should be considered as a key source of the adaptability of China's political economy.[6] Others have similarly argued that China's economic success lies not in a specific set of policies per se but in the state's ability to make policy shifts, especially when the negative consequences of earlier policies become apparent (H. Yang and Zhao 2015). Moreover, local practices that contravene central policies sometimes open up new possibilities and create new alternatives (Nahm 2017).

Going beyond the hierarchical relations that have been the focus of much of the existing literature, this dissertation finds that new entrepreneurial firms in integrated circuit and pharmaceutical often develop products in close collaboration with domestic and foreign partners. The rise of this new types of firms has helped to transform the sectors' governance structures into ones where decentralized and transnational networks play a more important

[6] For origins of China's experimentalist approach, see Heilmann and Perry (2011). For local experiments in the political realm, see Florini, Lai, and Tan (2012).

role. It also shows that this transformation has been sustained by a shift in industrial policies that rely more heavily on entrepreneurship in these sectors. Several studies have highlighted the role of globally connected entrepreneurs in China's high-tech development (Saxenian 2006; Fuller 2016; Ibata-Arens 2019). I contribute to this literature by examining the policy shift behind the rise of entrepreneurial firms, which helped to transform sectors that initially featured rigid governance structures and relatively uncompetitive incumbent firms—many of them state-owned. I also suggest how and why the contribution of entrepreneurship to China's advance in integrated circuits and pharmaceuticals has been limited by various political factors.

The Changing Global Context

Part of the reason that old development models may no longer be effective is that the contemporary global economy is drastically different from the one in which newly industrialized economies took off. Developing countries increasingly find their hands tied by international pressures for liberalization in trade and foreign investment and government retrenchment as well as more stringent intellectual property rules. Whereas newly industrialized countries used a wide range of protective and discriminatory measures to foster indigenous industries, many of these policy tools are no longer feasible due to developed economies "kicking away the ladder" (Chang 2002). Not only have tariffs been substantially brought down and many restrictions over foreign investment removed, but developmental measures that were widely used such as subsidies and export credits can also incur considerable international pressures now (Weiss 2005). In addition, international rules regarding intellectual property that are championed by western multinationals, such as the Agreement on Trade-Related Aspects of Intellectual Property Rights, confer considerable

benefits on developed nations while constraining developing countries' ability to make headways in knowledge intensive industries (Sell 2003).[7] Indeed, thanks to increasingly stringent intellectual property rules, many high-tech industries have become quintessential versions of what Wallerstein (2004) called "quasi-monopolies," where western-based multinational corporations (MNCs) could prevent entry and competition and enjoy exorbitant royalty payments and profits.

At the same time, the increasing cross-border movement of production, capital and talents have created new opportunities for countries to develop high-tech by leveraging resources globally. First, the fragmentation and globalization of production and R&D have brought new possibilities for developing countries to enter high-tech. This is most notable in the increasing separation of design and manufacturing across firm and national boundaries, a phenomenon that is epitomized by Apple products that are "designed in California, assembled in China." More recently, even R&D has been disintegrated into more fine-grained tasks that are performed by specialized actors in different locations (Ernst 2005). This fragmentation provides startups in developing countries with more entry points into high-tech (Breznitz 2007) and creates possibilities for new kinds of relations between indigenous and foreign firms, going beyond the hierarchical relations that have been the focus of much of the global production literature (Ernst and Kim 2002; Henderson et al. 2002; Sturgeon 2002). Firms in developing countries not only can serve as suppliers for western-based lead firms but can also develop their own products drawing on the input from suppliers based in developed regions or relying on MNCs to bring those products to market. For instance, startups can provide R&D services to foreign companies developing and marketing their own products; or they can design and market their own products while relying on modules, tools,

[7] Schwartz (2019) has argued that intellectual property rights have played a key role in sustaining U.S. geo-economic power by allow American firms to extract disproportional profits from the global economy.

and manufacturing services provided by others; or they develop new products but rely on MNCs to bring those products to market. Whereas newly industrialized economies caught up by replicating entire industries through careful coordination, the key to success in the age of global production is identification of opportunities and specialization.

Responding to the globalizing technology landscape, venture capital (VC) is also becoming an increasingly international industry. Traditionally, VC in the U.S., where it first originated, was highly locally oriented. Venture capitalists mostly invested in companies in close proximity in order to better access information and provide hands-on assistance to startups. As high-tech globalizes, there is a stronger imperative to explore opportunities elsewhere, particularly if synergies can be created among different high-tech hubs. As one venture capitalist observed, "VCs in Silicon Valley used to pride themselves on being local. That was well and good when the U.S. was the mecca for technology, but today the leading markets are China, Japan, Korea, Taiwan. Entrepreneurs need to talk to the people who are determining where the world is going, and they can't do that if everyone around the table is American."[8] Due to the importance of reputation and trust in the process of VC investment, this cross-border capital flow is facilitated not so much by factors shaping traditional foreign investment like host countries' formal institutions as skilled migrant networks (Pandya and Leblang 2017). These networks are also crucial for accessing overseas capital markets. For instance, Jewish American investors played an important role in helping Israeli tech companies to raise funds on Nasdaq (Breznitz 2007).

Transnational actors not only can bring capital from overseas but can also start new companies that often have dense cross-border ties. The role of these technically skilled transnational entrepreneurs with extensive professional experiences in established high-tech hubs has been highlighted by Saxenian (2006), who shows how these actors facilitate "brain

[8] *Forbes*, "The Global Startup," November 29, 2004.

circulation." A key point is that their contribution is not so much returning to their home countries with knowhow as deepening linkages with established high-tech hubs like Silicon Valley. In other words, these transnationally connected entrepreneurs, who are well placed to identify entry points in global high-tech industries, can help their home countries upgrade by building collaborative relations with advanced regions and diversifying participation in global production.

These new facets of globalization create opportunities for developing countries to leverage overseas resources and participate in global production in new ways, not merely as recipients of foreign investment by MNCs. But these opportunities will not turn into fruitful outcomes automatically unless the state takes active measures to take the most advantage of them. After all, many countries have failed to make the necessary investment in higher education or R&D (Doner and Schneider 2016) to be able to create local advantages or foster transnational networks. And returnee entrepreneurs sometimes find the state to be more of an impediment than a partner (Zweig, Tsai, and Singh 2021). In a word, the state still has important roles to play in rapidly evolving technologies in a globalizing world, though its key tasks differ substantially from those for the development of relatively mature, vertically integrated industries.

Main Arguments

This dissertation addresses two related issues: the rise of tech entrepreneurship in China and its impact on the country's advance in high-tech. Following Schumpeter (1934), I define entrepreneurs as those who carry out new combinations of productive means, including the introduction of new products (or of existing products to new markets), new methods of production, and new ways of organizing production. Thus, entrepreneurs are not merely

actors who start new businesses, but those who do so in a way that could bring "creative destruction" and drive economic development. By tech entrepreneurship, I mean the carrying out of new combinations in high-tech industries especially through the creation of new ventures. Entrepreneurship is intrinsically a risky endeavor as there is no guarantee that the new combination will generate sufficient return to compensate for the investment made to carry it out. This is especially true in high-tech, because technologies rapidly evolve, and the resources required to bring a product to market are substantial. Thus, an "entrepreneurial state," that is, a state that actively invests in technologies and shares risks, is often needed for entrepreneurs to succeed in high-tech (Lazonick 2008; Mazzucato 2015).

How did a political economy originally hostile toward entrepreneurship gradually evolve into one that supports and actively harnesses it, especially that in technology? I argue that local tinkering of existing institutions and China's embrace of transnational venture finance[9] helped to create space for tech entrepreneurship in China when private businesses faced various restrictions and discrimination. Local tinkering refers to seemingly small adjustments or additions that foster new activities and reorient existing institutions by actors who have no authority over national level rules. These innovative actions were actively carried out or supported by local officials incentivized to deliver economic growth, and promising ones received backing from actors within the central state. These local tinkering created space for tech entrepreneurs, who founded and grew ventures in innovative ways and through their success helped to change perceptions and forge new interests. The key instances of local tinkering were the emergence of hybrid tech startups in the 1980s, which combined formally public ownership with substantial autonomy of the entrepreneurs when there were strict restrictions over the private business, and the creation of startup-friendly areas under the

[9] Transnational venture finance refers to cross-border capital that funds new ventures and includes transnational venture capital and overseas stock markets. The two are closely connected because when portfolio companies list their shares in overseas stock markets, the initial investment by transnational venture capital becomes liquid, which allows venture capitalists to easily exit.

high-tech zone program in the 1990s, which provided resources to startups when private businesses were legalized but continued to face various kinds of discrimination. These efforts created several fledgling startup hubs, particularly in Beijing and Shenzhen, and attracted transnational venture capital (VC), which was embraced by its allies within the Chinese state. The state not only accommodated the entry of transnational VC and encouraged the utilization of overseas stock markets but also allowed the wave of internet startups to access transnational venture finance, even though foreign investment was legally forbidden in much of the internet industry. The state's accommodating stance deepened China's integration in transnational networks of venture finance, which played a crucial role in expanding the coalition supporting tech entrepreneurship by changing the perceptions of powerful officials and facilitating the rise of a prominent group of entrepreneurs and investors.

In the meantime, China's institutions for venture finance have not converged toward the U.S. model, as the state has actively sought to harness tech entrepreneurship and VC. This was facilitated by local tinkering, which helped to transform the state's role and allowed it to combine public and private initiatives. After the initial efforts of acting as direct supplier and investor of VC produced mixed results, officials through local experiments devised new arrangements that fuse state and private capital and allow the state to remain active in a way that relies on the initiatives, expertise, and networks of private entrepreneurs and venture capitalists. Government established VC guidance funds created a new kind of VC that is distinct from the mostly overseas supplied, return-oriented VC. The recent proliferation of guidance funds further boosted tech entrepreneurship in a period where the Chinese state was considered to have advanced in the economy. I compare the state-guided VC with the return-oriented VC and show they have different priorities and sectoral focus. As a result, China's institutions for venture finance feature a combination of state guidance, increasing role of the domestic capital market, and integration in global networks of venture finance.

Through detailed case studies of the integrated circuit (IC)[10] and pharmaceutical[11] sectors, I further argue that state experimentation and flexibility facilitated the embrace of and increasing reliance on entrepreneurship as an important means of advancing high-tech in China and that this helped to encourage bottom-up exploration and deepen participation and learning in global networks. I show that state embeddedness in entrepreneurial networks was created in the process of the sectors' development, not a structural condition that led to the latter. Prior to 2000, these sectors featured rigid governance structures firms with limited innovative capabilities, many of which were state-owned. Then various state actors supported returnee entrepreneurs and encouraged organizational forms previously overlooked, and the success of early startups led officials to more actively rely on entrepreneurship to develop these sectors. With an increasingly supportive institutional environment, entrepreneurs explore new products and business models as well as new ways of organizing development and production, thereby helping to reveal information about what high-tech products and how they can be profitably produced. Experimentation thus helped to refashion China's industrial development efforts such that bottom-up initiatives are encouraged, similar to what Dani Rodrik (2007) envisions to be discovery-based industrial policy. By actively supporting entrepreneurs to explore new strategies and generate new information, this goes beyond the traditional emphasis on collecting information through linkages between the state and the private sector. In the age of global production, startups often find it imperative to specialize while working closely with domestic and foreign partners in a variety of relations. Thus, the rise of entrepreneurship also facilitated decentralized collaboration and cross-border learning

[10] An integrated circuit, colloquially known as a chip, is an arrangement of electrical circuits and components that are embedded on a semiconductor chip. It is the most important subcategory of semiconductor products, accounting for over 80 percent of total sales. In this dissertation, "integrated circuit" (IC) and "chip" are used interchangeably.

[11] Colloquially "pharmaceutical" is sometimes used to refer only to the chemical-based drug segment that is dominated by large pharmaceutical companies. In this project, "pharmaceutical" is a more general category that refers to the industry that develops and produces medicine, including both the chemical-based segment and the newer biopharmaceutical segment.

and deepened China's embeddedness in global networks of capital, production, and technology.

Importantly, I show that the patterns of sectoral development cannot be fully accounted for by the state's industrial policies; rather, they are significantly shaped by entrepreneurs' innovation in business models and strategies, though the state certainly played an important supportive role in facilitating these innovations. Much like Yuen Yuen Ang's account of China's escape out of poverty (2016), I show that sectoral development in high-tech unfolded in a coevolutionary process in which the rise of entrepreneurial firms stimulated changes in the state's relations with the private sector and global networks as well as its industrial strategies and in turn benefited from them. Simply put, the development of China's IC and pharmaceutical sectors owe to an active and adaptive state as well as the exploration of entrepreneurs.

In addition, I argue that the gains of entrepreneurship have been limited by the state's pursuit of self-sufficiency and inadequate investment and regulatory capacity. In the IC sector, concerns about national security have diverted state support away from market-oriented, entrepreneurial firms and blunted efforts to specialize and upgrade. While entrepreneurs helped to build a vibrant IC design subsector and have been receiving stronger state support, sense of vulnerability in information security and, increasingly, supply chain security has led the government to keep pouring resources into state-run entities that focus on other parts of the IC production chain, shifting resources away from areas where Chinese firms have better chances of reducing their gaps with global leaders. In pharmaceuticals, while entrepreneurs created a vibrant subsector that provides outsourced research services, the growth of startups dedicated to bringing innovative products to market was hampered by the state's inadequate investment in healthcare provision and limited ability to screen and approve new drugs. It is only in recent years that a healthcare reform, which boosted

domestic demand for high-quality medicine, and an overhaul of the regulatory apparatus stimulated entrepreneurship in the development of new drugs. Even so, in both sectors the state's investment in R&D, which supports the knowledge base for entrepreneurship, is still a far cry from the U.S. Thus, in contrast to popular perception of a powerful government spearheading technological advance in China, I suggest the contribution of the Chinese state has in fact been inadequate due to non-developmental objectives and the lagging behind of capacity and investment. These findings reveal the tension between the gains from integration in global networks and the pursuit of national autonomy, which is particularly pertinent for a rising power increasingly viewed with suspicion by the leading power that holds a central position in high-tech. They also indicate that the state has an important role to play in fostering successful entrepreneurship in knowledge intensive industries.

Data, Methods, and Plan of the Dissertation

This dissertation draws from eight months of fieldwork in China in 2018 and 2019. I conducted about 100 interviews with government officials, entrepreneurs, venture capitalists, scholars, and industry consultants in Beijing, Shanghai, Shenzhen, and Suzhou. These cities are the ones where some of the most important local tinkering and experiments regarding tech startups took place. They are also presently the most vibrant tech hubs in China, accounting for over 60 percent of VC invested in the country in 2017 (Zero2IPO 2018) and over 70 percent of active VC firms (*China Venture Capital Yearbook 2015-2016*). In addition, these cities are home to China's most important startup firms in semiconductor and pharmaceutical as well as the sectors' largest clusters, particularly Beijing's Zhongguancun and Shanghai's Zhangjiang. I also consulted a variety of materials including local gazetteers, yearbooks,

memoirs, government statistics, listed company documents, venture capital databases, industry research reports, and news articles.

To maintain the anonymity of the interviewees, I do not name the organizations they work for. Instead, I identify them by the year in which the interview was conducted and an ID number. I also use a letter to denote their profession: C for consultants, E for entrepreneurs, G for government officials, S for scholars, and V for venture capitalists. Thus, "Interview V2018-020" stands for an interview with a venture capitalist in 2018.

While this study focuses on a single country, I use comparison to illustrate my argument wherever it is appropriate. More concretely, to show that China has created a unique type of VC through the hybridization of state and private capital, I compare it with return-oriented VC. In the sectoral case studies, I compare the governance structure before and after the rise of entrepreneurship in each case. In addition, I examine both the commonalities and the differences between the two sectors, that is, how the rise of tech entrepreneurship produced similar effects on sectoral development and how the effects differed due to political factors and their interaction with sectoral characteristics.

I use sectoral case studies to assess the impact of the rise of tech startups on China's advance in high-tech. The integrated circuit and pharmaceutical sectors are chosen due to their importance, high thresholds for entry and success, and known affinity for entrepreneurship. IC is a critical component of nearly all electronic devices and is often considered as the foundation of modern-day information technology. It is also a key sector for the U.S.—the world's leader in high-tech—and for the Asian Tigers of Singapore, South Korea, and Taiwan, for all of whom chips are the top export item. Pharmaceuticals is a one-trillion-dollar industry globally, but more importantly the development of new drugs—which are increasingly biologics-based—is a vital source of improvement in healthcare provision, which leads many governments to invest heavily to support R&D. But the complexity and

knowledge intensity of the sectors as well as leading countries' efforts to maintain their advantages have made it very challenging for developing countries to advance, and only a handful of late developers have so far been able to make some headway in the IC and pharmaceutical sectors. Thus, they are more difficult cases than the internet-based businesses like e-commerce, which has been growing rapidly in quite a few developing countries with a sizable population. At the same time, the fact that American startups have played an important role in technological advance in both sectors makes them natural candidates to assess the impact of tech entrepreneurship in China. After all, not all high-tech sectors are susceptible for frequent combinations and experimentations by entrepreneurs.

The dissertation is divided into two parts. The first part focuses on the historical processes of institutional evolution with respect to tech entrepreneurship and the unique venture finance arrangements that have been created. Chapter 2 discusses how local tinkering of existing institutions and embrace of transnational venture finance fostered tech entrepreneurship and forged new interests in favor of expanding startups' access to resources. It traces key developments since the 1980s, including the emergence of hybrid startups, the creation of entrepreneur-friendly areas, and China's integration into transnational networks of venture finance, and shows how they cumulatively created new coalitions and changed perceptions of state officials. Chapter 3 examines the state's efforts to harness tech entrepreneurship and VC. It first traces how the state's role in VC evolved and how officials through local experiments came up with and promoted the arrangement of VC guidance funds, in which the state is a "limited partner" of professional venture capitalists. I show this led to the creation of a new type of VC, which differs in its priorities and sectoral focus from VC seeking maximum return.

The second part of the dissertation uses the IC and pharmaceutical sectors to assess tech entrepreneurship's impact on high-tech development in China and how it is conditioned by

the state's priorities and capacity. In Chapter 4, I show how officials, unsatisfied by the performance of state-owned enterprises (SOEs), tried to work with transnational entrepreneurs to develop the IC sector. The increasing support to and reliance on entrepreneurship facilitated the exploration of new products and vertical disintegration. Startups specializing in IC design grew particularly rapidly, thanks to the increasing sophistication of the domestic consumer electronics market and the startups' dedication of working with local electronics producers. At the same time, they often leverage capital, input, and manufacturing capabilities of overseas partners and learn from participation in these networks. However, the resources and support received by this design subsector have been limited by the state's focus to other parts of the IC value chain, which results from concerns that dependence on foreign technology and input—a natural outcome of integration in global networks—can create vulnerabilities. The recent tension between the U.S. and China in technology has only exacerbated this dilemma between global integration and self-sufficiency.

Chapter 5 switches to the pharmaceutical industry, which was dominated by numerous small firms focusing on generic drugs or traditional Chinese medicine with negligible ability in innovation. Overseas trained scientists began to return to create startups in the late 1990s, often with support from the local state. A group of startups that leveraged China's large talent pool in biology and chemistry to provide R&D services to foreign companies became particularly successful and helped to embed China into global networks of drug innovation. On the other hand, those focusing on the development of new drugs struggled due to the state's insufficient support for R&D and incompetence in regulating drug development. It was only after a series of state initiatives since the late 2000s—including healthcare reform, increased support for R&D, and overhaul of the regulatory apparatus—that scientists and venture capitalists recently showed great interest in starting and supporting companies

dedicated to the development of new drugs. Importantly, the state's increasingly embeddedness in transnational networks facilitated the introduction of new measures supporting entrepreneurial firms. Like those in IC, these startups in pharmaceuticals develop products while collaborating closely with domestic and foreign partners.

The concluding chapter puts the rise of tech startups in China in comparative perspectives. I show China not only differs from the archetypical developmental states of Japan and South Korea—which had more insulated political economies—but also has developed distinctive features compared to the more networked developmental states like Israel and Taiwan. I also discuss the similarities and differences between the tech startup sectors in China and the U.S. and show that both in fact feature an active state and the mixture of public and private, though there are differences in the state's involvement. I then discuss the limits placed on China's tech startup sector by continued single-party rule and political control and increasingly confrontational U.S.-China relations.

Chapter 2 Local Tinkering, Global Integration, and Institutional Change

The rise of tech entrepreneurship is an important yet understudied facet of China's transformation from plan to market economy. This chapter examines the gradual evolution of institutions that governed tech startups in China since the 1980s, paying special attention to how hybrid startups emerged when China was still a predominantly socialist economy, how a few areas became fledging tech hubs when private ownership was recognized but continued to be discriminated against, and how transnational venture finance was embraced and helped to create a vibrant and globally connect tech startup sector in China. Groups supporting institutional change were initially weak—just a few researchers and officials inspired by the Silicon Valley model at the very beginning. But local tinkering created the space for tech startups, whose development gave rise to new groups, changed perceptions of officials, and helped to attract transnational venture capital. The embrace of the latter turbocharged the tech start sector when China's formal financial system was hardly accessible for startups. This helped to create a prominent group of entrepreneurs and venture capitalists with allies within the state, which further facilitated the reorientation of policies and institutions such that the state could support and harness tech entrepreneurship. Thus, institutional evolution in this case has been an interactive process in which new interests and preferences were forged and domestic as well as transnational sub-processes were involved.

Fostering Tech Entrepreneurship in a Socialist Economy

In the early days of China's reform and opening up, a new type of tech enterprises emerged in a few urban areas with a concentration of public research institutes and universities, such as Zhongguancun in Beijing and Donghu in Wuhan. These so-called *minying* (nonstate-run) tech

enterprises[1] combined nominal nonprivate ownership—the only ownership form allowed at the time to organize substantial business—with managerial autonomy of the founders and a market orientation to foster entrepreneurship without challenging the predominantly socialist economy. *Minying* tech enterprises, an umbrella category composed of a variety of enterprise forms improvised by tech entrepreneurs and supported by central and local officials, created the space that enabled the emergence of tech entrepreneurship in urban centers.

The loosening of the planned economy in the late 1970s created opportunities for science and technology (S&T) personnel—researchers and engineers working at state-owned entities—to benefit financially from their knowledge and skills. In the Yangtze River Delta, engineers from SOEs moonlighting and working for the rapidly growing TVEs became a common practice. In Beijing's Zhongguancun, an area filled with universities and research institutes, some S&T personnel started to provide technical support for other enterprises on a part time basis. A few even formed independent entities and hired employees. Given the restrictions on private business, these startups maintained an ambiguous status: many operated informally without business registration and self-identified as research institutes (研究所), development centers (开发中心), or service cooperatives (服务社) to obscure their business nature. The founders and key technical staff—usually researchers and professors at state institutes and universities—mostly worked on a part-time basis while keeping position at and obtaining resources from their state employers.

These tech startups emerged at a time when many within the state, after being exposed to the development of high-tech industries in the west thanks to increasing international exchanges, became dissatisfied with China's rigid S&T system and were open to new ideas

[1] The state first used the moniker "nonstate-established scientific research organizations" (民办科研机构) to refer to entities established by S&T personnel without much state input. A broader designation "nonstate-run S&T enterprises" (民营科技企业) was later used to incorporate enterprises that were established with substantial state input but enjoyed managerial autonomy.

and experiments. Specifically, they saw the hierarchically organized research establishment and its separation from production and commercialization as major sources of rigidity and low efficiency. This was reflected in the experience of Chen Chunxian,[2] a researcher at the Institute of Physics of Chinese Academy of Sciences (CAS) who was credited for establishing China's first *minying* tech enterprise. Chen had the opportunity to visit Silicon Valley in the late 1970s and was very impressed by the region's dynamism. After returning to China, he discussed what he observed with colleagues, gave lectures about the Valley, and soon found some supporters. Backed by the semi-governmental Beijing Association for Science and Technology (BAST), where Chen was a member, he founded a technological consulting business in 1980 with several colleagues.[3] Chen later recalled:

> I had two motivations for starting this nonstate-established research entity. First, I worked at CAS for a long time and felt strongly that a fundamental weakness of our country's science and technology system is the fact that many research projects are stuck at the stage of exhibits and prototypes but cannot be timely transformed into material wealth of the society…Second, I visited foreign countries three times between 1978 and 1981. Several small factories that I visited in Silicon Valley particularly impressed me. These factories transform technologies into products very quickly and are full of energy (C. Chen 1985, 6).

Chen Chunxian's initiative was significant because it was noticed by several leaders in the top echelon of the ruling Chinese Communist Party (CCP), who took a stand on the matter. To avoid trouble, Chen named the startup "advanced technology service department" affiliated with BAST. He and other consultants at the entity—mostly fellow CAS researchers—worked on a part-time basis. Still, he was soon accused of disturbing work at state entities and of using state property for private benefits and encountered censure and

[2] In this dissertation, the names of all Chinese figures are written according to the Chinese custom, in which the surname comes first.
[3] Xin Junxing, Ji Shiying, and Li Kemei, "Gardener of New Things, Intimate Friend of Scientists (新事物的园丁 科学家的挚友), Science Times (科学时报), August 16, 2010, http://news.sciencenet.cn/sbhtmlnews/2010/8/235552.html.

harassment. At the time, some among the CCP leadership were pushing for reforms in S&T so that it could better serve the priority of economic development, and they saw Chen's initiative as a valuable experiment. When internal reports on Chen Chunxian's initiative reached top leaders in January 1983, Fang Yi, a politburo member who also headed the State Science and Technology Commission (SSTC), and Hu Qili, a member of CCP's Secretariat, expressed support to the entrepreneurs, arguing that this type of initiatives should be encouraged, and General Secretary Hu Yaobang endorsed their comments (Association for Nonstate-Established S&T Entrepreneurs in Beijing 1994).[4]

Endorsement from the top provided a powerful boost to the entrepreneurs and their supporters. Encouraged by the endorsement, more S&T personnel took their chances of starting new businesses. Various state entities also showed more willingness to allow for and support these initiatives. In addition, the startups no longer operated informally but began to carry formal business status, though mostly as collective enterprise. There were several reasons for registering businesses as collectives. First, since individuals had limited savings, startup funds often came from public organizations (associations, institutes, local governments etc.) in the form of investment or loans. Second, even those that primarily relied on personal savings chose to register as collectives due to the socialist era restrictions on private business. In urban areas, the only form of private business allowed at the time was household businesses with no more than a handful of employees—those with more were considered capitalist. In addition, household businesses were regarded as a marginal sector of the urban economy and were commonly discriminated against. Thus, even entrepreneurs that mainly relied on personal savings and technically could choose the household form often registered their startups as collectives and affiliated with a public organization.

[4] It is worth noting that all three leaders had close connections to CAS. Fang Yi and Hu Yaobang once headed the academy, while Hu Qili's sister was then director of an institute under CAS.

Recognizing that some in the center backed tech entrepreneurship, other state agencies become active supporters of the nascent nonstate tech sector. The government of Haidian District, where Zhongguancun is located, was sympathetic to the early entrepreneurial initiatives but initially refrained from openly supporting them due to the sensitivity of the issue (Duan 2017). With endorsement from the top, officials now actively helped informal startups obtain formal status and helped aspiring S&T personnel create new businesses.[5] They also protected the entrepreneurs from criticism and harassment. While many within state research institutes were initially concerned about the disruption created by people leaving to run businesses, the attitude began to shift with ongoing S&T reform, which cut the institutes' budgets and forced them to earn income on their own. For instance, the Institute of Computing Technology of CAS, under the funding pressure, formed a spinoff which later became Legend Holdings, the parent company of Lenovo. The Institute provided seed capital and many other resources to the startup and the founders kept their status as the institute's employees (Lu 2000). While the company was formally state-owned, the founders enjoyed high degrees of autonomy and pursued profitable businesses outside of state plans. Leadership at CAS later promoted this formula—known as "one academy, two systems"—of encouraging subordinate research institutes to establish market-oriented spinoffs while maintaining some basic research under the old system. Since researchers who became entrepreneurs only collected basic salary (in some cases no salary at all), often contributed revenue through research and equipment sharing, and could potentially bring interests or dividends, research institutes gradually became willing to let them start business and support them with funds.

[5] The government of Haidian District provided startup funds to three of the four most prominent early Zhongguancun tech startups (Office of Beijing Municipal Committee for Local Chronicles Compilation 2008).

At the center, SSTC, which was actively involved in the ongoing S&T reforms, emerged as a major champion of the *minying* tech sector. After the emergence of nonstate tech startups, SSTC led the drafting of a major reform program promulgated in 1985, which formally allowed collectives and individuals to establish for-profit "scientific research or technical service entities." The agency became more active as the political environment became more permissive and the nonstate tech sector became more prominent. By 1987, the four most prominent tech startups in Beijing achieved a total revenue of 730 million yuan in 1987 (Office of Beijing Municipal Committee for Local Chronicles Compilation 2008), which was equivalent to more than two percent of the city's annual economic output. Reform-minded party leaders showed their appreciation by attending a symposium held for tech entrepreneurs. With endorsement from the top, SSTC made nonstate tech enterprises an official category under its jurisdiction. It also sponsored the establishment of associations for tech entrepreneurs, which served as important platforms for tech entrepreneurs to organize, self-protect and channel their concerns to their patrons in the state. In a period when entrepreneurs often encountered difficulties doing business and sometimes faced charges of various economic crimes, this kind of protection was crucial for entrepreneurs to navigate in a hostile environment full of uncertainty.

Because the nonstate tech sector emerged in an institutional environment hostile toward private ownership and that many startups relied upon resources from state entities, the property rights of these enterprises were vaguely defined. In practice, control of the assets was worked out through bargaining and negotiations, particularly between the entrepreneurs, sponsor entities, and local governments. While underspecified property rights later became an issue after China embraced private businesses,[6] the unique solutions of these hybrid

[6] In the 1990s, many hybrid tech enterprises spent much of their energy on clearly defining their property rights, often at the expense of focusing on their businesses. Legend Holdings, the more successful case of property clarification, established its current sharing holding structure in the late 2000s.

enterprises helped to encourage entrepreneurship in an otherwise uncertain environment and bring resources under state control to more dynamic ventures (Francis 1999).

Creating Startup-Friendly Pockets

An important institutional evolution in the 1990s was the emergence of startup-friendly areas, often within high-tech industrial development zones (HTZs). These zones, however, were not originally created to facilitate tech entrepreneurship per se but were given the more general task of integrating S&T and the economy and advancing high-tech industries. The idea of creating special zones for high-tech industries had been discussed since the early 1980s (Suttmeier 1991), but there was disagreement over whether China—being a poor country at the time—should devote valuable resources to these fund-consuming and risky industries. Early proposals of HTZs advocated a top-down model and involved heavy state investment in infrastructure and were deemed unaffordable by central leaders (Du 2017). In 1988, following positive assessment of the Zhongguancun area's recent development, the Central Leading Group of Economics and Finance approved the creation of the nation's first HTZ in the area. Officials, however, did not have a clear blueprint of how the zone would be developed. A top leader specifically advised to just have two or three such zones at the beginning as pilot programs (Yu 2002), and Zhongguancun was designated an "experimental zone."[7] Beijing's municipal government was given broad authority to design policies for the zone and after drawing input from the local *minying* tech sector decided to use favorable tax rates for tech companies as the zone's key policy instrument.[8] Tech enterprises were

[7] Its full name was Beijing New Technology Industrial Development Experimental Zone (北京市新技术产业开发试验区). In 1999, it was renamed to Zhongguancun Science and Technology Park (中关村科技园区).
[8] Interview G2018-042.

exempted from the prevailing 35 percent income tax for three years since inception and only needed to pay 15 percent afterwards, and those exporting over 40 percent of their products could enjoy an even lower rate. In addition, enterprises within the zone faced fewer import/export and pricing restrictions.

Local governments in other parts of the country soon followed to create their own HTZs and in 1991 the State Council bestowed the status of national HTZs on 26 of them. Given the lack of clear blueprint, local officials running these HTZs enjoyed substantial flexibility in implementation. Since one of central leaders' main motivations in setting up these zones was in fact to support the export-oriented coastal development strategy,[9] many HTZs initially focused on luring foreign investment, making them resemble export-processing zones more than entrepreneurial hotbeds (Sutherland 2005; Heilmann, Shih, and Hofem 2013). Even Zhongguancun for a while actively courted MNCs that were eager to enter the Chinese market (Zhou 2008a).[10]

A few HTZs and local governments became particularly supportive of existing *minying* tech enterprises and new startups through tinkering and experimentation. First, areas with a sizable *minying* tech sector served the important function of protecting the firms from political pressures from the top and uncertainties from the legal environment. In the late 1980s and early 1990s, conservatives within the CCP, who viewed the *minying* sector as disruptors of existing social and economic order, periodically launched attacks against the sector, taking issue with activities violating socialist-era rules, which were common in the sector.[11] The fact that a few entrepreneurs including the founder of Stone Group—a well-known *minying* firm in Beijing—were involved in the 1989 protest gave officials

[9] Interview S2018-022.
[10] On the other hand, attracting FDI produced the unintended consequence of increasing the heterogeneity of actors in the region, with MNC branches both increasing cross-border linkages and serving as training grounds for engineers, entrepreneurs, and executives for the region.
[11] Interview G2018-042.

justifications to put pressure on the sector. Zhongguancun officials, recognizing that these firms were important sources of local growth, shielded the sector from being strangled. In the case of Stone Group, they worked hard to limit the blame on the founder to protect the company from being shut down (Ling 2007). Local officials in Beijing also flexibly dealt with charges of smuggling. At the time, companies needed to have licenses to conduct cross-border trade and needed specific approvals for importing certain types of products (e.g., assembled computers). In addition, foreign exchange was allocated via quotas, most of which were given to SOEs. *Minying* firms commonly used various means to evade these restrictions, such as paying other firms for licenses and quotas and buying parts from smugglers, but these evasive practices exposed them to charges of smuggling Beijing officials argued for lenient treatment of these practices by framing the issue as a clash between planned economy and market economy and separating the evasive practices from outright smuggling. Addressing the issue, the municipal government explained that "the experimental zone's work is experimental in nature and is an experiment for reform" and called for issues of smuggling to "be dealt with case by case, with lines being drawn at the right place" (Z. Hu 2011). A local official later provided the following justification for resisting pressure from above to protect *minying* firms:

> Why did Haidian [government] give so much pressure to itself then to support these startups in Zhongguancun? I think the biggest motivation was that the center had taken economic development as the central task. Where was Haidian's way out? What could Haidian depend on to develop its economy? ... [Our] thinking at that time was that universities and research institutions were Haidian's only way out and [we] should come up with measures to support the development of these startups (Shao 2017).

Second, local governments actively helped *minying* firms to access finance using what was available to them and sometimes bending the rules. A common method was for them to serve as guarantors for firms taking out loans. A few HTZs also helped to create and provided funds to mutual aid groups where local firms pooled funds to support members that ran into

cash-flow difficulties or needed guarantors for loans. The Zhongguancun HTZ even used its own funds to provide short-term loans to local *minying* firms with liquidity problems despite the fact it had no authorization to do so. Between 1989 and 1995, it provided the so-called "revolving funds" to over 200 firms (Z. Hu 2011). In Shenzhen, the local government allowed Huawei, which had trouble borrowing from banks, to raise funds from its own employees even though this was only allowed for certain SOEs.[12]

The rapid growth of *minying* firms in cities such as Beijing and Shenzhen spurred the creation of new startups by technical talents working at public institutions as well as established *minying* firms. It also induced local officials to increase their efforts to support startups, in the hope of nurturing more market-oriented tech firms. Through the Torch Program, the SSTC had encouraged local officials to create incubators, startup service centers, and venture capital firms, but these institutions initially had limited resources and could only provide limited services such as assistance in obtaining business registration and custody of entrepreneurs' personal files. To better realize the potential of tech entrepreneurship, local officials expanded existing institutions and created a host of other ones to assume a variety of startup-supporting functions including accounting and legal services, management training, provision of office spaces and equipment, loan guarantee, and equity investment. For instance, the Shenzhen government established a company in 1994 to specifically address tech startups' lack of access to finance. The company used various ways to provide finance to startups, some of which developed into listed companies. In 1998, Beijing created a special fund to guarantee loans to startups, which helped over 70 startups to borrow a total of 70 million yuan by the end of 1999. The government also encouraged local universities and companies to set up incubators, with over 40 new ones being created between 1997 and 2004 (Office of Beijing Municipal Committee for Local Chronicles

[12] Shuliang Ming et al. "The Nature of Huawei Shares (华为股票虚实)," *Caijing*, No. 16, 2012.

Compilation 2008). In addition, these areas simplified the procedures of creating businesses, lowered the thresholds for registered capital, and allowed the use of intellectual property instead of cash as contributed capital. To ensure that more startups could qualify for preferential policies, the standards for "high-tech industries" were loosely interpreted by officials during accreditation. In Beijing, being able to offer products not available before—even small additions on imported products—usually sufficed.[13] This flexibility was important for the nascent nonstate tech sector because early startups primarily engaged in localization and distribution instead of intensive R&D (Gu 1996, 199; Lu 2000).

Government support was crucial for tech entrepreneurs as the lack of private wealth and venture capital meant there were limited resources available elsewhere. In addition, when many overly rigid rules continued to exist as part of the economic transition process, government facilitation could help remove many of the potential obstacles. In Beijing, a survey of 184 tech ventures in the HTZ found that institutional support from the government—including beneficial policies and programs, information and technical support, financial support, and assistance in obtaining importing license—had a large positive impact on firm performance, especially for those that developed new technologies (H. Li and Atuahene-Gima 2001).

The tech startup sector's development was uneven across China, with some localities keeping their focus on state-owned firms (Segal 2002). But by the late 1990s, fostering entrepreneurship had been elevated by a few localities as a key means to promote economic and technological development. The place that embraced entrepreneurship most fully was perhaps Zhongguancun, whose evolving definition of roles demonstrated the change. Whereas the policy document promulgated at the zone's inception in 1988 did not mention the words "startup" or "entrepreneurship" at all, its 1999 action plan listed "policies

[13] Interview S2018-023.

conducive to the emergence of high-quality entrepreneurial talents" at the top of the agenda.[14] The revised bylaw of the zone also highlighted the function of "providing service to organizations and individuals pursuing innovation and startup activities."[15] Areas that actively fostered entrepreneurship were rewarded with substantial economic output and the associated local revenue. In 2000, *minying* tech firms in Beijing, Shanghai, Jiangsu, and Guangdong achieved total sales of 654 billion yuan, which accounted for about half of the national sum. In all, the sector accounted for 10 percent of China's manufacturing output and 6.2 percent of total tax revenue and hired 5.5 million people (MOST 2002). The potential of entrepreneurship was increasingly recognized by the central government, which set up a national fund in 1999 to support tech startups. The CCP was also promoted by the sector's growing importance to recognize their contribution and elevate their social status. In 2001, in a major speech on how the CCP should adapt to new situations, General Secretary Jiang Zemin listed various groups, the first of which being "entrepreneurs and technical personnel at nonstate tech enterprises," as new social strata that emerged during reform and opening up and contributed to "socialism with Chinese characteristics." He argued that members of the new groups who accepted the CCP's principles should be incorporated into the party (Jiang 2001). In addition, successful entrepreneurs were increasingly appointed to the legislatures and semi-governmental organizations.

Efforts to attract returnee entrepreneurs also developed through local experiments. The value of having talents obtain overseas training and experiences was realized by Chinese leaders early on, but until the late 1990s the central government focused on attracting talents to return and work for state research institutes and universities (Zweig and Wang 2013). At the same time, sporadic efforts targeting returnee entrepreneurs began to emerge from the

[14] Request for Instructions regarding the Building of Zhongguancun Science and Technology Park (关于实施科教兴国战略加快建设中关村科技园区的请示).
[15] Ordinance of Zhongguancun Science and Technology Park (中关村科技园区条例).

bottom up, as local governments sought to attract new technologies and capable talents that could contribute to the local economy. Early experiments included Shenzhen government sending a delegation to the U.S. to recruit talents in 1992 and the incubator created specifically for returnees by the Shanghai government in its HTZs in 1996, which were soon imitated by other cities. While these measures made it more attractive for returnees to start businesses, the resources from the government alone were insufficient for substantial undertakings. Given the lack of venture capital and the unwillingness of banks to lend to startups, most returnees that founded businesses in the 1990s and early 2000s relied on personal savings—mostly income earned abroad—and support from family and friends (Vanhonacker, Zweig, and Chung 2006). In addition, for much of the 1990s there were considerable concerns and reservations among overseas Chinese about returning to a country that not too long ago violently repressed protestors.

Around the turn of the century, overseas Chinese showed more interest in exploring entrepreneurial opportunities in China, and the government also became more active in luring and supporting returnee entrepreneurs. The confidence of overseas Chinese was boosted by China's rapid economic growth and continued commitment to reform and opening up, particularly signaled by the 1999 constitutional amendment that declared the private sector a key component of the "socialist market economy" and China's imminent entry into the World Trade Organization. Many returnees had by then accumulated substantial work experiences overseas—some even as founders of startups—and felt better prepared to take their chances. In addition, the internet boom in the U.S. stimulated entrepreneurs to replicate the success of internet startups back in China. Local governments, responding to the center's call for prioritizing science and technology and innovation, also made more efforts to attract returnee entrepreneurs. In Beijing, local officials studied the role of ethnic Chinese entrepreneurs in developing the Hsinchu Science Park. Taking inspiration from Hsinchu's success, they

established a liaison office in Silicon Valley in 2000 to help aspiring entrepreneurs build connections to Zhongguancun and frequently sent teams to the U.S. to recruit the Chinese diaspora there (D. Wang, Zhao, and Zhang 2012). In smaller cities where qualified returnees were rare, local officials provided more hands-on support to the startups. When Shi Zhengrong, who received a Ph.D. in electrical engineering at the University of New South Wales and studied with one of the world's preeminent solar energy researchers, returned to China in 2000 to search local partners, he was received by the deputy party secretary in charge of industry in Wuxi, Jiangsu Province. The municipal government later coordinated $6 million of investment into Shi's solar technology startup and was for a while its largest shareholder.[16] After the company, Suntech, was listed on Nasdaq in 2005, Wuxi municipal government formalized measures to attract talented returnee entrepreneurs in the hope of replicating Suntech's success and many of these measures were emulated by localities both inside and outside of Jiangsu. These local initiatives later fed back into the formulation of central government policies. After Li Yuanchao, then Jiangsu Province party secretary, became head of the Central Organization Department, he launched the Thousand Talents Program, a key objective of which was to lure highly qualified overseas talents to start new tech ventures in China (Heilmann, Shih, and Hofem 2013).

Embracing Transnational Venture Finance

Transnational venture capital (VC)[17] began to trickle into China in the early 1990s and the state actively collaborated with them. At the time, most mainstream VC firms overseas were

[16] He Yifan, "The Richest, Made by Government (首富, 政府造)," *China Entrepreneur (中国企业家)*, March 20, 2006.

[17] I use the term "transnational venture capital" to refer to venture capital/private equity funds that are primarily raised overseas. These funds may be managed by China branches of foreign-based venture capital firms or China-based ones. Thus, key to being "transnational" is the cross-border movement of capital rather than the location of the VC firm or the nationality of venture capitalists. In this dissertation I do not draw a clear

dismissive of the entrepreneurial environment in China, and the earliest players entered the country somewhat unintentionally. International Data Group (IDG), one of the first foreign-based VC firms that operated in China, was primarily known for its media and marketing service businesses and started investing in startups in China partly due to the difficulty of repatriating the profits from its publishing operation.[18] ChinaVest, another early entrant, initially focused on investing in listed companies in Hong Kong with substantial operations in the mainland.[19] Those who pioneered cross-Pacific investing in Silicon Valley and Taiwan, such as H&Q Asia Pacific, Walden International, and its spinoff WI Harper, also started to operate in China around this time, though their initial focus was restructuring SOEs and helping multinationals entering China.[20] These early entrants were typically run by ethnic Chinese or relied much on returnees.

As tech entrepreneurship continued to grow, particularly in Beijing and Shenzhen, transnational capital began to pay more attention to young tech firms. Some of their first VC investments included ChinaVest's investment in AsiaInfo and Walden International's investment in Sina. The government, eager to utilize foreign capital and develop VC, closely collaborated with many of the early entrants. Through the Torch Program and various incubators, the government possessed valuable information about the entrepreneurial sector and was often willing to contribute capital. For instance, IDG worked closely with the Ministry of Science and Technology (MOST, renamed from SSTC in 1998), which supported its investment in Chinese startups, and established joint venture VC firms with the governments of Beijing, Shanghai, and Guangzhou.[21] That some government officials

distinction between venture capital and private equity, because prior to 2010 the distinction was blurred in China.

[18] Interview V2018-044. IDG's VC arm was spun off to form IDG Capital, which now has its main offices in China.

[19] SCMP 1990.

[20] Interview V2018-028.

[21] MOST also helped to arrange a meeting between IDG's founder Patrick McGovern and President Jiang Zemin.

actively advocated for the development of a VC market in China also created a favorable environment for transnational VC. Important advocates included officials at MOST, who were attracted to the idea of VC in the 1980s, and Cheng Siwei, then a Vice Chairman of the National People's Congress who was formerly an engineer with study experiences in California. In 1999, the State Council, with active promotion by MOST, issued a policy guideline about developing VC in China. The guideline encouraged actors other than the government—including foreign investors—to engage in VC investment in China. Importantly, it also encouraged listing on overseas stock markets to facilitate VC exit, because it would "help utilize international capital to develop high-tech industries in our country, help attract overseas venture capital into our market, and help high-tech enterprises enter international markets."[22]

Importantly, the state took a flexible stance on the issue of foreign investment in restricted sectors, particularly the internet. The internet boom in the U.S. spurred a large wave of entrepreneurship in China, by both indigenous and returnee entrepreneurs. Many of these internet startups raised funds from transnational VC and aimed to eventually list their shares overseas. To do so, these internet companies were typically registered offshore and operated in China through subsidiaries wholly owned by the offshore entities. Although the Chinese government embraced the internet revolution, officials felt it necessary to keep the country's cyberspace from foreign influence. Regulators declared that the internet content provider business was off limits for foreign investors and put a brake on the application of leading internet companies such as Sina and Sohu for overseas listing. These companies and their investors, working with accountants and lawyers, came up with a solution that ostensibly complied with the restrictions while keeping the offshore structure. In this solution, later

[22] Several Opinions on Establishing a Venture Capital Mechanism (关于建立风险投资机制的若干意见), December 1999.

called the variable interest entity (VIE) model, the listing company separates restricted parts of its business into an onshore company owned by members of the management team who are Chinese nationals (i.e., the VIE). Then it establishes a series of contracts with the VIE that allow the listing company to have substantial rights to the latter's operation and revenue without directly holding its equity (Gillis 2012). This ambiguous arrangement allowed the entrepreneurs to access overseas capital while complying with foreign investment restrictions. The companies and their investors worked hard to reassure regulators that this solution would help ensure legal compliance and used their connections to lobby officials. Eventually the government acquiesced to this arrangement.[23]

The state's flexibility regarding transnational VC's investment in China's internet industry was significant because it helped to stimulate vibrant entrepreneurship in the sector and further embed it into transnational networks of capital. The successful overseas listing of a series of internet companies in the early 2000s caught the attention of other foreign investors, including mainstream VC firms in Silicon Valley, which had been traditionally locally focused but were showing growing interests in tech hubs outside of the U.S. In addition, returnees and transnational venture capitalists established new China-based VC firms that raised funds primarily overseas. VC firms of this type included Northern Light, established in 2005 by a returnee who had founded a Nasdaq -listed company in Silicon Valley, and Qiming Venture Partners, founded by seasoned venture capitalists with extensive experiences in both China and the U.S. To better help local startups list overseas, both Nasdaq and the New York Stock Exchange (NYSE) opened offices in China in 2007. By the late 2000s, there existed a well-developed ecosystem of venture capitalists, financial advisors,

[23] For Sina's efforts to persuade regulators, see Sheff (2002). The Chinese government has since taken an ambiguous stance toward the VIE structure, neither fully legalizing it nor systematically cracking down on it, which gave officials much leeway and created substantial risks and uncertainty (Y. Liu 2013). In 2021, the central government explicitly banned foreign investment in education and training organizations via the VIE method, even though quite a few of these organizations had accessed overseas capital markets using the VIE structure. For VIE's role in China's education and training sector, see Lin (2017).

lawyers, accountants, and investment bankers that helped Chinese startups raise overseas capital. Throughout the decade, transnational capital was the most important source of funding for Chinese tech startups (Table 2.1), particularly those in internet-based businesses. As one venture capitalist remarked, "Basically, China's entire internet industry was created by foreign capital, even though technically it was largely forbidden in the sector."[24]

Table 2.1 Top Venture Capital Firms in China in the 2000s

2002	2004	2006	2008
Shenzhen Capital Group*	**SAIF**	**IDG Capital**	Shenzhen Capital Group*
Guangdong Technology VC*	**IDG Capital**	**SAIF**	**IDG Capital**
IDG Capital	**DCM**	**Sequoia China**	**Sequoia China**
Warburg Pincus	CDH Investments	Legend Capital	**SAIF**
H&Q Asia Pacific	NewMargin	**GGV Capital**	Legend Capital
Shandong High-Tech Investment*	**Carlyle**	**SoftBank China**	CDH Investments
Guangzhou Technology VC*	**Warburg Pincus**	**Walden International**	**Orchid Asia**
Walden International	Legend Capital	**JAFCO Asia**	Fortune VC
DragonTech	**Acer VC**	**Intel Capital**	**KPCB China**
JAFCO Asia	Shandong High-Tech Investment*	CDH Investments	**DT Capital Partners**

Source: Zero2IPO annual rankings.
Note: The ranking takes into consideration fundraising, investments, exits, and returns. Those in bold were headquartered outside of China or relied mostly on capital raised overseas. CDH Investments and Legend Capital also raised substantial funds overseas.
* Operated by local governments.

The boom of internet startups and the pouring in of transnational VC created a prominent group of entrepreneurs and investors, who worked with their allies in the state and used their access to advocate for a more liberalized environment for tech entrepreneurs. Investors that primarily raise funds from overseas formed the China Venture Capital Association (CVCA), which became an influential lobby group that managed to persuade the government to remove some of the restrictions affecting the investment and exit of

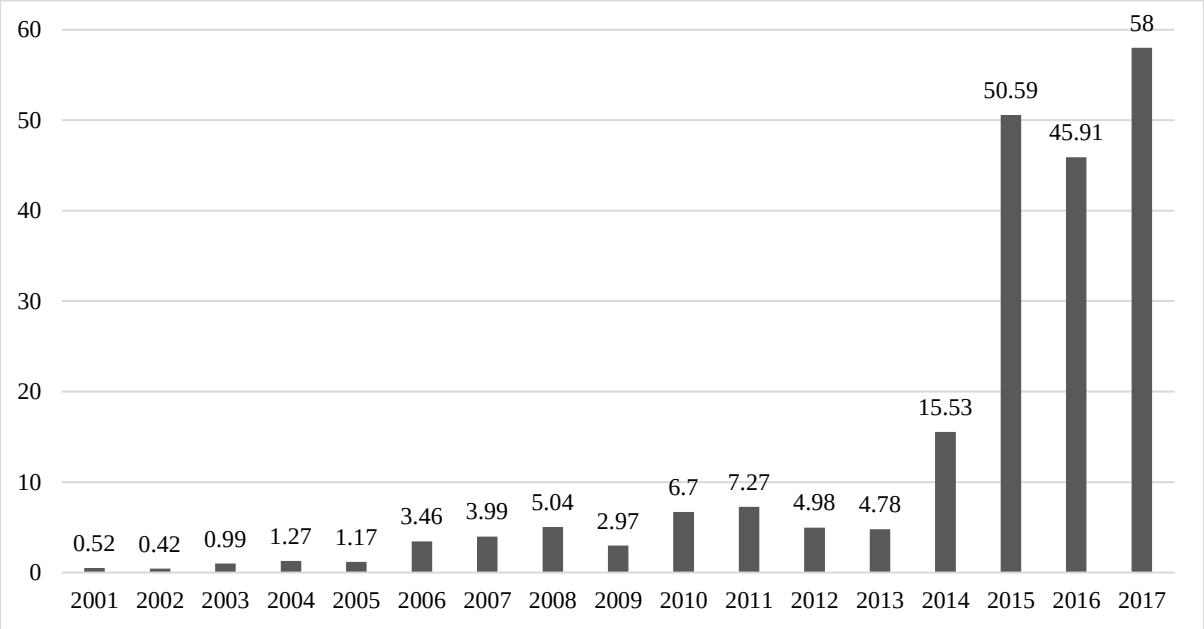
[24] Interview V2018-016.

transnational VC.[25] China's VC/PE industry is also well-known for the involvement of high-level officials' offspring, many of whom have been educated in the west.[26] More importantly, the rapid growth of a series of startups that leveraged transnational capital expanded the coalition that supported the improvement of venture finance. Enhancing access of the domestic stock exchange to tech startups was initially resisted by some of the financial regulators who were from the banking system. They were concerned about the market volatility that would result from relaxation of the listing standard and argued that banks could well serve the function of financing high-tech development by lending to established businesses to engage in R&D.[27] But prominent cases of startup success drew more officials to the other side. One case that attracted particular attention was Vimicro, a chip design startup founded by a Berkeley-trained returnee. The company received seed funding from the Ministry of Information Industry (MII) as well as transnational VC, achieved rapid sales growth of its multimedia processors, and was listed on Nasdaq in 2005. MII officials, which traditionally relied on SOEs in the chip sector and were frustrated by the lack of progress, hailed this case of VC-funded entrepreneurship as an innovative and successful model, which was also endorsed by a Vice Premier. Within the financial system, some officials cited the success of internet companies and argued that such a market would help young but innovative firms raise funds, allow domestic investors to partake of their growth, and avoid the potential risks associated with overseas listing (e.g., Zhou 2007). MOST, which was an earlier champion of a Chinese version of Nasdaq, continued to call for a more liberalized stock market, with the minister at one point blaming the domestic capital market as the most serious bottleneck hindering the integration of technology and capital (Xu 2006). With a stronger coalition advocating for improvement of venture finance, the central government

[25] Interview V2018-017.
[26] "To the Money Born," *Financial Times*, March 29, 2010. David Barboza and Sharon LaFraniere, "China 'Princelings' Using Family Ties to Gain Riches," *The New York Times*, May 18, 2012.
[27] Interview S2018-047.

took a series of measures in the late 2000s, such as increasing the supply of VC from the state, relaxing restrictions over insurance companies investing in VC funds, and establishing the ChiNext, which was a new stock market with less stringent listing requirements.

Figure 2.1 Venture Capital Investment in China (in billion U.S. dollars)



Sources: Figures for 2001-2005 are from Zero2IPO. The rest are from VentureSource.

Chapter 3 Harnessing Venture Capital

We have examined how China's institutions evolved such that they are more favorable toward tech entrepreneurship. Local tinkering helped to create space for entrepreneurs when the Chinese economy was to a large extent still governed institutions in the socialist era. Since the late 1990s, thanks to the state's embrace of transnational venture finance, China became increasingly deeply integrated in global networks and a prominent group of entrepreneurs and venture capitalists emerged. However, this by no means suggests that China's political economy is converging toward liberal market economies. Rather, as we will see in this chapter, state actors through local experimentation have come up with new measures to guide and harness entrepreneurial initiatives, rendering the state more active, particularly in the venture capital (VC) market. The state not only has tried to enhance the availability of VC but also increasingly deploys it as a tool for various policy objectives, including the development of prioritized industries. This state activism in the tech startup sectors, however, rests on a recognition that the state should limit its role to certain activities and work with private actors. New methods of state involvement are intended to complement—rather than substitute—market forces. With increasing state participation, the roles of professional venture capitalists and entrepreneurs are also elevated in China's political economy. In a sense, both the state and the private sector have advanced in a mutually supportive manner.

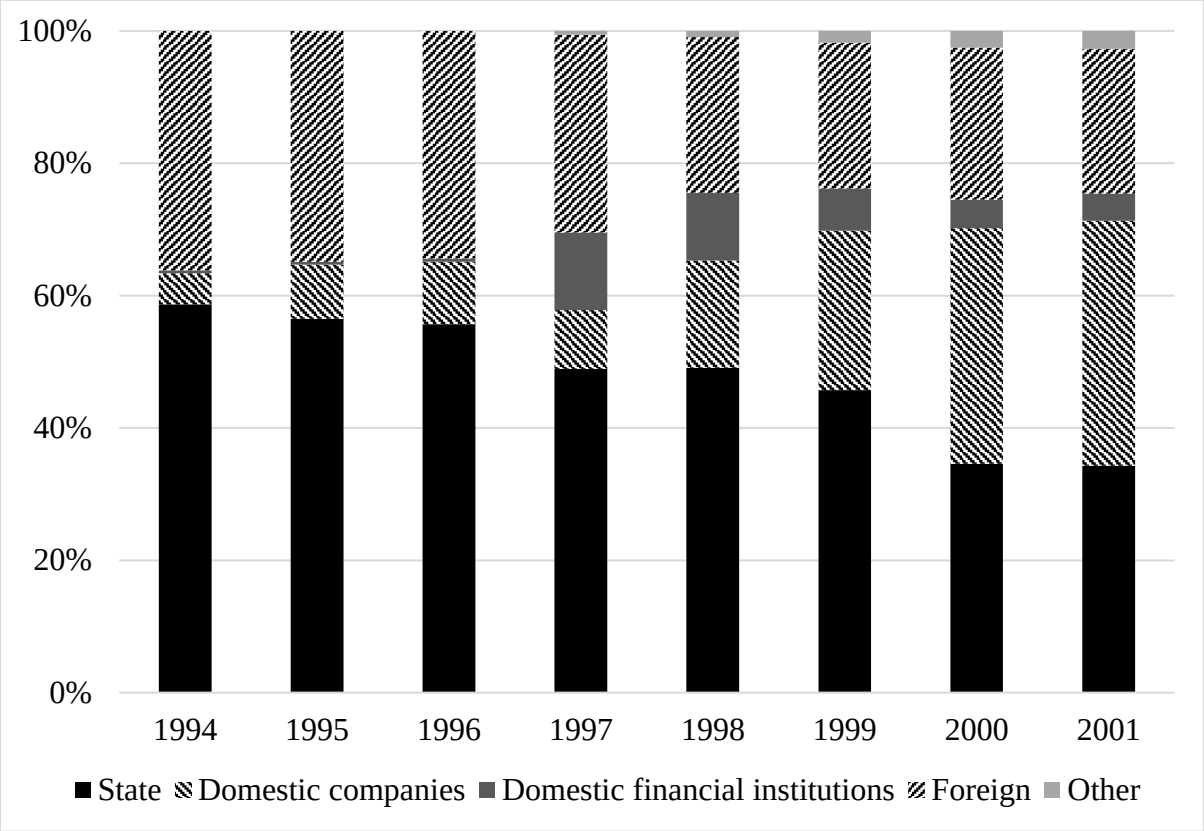
This chapter first examines the state's changing mode of involvement in the VC market. I highlight how local tinkering helped to shift the state's role from "venture capitalist" to "limited partner," which allows it to complement and harness rather than replace private initiatives. I then discuss how the state's involvement has produced a distinct type of VC, whose priorities, sectoral focus, and geographical distribution are different from private VC.

From "Venture Capitalist" to "Limited Partner"

The origin of China's VC industry can be dated back to the 1980s, when economic transition was just under way. For a study on the so-called "New Technological Revolution," SSTC convened research on technological advancements and the organization of R&D in the west. Some participants of the study had just visited the U.S. and noted the importance of Silicon Valley and its VC industry. To imitate this model of risk finance, SSTC established the country's first VC firm, China Venturetech Investment Company (CVIC) in 1986. The company, with $10 million of capital, was staffed by SSTC officials. Partly due to the lack of high-quality startups, CVIC mostly invested in mature ventures and later veered away to be involved in a variety of businesses unrelated to VC, including real estate and securities brokerage. The company encountered financial difficulties after a period of overexpansion and was subsequently shut down in 1998.[1] But CVIC was not the state's only effort. Through the Torch Program, SSTC also encouraged local governments and other state entities to set up VC firms, many of which were created in HTZs. In the early 1990s, dozens of state VC firms were established across the country. While transnational VC also started to trickle in, for much of the 1990s the state was the main source of VC in China (see Figure 3.1).

[1] Cao Haili and Fu Qiang, "Inside Story of the Shutdown of CVIC (中创关闭内幕)," *Asian Business Leaders (东方企业家)*, September 15, 1998, 87–90.

Figure 3.1 Source of Venture Capital in China, 1994-2001



Source: *China Venture Capital Yearbook 2002*.

These state VC firms were typically established and supervised by local governments and run by officials who were transferred there. They made decisions about whether to invest in companies and the firms practically operated as VC arms of the government, meaning the state was essentially taking the role of venture capitalist. While these VC firms provided an additional source of capital for startups, they were plagued by a number of difficulties and produced mixed results. First, these firms lacked professionals who had a good grasp of technological trends and could help entrepreneurs solve problems or connect to important actors in the market, as most official-turned-venture capitalists did not have industrial experiences and management skills (L. Zhang 1999). Due to their close affiliation with state agencies, these VC firms also tended to be exposed to and narrowly focus on startups favored

by local officials.[2] Second, these state-owned VC firms often lacked sufficient autonomy. One issue was frequent management turnover due to promotion or transfer. As one state-owned VC firm employee put it, "leaders were replaced both when they did well and when they did badly," which resulted in frequent management turnovers.[3] Many state-owned VC firms also needed approval by supervising agencies before making investment decisions, which prolonged the deal-making process and put the firms at a disadvantage. Finally, the way in which state capital was managed seemed incompatible with VC's high-risk, high-return investing style. State-owned VC firms, like other state entities, usually gave priority to the safety of state capital, even though they were intended to support risky ventures.[4] After all, a stellar investment might not bring high returns to the decision-maker, but a bad investment could result in accusation of "losing state assets," which could bring disciplinary sanctions to the managers. As a result, these firms tended to be conservative and often invested in more mature companies in familiar industries with manufacturing and shunned those with few physical assets such as internet startups. Moreover, to avoid being held responsible for losing state assets, these firms often spent much energy on portfolio companies that were not doing very well. A manager of a state-run VC firm described the issue,

> Let's say we have invested in ten companies. The return from the two or three that are doing really well can already make our entire portfolio profitable. But everyone will be focused on those that are not doing well to ensure that there won't be further losses from them. This is basically the opposite of what professionals do.[5]

[2] Interview S2018-053.
[3] Interview V2018-058.
[4] In the early years, venture capital was sometimes translated as 风险投资, or literally "risk investment," in China, but some high-level leaders had reservation about the "risk" in the moniker. Eventually, officials decided to use the more neutral 创业投资, or "startup investment," in official language. Interview G2018-041.
[5] Interview V2018-057.

At the same time, it could be argued that the state hardly had other options than taking the role of venture capitalist itself. In the early 1990s, there was little private capital available for high-risk investment, and few people were familiar with the idea of VC, not to mention having the experience and skills of good venture capitalists. As one SSTC official observed, "There were very few good startups and very few good venture capitalists. It was a period in which the government tried to create a VC market."[6]

Although these early state VC firms struggled, officials, sometimes drawing from other countries' experiences, believed that the state could play a meaningful role in VC. As a National Development and Reform Commission (NDRC) study group stated, "The solution to the problems in state VC is not simply calling off state VC but setting reasonable roles and modes of operation and exploring the complementary combination of state and market…What should be done is to study concrete solutions to the concrete issues and replace old state methods with new ones" (NDRC study group 2005, 13). At the local level, officials reflected on past experiences and experimented with alternative methods of providing VC. For instance, a few cities created joint venture VC firms with foreign venture capitalists. These joint ventures were managed by representatives of the local state and foreign VC firms, who tended to have conflicting priorities and often disagreed over investment strategies. This method later disappeared as neither side found the arrangement satisfactory. A second method, known as follow-up investment and pioneered by the Zhongguancun HTZ, was for the government to invest alongside foreign VC firms into portfolio companies without the state providing input to the investment decision making. This was intended to encourage transnational VC by reducing its risks. While follow-up investment helped to attract professional venture capitalists, it gave the state little leverage to influence the flow of capital. In Shenzhen, the municipal government established a new VC

[6] Interview G2018-033.

firm to be run differently from existing ones: the government would not intervene in the company's operation and would not force it to take projects or employees. The company, Shenzhen Capital Group, hired mostly from outside the local government—including a Japan-trained investment banker and a university professor—and brought in outside shareholders so that the company could operate more independently. The firm's professional and flexible management allowed it to overcome some of the issues that beset state VC firms in the past, enabling it to become one of the most successful VC firms in China, with over 150 listed companies in its portfolio.[7]

The experiment that had the most significant impact took place in Shanghai. Like many other cities, Shanghai created its first state VC firm in the early 1990s. The firm invested directly in companies and set up a joint venture fund with IDG. The overall performance was however rather poor—as a local official admitted, "millions were lost…and many projects went down the tubes."[8] After visiting the U.S. and carefully studying VC there, local officials concluded that it would be crucial to separate the roles of contributor and manager of capital and rely on professional venture capitalists. In 1999, Shanghai's government started a new state VC firm, which would collaborate with professionals—both domestic and foreign—to set up funds in which the local state contributed capital but would not be involved in management.[9] In the VC industry, investors like these are referred to as a fund's "limited partners," as they bear limited liability for the fund's debts (not exceeding their contribution). In China's context, this label also aptly captures the state's new role: it no longer takes the

[7] One example of flexibility is that while most state VC firms are locally oriented, Shenzhen Capital Group actively expanded beyond Shenzhen to set up VC funds with other local governments. It now has over 20 offices across the country.

[8] Weijing Zhou, "Inside story of China's first local venture capital firm (华裕达口述: 中国第一个地方风险投资公司秘史)," *21st Century Business Herald*, May 26, 2008.

[9] China had no legislation for limited partnerships until 2006, therefore the onshore funds were organized as companies in which the local government as a shareholder had representatives. But this was for the purpose of overseeing and learning how the professionals would conduct investment. In other words, it was mainly the professional venture capitalists that were responsible for management (Interview G2018-054).

role of venture capitalist but instead works with private professionals in a restrained manner. It contributes capital and may provide guidelines for the venture capitalist to follow but does not concern itself with assessing the quality and potential of startups. Taking this new and narrower role is a recognition that the state has limited information and capacity and needs to partner with private professionals.[10]

Shanghai's experiment of being a limited partner was considered by both local and central officials as a success.[11] It helped to attract professional venture capitalists to take root in the city and some of the funds were investors in China's most successful startups including Alibaba and Baidu. This method then diffused through learning, imitation, and promotion. Shanghai's experiments were hailed as a model by MOST and NDRC officials in internal discussions.[12] Other local governments, eager to develop high-tech, were quick to imitate. At the same time, officials seeking to improve China's entrepreneurial ecosystem studied other countries and found that similar practices, particularly Israel's Yozma program, achieved remarkable outcomes, which boosted their confidence in the method. In 2005, the central government formally endorsed the method of "VC guidance funds," in which the state would contribute capital to professionally managed VC funds. Soon after, the China Development Bank and the municipal government of Suzhou created the country's first fund of funds. As the new fund had few restrictions on where venture capitalists could invest, it was a popular source of capital and the one billion was soon invested in newly created VC funds. Another 13 billion-fund was created in 2010.

[10] Chen and Rithmire (2020) have argued that the pursuit of state goals through minority investment in private firms represents a new mode of state involvement and referred to it as the "investor state." This concept, however, does not distinguish between the state's roles as "venture capitalist" and "limited partner." In the latter, the defining feature is that state capital is combined with private capital and managed by private venture capitalists under guidelines—sectoral, geographical, etc.—set by the state. It is the venture capitalists, rather than the state, that directly monitor and influence the invested firms.

[11] The provincial government of Jiangsu also tried similar methods, though their initial attempts were not as successful (Y. Chen, Liu, and Liao 2011).

[12] Interview G2018-025.

This method of contributing to professionally managed VC funds was soon relied upon to confront what officials considered to be major issues in China's VC market: insufficient amount of overall capital and lack of investment in early-stage startups. As noted above, many foreign investors—including those known for VC investment—initially entered China focusing on investing mature companies in mature industries, and the line between VC and private equity (PE) was blurred. In addition, domestic private capital, which was attracted into the VC/PE market in the mid-2000s by the opening of the SME Board and the imminent launch of the ChiNext, also flowed mostly to late-stage investments. Many domestic private investors hoped to make some quick bucks from companies with imminent initial public offerings (IPOs), setting up funds with a time horizon that was sometimes as short as five years—half of that of most dollar funds. In other words, little of the private VC—both foreign and domestic—was being invested in early and risky ventures, because other areas provided plenty of opportunities to make handsome profits in a short amount of time. To address these problems, the state took an increasingly active role in the VC market. In 2008 NDRC issued a directive defining the role of VC guidance funds as guiding private capital to enter the VC market and particularly to invest in early-stage startups. At the same time, guidance funds were forbidden from directly investing like VC but should rely on professional venture capitalists to find, evaluate, and manage investment projects. The goal of state involvement was, according to the document, "to overcome market failures that result from purely allocating venture capital through the market."[13] In addition, officials hoped that through this directive VC guidance funds would be widely adopted as the main method through which local governments participate in the VC market.[14]

[13] NDRC, Guiding Opinions regarding Establishing and Operating Venture Capital Guidance Funds (关于创业投资引导基金规范设立与运作的指导意见), October 2008.
[14] Interview G2018-025.

As the state increasingly prioritized high-tech and innovation, signaled for instance by the introduction of Medium- and Long-Term Plan for the Development of Science and Technology in 2006, VC guidance funds were also adopted with sectoral emphases, essentially becoming an instrument of industrial policy.[15] Again, this was partly intended as a measure to correct market failures, more specifically the lack of investment in sectors that were considered important but might not produce spectacular short-term returns, such as biotechnology and semiconductor. The central government's 2010 initiative to develop "strategic and emerging industries" explicitly stated that the government would play a guiding role to encourage private capital to invest in those prioritized industries, and a special guidance fund was created to support this initiative. Increasingly, VC guidance funds are incorporated in various industrial policy programs—such as the 2011 policy for integrated circuits and Made in China 2025—as a key instrument to develop high-tech industries. Numerous VC guidance funds have also been created at the local level, often with the objective of developing and upgrading the local economy. VC funds with capital from these local guidance funds are typically required to invest a certain portion of the fund within the locality. Between 2006 and 2014, over 200 billion yuan was allocated to guidance funds by various branches of the state (Zero2IPO 2015). The total amount of capital available from guidance funds grew substantially after the State Council launched the "Mass Entrepreneurship and Innovation" program in 2015, as part of which the central government created two large-sized funds (see Table 3.1) and many local governments created their own guidance funds.

The state, however, has not always been able to work with top venture capitalists, due to the sometimes-conflicting objectives between them. Venture capitalists with outstanding

[15] On the evolution of industrial policies in China, see Heilmann and Shih 2013; Y. Wang 2019; Tan 2020. On the more active state involvement in technology and innovation, see F. Liu et al. 2011, and L. Chen and Naughton 2016.

performances can easily raise funds from overseas investors and are often reluctant to work with guidance funds. Although the state typically forgoes its right to handsome profits by allowing private investors to buy back state shares at a predetermined premium, venture capitalists often worry that sectoral and geographical restrictions would have a negative impact on their return. A top early-stage VC firm has for instance avoided working with guidance funds because it is unwilling to be constrained by their requirements and prefers to be indifferent with respect to location.[16] Consequently, some guidance funds have trouble finding capable partners. One venture capitalist described the government's dilemma, "Guidance funds have made available plenty of capital, but top venture capitalists do not necessarily want it. Many venture capitalists with less experience want the capital, but guidance funds do not necessarily want to give it to them."[17] Even when these venture capitalists are able to obtain capital from the state, they may fail to attract private investors to eventually set up the fund.[18] According to a random inspection of 206 VC funds conducted by the National Audit Office in 2015, 39 of the funds could not be closed because not enough private capital could be raised.[19] The problem is more severe for guidance funds created by local governments in less developed areas. Due to the lack of a decent ecosystem for startups, these areas often could not attract venture capitalists to set up funds and invest in the local area. One healthcare-focused venture capitalist explained,

> Guidance funds in coastal areas are popular because entrepreneurs are willing to create companies there. Entrepreneurs consider many things when deciding on the location of their companies, and whether high quality talents are available is a key factor for R&D intensive startups like those in pharmaceuticals. For some cities, there are just not enough good talents and people would be reluctant to move there. For instance, [the

[16] Interview V2018-036.
[17] Interview V2019-064.
[18] State share often cannot be over 50 percent of a VC fund, meaning the venture capitalist will need to raise at least as much private capital as state capital to establish the fund.
[19] State Council Audit Report on Central Budget Execution and other Financial Revenue and Expenditure for the Year of 2015 (国务院关于 2015 年度中央预算执行和其他财政收支的审计工作报告), http://www.audit.gov.cn/n9/n1012/n1023/c84916/content.html.

> guidance fund of] an inland city once contacted us. We visited the city and felt not many R&D-focused startups would want to locate there, so we did not take their money because there wouldn't be good startups to invest in.[20]

To address this issue, some local governments have relaxed the requirement by reducing the percentage of the fund that needs to be invested locally or counting firms headquartered elsewhere but with offices or facilities in the city into the percentage.[21] This, however, means that the local state has less ability to condition VC in these instances. Thus, the state's ability to guide private VC has been limited by the abundance of capital that venture capitalists could raise overseas, and this ability is also geographically uneven due to local conditions.

Table 3.1 Major VC Guidance Funds Established by the Central Government

Guidance fund	Supervising agency	Year established	Note
S&T Small and Medium-Sized Enterprise VC Guidance Fund	MOST	2007	Invested 1.2 billion yuan in 46 VC funds by 2012.[22]
National S&T Commercialization Guidance Fund	MOST	2011	Main objective is to support commercialization of national S&T projects. Invested in 14 funds (whose capital totaled 24.7 billion yuan) by 2018.[23]
National Small and Medium-Sized Enterprises Development Fund	MIIT	2015	Fund size is 60 billion yuan. Priorities are SMEs at seed and startup stages.
National Emerging Industries VC Guidance Fund	NDRC	2015	Fund size is 40 billion yuan. 80 percent will be invested in VC funds that focus on early-stage startups.[24] Its predecessor was the VC for Emerging Industries Program created in 2009.

Source: Compiled by author.

[20] Interview V2019-080.
[21] Interview V2018-007.
[22] Interview with Wan Gang, Minister of Science and Technology, *Science and Technology Daily*, February 27, 2013.
[23] Ding Yiting, "National S&T Commercialization Guidance Fund Has Invested in 161 Projects (国家科技成果转化引导基金已投资转化项目 161 个)," *People's Daily*, July 30, 2018, http://finance.people.com.cn/n1/2018/0730/c1004-30176677.html.
[24] Wang Xi, "An 18-Billion National Policy Venture Capital Fund-of-Fund Was Unveiled "规模近 180 亿元国家级政策性创业投资母基金揭牌)," *Xinhua*, May 5, 2017, http://www.xinhuanet.com/2017-05/09/c_1120944806.htm.

Varieties of Venture Capital

With the continuous inflow of VC raised overseas and the proliferation of guidance funds, there is an emerging feature of China's VC market: the coexistence of two distinct types of VC. First, an increasing number of VC funds raise capital from guidance funds. Managed by professional venture capitalists and raising funds also from private investors, these funds are hybrids and seek high returns, but their profit-seeking orientation is conditioned by the state's policy objectives. Hence, I will refer to them as policy-guided VC. Second, there are funds that rely on return-seeking capital, mostly raised overseas. These funds may be managed by the Chinese branches of foreign VC firms (e.g., Sequoia China) or China-based VC firms (e.g., Qiming Venture Partners). From the ownership perspective, these funds are also hybrids because they raise capital not only from private investors such as wealthy individuals, foundations, university endowments, and asset management companies but also from pension funds and sovereign wealth funds.[25] However, these investors and the venture capitalists that manage the funds share the objective of seeking high returns on their capital. Thus, these funds will be referred to as return-oriented VC. As noted earlier, venture capitalists managing the second type of VC are sometimes reluctant to work with guidance funds, so the distinction between policy-guided and return-oriented at the VC fund level also to some extent exists at the venture capitalist level.

[25] Ching Kwan Lee (2018) has shown how China's state capital in Africa differs from globally mobile private capital in priorities for accumulation and production. In the global VC market—not just in China—public and private capital are increasingly fusing with each other. For instance, sovereign wealth funds like Singapore's GIC and Temasek and those from the Middle East are active investors in VC funds. Saudi Arabia's sovereign wealth fund is the main backer of SoftBank's $100 billion Vision Fund, the world's largest technology-focused VC fund. Thus, the key distinction is no longer ownership but priorities of capital.

The two types of VC share some similarities. They both have hybrid ownership of public and private capital and are both organized as limited partnerships managed by professional venture capitalists, who are typically entitled to a two percent annual management fee and 20 percent of the fund's profit. They also tend to have similar time horizons—usually with a life span of eight to ten years. The two types of VC are different in that they tend to have distinct priorities, sectoral focus, and geographical distributions. Return-oriented VC funds in China, like VC funds elsewhere, seek high return on investment above all. They invest in a variety of profitable areas from mature models that are introduced to China (e.g., car rental, convenience stores) to knowledge-intensive technologies. However, internet-based new business models have attracted the most capital and produced the best returns, as startups can achieve high levels of dominance in China's huge domestic market and become essential platforms for hundreds of millions of users. The most well-known investment of this type is perhaps SoftBank's $80 million investment in Alibaba in the early 2000s—now worth hundreds of billions—which is the kind of investment many venture capitalists aspire to. With deals producing windfalls like these, return-oriented VC funds are particularly active in investing in new business models—initially copying successful models in the U.S. (known as "copy to China") and more recently coming up with original models. As shown in Table 3.2, major platform companies were mostly funded by overseas capital and, increasingly, established platforms such as Baidu, Alibaba, and Tencent (known as BAT).

The promise of high returns has led to increasingly fierce competition, which often involves "burning cash" to subsidize customers. The startups and the VCs that back them are willing to throw billions into the competition over market share because the endgame is straightforward: only a few companies would survive to dominate the market.[26] Oftentimes it

[26] Chinese startups not only fight with each other but also with foreign competitors, such as Groupon and Uber. For how a Chinese startup defeated Groupon in the battle for China's group-buying market, see K.-F. Lee (2018).

is the investors—who can no longer tolerate the companies to keep bleeding—that pressure companies to consider merger. As one venture capitalist explained, "That's the story of the Chinese internet—the last man standing always wins. And sometimes when there are two last men standing they will merge."[27] To finance these increasingly expensive market share wars, VC firms are raising ever larger funds. Sequoia China, a top VC firm, raised a $1.8 billion growth fund in 2019, which was twice as large as its previous growth fund raised two years ago. Hillhouse Capital, a firm focusing on mid- to late-stage investments, raised a $10.6 billion fund in 2018 "to drive long-term growth in portfolio companies."[28]

Table 3.2 Major Chinese Internet Platforms

Company	Business	IPO location & year	Major investors
Ctrip	Travel booking	Nasdaq 2003	**Carlyle**, **Tiger Technology**, **IDG**, Shanghai Industrial
Tencent	Social networks	SEHK 2004	**Naspers**
Baidu	Search engine	Nasdaq 2005	**Draper Fisher Jurvetson**, **Integrity Partners**, **Peninsula Capital**
Alibaba	E-commerce	SEHK 2007	**Yahoo**, **SoftBank**
Youku	Video-sharing	NYSE 2010	**Chengwei**, **Brookside Capital**, **Sutter Hill Ventures**, **Maverick Capital**, **Farallon Capital**
Renren	Social networks	NYSE 2011	**SoftBank**, **DCM**, **General Atlantic**
58.com	Online marketplace	NYSE 2013	**Warburg Pincus**, **SAIF**, **DCM**
JD.com	E-commerce	Nasdaq 2014	**Tiger Global**, **Hillhouse Capital**, **DST Global**, **Capital Today**
Meituan	Food delivery	SEHK 2018	Tencent, **Sequoia**
Bilibili	Video-sharing	NYSE 2018	CMC, **Loyal Valley Capital**, **IDG**, Legend Capital, Tencent
Pinduoduo	E-commerce	Nasdaq 2018	Tencent, **Gaorong Capital**, **Sequoia**
Beike	Housing transaction	NYSE 2020	Tencent, **SoftBank**, **Hillhouse**
Kuaishou	Video-sharing	SEHK 2021	Tencent, **Morningside**, **DCM**, **DST Global**
Zhihu	Online content community	NYSE 2021	**Innovation Works**, Tencent, **Qiming**, **SAIF**, Kuaishou, **Capital Today**
Didi	Mobility	NYSE 2021	**SoftBank**, Tencent

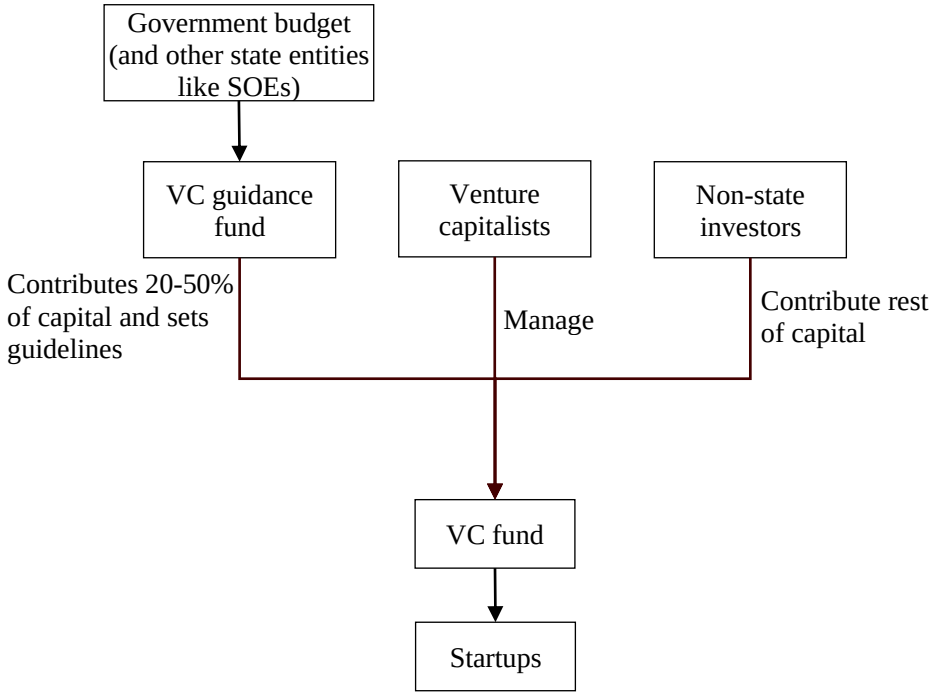
Sources: Compiled by author based on company prospectuses.
Note: The "Major investors" column only lists those with substantial shares at the company's IPO. Foreign firms, foreign-based VC/PE firms, and China-based VC/PE firms that have raised substantial capital overseas are in bold.

[27] Charles Clover, "Renminbi to burn," *Financial Times*, April 11, 2016.
[28] *Reuters*, "China's Hillhouse raises $10.6 billion in Asia's biggest private equity fund," September 18, 2018.

Policy-guided VC funds, on the other hand, are conditioned by guidelines set by the government. In exchange for the latter's investment, these funds are typically required to invest in certain types of companies (designated sectors or growth stages) within a geographical limit. The VC for Emerging Industries Program, for instance, stipulates that VC funds with capital from the program need to follow the government's industrial policies and invest in prioritized sectors such as clean technologies, biopharmaceutical, and new energy vehicles. In addition, each fund has to invest at least 60 percent of capital in "innovative companies at the startup or early stages." The "innovative" qualification requires R&D personnel to be over 20 percent of total staff. Startup and early stages are also explicitly—and perhaps more loosely—defined: the former refers to companies with fewer than 300 people and a revenue smaller than 30 million, and the latter 500 people and 200 million in revenue.[29] In addition, many funds involve capital contribution from both the central government and local governments, which typically require funds to invest a certain portion of capital within their jurisdiction to support the local economy.

[29] Ministry of Finance and National Development and Reform Commission, Interim Measures for Participation in VC Funds by the Venture Capital for Emerging Industries Program (新兴产业创投计划参股创业投资基金管理暂行办法), August 2011, http://www.gov.cn/zwgk/2011-09/09/content_1944275.htm.

Figure 3.2 Structure of Policy-Guided Venture Capital Funds



Source: Created by author.

The difference in sectoral focus between state and private capital is manifest in the popularization of the notion "hard technologies." This concept was reportedly first brought up by Mi Lei, a former researcher at a CAS institute who then became a venture capitalist at the VC firm established by the institute. According to Mi, "hard technologies" refer to those that require long-term investment and R&D and have high technological thresholds such that they cannot be easily copied. "Hard technologies" are explicitly set against business model innovations that had attracted most capital and attention; the former belong to the physical world, and the latter constitute the virtual world.[30] What is more revealing, however, is that examples of "hard technologies" are mostly areas that have been identified by the state as

[30] Mi, Lei, "Hard Technologies Change the World," October 23, 2018, https://xian.qq.com/a/20181023/104626.htm

priorities, such as artificial intelligence, biotechnologies, chips, and new materials. Thus, it is perhaps not surprising that as the state becomes more active in shaping the VC market in recent years, this concept has also gained much popularity. It was also frequently mentioned in my interviews with those working at guidance funds and policy-guided VC funds. When asked about selection criteria, one guidance fund manager responded, "The most important thing for us is their track records in investing in hard technologies. Our favorite would be those who have consistently focused on solid technological areas, not those flashy ones investing in business models."[31] At a VC firm that has worked closely with guidance funds, a manager compared the sectoral distribution of their portfolio companies with that of transnational VC,

> We are particularly dedicated to hard technologies. Our portfolio companies cover all of the strategic industries identified by the central government, whereas foreign VC firms like [Firm A] and [Firm B] are more narrowly focused. For them, making good profits is paramount. For us, there are more things to consider, such as whether a company's business lies in the priorities set by the guidance funds.[32]

This difference in operation at the fund level is largely a result of different orientation at the limited partner level. Foreign limited partners prioritize return on investment regardless in which sectors or regions the return is produced. Typically, they first listen to venture capitalists' pitches of investment strategies and then decide based on how good the venture capitalists' track records have been and how promising their strategies are. Those who have produced stellar returns are naturally the most popular, and their funds are often oversubscribed. State guidance funds, however, are a distinctive type of limited partner that focuses on conformity with policies and rules instead of financial returns. According one venture capitalist,

> The government does not really care about return, because it is not their KPI. Their KPI

[31] Interview V2018-011.
[32] Interview V2018-066.

> first and foremost is compliance with rules, which ensures that no one will get into trouble. Then it is how many VC funds are created, how many times of private investment is induced, how many portfolio companies are supported, whether there are star companies in the portfolio. Making profit is the last consideration.[33]

At the same time, there is evidence that the state through its involvement in the financial system has been able to induce some return-oriented venture capitalists to pay more attention to prioritized sectors. The state does so by giving firms in those sectors better access to the domestic stock market. Because IPOs are almost always profitable for investors due to government control of access to the market and that high-tech companies often receive better valuations in the domestic markets than in overseas ones, preferential access for high-tech companies means better opportunities for their investors to reap excellent returns. In 2019, a new Science and Technology Innovation Board (STAR Market) was created in Shanghai. The market has a more streamlined listing process that emphasizes information disclosure over profitability, much like Nasdaq. But a distinctive feature of the STAR Market is that only firms that are in leading edge technologies and meet major national needs are eligible to raise funds there. Among the first 25 companies that were granted IPO, there were 13 companies in information technologies (including several in the semiconductor industry), five in new materials, five in equipment manufacture, and two in biotechnologies. This overt policy guidance has created great enthusiasm in "hard technologies" among venture capitalists, even those who have mostly raised capital overseas. Many VC firms have since hired new partners who specialize in those fields. As one venture capitalist explained, "Now everybody is busy with assessing companies in chips, biopharmaceutical, and so on, because they sense these will be good businesses."[34]

[33] Interview V2018-064. KPI stands for Key Performance Indicator, a term commonly used in the business world to refer to measurable metrics against which performances can be assessed.
[34] Interview V2018-062.

Discussion

This chapter discussed the evolution of the state's role in the VC market and how through local experiments it came up with a new way to combine public and private capital and initiatives. China thus created a unique model of venture finance in which the line between public and private is blurred. Active state involvement is combined with the expertise and connections of professional venture capitalists, and policy-guided VC coexist with transnational, return-oriented VC. The state no longer picks which startups deserve investment, which is now mostly the job of venture capitalists. Rather, the state provides incentives for venture capitalists to make certain kinds of investments by enhancing availability of state capital for the VC market in prioritized areas and giving tech startups in those areas preferential access to the domestic stock market. As state capital is not the only source of capital for venture capitalists, the state's ability to shape the VC market has been limited. Nevertheless, the surge in startup activities with the increase in government VC guidance funds suggests that state involvement and private initiatives can be mutually supportive in the realm of VC and startups.

After we discuss the trajectory of institutional evolution regarding tech entrepreneurship in China, the next two chapters will switch gears to examine the government's increasing reliance on entrepreneurship to develop the IC and pharmaceutical industries and the impact of entrepreneurship on the development of those industries.

Chapter 4 Integrated Circuits

Integrated circuits (ICs), a key component in electronic devices such as laptops and smartphones and used more intensively in objects that predated the digital age like automobiles and home appliances, are a cornerstone of modern-day information technology. The industry carries the hallmark of other high-tech industries, including high demand of capital and knowhow and the rapid evolution of technologies. For this reason, along with leading countries' use of intellectual property rights to prevent entry, the industry is highly concentrated in the developed world. The U.S. has been the dominant country in the IC industry, developing the world's first IC in the late 1950s and now accounting for half of sales. Since the 1970s, East Asian has emerged to become an important region in the global IC industry, with Japan and later South Korea and Taiwan making remarkable advances. Over the past two decades, China has seen rapid development of its IC industry, which enabled the country to join the club of important players in the industry.[1] China now has five percent of the world market share, compared to almost nothing twenty years ago, and the country has advanced particularly in the segment of IC design, in which China now ranks the third.[2]

This chapter examines the role of entrepreneurship in the development of China's IC sector. Prior to 2000, the sector mainly involved state-owned, vertically integrated manufacturers that mostly produced for the state or their joint venture partners. State experimentation helped to facilitate entrepreneurship in IC, which transformed the sector into one that increasingly features bottom-up exploration, decentralized networks, and

[1] A good indicator of this status is membership in the World Semiconductor Council. China is a member along with the U.S., South Korea, Japan, Europe, and Taiwan, who together account for 98 percent of global semiconductor sales.
[2] Semiconductor Industry Association and IC Insights.

participation in global networks of capital, knowledge, and production. China's IC entrepreneurs experimented with new products and business models, worked closely with the burgeoning indigenous electronics industry, leveraged input from overseas, and created a vibrant chip design subsector. The state not only embraced entrepreneurship but also devised hybrid arrangements to combine public and private initiatives in new ways. At the same time, concerns over information and economic security—partly heightened by China's increasing dependence on foreign technologies—have resulted in pursuit of self-sufficiency in chips. Thus, the state has continued to invest substantial resources in products and technologies that are considered strategically important but would be very difficult to be commercially successful given the lead held by top foreign producers, at the expense of areas where entrepreneurial firms have excelled. In Peter Evans' terms (1995), the state's role in IC has evolved from that of demiurge only to a combination of demiurge, midwifery, and husbandry.

Before we start, a brief introduction of the IC industry is in order.[3] Initially chips were mostly produced by divisions within large companies such as IBM and Motorola for internal use. Then merchant chip producers that make and market chips independently like Intel began to gain importance. These producers performed all key steps in the making of a chip—design, fabrication, and packaging and testing—and were called integrated device manufacturers (IDMs). In the 1980s, the industry began to vertically disintegrate: companies that focused on design but outsourced fabrication, packaging, and testing to other specialized producers flourished. This led to the rise of so-called "fabless" firms—IC design companies that do not own fabrication facilities (e.g., Nvidia)—and pure-play foundries—dedicated providers of chip fabrication service. (e.g., Taiwan Semiconductor Manufacturing Company, or TSMC). But this vertical disintegration has not progressed uniformly in the IC industry, which includes a large variety of products. The two most important products are

[3] For a more detailed account of the industry's evolution, see Brown and Linden (2009).

microprocessors and memories, which together account for about half of global IC sales. The former has experienced substantial vertical fragmentation whereas the latter is still dominated by IDMs.

The Rise of Entrepreneurship in China's IC Industry

Early State-Run Efforts

Due to its importance, the IC industry has always received special attention from China's leaders.[4] Compared to pharmaceuticals, the IC industry also benefited from a relatively stable developmental agency. It has been overseen by essentially the same ministry since the 1980s, though the name of the ministry and its jurisdiction has been adjusted several times.[5] Prior to 2000, the ministry and the SOEs under its supervision were the main actors in China's quest for an advanced IC industry. SOEs started to be engaged in semiconductor production in the planning era, but due to China's isolation from the west, they lagged significantly behind leading western firms in technology. With reform and opening up, China began to acquire technologies from the west by importing production lines in the early 1980s, with the expectation that SOEs that imported production lines and associated technologies would quickly absorb the knowhow and develop indigenous capabilities. A high-profile effort at the center of the state push was the No. 742 Factory in Wuxi (later known as Huajing), which imported production lines and technologies from Lucent, Siemens, and Toshiba. Beginning in the late 1980s, China also pursued joint ventures with western firms as a key strategy in the hope of accelerating catch-up. Much like the strategy used in automobiles, foreign partners

[4] That many national leaders worked in the electronics industry also helped. For instance, Jiang Zemin, China's paramount leader between 1989 and 2002, served as Minister of Electronic Industries in the 1980s.
[5] The supervising agency has had the following names: Ministry of Electronics Industry (MEI) before 1988; Ministry of Machinery and Electronics Industry from 1988 to 1993; MEI again from 1993 to 1998; Ministry of Information Industry (MII) from 1998 and 2008; and Ministry of Industry and Information Technology (MIIT) from 2008 onwards.

were invited to transfer technologies in exchange for access to China's growing domestic market. Prominent joint ventures included Shanghai Belling and Shougang-NEC.

The most notable joint venture was Huahong-NEC, the cornerstone of a major state effort dubbed the 909 Project that had the objective of turbocharging China's IC industry. The push was made at the top of China's leadership, with the project being decided at a State Council meeting and receiving much attention from top leaders. The central government and Shanghai's municipal government allocated special funds for this project. The Minister of Electronics Industry, Hu Qili, was asked to take direct charge of its execution and was appointed chairman of Huahong Group, an SOE established for the project.[6] The main objective of the 909 Project was to build an 8-inch foundry using 0.5μm technology. To access equipment, technology, and market, Huahong formed a joint venture with NEC in Shanghai. Thanks to strong support and supervision from top leaders, the joint venture was able to avoid delays caused by bureaucratic red tape and commenced production in 1999.

To both outside observers and Chinese officials, these state-run efforts were hardly successful. The SOEs often suffered huge losses and failed to substantially reduce the technological gap with leading foreign firms. One factor seems particularly important for these SOEs' unsatisfactory performance. First, they lacked autonomy to make investment decisions or pursue technologies and products independently (Y. Li 2016). One infamous example was the long delay encountered by Huajing due to the need to secure approval and funding from supervising agencies. The 6-inch fabrication line took eight years to complete and by then the technology was rather obsolete given the rapid advance in fabrication technologies (Mays 2013; Fuller 2016). SOEs and their joint ventures either took orders mostly from the government or produced for the foreign partner and lacked the ability to

[6] Hu, mentioned in Chapter 2, became a member of the Politburo Standing Committee of the CCP in the late 1980s but was later relieved from this position due to his sympathy to the student movement during the Tiananmen protests. However, he returned to politics in the 1990s and served as Minister of Electronics Industry between 1993 and 1998.

develop and market their own products. Huahong-NEC, for instance, initially focused on producing dynamic random-access memory (DRAM) for NEC but soon suffered losses as NEC itself struggled in the business (Q. Hu 2006).

Fostering Entrepreneurship through Experimentation

Unlike the early state-run efforts, China's embrace of IC startups was not top-down mandated but came about thanks to experiments initiated by various state actors and entrepreneurs. Frustrated with the lack of progress under the previous strategies of relying on SOEs and their foreign partners, officials began to seek alternatives and were open to new ideas. Beginning in the late 1990s, two types of entrepreneurial firms in IC—most were specialized firms that focused on design—started to emerge in China. The first were created by indigenous entrepreneurs who often had worked with Taiwanese IC design firms that looked to access the market and talents on the mainland. These firms were mostly located in regions favored by Taiwanese investors such as Fujian and the Pearl River Delta and typically focused on lower-end products like chips used in phones and toys and received little government support. The second type of IC startups were those established by returnees, which often relied on support from both officials exploring new measures and foreign investors and aimed to develop more sophisticated products. While some of the first type also became important players in China's IC industry later, it was the returnee entrepreneurs that achieved more rapid growth, deepened China's participation into global networks, and induced the state to embrace entrepreneurship as a key measure to develop the IC industry.

One of the first returnee-founded startups was Newave, which was established in 1997 by two returnee engineers, who were recruited earlier by Shanghai Belling, and a Taiwanese entrepreneur. To raise funding, the founders approached Huahong, which was considering establishing design offices in Silicon Valley but felt the risk of failure was too high. After

being exposed to the startup model in Silicon Valley, Huahong's chairman Hu Qili found the model appealing and decided to give it a try. Thus, Huahong invested $1.5 million in Newave, becoming its second largest shareholder. Hu later explained, "Reform means crossing the river by feeling the stones. There has to be someone who tries the crab first.[7] China successfully built several special economic zones, so we can also try to set up a few 'special zones' among high-tech enterprises" (Q. Hu 2006a, 156). Huahong later invested in several startups founded by ethnic Chinese engineers including Amlogic, OmniVision, and Spreadtrum. Another prominent early startup founded in the late 1990s was Vimicro. Its founder Deng Zhonghan went to the U.S. in 1992 to pursue graduate studies and later received a Ph.D. in electrical engineering and computer science from the University of California at Berkeley. After working for IBM's T.J. Watson Research Center, Deng cofounded a startup in Silicon Valley. In late 1990s, he met with Chinese officials visiting the valley and was invited to establish an IC startup in China. Deng and his sponsors—officials at the Ministry of Information Industry (MII)—decided that the startup, Vimicro, would be supported by the state in a way that conformed to the Silicon Valley model: the founders would have high level of autonomy without the state telling it what to do and the state would be one of the venture investors. To do so, MII set aside a portion of the funding traditionally earmarked for SOEs and created an VC firm to invest 10 million yuan in Vimicro, which also raised funds from foreign investors. The VC firm would continue to invest in startups in information technologies and had invested in 24 startups by 2006.

Apart from design houses, the state also worked with returnee entrepreneurs to create a new manufacturing-focused startup, Semiconductor Manufacturing International Corporation (SMIC), the first Chinese company to start with the foundry business model.[8] SMIC's

[7] This is a Chinese saying that means a person who tries something first.
[8] A few IDMs including Advanced Semiconductor Manufacturing Corporation and Huajing had entered the foundry business earlier, but SMIC was the first Chinese company that started with a dedicated foundry business model.

founder, Richard Chang, was born on the mainland and educated in Taiwan and the U.S. and worked as an engineer at Texas Instruments. After starting a foundry in Taiwan that was later acquired, Chang sought to start a new foundry on the mainland and obtained backing from officials at the municipal government of Shanghai government, who were looking for new ways of developing the IC industry. The local state similarly played the role of venture investor, providing land and equity financing. At the same time, substantial funds were raised by Chang from other Chinese and foreign investors, including American VC firms and investment banks. Chang and other executives, many of whom were recruited overseas, were able to pursue strategies based on their understanding of the trend and future opportunities of the global IC industry.

Overseas Chinese not only started new companies but also contributed to policy reorientation in a way conducive to entrepreneurship, specialization, and global integration. In the late 1990s, a group of overseas Chinese including IC veterans and university professors familiar with the industry worked with officials interested in alternative routes of sectoral development to push for new industrial policies (L. Chen 2011). A central figure in this effort was Ma Qiyuan, previously a professor in electrical engineering at Columbia University. Ma was then president of the Chinese Association for Science and Technology, USA—an organization of Chinese scientists and engineers working in the U.S.—and had been travelling frequently back to China to attend seminars and conferences. At one conference, he met the official in charge of the electronics industry in Shanghai. They worked with other officials and overseas experts and submitted an influential proposal to high level policymakers. Parts of the proposal were adopted in the 2000 national policy document encouraging the and IC industry—commonly called "Document 18" because it was the 18th

document promulgated by the State Council in that year.[9] Ma also advised the municipal governments in Beijing and Shanghai and helped the latter launch SMIC.[10]

Although much of "Document 18" was focusing on chip manufacturing, there were clear indications that the state began to embrace entrepreneurship and vertical disintegration. The policy highlighted the role of VC and proposed to both supply VC from the state coffer and attract private VC from China and overseas. In addition, it encouraged companies to raise funds in overseas capital markets and called for the opening of a startup board in the domestic stock market that would be more friendly to startups. Moreover, the policy also put forward a "global talent strategy" that involved luring overseas talents to start companies in China. Reflecting the need of returnee-funded startups to outsource manufacturing overseas due to the backward fabrication technologies in China, the policy also stipulated favorable tariffs for chips designed by Chinese companies but manufactured abroad. Due to domestic and international conditions, some of the measures in the policy were not implemented—the government did not launch the startup board (ChiNext) until 2009, and the tax rebate was met with pushback from the U.S., which filed a complaint at the World Trade Organization and pressured the Chinese government to eliminate the rebate. Still, the policy marked an important shift in the state's attitude toward entrepreneurship in IC. In addition, MOST helped to launch several IC design centers in cities with a decent foundation in the IC industry. These centers provided various support—including electronic design automation software and tape-out services—to design startups and helped to lower the latter's costs in product development. To facilitate communication with the burgeoning design sector, the

[9] The policy document's full name is "Some Policies to Encourage the Software and Integrated Circuit Industries (鼓励软件产业和集成电路产业发展的若干政策)." The document stipulated that favorable policies for the software industry would also apply to IC design.
[10] Xing Ke, "Active promotion of China's IC industry (中国 IC 产业的积极推动)," *China High-Tech Enterprise (中国高新技术企业)*, August 25, 2004.

MII-supervised China Semiconductor Industry Association established the IC Design Branch, which later invited entrepreneurs and venture capitalists as members.

Several scandals notwithstanding,[11] some of the early startups produced remarkable results. Newave's encoder/decoder chips were well-received in the market and the company was acquired by a California-based IC company for $80 million in 2001. Vimicro obtained orders from major mobile phone manufactures for its multimedia processors. SMIC became the world's third largest pure-play foundry in 2004 and raised $1.8 billion through a dual-listing on stock exchanges in Hong Kong and New York in the same year. These successes showed the potential of the VC/startup model and had a strong demonstrating effect on Chinese officials. The success of Vimicro played a particularly influential role as MII officials were directly involved in its founding, provided equity investment, and paid close attention to its development from the very beginning. The company was given one of the highest national awards for technological progress for its multimedia processors. And after it successfully raised funds on Nasdaq in 2005, MII held several symposiums publicizing the new model, to which a standing politburo member and a vice premier sent letters of endorsement. To have more firms like Vimicro in the future, it was concluded that China needed to improve conditions for venture finance, including enlarging the pool of VC and making the stock market more accessible for entrepreneurial firms.

The early successes also attracted more private VC—especially those raised overseas—into China's IC industry. Foreign VC firms that already had a foothold in China, such as Walden International and IDG, began to pay more attention to China's IC sector. In addition, the VC arm of foreign IC giants increased their presence in China to foster startups with complimentary products and keep abreast of development in China's technology sector. For

[11] The two well-known scandals involving returnee entrepreneurs were ARCA and Hanxin, which were recounted in Fuller (2019).

instance, Qualcomm Ventures opened its China office in 2003; Intel, which had been investing in China since the late 1990s, launched a $200 million fund dedicated to the China market in 2005. These foreign VC firms not only expanded the pool of capital available for entrepreneurs, but also provided valuable knowledge and guidance through the venture capitalists' experiences in and understanding of the global IC industry.

With the state's increasing attention to innovation and the institutionalization of VC guidance funds, the state took a more active role in the provision of VC in the IC industry after 2010. Apart from increasing recognition among officials of the contribution of entrepreneurship, a key factor that led to more state involvement was private VC's diminishing interest in the IC sector. The unsatisfactory performance in stock prices of the IC startups—aggravated by the Global Financial Crisis and the consequent slump in the electronics industry—dampened interests of venture capitalists, whose attention was diverted away to areas that had produced stellar returns, particularly internet. One venture capitalist explained, "Initially foreign VC was interested in IC, but more recently they made very little investment [in IC], because in China the same amount of capital would bring much better returns when put in the internet sector. You cannot really blame them because investment is ultimately for higher returns."[12] Another venture capitalist echoed, "IC startups in China have a high rate of failure. Even if you are lucky to invest in a decent company, the upside potential is limited. You very rarely see a company reach a $1 billion valuation, but there are plenty of opportunities in the new economy."[13] Part of the reason for the limited potential, according to one consultant, is cutthroat domestic and foreign competition,

> "Once a company develops a well-selling product, you will soon see other startups enter the market and very quickly reduce profit margins to bare minimum if there is not a high technological entry barrier for the product. For more sophisticated products, it is difficult to compete with big foreign companies with large R&D spending and talent pool. Large

[12] Interview V2019-073.
[13] Interview V2018-048.

> system companies usually prefer to just buy imported chips from established companies."[14]

A returnee entrepreneur who founded a design startup in the mid-2000s confirmed the difficulty of raising private VC. He approached VC both in Silicon Valley and in China but failed to raise funds from them. The former "evaluated us like they evaluate U.S. startups" and were only interested in startups with the best technologies and market potential, whereas domestic private VC was mainly interested in mature companies close to IPO. Eventually it was a local-government-controlled VC firm that provided startup funding.[15]

The lack of interest by private capital in IC startups created concerns about insufficient investment. For Chinese policymakers, market forces alone did not generate the amount of VC investment that would be sufficient for boosting China's IC sector. In response, officials sought to use VC guidance funds to induce private VC to invest in IC startups. This was reflected in the new industrial policy introduced in 2011, which proposed to use VC guidance funds to steer private capital toward supporting IC entrepreneurship.[16] At the central government level, a few programs such as NDRC's Venture Capital for Emerging Industries Program facilitated the creation of professionally managed, IC focused VC funds. An example of such funds was an $80 million VC fund set up in Shanghai in 2011. The fund was managed by Walden International, a renowned VC firm with excellent track records in the IT industry and offices in several IC hubs including Silicon Valley, Taipei, and Tel Aviv. The NDRC program and the local government in Shanghai together contributed 35 percent of capital, in exchange for the fund focusing on IC design startups. The rest was raised by Walden International from other private investors including major IC companies like Micron, Samsung, SMIC, Toshiba and TSMC. At least two companies in the fund's portfolio have

[14] Interview C2019-071.
[15] Interview E2019-072.
[16] State Council, Several Policies on Further Encouraging the Development of the Software and Integrated Circuit Industries (进一步鼓励软件产业和集成电路产业发展的若干政策), January 2011.

reached $100 million of annual revenue (Amlogic and GigaDevice). Increased availability of capital from the state also attracted IC veterans to set up several new VC firms that now actively invest in IC, such as Summitview and WestSummit. As these venture capitalists are in frequent contact with entrepreneurs and their limited partners including government agencies that contributed to their funds, they also facilitate communication between the state and the private sector.[17]

Entrepreneurship and Development of the IC Industry

The rise of entrepreneurship had a profound impact on China's IC industry by encouraging bottom-up exploration and embedding the industry in global networks of capital, knowledge, and production. Homegrown and returnee entrepreneurs explored a wide variety of products and business models that had not been pursued by the state-owned firms. In addition, entrepreneurial firms often specialized in a stage of production—particularly in chip design—and worked closely with upstream and downstream partners, both benefiting from and growing with China's thriving electronic device makers. The most sophisticated ones often leveraged resources and capabilities located overseas and learned from participation in global networks. They thus formed new kinds of relations with foreign partners in the global production network that went beyond the hierarchical relations in much of the literature.

Whereas state-owned IC firms focused on a small number of products considered important by policymakers, entrepreneurial firms explored a wide range of products to tap into the opportunities created by China's large and unique market for consumer electronics. In IC design, startups have pursued relatively undifferentiated products for niche markets, which were easier for startups to enter compared to those for commodity chips that were

[17] For instance, VC firms provide an institutionalized venue through their annual meetings, which bring together limited partners and entrepreneurs of portfolio companies.

dominated by powerful incumbents such as DRAM. Examples include NOR flash developed by GigaDevice, which benefited from a more fragmented market. They have also sought to enter export-oriented production networks led by global flagships. An example was Vimicro, which supplied multimedia chips to global computer and accessory makers such as Hewlett-Packard and Logitec. But these routes could be challenging as global system companies often preferred to work with existing suppliers in the U.S. and Taiwan.[18] More often, therefore, fabless startups focused on providing highly cost-effective and customer-centered solutions to the domestic consumer electronics market (mobile phones, MP3 players, tablets, etc.), where large and unique local demand provided many opportunities. Several features of the domestic market were favorable for local chip companies. First, most consumers tended to favor affordable products with less advanced technologies, which enabled local fabless firms to distinguish themselves by offering cost-effective products. Some entrepreneurs spoke of an "80 percent principle," that is, if the minimum performance requirement is 60 on a scale of 0-100, design firms should aim for 80 instead of 100, because overdesign would delay the product's time to market and make its price less competitive.[19]

In addition, indigenous system makers—the main customers of fabless firms—initially possessed very limited technological knowhow and relied on suppliers to provide hands-on support. They naturally favored chip companies that could provide dedicated customer service, which were mostly Chinese and Taiwanese firms. Due to customers' sensitivity to price and limited technical sophistication, local fabless firms offered highly integrated and turnkey solutions that were popular among system makers. Moreover, emerging local system makers, to distinguish themselves, often hoped to develop unique features that catered to

[18] Interview V2019-073.
[19] Interview E2019-070.

Chinese consumers, but they often could not receive customized support from foreign chip companies. One venture capitalist explained,

> The local customers do not want to keep producing products similar to those made by large foreign companies, whose stronger brands provide a big advantage…They [local system makers] wanted to develop new functions that large foreign brands did not have and would make demands to chip companies, but foreign chip companies were often reluctant to help because they were focused on serving global flagships such as Apple and Samsung.[20]

The ability and willingness of local IC startups to offer customized products and dedicated services helped them to win over local customers. A key feature of China's IC design industry is that local producers of consumer electronics were the main customers of almost all top fabless firms (see Table 4.1). System makers were willing to work with untried startups, which provided competitive products tailored to the local market and superior customer service. By working closely with local system makers, fabless companies contributed substantially to the growth of the indigenous consumer electronics industry and benefited from this growth. In other words, Chinese fabless firms established themselves by closely collaborating and growing together with their customers.

[20] Interview V2019-073.

Table 4.1 Major Chinese IC Design Companies

Company	Year established	Headquarters	Application of products in consumer electronics[#]	IPO location and year	Transnational investors[†]	Investment by CICF
Vimicro[*]	1999	Beijing	Mobile phone	Nasdaq 2005	General Atlantic, Power Pacific	
Spreadtrum[*]	2001	Shanghai	Mobile phone	Nasdaq 2007	NEA, Fortune Venture, Pacific Venture Partners, Acer Technology Ventures	Yes[§]
RDA Microelectronics[*]	2004	Shanghai	Mobile phone, set-top boxes, multimedia	Nasdaq 2010	Warburg Pincus, IDG	
Rockchip	2001	Fuzhou	Mobile phone, multimedia	SSE 2020	NA	Yes
Goodix	2002	Shenzhen	Mobile phone	SSE 2016	MediaTek	Yes
SG Micro[*]	2003	Beijing	Mobile phone, multimedia	SZSE 2017	ComVentures	
Galaxycore[*]	2003	Shanghai	Mobile phone	SSE 2021 (expected)	Sequoia, Walden International	
Amlogic[*]	2003	Shanghai	Set-top boxes	SSE 2019	Walden International, IDG	
Montage[*]	2004	Shanghai	Set-top boxes	Nasdaq 2013	Intel, UMC, AsiaVest	
Beken[*]	2004	Shanghai	Smart home	SSE 2019	Silicon Federation International, WK Technology	
GigaDevice[*]	2005	Beijing	Mobile phone	SSE 2016	Walden International	Yes
Maxscend[*]	2006	Wuxi	Mobile phone	SZSE 2019	NA	
Allwinner	2007	Zhuhai	Mobile phone	SZSE 2015	NA	
Espressif[*]	2008	Shanghai	Smart home	SSE 2019	Shinvest Holding, Intel	
ASR Microelectronics[*]	2015	Shanghai	Mobile phone, smart home	SSE 2021 (expected)	Walden International	
Bestechnic[*]	2015	Shanghai	Smart audio	SSE 2020	IDG, ARM	
SmartSens[*]	2017	Shanghai	Mobile phone	SSE 2021 (expected)	Samsung Venture, Sequoia, WK Technology	Yes

Sources: Company prospectuses.

Note: All firms in this table have reached $100 million in sales. This table does not include captive fabless divisions of large system companies like Huawei's HiSilicon. [*]Founded by returnees. Espressif was founded by a Singaporean entrepreneur who worked for Montage. [#]This column only lists major applications in consumer electronics. The companies' products may be used in other areas. [†]This column lists selected transnational investors at the time of the companies' IPO. [§]Spreadtrum and RDA were acquired by Tsinghua Unigroup in 2013 to form Unisoc, which received investment from CICF.

Returnee entrepreneurs, with stronger skills and global connections, were particularly active in the more sophisticated segments of the market such as wireless communications and image sensors. For instance, Spreadtrum, a fabless company that specialized in baseband processors for mobile phones, became an important player in the segment thanks to close collaborations with local brand manufacturers, handset design houses, and original design manufacturers. Founded in 2001 by several returnee IC veterans with entrepreneurial experiences in Silicon Valley, the company targeted a large market dominated by foreign firms. When Spreadtrum was founded, the second-generation cellular technology had already matured in the west but was growing rapidly in China. After intensive R&D, Spreadtrum rolled out highly integrated chips that combined baseband, power management, and multimedia. These cost-effective projects were popular among local customers, who dominated the lower end of the handset market. In addition, the company offered both chip and software support in turnkey solutions, allowing local companies producing white box phones to come up with new models easily and rapidly.[21] Returnee entrepreneurs also played an active role in the local broadcasting market. Several returnee-founded startups managed to develop integrated solutions that could also better deal with local conditions (e.g., suboptimal signal quality) and cost a fraction of imported alternatives. Similarly, part of their advantage also came from hands-on customer service, with some of the startups (e.g., Availink and Legend Silicon) also working with the broadcasting authorities—a major customer—to develop technological standards.

Startups founded by indigenous entrepreneurs also focused on the domestic market, though they tended to start from less sophisticated products and then enhanced their capabilities to develop more complex ones. Rockchip, a design house founded by local entrepreneurs in 2001, initially focused on chips used in repeaters, a Walkman-like device

[21] Interview C2019-081.

widely used by Chinese school children for English learning. Collaborating closely with repeater manufactures, Rockchip developed chips with unique functions that were well received by repeater users, such as the ability to change repeating speed without changing pitch. Profits from repeater chips allowed Rockchip to hire returnee engineers and invest in R&D as the company and its downstream partners moved into more sophisticated products such as MP3 and MP4 players and tablets. In 2017, Rockchip's chips were selected by Samsung for its lower-end Chromebook models. Goodix, a Shenzhen-based fabless firm, initially focused on chips used in landline telephones, a product that had been abandoned by top IC players. While margins were low, Goodix made decent profits from large volumes and then invested in the development of controllers used on mobile phones. Its touchscreen controllers and fingerprint sensors had particularly good performances on the market partly thanks to Goodix's close collaboration with local phone makers and MediaTek, a Taiwanese chip design house and one of Goodix's shareholders.

It is worth noting that the government's role in creating the market for entrepreneurial chip design firms was inconsistent and partial at best.[222] The famous *shanzhai* (unauthorized) mobile phones, which were very popular in the late 2000s and created opportunities for chip design firms in mainland China as well as Taiwan, emerged despite the state's strict licensing policy that sought to protect the mobile phone market for SOEs. *Shanzhai* entrepreneurs not only created a vibrant indigenous phone industry but also managed to compel the state to abandon license control through contestation and success in the market (C.-K. Lee and Hung 2014). The state's introduction of the TD-SCDMA as a standard for the third-generation mobile telecommunication was widely perceived to be a major effort to create a market for Chinese firms. But disagreement within the state resulted in long delays (Gao and Liu 2012),

[222] As Brandt and Thun (2016) have argued, China's large domestic market creates unique advantages for local firms, but the state through its restrictive policies on the demand side sometimes inadvertently limited the opportunities for upgrading.

which created substantial difficulties for firms that engaged in the development of TD-SCDMA-compatible chips. Spreadtrum, for instance, committed large resources to the standard and developed a chip in a relatively short period of time but for several years could not market it, which created severe financial pressure for the company.[23] When the government finally give the greenlight to the standard's commercialization in 2009, some of the firms developing the standard had already gone bankrupt. Though the standard did contribute to Spreadtrum's revival (Fuller 2016), one has to wonder if a more coordinated and determined effort to introduce the standard would have produced a larger boost to China's chip industry.

Not only did entrepreneurial firms pursue new products, but they also specialized in a stage of product development and deepened the sector's vertical fragmentation. Prior to the rise of entrepreneurial firms, local IC producers were mostly state-owned IDMs, companies that integrated design, fabrication, and packaging and testing. The new startups mostly specialized in design and their growth provided opportunities to other specialized firms like dedicated foundries and providers of finished modules or design service. Returnee entrepreneurs, through their access to officials, facilitated the state's embrace of specialization. For those who returned from Silicon Valley, this specialization is what makes the Valley stand out. Vimicro's founder Deng Zhonghan once commented, "When talking about Silicon Valley before, we always spoke about things like IPO and stock options. In fact, these are very superficial understanding of Silicon Valley. Integrating into the industry's ecological chains and doing things you are best at are the true essence of the Silicon Valley model."[24]

[23] Interview C2019-081.
[24] Yang Jian, "Deng Zhonghan: Lighting up the Starlight (邓中翰 燃亮星光)," *People's Daily*, February 5, 2004.

Moreover, entrepreneurial firms—especially the more sophisticated ones—are often deeply embedded in global networks through investment, talents, and production relations. As Table 4.1 shows, most of the top fabless companies have foreign investors—either overseas-headquartered VC firms with expertise in IC or foreign chip companies. These investors not only provide capital but also serve as advisors and source of information and may open opportunities for collaboration. In addition, entrepreneurial firms through talent networks became members of the transnational technical community. This was especially true for startups founded by returnees, who helped to bring in practices and procedures of product development that were especially lacking in China. An early returnee entrepreneur recalled, "When we started, local engineers were mostly doing reverse engineering and had almost no understanding of design, so we spent much time training local engineers and getting them familiar with the design workflow."[25] At the same time, returnee entrepreneurs often maintained close contact with Silicon Valley or traveled frequently back and forth between China and the U.S. To accommodate those who prefer to stay in the U.S., returnee-founded startups often had offices in Silicon Valley since inception and were thus multinational from the very beginning.[26] For firms founded by indigenous entrepreneurs, the more established ones also hired executives and engineers with overseas experiences and connections. Thus, the rise of entrepreneurship helped to deepen the sector's embeddedness in transnational talent networks, which facilitated learning, information transmission, and collaboration.

A key characteristic of China's fabless sector is its close collaboration with local and foreign partners to develop products. Rather than participating in hierarchical production networks dominated by western-based "lead firms" or "flagships," China's IC design

[25] Interview E2019-086.
[26] In fact, several design startups were first founded in Silicon Valley and then moved main operations to China.

companies work closely with local customers while drawing from input and manufacturing capabilities provided by foreign firms. As chips become increasingly complex, specialized firms often rely on capabilities located in firms in other parts of the world to bring a product to market. Specialization and global integration, in other words, are two sides of the same coin. China-based fabless firms are able to source input from many parts of the world due to the IC industry's increasing fragmentation, even within the design phase (Ernst and Naughton 2012). For instance, they can concentrate on specific functional blocks of chips, system integration, marketing and customer service while using design tools developed by U.S. firms, licensing designed modules from British or Israeli firms, and outsourcing production to Taiwanese firms. This not only allows Chinese firms to develop sophisticated products based on advanced technologies developed elsewhere but also facilitates learning, as Chinese firms need to study their suppliers' design and manufacturing processes for their own designs. In the process, engineers at Chinese firms and their foreign suppliers often collaborate closely to facilitate product development. This demand of technological support and collaboration from Chinese fabless firms prompted advanced suppliers such as ARM, Synopsys, and TSMC to increase technical staff in China, creating an increasingly sophisticated ecosystem that facilitated product development, troubleshooting, and learning. This ecosystem benefited independent fabless companies as well as the design division of system makers such as Huawei's HiSilicon.

The Dilemma between Global Integration and Self-Sufficiency

While the rise of entrepreneurship and integration in global networks brought about substantial progress in China's IC industry, particularly in design, the continued reliance on imported microprocessors and on foreign production technologies has led to rising concerns over information and economic security. Sense of vulnerability drove the state to pour

resources into areas where it hoped to be self-sufficient. Yet leading foreign firms have accumulated enormous advantages in these areas and Chinese firms found exceedingly difficult to be commercially successful. Since private actors were reluctant to enter these areas and take on global giants, state-run entities have been relied upon to undertake many of the projects aimed at self-sufficiency, persisting a bifurcated sectoral structure—market-oriented entrepreneurial firms on the one hand, and state-run companies and research institutes on the other.

As much of China's science and technology research—including that on semiconductors—was geared toward military need during the Mao era, there has been a strong ideological legacy of pursuing self-reliance, or what is often called technonationalism (Feigenbaum 2003; Naughton and Segal 2003). But ideology is only part of the story, as policymakers were not fully determined to be self-sufficient in the entire production chain from the outset; rather, the pursuit for technological autonomy evolved in response to threats and vulnerabilities that were perceived.[27] Concerns first emerged among some officials and researchers at state institutes over China's reliance on imported microprocessors for computers, mostly from Intel. But many dismissed the feasibility of challenging an established global giant and developing indigenous central processing units (CPUs). Thus, state efforts were limited before the late 2000s, and early initiatives to develop microprocessors, such as the Loongson (龙芯) project by the Institute of Computing Technology of CAS, often had to find funds by themselves.[28] This began to change after the launch of National Science and Technology Major Projects (国家科技重大专项), one of

[27] Absolute technological self-sufficiency is increasingly difficult to achieve in the era of global production, especially for complex products like ICs, where different countries specialize in different areas and production stages and rely on others for input. Even Japan, which arguably has had a longer and more consistent tradition of technonationalism (Samuels 1994), relies on foreign technologies for chip production. When the U.S. government restricted sales to Huawei by any producer—including those outside of the U.S.—that use American technologies, Japanese producers were also affected. See "Sony and Kioxia seek US approval to bypass Huawei ban," *Nikkei Asia*, October 4, 2020.
[28] Interview S2019-084.

which was for "core electronic components, high-end general-purpose chips, and basic software" (hereafter Project 01).[29] The project's objective was to develop indigenous CPUs and operating systems, the two most important components of personal computers where China almost exclusively relied on imports. The project was given additional urgency by a Microsoft anti-piracy campaign, which turned many computer screens in China black. Although Microsoft's action was intended to target pirated software, it caused much anxiety within the state because the incident clearly revealed how vulnerable China's information system was to potential sabotage. Li Guojie, the initial mastermind of the Loongson project and a key proponent of indigenous microprocessors, complained after the incident, "We fight for every inch when defending territorial integrity, but our information space is almost unguarded. Foreign countries can even turn our computers to black screen or shut them down, because we have adopted foreign made products in everything from chips to basic software."[30] With increasing recognition of the importance of information security, Project 01 was given the clear objective of self-sufficiency in devices used in government and key infrastructure such as electric grids.[31] It funded several indigenous CPU projects, which were based on different architectures to balance the need for compatibility and autonomy.

In addition to information security, there was also the fear that reliance on imported foreign equipment and manufacturing technologies would enable foreign countries to contain industrial upgrading in China and that disturbance of such supply would create severe disruption to the domestic economy. This concern has been vividly referred to by officials as "neck choking" (卡脖子). It stemmed in large measure from the fact that Chinese chip foundries have long had trouble accessing advanced manufacturing equipment due to export

[29] It is commonly called Project 01 because it was listed as the first of a total of 16 Major Projects. In Chinese media, it has also been referred to as *hegaoji* (核高基) for short.
[30] Liu Shu, "China Chip: Guardian of Information Security (中国'芯': 信息安全守护神)," *Science and Technology Daily (科技日报)*, November 14, 2008.
[31] Zhang Yu, "Hegaoji, Before Dawn (核高基 黎明之前)," *Oriental Outlook (瞭望东方周刊)*, May 20, 2013.

restrictions by western countries, particularly the U.S.[32] At one point, semiconductor manufacturing equipment was the largest item in terms of dollar value in U.S. exports to China that required an export license.[33] This means although Chinese firms have acquired substantial equipment from the U.S., this supply could easily be cut off if U.S. officials see cause to revoke the licenses. To address this issue, another Major Project was created for equipment and process technologies used to manufacture very large-scale integration chips (hereafter Project 02).

The exposure of the PRISM program in 2013 reinforced the urgency to enhance China's information security. Soon after the exposure, Ma Kai, a Vice Premier, visited several Chinese chip and information technology companies, where he described an indigenous IC industry as "an important safeguard for national security."[34] A few months later, the State Council launched a forceful IC development program, a key objective of which is to establish a "technologically advanced, secure, and reliable" IC industry. As part of the program, a leading group chaired by Ma Kai was created and a 138.7-billion-yuan China Integrated Circuit Industry Investment Fund (CICF, colloquially known as "the big fund") was established. Unlike the Major Projects, the fund supported firms through equity investment instead of grants or subsidies. Reflecting the state's recognition of the importance of entrepreneurship, the fund has also contributed capital to VC funds dedicated to IC startups. In addition, CICF has directly invested in several established design firms to strengthen their

[32] Western countries are coordinated through the Wassenaar Arrangement, which governs conventional arms and dual-use technologies. The latter include chip manufacturing equipment, as chips are widely used in advanced weaponry.

[33] Testimony at U.S.-China Economic and Security Review Commission, Peter Lichtenbaum, Acting Under Secretary for Industry and Security, U.S. Department of Commerce, June 23, 2005, https://www.uscc.gov/sites/default/files/6.23.05lichtenbaum_statement_wrts.pdf.

[34] Zheng Xiaoyi, "Ma Kai Stressed to Strive for a Better, Stronger, and Larger Integrated Circuit Industry (马凯强调: 努力推动集成电路产业做优做强做大)," *Xinhua*, September 12, 2013. Ma Kai made a more elaborated remark in 2017 tying the necessity of building an IC industry to information security, "Chips, as the heart of the internet, bear on the nation's economic, political, and military security. It is an open secret that chips all have back doors. The internet age brings both convenience and vulnerabilities. Therefore, developing our own integrated circuit industry is necessary." See Qu Yunxu and Chen Mengfan, "Ma Kai: Cannot Be Dependent on Others for Core Technologies like Chips (马凯: 芯片等核心技术不可受制于人)," *Caixin*, March 7, 2017.

R&D capabilities and facilitate merger and acquisition (see **Error! Reference source not found.**). But CICF's top priorities are areas that are important in the IC value chain but in which China continues to lag, rather than areas where entrepreneurial firms have made substantial progress. In the words of CICF's chairman, the fund seeks to enhance "competitiveness in the *entire* IC value chain" (emphasis added).[35] A key focus of the fund was manufacturing, which received two thirds of the fund's total investment, whereas chip design firms only accounted for 17 percent of total investment.[36] This is almost the opposite of the investing patterns of VC, about 70 percent of which goes into the design segment.[37] The intensifying conflict between U.S. and China in IC, including the sanctions on Huawei and ZTE and the placing of dozens of Chinese companies on the entity list, has exacerbated the sense of vulnerability regarding "neck choking" and led to addition scrambles, including a 200-billion-yuan second edition of CICF.[38]

These efforts were carried out in a highly top-down manner, with the state setting objectives, providing most of the funding, and relying mainly on state-run research institutes and companies for implementation. Part of the reason for the reliance on state-run entities was that private actors were reluctant to enter these areas where challenging incumbents would be extremely difficult if not impossible. Microprocessors, foundry, and semiconductor equipment are all highly oligopolistic markets where global leaders invest huge sums in R&D to maintain their technological advantages and use intellectual property measures to prevent entry. In addition, incumbents benefit from the ecosystem of complementary products built

[35] Interview with Wang Zhanfu, CICF chairman, *People's Posts and Telecom (人民邮电)*, December 20, 2017.
[36] Wang Zhanfu, "CICF: Implementing National Strategy through Market Means (国家集成电路产业投资基金: 以市场化手段实施国家战略)," *Study on Manufacturing Power (制造强国研究)*, no. 32, November 1, 2017, http://www.cm2025.org/uploadfile/2017/1219/20171219094926627.pdf.
[37] Winsoul Capital, "Understanding Investment in China's Semiconductor Industry in 2020 (2020 年中国半导体行业投资解读)," January 2021.
[38] The export ban imposed on ZTE in 2018 paralyzed the company until the U.S. government relented after ZTE agreed to what many in China considered humiliating punishments. Some regarded this incident as China's "Sputnik Moment." Li Yuan, "Near-Collapse of ZTE May Be China's Sputnik Moment," *The New York Times*, June 13, 2018.

around their own products, which increases the cost for customers to switch to a different product. For instance, Intel's microprocessors' compatibility with the Windows operating system and the numerous kinds of Windows-based software has created an almost insurmountable barrier for newcomers. Hence, the difficult tasks of developing these products and technologies were mostly assumed by state entities, which, perhaps unsurprisingly, struggled to make headway, despite substantial investment from the state by China's standards. Between 2006 and 2010, Projects 01 and 02 together spent almost 40 billion yuan, to which the central government contributed 17 billion and local governments and companies provided the rest.[39] But the products developed under these projects remain being used primarily by government agencies. Market-oriented firms, in the hope of making more sophisticated products, would rather buy foreign technologies if they are available.

This revealed a central dilemma confronting China's industrial policymakers. On the one hand, embrace of entrepreneurship and the associated participation in global division of labor has brought substantial progress, particularly in the IC design sector. On the other hand, pursuit of self-sufficiency has led the state to invest huge sums in areas where Chinese firms do not have comparative advantage—at least for the moment—and find it very challenging to compete with leading foreign firms. This inevitably shifts limited resources and talents away from top market-oriented firms, which could have advanced more with larger state support. When compared to the large amounts invested in state-run projects, the support given to entrepreneurial firms immediately appears rather limited. In 2019, the top four listed design firms together received 400 million of government grants and subsidies,[40] which was a small fraction of the billions invested by the state in IC each year. When asked about the role of state support, a founder of one of the most successful fabless firms commented, "The

[39] 2010 China Science and Technology Development Report.
[40] Annual reports of Amlogic, Galaxycore, GigaDevice, and Goodix.

government did not really give us much help, especially not when we were in difficult periods. They only provided some icing on the cake when we were doing better."[41] Simply put, most of the state's resources did not actually go to the real champions. In addition, with openness for imported products and domestic firms' preference of foreign technologies, there has been limited synergy between state-run entities and market-oriented entities, contributing to the persistence of the sector's bifurcation and ultimately the limited upgrading of China's IC sector.[42]

The pursuit of self-sufficiency reflects a key distinction between China and its East Asian neighbors, which emerged to become important players in the global IC industry through specialization in certain products or phases of production and have continued to rely on foreign technologies. As U.S. allies, they need not worry much about losing access to American technologies, and the potential cost in terms of information security would seem bearable compared to the challenges of developing indigenous microprocessors. For China, however, these issues would cause policymakers nightmares, especially when U.S.-China relations deteriorate. Moreover, the pursuit of self-sufficiency may have the unintended consequence of adding up to the tension between the U.S. and China in high-tech, which would make global participation by Chinese firms more difficult. The Chinese government's efforts to develop areas dominated by American firms—though often exaggerated by foreign officials and observers—have drawn attention from U.S. government and industry. For instance, China's 2014 policy drive for IC was characterized by U.S. Secretary of Commerce Penny Pritzker as a threat to the semiconductor industry.[43] With the Chinese government's

[41] Interview E2018-010.
[42] This issue has been ameliorated by the recent tension between U.S. and China in high-tech, which prompted Chinese firms to "de-Americanize" their supply chain and be more willing to work with local partners. In addition, CICF has also tried to serve as a broker that fosters collaboration among its portfolio companies. For instance, it has encouraged fabless firms to work with foundries in its portfolio and encouraged foundries to use equipment and materials supplied by local producers.
[43] U.S. Secretary of Commerce Penny Pritzker Delivers Major Policy Address on Semiconductors at Center for Strategic and International Studies, https://2014-2017.commerce.gov/news/secretary-speeches/2016/11/us-secretary-commerce-penny-pritzker-delivers-major-policy-address.html.

emphasis of indigenous products, the Semiconductor Industry Association, a trade association that represents the U.S. chip industry, also raised concerns for market access.[44] Given the importance of the semiconductor industry for the U.S. economy—it is the third largest source of manufactured exports—it would not be surprising if the U.S. government takes measures to slow down China's advance in areas dominated by American producers, such as equipment, microprocessor, and chips used in telecommunication. The U.S. can impose restrictions over export, foreign investment, and Chinese students. It can also cut off Chinese firms' access to input produced by non-American producers by virtue of its central position in the global supply chain, as demonstrated by the U.S. stopping British, Japanese, South Korean, and Taiwanese firms from supplying Huawei. Increasing tension between U.S. and China in high-tech will only further hamper China's ability to participate in global networks.

Discussion

The rise of entrepreneurship is arguably the most important development in China's IC industry in the first two decades of the twenty-first century. It deepened specialization and helped to create a vibrant design subsector that is a key component of the increasingly competitive local electronics production network and simultaneously collaborates closely with firms in the global chip production network. This has happened despite the fact that the government's industrial policy for chips has increasingly sought to develop all areas of chip production and reduce reliance on foreign technologies.

However, the pursuit of self-sufficiency has taken a toll on efforts to specialize in global networks by shifting valuable resources away from entrepreneurs. This presents a major

[44] Written Comments to the United States Trade Representative Regarding the Initiation of a Section 301 Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation, Semiconductor Industry Association, October 5, 2017, https://www.semiconductors.org/wp-content/uploads/2019/03/SIA-Submission-to-USTR-China-Section-301-Investigation-October-5-20171.pdf.

dilemma for China's policymakers. On the one hand, with the increasing sophistication of technology, specialization and global production has been deepening, even for arms production (Brooks 2005). This, however, has mostly taken place among the U.S. and developed economies with close relations with it, particularly Europe, Japan, South Korea, Taiwan, and Singapore, which enjoy easy access to input provided by other members in this network. China, as a country increasingly perceived as a potential adversary of the U.S., cannot take this access for granted. In addition, just like the U.S. government has tried very hard to exclude Chinese equipment from its telecommunication infrastructure, Chinese officials worry about the implication for national security of relying on foreign technology for critical information processing and communication. On the other hand, being completely self-sufficient in areas like advanced chips will be detrimental to competitiveness and may not even be possible. As an illustration, a state-of-the-art chip fabrication plant can cost over $10 billion and would require highly sophisticated equipment developed through the work of thousands of engineers across North America, Europe, and East Asia. It is highly unlikely that China will be able to independently develop such technology by itself in the foreseeable future. Navigating this dilemma, which has been exacerbated by China's deteriorating relations with the U.S., will be a central challenge for China's policymakers.

Chapter 5 Pharmaceuticals

This chapter switches to the rise of entrepreneurship in China's pharmaceutical industry. Like IC, pharmaceutical is a knowledge-intensive industry dominated by developed countries. Of the world's 100 largest pharmaceutical companies, 79 are headquartered in Europe, Japan, or the U.S.[1] With huge R&D expenditures, this group of countries also account for the lion's share of new drugs, which are usually patented and a major source of handsome profits. The pharmaceutical industry is different from IC in its heavier reliance on basic research, especially in biology, chemistry, and pathology. Much of the research that informs and leads to the discovery of new drugs is conducted at universities and research institutes, which depend substantially on government funding. For instance, the U.S. National Institutes of Health, with an annual budget of over $30 billion, serves as a key knowledge base for the American biopharmaceutical industry, which, as Lazonick and Tulum quipped, "has become big business because of big government" (2011, 1180). Second, the pharmaceutical market features much heavier regulation by national governments, which not only independently approve drugs but also set policies regarding prices and insurance reimbursement. This means that governments have a more prominent role to play in spurring pharmaceutical innovation.

Compared to IC, China's pharmaceutical industry received less government attention, was governed by a less coherent set of agencies, and featured a more fragmented industrial structure in the late twentieth century. The large number of indigenous pharmaceutical companies produced known products and had very limited innovative capacity. Returnee entrepreneurs, first mostly supported by local governments, created a successful subsector

[1] *The Novasecta Global 100*, https://novasecta.com/wp-content/uploads/2019/04/The-Novasecta-Global-100-2019.pdf.

that provided outsourced R&D services to foreign drug companies—an area that was initially neglected by industrial policy—and helped to deepen China's integration in global networks of pharmaceutical innovation. But entrepreneurship in the development of new drugs was impeded by the state's lack of investment in healthcare and basic research as well as inadequate regulatory capacity. It was only after these conditions were ameliorated in recent years that an entrepreneurial boom in drug innovation appeared. This boom has produced some encouraging results—a drug for cancer treatment developed by a young entrepreneurial firm became China's first innovative drug approved by the U.S. Food and Drug Administration (USFDA) in 2019, and in each of the past few years over 200 innovative drugs started development in China, half of which by R&D-focused entrepreneurial firms.[2] But this remains a work in progress, and whether China can build an innovative pharmaceutical industry remains to be seen. Thus, in pharmaceuticals the rise of entrepreneurship has had a similar impact on sectoral development as in IC, though the contribution has been hampered by different factors regarding the state due to sectoral characteristics.

It will be useful to briefly discuss the R&D process that leads to a new drug.[3] It starts with efforts in understanding a disease and the possible means to cure or ameliorate it. This is considered as the most creative part of the process and is mostly done by universities or government research labs, which in the U.S. receive the lion's share of funding from the National Institutes of Health. Once a disease is well understood, efforts are then made—mostly by companies—to develop drugs, that is, to discover or synthesize a molecule for it. This development part can be divided into preclinical and clinical stages. The former includes screening of molecules and studying their properties and safety in animals. The vast majority

[2] The other half are developed by more traditional pharmaceutical companies that initially focused on generics and multinationals in China. "Xi Mobilizes China for Tech Revolution to Cut Dependence on West," *Bloomberg*, March 1, 2021.
[3] This paragraph draws mostly from Angell (2005).

of drug candidates are weeded out at this stage. The most promising ones, after being cleared by regulators to be reasonably safe, can then be tried on humans in the clinical stage. If that goes well, companies will need to secure the approval of regulators again to take the drugs to market. New drug development is a highly risky process—only about one in five thousand drug candidates eventually makes it.

The Rise of Transnational Entrepreneurs in Pharmaceuticals

In the 1990s, China's pharmaceutical industry featured a legion of local producers with very limited innovative capacity. Many of these firms were created following the sector's decentralization in the 1970s, which allowed local governments to establish firms for the protected local market. This resulted in a highly fragmented sectoral structure, with more than 3,000 firms, most of which were small-scale producers of generic drugs—those with the same active substance as off-patent drugs—or traditional Chinese medicine. Some of the largest emerged to become major producers and exporters of active pharmaceutical ingredients, though these firms mainly produced technologically mature and low-margin products such as antibiotics and vitamins. With R&D spending representing less than 1 percent of total sales, the indigenous pharmaceutical industry produced very little innovation. Between 1985 and 1998, the industry developed only two new chemical entities (Yeung 2002). The other major players in the sector were global pharmaceutical companies, which began to enter the Chinese market through joint ventures in the 1980s. While they accounted for a smaller share of the market than the local firms, their operations were more profitable due to more sophisticated products and exclusivity granted by the government. Prior to 1992, China, like many other developing countries, did not recognize patents for medicine. But the government was forced to yield to pressure from western countries during trade negotiations and harmonized the patent law to include medicine and extend exclusivity from 15 to 20

years. It also offered exclusive rights to dozens of drugs for which MNCs had obtained patents elsewhere before 1992.

Compared to the IC sector, which received attention from the highest level of the Chinese leadership and has enjoyed a relatively stable supervising structure, before the late 2000s the pharmaceutical sector suffered from the lack of substantive developmental initiatives by the central government and was victim of frequent organizational reshuffles. For much of the 1990s, the sector's development and regulation were both overseen by the State Economic Commission (SEC, later renamed to State Economic and Trade Commission, or SETC). In 1998, the two responsibilities were separated: sectoral development remained in SETC's jurisdiction, whereas a new agency regulating drugs was created directly under the State Council. Just five years later, SETC was abolished, and industrial policy regarding pharmaceuticals was transferred to NDRC, and in 2008 it was transferred again to MIIT. Due to this constant shifting of authorities, along with the fact that the Ministry of Health also had substantial influence over the sector, there was no lead agency that consistently played an active role or launched meaningful initiatives as MIIT and its predecessors did for the IC sector. On the other hand, officials at SSTC, who had long noticed the advance of biotechnology in the west, understood it would create new opportunities for the pharmaceutical industry and started to take measures in the 1980s including the creation of a biotechnology development center. Though SSTC lacked resources and authority to directly shape sectoral development, it helped to identify biopharmaceutical as a key sector and encouraged local officials to prioritize it. Beijing's Zhongguancun and Shanghai's Zhangjiang, China's largest and best-endowed high-tech zones (HTZs), designated biopharmaceutical as one of the main sectors to develop in their planning in the late 1990s.

By the turn of the century, the central government had been paying increasing attention to high-tech and innovation and demonstrated a more welcoming attitude toward overseas

talents. Against this backdrop, startups created by returnees with training in biology, chemistry or medicine and work experiences in pharmaceutical R&D in western countries began to emerge. These early startups fell into two categories. The first focused on the development of new drugs that were not available in China. The second, known in the industry as contract research organizations (CROs), provided R&D services for drug companies—mostly foreign ones—developing novel medicine.

Apart from a more welcoming state, these early returnee entrepreneurs were also drawn by China's economic growth and continued opening to the outside world. But the local ecosystem for entrepreneurs was far from ideal. Since China's VC industry was still in infancy and venture capitalists with expertise in the pharmaceutical industry were almost nonexistent, there was little hope for these early returnee entrepreneurs to obtain private VC. Thus, support mainly came from their local partners, especially local governments, which essentially acted as venture capitalists and supported these new ventures whose prospects were uncertain. While some of the startups received equity investment from local governments, more often support took the form of various resources such as office space, land, subsidies, research grants, loans, and tax rebates.

Local governments and HTZs played a key role in the rise of entrepreneurship in pharmaceuticals, especially when the sector lacked an active patron central government agency like MIIT for IC. Crucially, their experimentations and adaptations helped to accommodate the early startups and their business models and facilitated their expansion. This can be illustrated by the process through which the Zhangjiang HTZ in Shanghai became a hub for pharmaceutical entrepreneurship. In the late 1990s, local officials, with the support of several ministries including MOST and the Ministry of Health, designated biotech and pharmaceuticals as prioritized sectors of Zhangjiang. Initially, they placed much hope on MNCs and local research institutes and universities. Thus, early efforts included attracting

foreign drug companies (GlaxoSmithKline, Roche, etc.) to set up production plants, relocating the Shanghai Institute of Materia Medica of CAS to Zhangjiang, and having local universities including Fudan and the Shanghai University of Traditional Chinese Medicine to open new campuses there. Coming into contact with the returnee entrepreneurs that started arriving, local officials displayed great interest in the startups, but since they were preoccupied with developing a pharmaceutical sector with new products, they gave more much attention to the new drug startups—providing equity investment to some—than to the CRO startups. When WuXi AppTec, a young startup which would later become China's largest CRO, moved its headquarters to Shanghai in the early 2000s, it chose to relocate to the Waigaoqiao Free Trade Zone instead of the Zhangjiang HTZ.[4] But seeing the rapid growth of early CRO startups, Zhangjiang soon realized the potential of the CRO sector and began to actively support it. Local officials helped CRO startups to find customers and subsidized their participation in industry exhibitions overseas. When CROs pointed to the complicated customs clearing procedures as a hindrance, local officials took measures to facilitate the importing and exporting of biological materials by CROs. In the late 2000s, CRO was designated as a key industry of the Zhangjiang HTZ. To further encourage entrepreneurship in pharmaceuticals, local officials helped to create dedicated VC funds managed by experienced venture capitalists. An early example was a fund created in 2005 and managed by BioVeda. The fund was run by a returnee with a Ph.D. in biology from Harvard and extensive experiences in the pharmaceutical industry. It raised funds not only from the local government but also from overseas institutional investors such as Temasek and the International Finance Corporation. When entrepreneurs experimented with the new

[4] Ye Jing, "Wuxi AppTec's Li Ge and His CRO Empire (药明康德李革和他的新药 CRO 帝国)," *The Founder (创业家)*, No. 9, 2015. Zhangjiang was originally a township in Shanghai's Pudong New Area. In a good example of local governments' stretching HTZs, Zhangjiang HTZ was later expanded to incorporate 22 high-tech parks across Shanghai including the Waigaoqiao area. Thus, Waigaoqiao is now technically part of the larger "Zhangjiang."

business model of combining the local ecosystem of specialized service providers and VC with drug candidates developed elsewhere, Zhangjiang enthusiastically supported it and directly invested in some of the projects.[5] Now this business model—called VIC because it combines VC, intellectual property, and CROs—is widely adopted by startups in the area. Thus, the rise of pharmaceutical entrepreneurship in Zhangjiang is in large measure the result of experimenting with new measures, actors, and organizational forms.

The Unplanned Growth of CROs

While in the early days those dedicated to the development of new drugs received more attention and support from local governments, it was the CROs that grew more rapidly and emerged as a bright spot, helping to further draw overseas talents and capital to China's pharmaceutical industry. CROs provide preclinical, clinical, and customized manufacturing services to firms that develop and market new drugs.[6] It had been a burgeoning industry in the west since the 1980s, as large pharmaceutical companies increasingly outsourced tasks in the drug development process to outside service providers to diffuse the growing risks associated with drug innovation. Compared with in-house R&D, specialized providers can offer R&D services in a more timely manner at lower costs, make it easier for pharmaceutical companies to terminate unpromising research, and take better advantage of the technological advances that facilitate the screening and testing of drugs (Mirowski and Van Horn 2005). In addition, the advance of biotechnology created opportunities for small startups to exploit knowledge that originated from universities and research institutes. Since the large amount of skills and resources demanded to bring a biotech drug to market could not be easily

[5] Interview E2019-088.

[6] Those offering manufacturing services are referred to in the industry as contract manufacturing organizations (CMOs). A subset of CMOs offer more customized services by engaging with customers early in the drug development process (small-scale manufacturing for preclinical and clinical research) and investing in the development of manufacturing technologies. Since these more differentiated manufacturing service providers are important partners in new drug development, they are also included in the category of CROs in this chapter.

marshaled by a single organization (Powell 1996), these dedicated biotech firms formed collaborative relations with a variety of actors, including universities, research institutes, and specialized R&D, clinical trial, and manufacturing service providers. The rise of CROs thus represented the increasing vertical disintegration of the pharmaceutical industry in response to the increasing risks in R&D and technological change.

Initially CROs were concentrated in western countries, which were home to the largest pharmaceutical companies, the most vibrant biotechnology industry, and the most important drug markets, and it was not clear whether it would become a successful business model in China, though the country clearly possessed certain advantages. Though Chinese officials had been interested in developing the biopharmaceutical sector, the central government did not identify CRO as an important subsector to develop until much later, and little targeted support was offered to the early entrants. Thus, the emergence of a vibrant CRO sector in China was not the product of the state's industrial policy. Rather, it emerged without targeted support and expanded as local governments and then the central government became more supportive.

The origin of the CRO industry in China can be traced to the late 1990s, when local entrepreneurial firms began to emerge and foreign CROs set up offices in China. The latter were mostly focused on the clinical stage and entered China in anticipation of helping MNCs to bring new drugs to the local market. But for several years much of their work was exploratory and preparatory, as the authorities did not issue Good Clinical Practice (GCP) standards or give explicit permission for CROs to conduct clinical trials for clients until 2003. Startups created by entrepreneurs, on the other hand, focused on preclinical research and manufacturing. Given the lack of targeted industrial policy, these CRO startups tended to receive less government support in the beginning compared to early drug discovery startups and many of them had to rely substantially on founders' own funds and reinvestment. The

central government's program on biotechnology mostly funded research at universities and research institutes, and CROs' emergence was independent of it (F. Zhang and Wu 2012). In addition, since CROs typically own few intellectual property rights due to their role as service providers, they were often ineligible for various tax benefits that the government provided to qualified "high-tech companies," which were designated based on rigid criteria such as whether the company held patents.[7]

The lack of targeted state support notwithstanding, CRO soon proved to be an activity that provided much potential for Chinese firms, as the local advantages of low labor cost and rapid speed helped to offer attractive solutions for multinationals looking to outsource R&D. China has been producing a large number of STEM graduates whose salaries are a fraction of those in the U.S. This not only helped to reduce cost of development, but also allowed Chinese service providers to deploy more people per project for more standardized tasks, moving drug candidates faster along the pipeline. After returnee entrepreneurs used their connections to obtain initial orders from multinationals, they could use this local advantage to establish themselves as valued partners in the drug development process. As an entrepreneur put it, "While the U.S. is much better at getting from zero to one, China has the advantage of getting from one to 100 faster, because it has an abundant supply of mid and low-level talents, which is a great asset for scaling up."[8] The CRO business model could also generate revenue and turn profitable much faster than new drug startups, which helped to attract officials' attention and support.

While the state did not initially target the CRO sector, local officials gradually realized its potential and became increasingly supportive. A CRO entrepreneur observed, "If you grow fast, make good profits and pay more taxes, the local government attaches greater

[7] Interview E2019-088.
[8] Interview E2019-078.

importance to you and gives you more support, which accelerates your growth."[9] Seeing the rapid expansion of the most successful CROs, local governments began to enthusiastically promote the sector via land and tax benefits and helped to remove various obstacles so companies could more easily hire overseas talents. In the late 2000s, many HTZs also recognized CRO as a sector to be encouraged and actively sought to welcome returnee entrepreneurs in the CRO business. Following the momentum that had emerged locally, the central government for the first time explicitly encouraged the development of contract R&D services in 2012. As Wuxi AppTec's founder put it, "The government gradually realized that R&D outsourcing service could be an industry. Before, no one had considered it an industry."[10] Thanks to the local advantages and increasing support, China's CRO industry grew rapidly to 9.8 billion yuan in 2010.[11] It is worth noting that this achievement was only partially due to China's large population—a commonly cited reason for conducting clinical trials in populous countries like China and India. The drug discovery and preclinical segments in fact account for a higher share of China's CRO industry than the global average (one third). In other words, the segments of China's CRO industry that are more R&D heavy have comparatively outperformed the clinical segment.

With the success of early startups and increasing policy support, more local firms entered the sector and competition became increasingly fierce. Many small CROs offered undifferentiated services and competed based on lower costs with limited potential of upgrading. However, the more established players strengthened their competitiveness and built long-term relations with MNCs, which were the major customers of China's CRO industry. This involved accumulating expertise in specific technologies or lines of product

[9] Interview E2019-078.
[10] Ye Jing, "Wuxi AppTec's Li Ge and His CRO Empire (药明康德李革和他的新药 CRO 帝国)," *The Founder (创业家)*, No. 9, 2015.
[11] Tigermed prospectus.

development and broadening service areas to provide integrated solutions to customers. For instance, companies could start with a narrow area of activity, such as chemical compounds synthesis, and move into biological assays, lead screening, and manufacturing process development. These capabilities enabled these leading CROs to offer differentiated service and build stronger relations with MNCs, which considered them more as collaborators than as suppliers. Through these close collaborations with MNCs, the leading CROs became active members in the global pharmaceutical innovation networks. Top CROs could more easily attract overseas investors and access foreign stock markets, which facilitated organic growth and domestic as well as cross-border acquisition.

Table 5.1 Major Chinese CRO Companies

Company	Year established	Headquarters	Most sales overseas[#]	IPO location and year	Transnational investors
Joinn Laboratories	1995	Beijing	No	SSE 2017	NA
Asymchem[*]	1998	Tianjin	Yes	SZSE 2016	NA
Wuxi AppTec[*]	2000	Shanghai	Yes	NYSE 2007	Fidelity Asia Ventures, UOB Venture, General Atlantic, TianDi Growth Capital, J.P. Morgan
ChemPartner (ShangPharma)[*]	2002	Shanghai	Yes	NYSE 2010	TPG
Tigermed[*]	2002	Hangzhou	No	SZSE 2012	Qiming
Pharmaron[*]	2003	Beijing	Yes	SZSE 2019	DCM
Genscript[*]	2004	Nanjing	Yes	SEHK 2015	Kleiner Perkins Caufield & Byers
Medicilon[*]	2004	Shanghai	Yes	SSE 2019	NA
Porton	2005	Chongqing	Yes	SZSE 2014	DT Capital
PharmaBlock[*]	2008	Nanjing	Yes	SZSE 2017	NA
Viva[*]	2008	Shanghai	Yes	SEHK 2019	FengHe

Sources: Company prospectuses and annual reports.
Note: This table includes all firms that have reached $100 million in sales.
[*] Founded by returnees.
[#] Based on figures for the year of the company's IPO.

WuXi AppTec, the leading CRO in China, is a good example of how a startup could stand out leveraging local support and global networks.[12] Its founder Li Ge attended Peking University and went on to study at Columbia University, where he received a Ph.D. in organic chemistry. After working for a New Jersey-based biotech company, Li founded WuXi PharmaTech in Jiangsu Province in 2000, raising funds from a founder of the New Jersey company and a local SOE in Wuxi and receiving low-cost land and tax exemptions from the local government. The company started with lead generation and synthetic chemistry and was able to receive orders from multinationals such as Pfizer and Merck through Li's connections to the U.S. pharmaceutical industry. Like other CROs, WuXi PharmaTech benefited from the local advantage of a large pool of low-wage talents, which allowed it to hire a large number of researchers and offer services at a rapid speed. With the initial success, the company began to broaden its capabilities and was supported by several local governments in the process. While CRO was not a prioritized sector then, local governments hoping to develop high-tech industries were eager to support WuXi PharmaTech's expansion and facilitated its move of headquarters to Shanghai and the setup of manufacturing facilities and laboratories in Shanghai, Tianjin, and Suzhou. The ability to offer more integrated and differentiated services then allowed the company to convert relations with customers from the more flexible fee-for-service arrangement to the full-time-equivalent arrangement, in which the company would assign a dedicated team to the customer for a specified duration and would get paid based on workload rather than the successful execution of a project. The latter arrangement involved long-term commitments between the company and its customers and had greater profit margins. Through upgrading efforts combined with various local support and advantages, the company grew quickly and

[12] This paragraph is based on interviews, the company's prospectus and website, news reports, and Paulson Institute (2016).

accomplished $33.8 million in annual sales in 2005. Its great potential helped to secure equity investment from foreign investment firms including Fidelity, UOB, and General Atlantic, and in 2007 the company listed its shares on the New York Stock Exchange, raising $130 million. Access to the overseas capital market was crucial as it helped the company to acquire a U.S.-based company called AppTec Laboratory Services in the following year and strengthen its capabilities in biologics testing and manufacturing. The company, now called WuXi AppTec, offers a full spectrum of service from discovery and preclinical to clinical research and is a leading player in small molecule discovery. In 2018, it was among the three largest CROs in drug discovery, along with a U.S. company and Pharmaron, another Chinese startup.[13] It counts most of the world's largest pharmaceutical companies as customers.

The rise of CROs played a crucial role in deepening China's integration into global networks of drug innovation. First, as these specialized service providers mostly worked with foreign drug companies (see Table 5.1), they directly participated in the multinational effort of drug development, learning, and adopting prevailing practices and standards in the industry. For instance, top CROs typically have the credential of passing Good Laboratory Practice inspections by the USFDA. This is crucial for obtaining orders from American drug companies because it would allow the latter to submit results produced by Chinese CROs for regulatory approval in the U.S.[14] Through capability building, they helped to make China an important location for global pharmaceutical R&D rather than merely a large market for drugs. In addition, the rise of CROs drew more overseas talents to China to work as executives or lead scientists or to start new companies themselves. For many overseas Chinese who had reservations about the local environment, the success of returnee founded CROs offered strong evidence that good opportunities existed in China's pharmaceutical

[13] Pharmaron prospectus.
[14] Interview E2019-078.

industry for returnees. Moreover, with the development of CROs, multinationals were more willing to shift R&D activities to China so that their research teams could work more closely with local partners and more synergy could be created. This led many ethnic Chinese scientists working for western drug companies to relocate to China. Finally, the commercial success of CROs attracted more transnational VC including the VC arm of multinational drug companies (e.g., Lilly Asia Ventures) to China. In a word, the rise of CROs, spearheaded by returnee entrepreneurs, helped to embed China's pharmaceutical industry into global networks of innovation, talents, and capital, facilitating learning and coloration as well as diversifying the source of investment.

Obstacles for New-Drug Startups

Compared to CROs, startups focusing on the development of drugs that were not available in China struggled in the 2000s. Due to China's poor record in pharmaceutical innovation and officials' eagerness in making progress, this type of startups received more energetic support from the state. Local governments either helped to find companies to invest in these startups or became a substantial investor themselves. One example is Chipscreen, a startup focusing on small molecule drugs. The company's founder, Lu Xianping, did postgraduate studies at the University of California at San Diego and was involved in two startups in California. In 2000, Lu returned to China in 2000 to establish Chipscreen, which raised over 40 percent of startup capital from Tsinghua University and another 15 percent from the state-run VC firms created by the municipal governments of Beijing and Tianjin.[15] In addition, officials helped these startups to obtain funding and conduct clinical trials, for which the approval procedures were opaque and infrastructure underdeveloped. In some cases, it appeared that officials were so enthusiastic about making progress that standards

[15] Chipscreen prospectus.

were compromised. This is illustrated by a high-profile startup that boasted the world's first approved gene therapy. The founder, a returnee who did postdoctoral research in Japan and the U.S., received zealous support from a district government in Shenzhen, which provided seed capital and office space and helped it receive attention from officials in Beijing.[16] The government supplied millions of funding and facilitated its application for clinical trials and drug registration, but the efficacy of the approved drug was questioned by overseas experts, who pointed out the drug did not even go through a proper phase III trial.[17]

This points to a major obstacle for drug discovery startups: the state lacked the capacity of assessing and approving innovative drugs. The regulatory apparatus mostly dealt with generic drugs, the main products of China's pharmaceutical industry. In a year it could receive over 10,000 applications, most of which were different versions of known drugs filed by the numerous local firms. This provided plenty of opportunities for rent-seeking and led to a series of scandals, including the conviction and execution of the commissioner of the State Food and Drug Administration (D. Yang 2009). In addition, the reviewing agency was extremely understaffed and had only about 100 reviewers in the 2000s. With inadequate training or experience in screening new chemical entities or molecules, reviewers took a rather conservative approach and were often reluctant to approve clinical trials for drugs that had not received approval from the USFDA.[18] The lack of capacity led to long queues and processing time. As a result, it often took drug discovery companies one or two years just to obtain the approval for clinical trials and much longer for new drug registration. This laborious process increased the uncertainty of drug development and cost companies much time and energy. Since startups usually only have a handful of drugs under development and

[16] He Yifan, "Genetic community emerging in Shenzhen (深圳: 基因群落浮现)," *China Entrepreneur (中国企业家)*, May 26, 2006.
[17] Hao Xin, "Gendicine's Efficacy: Hard to Translate," *Science*, 314, no. 5803 (November 24, 2006): 1233–1233.
[18] Interview V2019-077.

are constantly under the pressure of generating cash flow, the time-consuming approval process created by the lack of regulatory capacity posed a major issue for their growth.

In addition, the state's inadequate investment and spending in healthcare inhibited the demand for new drugs. Due to the lack of insurance coverage and the high prices of innovative drugs, most of which were imported, very few Chinese patients could afford them, and most were forced to rely on generics—sometimes smuggled ones if there were no locally available generics.[19] Partly due to the lack of state investment in healthcare, Chinese hospitals and physicians depended heavily on the prescription of drugs and the kickback from pharmaceutical companies for income. This not only contributed to high drug prices but also meant doctors had little incentive to prescribe locally developed new drugs, which typically had more reasonable prices than similar imported drugs but could not provide the same amount of kickback offered by multinationals.[20] When the founder of an innovative drug startup paid a visit to the president of a hospital hoping it would introduce a new drug, the president simply replied, "I never deal with home-made drugs."[21]

Moreover, the lack of an R&D ecosystem and rigid regulatory policies forced startups to conduct most steps in the development process in-house, which substantially slowed down the speed to bring products to market. For instance, early startups typically conducted preclinical and clinical research by themselves. But most clinical physicians in China only had experiences in testing generics, which involved a less demanding process than new drugs. Due to the lack of clinical infrastructure, companies needed to commit substantial resources to clinical trials and training of physicians.[22] Moreover, domestic regulation

[19] The story of a Chinese leukemia patient who helped to buy generic drugs from India for other fellow patients served as base for the popular movie *Dying to Survive*, which sparked much discussion about the cost of drugs in China and promoted the Premier to issue instructions asking officials to study ways to reduce price for innovative drugs.
[20] Interview V2019-077.
[21] Luo Ying and Liang Haisong, "Betta Pharma: The Challenge of Indigenous Innovative Drugs (贝达药业: 自主创新药的难题)," *Talents (英才)*, 2013 (12), 60-61.
[22] Interview E2019-083.

required that companies marketing drugs needed to produce in their own manufacturing facilities. This meant that apart from large sums invested in research, startups also had to invest millions in manufacturing. Due to these challenges, those entrepreneurs who took the risk of developing new drugs struggled to bring products to market and had to look for alternative ways to make revenue. Chipscreen, for instance, licensed the overseas rights of a drug underdevelopment to a foreign company and provided research services to universities and research institutes. A few startups that initially took a dual strategy of engaging in CRO and new drug development had to abandon the latter.[23]

Policy Reform and the Boom of New-Drug Startups

The conditions for drug innovation began to improve in the late 2000s. First, there was a substantial increase in the state's efforts to enhance R&D capabilities in biotechnology and pharmaceuticals as part of the larger initiative to spur technological innovation. Importantly, these efforts increasingly incorporated measures that supported entrepreneurship, which both owed to officials' contact with transnational entrepreneurs and venture capitalists and further deepened the state's embeddedness in these networks. Returnee scientists who founded the early pharmaceutical startups were appointed as outside experts for technology programs and consulted by officials hoping to foster a vibrant and innovative pharmaceutical sector. At the central government level, for instance, funding was made available to startups. In 2006 a project dedicated to drug innovation was launched as part of the National Science and Technology Major Project. Managed by the Ministry of Health and MOST, the project created an expert panel including several returnee entrepreneurs. With their input, the project allocated substantial funds for firms, especially startups focusing on R&D. Competent

[23] Interview V2019-077.

startups dedicated to drug research and development—typically founded and run by overseas trained scientists—could receive 8 to 12 million yuan of research support. In addition, the project also sponsored the creation of platforms supporting drug R&D, including those related to safety evaluation and clinical research, which improved the R&D infrastructure firms could have access to.

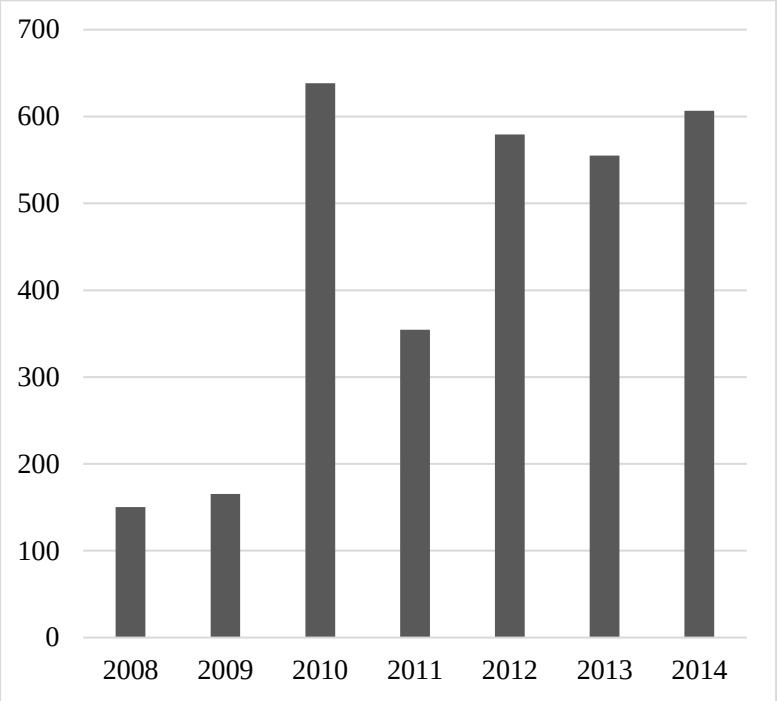
Apart from these new measures in favor of entrepreneurs in pharmaceuticals, another important initiative was a comprehensive healthcare reform launched by the central government in 2009, which would expand insurance coverage and reimbursement and increase demand for high quality drugs. The reform aimed to provide universal coverage to all citizens through increased government spending. In addition, it created the National Essential Medicine List, which included affordable drugs for common diseases and would be adjusted based on the evolving healthcare needs of citizens. Increased government spending in healthcare and China's large population meant a huge market for pharmaceuticals, which greatly spurred the interest of entrepreneurs and venture capitalists.

With an increasingly favorable policy environment, entrepreneurship in new drug development began to increase after 2010 (Figure 5.1). This startup boom was further facilitated by the unintended outcomes of earlier developments. First, universities, research institutes, domestic pharmaceutical companies, and R&D centers of MNCs had attracted many returnee scientists, who constituted a major source of entrepreneurs. While overseas Chinese continued to return, many startups were created by those who had returned and worked in China for a while and hence had stronger local connections than fresh returnees. Efforts by the central and local governments to attract overseas talents considerably facilitated this brain circulation. Of the 7,000 talents recruited by the central government's Thousand Talents Program, 1,400 were in life sciences (Ellis 2018). In addition, China-based R&D centers created by multinational drug companies also played an important role in

bringing overseas talents back and supplying future entrepreneurs. Many MNCs set up R&D facilities in China in the 2000s to access the local market and low-wage talent pool. But these R&D centers often lacked sufficient autonomy to pursue lines of products considered to have the greatest potential in the local market. In addition, the increasing sophistication of the Chinese CRO industry meant MNCs could easily outsource R&D to local partners, rendering the inhouse research staff redundant.[24] Many scientists thus left these R&D centers to create new companies or join existing ones. Second, the development of the local CRO industry also improved the innovation ecosystem, in which startups could more easily find partners to collaborate in R&D. In the words of one venture capitalist, the CRO industry "accidentally created the infrastructure for innovation," because it was not planned as such.[25] But this infrastructure was nonetheless crucial for the startup boom, because it considerably reduced the threshold for creating a company: the startups would not need to build labs or buy equipment to start operation.

[24] Interview V2019-080.
[25] Interview V2019-077.

Figure 5.1 VC Investment in New-Drug Startups in China (in million U.S. dollars)



Source: ChinaBio.

Compared to the first generation of drug discovery startups founded in the early 2000s, the new generation of startups are often deeply embedded in global networks from day one and rely heavily on cross-border partnerships for growth. While early startups could only count on capital from domestic investors initially, the new generation often could raise substantial amounts of capital from transnational VC or MNCs in early stages, which allows them to invest in R&D and pursue multiple drug candidates. In terms of talents, they are able to tap into the increasing number of returnees and recruit those with substantial overseas or MNC experiences for many of the senior and middle level positions. In the development of new drugs, they rely on a variety of collaborative relations with foreign partners. A popular strategy is in-licensing, where the startup licenses a drug under development—typically in the preclinical or early clinical stages—from a foreign company and continues its development in the hope of eventually marketing it in China. This allows the startup to bring a product to

market and generate cash flow more quickly. Startups able to discover compounds can also out-license them to MNCs, which can help the startups market the drug especially outside of China. For drugs still under development, out-licensing practically means the startup and its foreign partner share the risks in the innovation process. Companies may also cross-license to co-develop combination therapies. With the startup boom, these cross-border partnerships have been growing rapidly. In 2020, 271 such agreements were established between foreign and Chinese pharmaceutical companies, quadrupling the figure in 2015.[26] To be recognized by foreign firms as a capable partner, top Chinese startups continue to seek listing on U.S. stock markets even when the domestic stock market has been made accessible for drug companies that have not turned profitable. An executive of a Nasdaq-listed startup commented, "Before the IPO, we might have been seen as a mostly Chinese company working on interesting science and products, but now we are evidently a globally-ready and serious biotech looking to make a difference for patients across the world."[27]

A good example that illustrates these factors is BeiGene, a Beijing-based biopharmaceutical company. The company was cofounded by John Oyler, who had created a Beijing-based CRO that was later acquired, and Wang Xiaodong, the director of China's National Institute of Biological Sciences (NIBS). Wang, a member of the National Academy of Science and former investigator at the prestigious Howard Hughes Medical Institute, is a distinguished scholar in biomedical sciences. In the early 2000s, he was invited by officials to return to China and run NIBS, which was newly established as an experiment to invigorate the rigid state-run scientific research system in life sciences. With substantial autonomy given by the institute's main government sponsors, Wang set up a structure where funding was allocated and researchers were evaluated according to western customs, helping the institute

[26] Mercedes Ruehl and Demetri Sevastopulo "Pharma groups spend billions to tap into booming China healthcare," *Financial Times*, March 7, 2021.
[27] Interview of Jielun Zhu, CFO, I-Mab Biopharma, PharmaBoardroom, April 23, 2020, https://pharmaboardroom.com/interviews/jielun-zhu-cfo-i-mab-biopharma-china/.

to be nationally and internationally renowned in a short period of time. In 2010, sensing the large opportunities in the Chinese market, particularly in cancer-treating drugs, Oyler and Wang founded BeiGene and were soon able to recruit a highly capable team thanks to Wang's reputation. Just one year after founding, the company raised $20 million from Merck, which was a customer of the CRO that Oyler founded. While the startup conducted much of research and development in-house, it also worked closely with local CROs including Wuxi AppTec and Joinn Laboratories and relied on contract manufacturers in Germany.

Table 5.2 Major Chinese New Drug Startups

Company	Year established	Headquarters	IPO location and year	Supported by the new drug major project	Number of new drugs approved in China[#]	Transnational investors
Betta[*]	2002	Hangzhou	SZSE 2016	Yes	2	Lilly Asia Ventures, Sequoia
BeiGene[*]	2010	Beijing	Nasdaq 2016	Yes	2	Baker Bros., Merck Sharp & Dohme, Hillhouse
Innovent[*]	2011	Suzhou	SEHK 2018	Yes	4	F-Prime Capital, Capital Group, Temasek
Junshi[*]	2012	Shanghai	SEHK 2018	Yes	1	Loyal Valley Capital, GIC, Hillhouse
CStone[*]	2015	Shanghai	SEHK 2019	Yes	2	WuXi Healthcare Ventures, Boyu Capital, GIC
I-Mab[*]	2016	Shanghai	Nasdaq 2020	Yes		C-Bridge Capital, Genexine

Sources: Compiled by author based on company prospectuses and annual reports.
Note: This table includes new drug focused startups that has reached $100 million in revenue—from product sales, licensing, etc.
[*] Founded by returnee entrepreneurs.
[#] Based on information disclosed in 2020 annual reports.

Starting in 2015, the central government launched several regulatory reforms that helped to accelerate drug innovation. The first measure was a major overhaul of the regulatory apparatus. The regulatory agency hired scientists with drug approving experiences at USFDA and dramatically increased the number of reviewers from 120 to over 700 by 2018 (Huggett 2019). At the same time, the definition of a new drug was made more stringent to prevent the

regulatory agency from being inundated with repetitive applications. Instead of "new to China," drug candidates need to be "new to the world" to be considered as new drugs and be eligible for the fast-track review process. The second measure was the marketing authorization holder system, which allowed companies and institutions developing new drugs to rely on outside companies for manufacturing. This substantially lowered the threshold for startups to engage in drug discovery. Third, China joined the International Council for Harmonisation (ICH), which allows companies of member countries—mainly from the developed world—to submit data obtained outside of China to support new applications. This means MNCs can more quickly bring new drugs to the Chinese market and that local companies are subject to more fierce competition and under stronger pressure to innovate. It also facilitates application in overseas markets by innovative Chinese companies. These measures were widely welcomed by the sector including both local firms and multinationals. The head of McKinsey's healthcare practice in China commented that the reform "has been broader, deeper, and has moved faster than anyone could have anticipated," and considered it as one of the reasons why "China is the most exciting healthcare story in the world."[28] In addition, in 2018 the National Healthcare Security Administration was created to oversee various healthcare programs and the Essential Medicine List. The agency also centralized drug procurement, which put the government in a stronger position to bargain with pharmaceutical companies and allowed the government to create demand in a way that would also contain drug prices.

So far, much of R&D in China has been done on so-called "me-too" drugs, i.e., drugs that are aimed at the same targets as and have similar mechanisms of action to existing drugs. These drugs are easier and less risky to develop compared to first-in-class drugs, but they can

[28] Franck Le Deu, "8 reasons why China is the most exciting healthcare story in the world right now," https://www.mckinsey.com/cn/our-insights/perspectives-on-china-blog/8-reasons-why-china-is-the-most-exciting-healthcare-story-in-the-world-right-now.

be of significant commercial and social value, because they can have higher efficacy than existing drugs (referred to in the industry as "me-better" drugs) or, more commonly, have similar efficacy but are available at a lower price. [29] An example of the latter is a lung cancer-treating drug named icotinib, which was developed by a returnee-founded startup called Betta Pharmaceuticals. Clinical trials of icotinib found it had roughly the same efficacy as an existing drug that had been approved. But due to the lower development cost, icotinib could be priced at two-thirds of the existing drug (Camidge 2013). The drug was later included in several local medicine reimbursement lists and then the national list. It has been used to treat over 200,000 patients in China and recorded a total sale of over 7 billion yuan,[30] making Betta Pharmaceuticals one of the top drug discovery companies in China. Similarly, several Chinese drug discovery startups have developed medicine targeting programmed cell death protein 1. These are commonly known as PD-1 drugs and work on the immune system to fight cancer. The world's first PD-1 drugs were developed by American multinationals Bristol Myers Squibb and Merck Sharp & Dohme, which received USFDA approval in 2014. Several Chinese companies started to develop similar drugs in the early 2010s, and by 2020, four PD-1 drugs—three of which developed by entrepreneurial firms created after 2010—have been approved in China. All these drugs were priced substantially lower than the imported drugs. In addition, the increased variety allowed the National Healthcare Security Administration to further lower the prices through negotiations for inclusion in the national reimbursement list. After a negotiation in 2020, Chinese patients can access the domestic PD-1 drugs for less than 30,000 yuan a year out-of-pocket, whereas the imported drugs are

[29] Rao Yi, an outspoken academic at Peking University, commented that in some respects drug innovation in China today has not surpassed the 1970s, when Chinese scientists discovered, among other things, the malaria treating artemisinin. But he also acknowledged that the new drugs recently introduced by Chinese firms, though not highly original, helped to reduce expenses of Chinese patients and boost the local pharmaceutical industry. See Rao, Yi, "Has China's Drug Innovation Today Surpassed the 1970s?" *Caixin*, October 31, 2016, https://china.caixin.com/2016-10-31/101002215.html.

[30] Betta Pharmaceuticals 2019 annual report.

estimated to cost about 200,000 yuan annually.[31] One of the Chinese companies, BeiGene, struck an out-license agreement with Novartis, in which the latter will obtain rights for BeiGene's PD-1 product in major markets outside of China for an upfront payment of $650 million plus royalties and milestone payments.[32] This indicates that the drug is recognized by an established MNC to have some advantages over the first-in-class drugs.

At the same time, several factors are pushing entrepreneurs to more innovative drugs. First, competition for the less-risky-to-develop "me-too" drugs has intensified, which inevitably leads to lower prices and profit margins. To establish themselves, firms have to develop distinctive products, not just drugs similar to existing ones. Second, the regulatory reform streamlined the application process for clinical trials and approvals and helped to reduce risks in developing innovative drugs. In addition, harmonization with western regulatory systems made it easier for multinationals to bring their new products to China, which meant a smaller window of opportunities for "me-too" drugs. Thus, market development and regulatory structure have coevolved to create new incentives that private actors are responding to, as one venture capitalist explained,

> When I started in VC in the 2000s, opportunities were mainly in manufacturers of generic drugs and traditional Chinese medicine. If we saw profitable companies, we would invest in those that could go public very soon. Then in the early 2010s, there were a group of companies that developed drugs similar to those that were already available in western countries but for various reasons were not available in China. Now it seems these opportunities are largely gone, because as China entered ICH, MNCs can now conduct multi-center trials and bring new drugs to the Chinese and overseas markets at about the same time. So now opportunities lie in companies that do fast-follow and can

[31] Lin Zhiyin, "Healthcare security payment for three indigenous PD-1 revealed, BeiGene could offer the lowest annual treatment expense," *Yicai*, December 29, 2020, https://www.yicai.com/news/100895323.html. Peng Danni, "Healthcare security negotiated price for star anticancer drug plunges; are there bubbles in the domestic industry?" *China Newsweek (中国新闻周刊)*, December 21, 2020.

[32] Novartis expands Oncology pipeline with in-licensing of tislelizumab from BeiGene https://www.novartis.com/news/media-releases/novartis-expands-oncology-pipeline-licensing-tislelizumab-from-beigene.

perhaps develop first-in-class drugs in the future.[33]

Discussion

As this chapter shows, the rise of entrepreneurship played a similar role in China's pharmaceutical sector as in IC. Although the sectoral structures were different—the pharmaceutical sector was more fragmented and less top-down governed—entrepreneurs facilitated the sectors' vertical disintegration and global participation. In pharmaceuticals, they did so by first creating a successful CRO subsector that provided specialized R&D services for MNCs and then creating drug discovery startups that leveraged capital, knowhow, and talents from transnational networks. Thus, with the rise of entrepreneurship, the sector has become more specialized and deeply embedded in global networks of pharmaceutical innovation. Importantly, state planning and coordination cannot fully account for this outcome, as demonstrated by the fact that the CRO industry emerged without targeted state support. At the same time, the state has embraced transnational scientists, entrepreneurs and venture capitalists and adapted its policies and measures to facilitate entrepreneurship, specialization, and global integration. In addition, for many of these entrepreneurial ventures, local officials provided crucial support.

The pharmaceutical sector also shows that the state can play a key role in stimulating innovation by investing in basic research, enhancing regulatory capacity, and strengthening demand for innovative products. Prior to the late 2000s, the state's role was lacking in all three dimensions: investment in basic research was limited and poorly allocated; the regulatory agency was plagued by corruption and had insufficient ability to review new

[33] Interview V2019-080.

drugs; and healthcare provision generated limited demand for high quality medicine. These inadequacies dissuaded private actors from taking the risk of developing new drugs. It was only after the state became more active in promoting drug innovation and providing healthcare that more entrepreneurs and private investment were attracted to the sector. To make the recent entrepreneurial boom sustainable, the government will need to continue to increase spending on basic research. In addition, it will need to be active in containing drug costs to make innovative medicine both available and affordable to patients.

Chapter 6 Concluding Remarks

This dissertation has tried to explain how China gradually evolved from a political economy that was hostile to entrepreneurship to one that actively supports and harnesses it, and how entrepreneurship played a key role in key high-tech sectors in China. It argues that local tinkering of existing institutions and the embrace of transnational venture capital helped to create space for tech startups, forge new interests, and pave the way for gradual institutional change in favor of tech entrepreneurship. It has highlighted the distinctive model of venture finance—one that combines state guidance, a more open capital market, and integration into global networks—and a unique type of venture capital that has emerged in China.

In addition, detailed case studies of the IC and pharmaceutical sectors reveal parallel as well as different patterns. In both sectors, while a close and collaborative relationship between the state and private actors were initially absent, various state actors took initiatives to support entrepreneurs—especially returnees—and after initial success the state increasingly relied on entrepreneurship to develop these sectors, producing outcomes that were often unanticipated by industrial policies. In both sectors, the rise of entrepreneurship helped to deepen specialization and integration in global networks of innovation and transform the state's developmental role as well as its relations with private actors. Entrepreneurs' explorations also led to development paths unanticipated by the state: the expectation-exceeding performance of the IC design sector that grew with the indigenous electronics companies, and CROs' rise and its unintended boost to the recent entrepreneurial boom in new drug development.

On the other hand, the two sectors have encountered different challenges. The IC industry has to some extent benefited from the special attention that the government has paid to it and the supervision by a lead agency, whereas the pharmaceutical industry for a while

suffered from the lack of targeted policy and fluid and fragmented authority among agencies. China's dynamic local consumer electronics industry has provided many opportunities for chip startups even when the government's efforts to create market for local products were sometimes inconsistent. Comparatively, the pharmaceutical industry features a stronger role for the state in guarding products' entry into market and creating demand for them, and the Chinese state's inadequacies in these areas substantially inhibited sectoral development. In addition, since chips are closely related to national security, the state has set technological autonomy as a top priority, but this has worked at cross-purposes with the imperative to specialize in the age of global production, especially as the production of chips has become incredibly complex and capital and technology demanding. For the development of new drugs, China faces the challenge of substantially improving its basic research capabilities in life sciences, whose requirements for talents and investment even many developed countries find it difficult to keep up with. Thus, for the two sectors, the main challenges are not so much the absence of a given state structure as the emerging problems of the dilemma between global integration and self-sufficiency and the finite resources and regulatory capacity for high-tech development.

These findings suggest that dichotomies such as the state versus market or state capitalist versus free-market economies are inadequate to capture real world possibilities. The rise of tech entrepreneurship in China shows that actors can combine the state and the market in new ways and devise arrangements such that state guidance and entrepreneurial initiatives can be mutually supportive. These findings join other research in pointing to the possibility of combining market and nonmarket mechanisms and encouraging tech entrepreneurship in non-liberal political economies. France, for instance, has tweaked its financial and labor market institutions to foster startup creation without compromising state discretion and social solidarity (Trumbull 2004). In several Nordic countries, corporatist arrangements were

reformulated to enhance cooperation in the creation of risk capital, skills, and research capabilities to allow these countries to better compete in rapid innovation-based industries (Ornston 2013). Outside of Europe, policymakers in several economies governed by distinct institutional frameworks—most notably Israel and Taiwan—have also fostered tech entrepreneurship by stimulating local VC or creating linkages with VC elsewhere (Saxenian 2006; Breznitz 2007; Klingler-Vidra 2018). In other words, tech entrepreneurship-supporting arrangements can be creatively constructed in a variety of political economic contexts.

That a political economy under single-party rule has created a vibrant entrepreneurial sector also casts doubt on the association commonly made between political and economic freedom. It is often argued that regimes suppressing political participation lead to exclusive economic institutions which limit entrepreneurial opportunities for nonelites and allow those in power to reap most rents (North, Wallis, and Weingast 2009; Acemoglu and Robinson 2012). However, China has managed to maintain authoritarian rule while adjusting its economic institutions to support entrepreneurs, many of whom are from ordinary backgrounds. While SOEs have been conferred monopoly positions in a few sectors considered as strategically important, such as energy and telecommunication, many sectors are now open for entrepreneurial disruption and highly competitive. China's experience has shown that encouraging entry and disruption can in fact be very beneficial to the ruling elites. Economic growth and technological advancements produced by tech entrepreneurship boost CCP's performance, which is a crucial source of its legitimacy (Zhao 2009). Family members of CCP leaders who are in the VC/PE industry have also benefited from startups' success as investors.[1] The recent regulatory actions against prominent tech firms including Alibaba and Didi have also shown that the party-state can maintain substantial leverage over these tech

[1] The offspring of high-level CCP leaders have occasionally taken the role of entrepreneurs, but more often they back entrepreneurs as VC/PE investors, typically funding more established startups.

giants to ensure that they behave in line with the regime's priorities. After all, although China has embraced private ownership and profit-making, "capital" remains subordinate to the party-state.[2]

Thus, the rise of tech entrepreneurship in China shows that authoritarianism *can* create an open economic system that provides opportunities for those who are not part of the incumbent elites. To be clear, this is not to suggest that authoritarianism poses an advantage for economic growth.[3] Rather, the point is that regime type may not have much bearing on the openness of a country's economic system and that a political economy as authoritarian as China's could still foster entrepreneurship in a way that is compatible elites' interests.

This dissertation also enhances our understanding of the adaptability of China's political economy by highlighting a variety of sources of institutional evolution. Like prior works on the rise of China's private sector (Tsai 2006; Coase and Wang 2012; Nee and Opper 2012), I also stress the ingenuity of local actors. But a distinctive feature of the account here is that I highlight how actors can creatively recombine or reorient existing rules to come up with unfamiliar arrangements that defy categories such as "private business." As we have seen, actors in China have created unique types of businesses whose ownership status—public/private or domestic/foreign—was ambiguous. Apart from local innovations, global integration is another important source of institutional change, because the utilization of transnational capital and embrace of global networks create new interests and preferences. At the same time, the state has always been active to harness actors, resources, and institutions

[2] The government's official language acknowledges "capital" (资本) but not "capitalism" (资本主义) or "capitalist" (资本家), which still has derogatory connotations. Thus, venture capitalists in China would avoid the literal title in Chinese (风险资本家); the preferred term is 创业投资家, or literally "startup investor." When the government cracked down on monopolist behavior by internet platform companies, it considered the efforts as "preventing the disorder expansion of capital" (防止资本无序扩张).

[3] This argument has been made by some of the works in the developmental state tradition, which emphasize authoritarianism's advantages in mobilizing resources or formulating coherent policy facilitate necessary reforms (Haggard 1990; Johnson 1999). The former argument was rejoined by Paul Krugman (1994), who argued that East Asia's outstanding performance was not much different from what the Soviet Union enjoyed in the 1960s—both relied on mobilization of resources and would eventually run out of steam.

that it deems useful. It has sought to correct various market failures while acknowledging its limits and the need to work with private actors. The findings thus suggest that a key source of adaptability of China's political economy may lie in the simultaneous tolerance of local tinkering, embrace of transnational forces, and maintenance of an active and reflexive state.

In addition, findings regarding China's high-tech sectors suggest that successful sectoral development is a process in which the state and the private sector coevolve. The Chinese state's embeddedness in entrepreneurial networks certainly helped to transform the state's roles and policies such that they became more consistent with the needs of entrepreneurs, but it was largely absent when startups first emerged and thus it is itself something that needs to be accounted for. The fact that various state actors took initiatives to foster entrepreneurship and responded to issues and obstacles identified by entrepreneurs to adjust rules and policies offers support to calls by scholars to see development as institutional change and pay attention to local input and experimentation (Evans 2004). Due to different local conditions and problems, this process would inevitably lead to unique solutions. Indeed, while Chinese officials have long tried to imitate other models from national champions to Silicon Valley startups, the arrangement that has emerged in China still has its own distinct characteristics.

Another point is that while the Chinese government increasingly relies on entrepreneurship for the development of high-tech, it is by no means *the* model in China. While state-owned firms have retreated from many industries, they still play an important role in sectors attached with strategic importance (Hsueh 2016), especially in areas where private entrepreneurship is lacking, such as commercial aircraft, railway transit, and semiconductor manufacturing equipment (Chapter 4). The country of course has been, and continues to be, active in courting foreign investment and has recently relaxed some of the restrictions to allow MNCs to form wholly owned subsidiaries, an example of which is Tesla's new plant in Shanghai. Given China's large size and substantial regional disparities in

endowments and historical legacies, there is room for a variety of models.[4] Thus, tech startups are part of "the diversity of the types of business enterprises" and contribute to "the diversity of innovative experience across different industrial sectors" (Zhou, Lazonick, and Sun 2016, 4). This heterogeneity of models and actors is an asset and strength, as it can bring new dynamics and create possibilities for new linkages and combinations. For instance, while FDI creates more competition for local firms, multinationals—particularly those that engage heavily in R&D in China—also enhance the local entrepreneurial ecosystem by contributing to the cross-border flow of knowledge and talents and by creating new opportunities for collaboration. SOEs, often thought to compete with the private sector for resources, have also become more open to working with tech startups, as demonstrated by the partnerships between state-owned automakers and electric vehicle startups as well as large tech companies.[5]

In the rest of the chapter, I first put China in comparative perspectives and show how with the rise of tech entrepreneurship China's high-tech development has become similar to or different from that in other countries. I show China has followed a path that is rather distinct from the one taken by the developmental states of Japan and South Korea but is more similar to the one taken by Taiwan. I then compare China to the U.S. and show that the usual characterization of state versus free-market capitalisms immediately falls apart once we consider the state's role in the two countries' high-tech development. I then discuss the limits and future of China's startup boom under continued single-party rule and China's increasingly tense relations with the U.S.

[4] For a survey of subnational political economies in China, see Rithmire (2014).
[5] For instance, NIO, an electric vehicle startup, has worked with the state-owned JAC Motors for assembly and formed a joint venture with Guangzhou Automobile. The Shanghai government owned SAIC Motor, China's largest automaker, has formed an electric vehicle joint venture with Alibaba.

China's High-Tech Startups in Comparative Perspectives

A Unique Development Pathway

To better understand the distinctiveness of China's pattern of technological advance, it is useful to compare it with other countries that are active in high-tech. First, China differs substantially from the prototypical developmental states of Japan and South Korea in state-business relations and industrial structure. In the latter two countries, the key private actors in technological advancements were large, diversified, family-managed business groups—keiretsu in Japan and chaebol in South Korea. The business elites who ran these conglomerates collaborated closely with the political elites, who offered protection and large resources to help the conglomerates pursue capital and technology intensive products (Johnson 1982; Kim 1997). Financially, state support mainly involved the mobilization of savings to concentrate limited funds on a small number of large firms at the expense of small businesses and savers (Woo 1991). With generous state backing and the ability to fund new projects using profits from other divisions, these business groups could invest in large amounts and build vertically integrated operations. In IC, top Japanese and South Korean firms were often members of large conglomerates, and they were mostly in the capital-intensive activity of producing chips as integrated producers. Compared to Japan, South Korea was more similar to China in its heavier reliance on international networks from the very beginning. Due to the country's weaker science and technology base and status as a latecomer, South Korean chip companies actively sought to leverage knowhow and talents from both U.S. and Japan. They opened R&D centers in Silicon Valley, hired Japanese engineers as advisors, and acquired technologies from and formed alliances with both American and Japanese firms (Mathews and Cho 2007). Yet, compared to China's IC sector, the ones in Japan and South Korea were substantially more vertically integrated and saw a

much smaller role for VC and startups.[6] The difference between a big business centered political economy and one that features a more active role of startups can also be seen in the emerging industry of electric vehicles. Whereas development is led by established automobile companies in Japan and South Korea, several startups have emerged to become active players in the electric vehicle industry in China.

Within East Asia, Taiwan comes closer to China in the embrace of startups and integration in global networks. The island had vibrant small and medium-sized enterprises, but they were often unable or reluctant to take on capital-intensive and risky high-tech industries. It was the state itself that played a more direct role in taking the country into semiconductor and recruiting returnee entrepreneurs. Through the Industrial Technology Research Institute (ITRI), the state bought semiconductor technologies from the U.S. and incubated a series of new chip ventures, the most successful of which is TSMC. Returnee entrepreneurs and participation in global production played a key role in TSMC's success. Its founder, a U.S. trained engineer who was a manager at Texas Instruments, was recruited by the Taiwanese government to run TSMC and developed the pure-play foundry model to provide specialized manufacturing service to the fabless firms emerging in Silicon Valley. Taiwan also fostered a competitive fabless sector with the most prominent firms being spinoffs of ITRI-incubated companies.[7] Thus the chip industry in Taiwan succeeded by excelling in discrete stages in the global production of chips rather than replicating vertically integrated operations like what Japanese and South Korea firms did. The Taiwanese state also actively fostered a VC industry to support returnee and local entrepreneurs. One difference is that while Taiwan embraced transnational entrepreneurs and global production, it was less

[6] Some South Korean chaebols have recently joined the global division of labor. For instance, Samsung Electronics is actively pursuing the foundry business to serve foreign fabless companies, and Samsung Biologics is a provider of contract development and manufacturing service for the global biotechnology industry.
[7] The two largest Taiwanese fabless companies, MediaTek and Novatek, were both spun off from United Microelectronics Corp., itself a spinoff of ITRI.

welcoming than mainland China toward global financial markets: most VC was supplied locally and most startups raised funds in the Taiwan Stock Exchange (Breznitz 2007; Klingler-Vidra 2018). In addition, the high-tech in Taiwan is primarily geared toward exporting, whereas that in mainland China relies much more on the domestic market.

Comparison with other successful developers in the region shows that China's reliance on globally embedded tech startups represents a unique pathway of development. First, it is more inclusive than systems involving a narrow alliance between the state and large capitalists in the sense that previously unknown entrepreneurs could explore new combinations and potentially create a large company with the help of better access to finance. This not only encourages bottom-up experimentation but also provides an important upward passage for nonelites. As will be discussed below, China's tech startup sector is not all inclusive, as important stakeholders are often underrepresented in the system. At the same time, it is by no means an arena where only the well-endowed could form new businesses and succeed—many of China's tech moguls are from modest backgrounds and emerged from cut-throat competition. While investigative reporting has uncovered the politically connected beneficiaries behind some of China's most successful tech companies, it is worth noting they often became shareholders *after* the companies had established themselves.[8] Undoubtedly, some of the regime insiders have received handsome pecuniary benefits from China's tech startup boom by being investors in successful startups. But the winner startups are hardly picked by those in power, and the entrepreneurs' success cannot be solely explained by political connections or so-called "crony capitalism" (Pei 2016).

Second, China's tech startup sector features an innovative combination of state guidance and entrepreneurial exploration. State involvement in the financial market through

[8] When Alibaba went public on NYSE in 2014, it was revealed that the company's shareholders included some investment firms run by the scions of top Chinese Leaders. These firms, however, invested in the company in 2012, five years after the company's first listing in Hong Kong. See Michael Forsythe, "Alibaba's I.P.O. Could Be a Bonanza for the Scions of Chinese Leaders," *The New York Times*, July 20, 2014.

mechanisms like the VC guidance funds target relatively broad categories such as "high-tech" and sectors rather than specific products or technologies. Within these broad categories, entrepreneurs are encouraged to explore new ideas and pursue new opportunities. This is akin to what Rodrik (2007) describes as an industrial policy that focuses on promoting self-discovery.[9] In addition, the state does not assume the responsibility of picking promising firms worthy of investment, which is undertaken by professional venture capitalists under the constraints set by the government and the pressure to generate return by other investors who contribute funds. Like administrative guidance in Japan, China's guiding of entrepreneurship is an example of "market-conforming methods" (Johnson 1982), but is a method that provides more space for bottom-up experimentation and involves less micro-level, heavy-handed involvement.

Third, China's tech startup sector focuses on the domestic market while being open to various cross-border flows and foreign competition, which differs from the well-known important substitution and export led models. Compared with the former, which sought to build an integrated industrial structure with trade protection (Haggard 1990), China has opened its economy in an environment of trade liberalization and has actively participated in the global division of labor, subjecting domestic companies to fierce international competition but also allowing them to embed in cross-national networks.[10] Compared with the export led model, represented by neighboring newly industrializing countries in East Asia, China has relied much more heavily on its large domestic market even though export-oriented manufacturing—especially by overseas-based contract manufacturers like Foxconn and Pegatron—also plays an important role. The domestic market size offers a substantial

[9] One difference is that while Rodrik (2007, 114) proposes public venture capital, Chinese officials have created hybrid venture capital with both public and private funds.
[10] By promoting local firms that both compete and collaborate with foreign firms and embed in global production networks, China thus combines what Alice Amsden (2003) calls "independent" and "integrationist" models.

advantage as it both attracted foreign investment and provided opportunities for local firms, which could start from the lower-end and then compete with foreign firms for more profitable market segments (Brandt and Thun 2010). Or, for those that started from being part of the export-oriented production networks, they can seek synergy between foreign and local markets (Zhou 2008b). Thus, China has combined openness to the world economy with attention to the domestic market and industry.

It is often tempting to prescribe a successful development experience as a model to other countries. But the above discussion suggests that how China succeeded in enhancing its position in global high-tech industries may not serve as a model that is readily replicable. For one thing, most countries cannot match China's large population and domestic market size. In addition, the large and increasing number of Chinese that have studied and lived abroad is something that would be difficult for other countries to achieve overnight. Rather than prescribing a model, this dissertation offers a more general point about the usefulness of trying out new combinations of the state and market and new development measures, fostering and collaborating with new actors, and adapting policies and rules when promising solutions and new problems emerge. It is these experimental actions that allowed China to foster vibrant tech entrepreneurship in a statist political economy, turn openness into advantages, and make better use of local endowments.

Comparing China and the U.S.

Despite the tendency among commentators to characterize China and the U.S. as diametrically opposed political economies, the two countries' high-tech sectors share many similarities and are tightly connected. Both feature a prominent role for VC and startups, with the two countries now being the world's two largest VC markets. Vibrant startups not only facilitate the rise of specialized firms and vertical fragmentation but also bring about new

business models, particularly in the form of various kinds of internet platforms. With large domestic markets and regulatory frameworks friendly to new business models in the internet, the U.S. and China have produced the world's largest internet platforms, some of which are now global platforms.[11] The high-tech sectors in the U.S. and China have also forged close links in capital, knowhow, production, and talents. Many American VC/PE firms have been actively investing in Chinese companies, often through local offices and staff. It is estimated that a fifth of VC raised by Chinese startups since 2000 came from American investors (Lysenko, Hanemann, and Rosen 2020). The actual role of capital from the U.S. is likely substantially larger, as American institutional investors are also a main source of capital for China-based VC/PE firms that seek to create U.S. dollar funds. The New York Stock Exchange and Nasdaq have been favorite listing locations for Chinese tech startups, especially those with global ambitions.[12] But capital increasingly flows in both directions. China-based VC firms and tech companies, with more funds at their disposal, have been seeking greater synergy with high-tech sectors in the U.S., and their investment in American startups grew rapidly and surpassed U.S. investment in Chinese startups in 2015 (Lysenko, Hanemann, and Rosen 2020). Many of China's IC design and new drug companies were founded by returnees with education and work experiences in the U.S., and these companies often rely on input from American firms and collaborate closely with them. In other words, both countries are deeply embedded in cross-border networks of venture finance and high-tech production.

There are, of course, major differences between high-tech in China and the U.S. First, due to China's socialist legacy, many high-tech sectors still feature SOEs, even though their

[11] For how American political-economic institutions have facilitated the rise of platforms, see Rahman and Thelen (2019).

[12] China has surpassed Israel to be the country outside of North America with the largest number of companies listed on Nasdaq. As of May 2021, there were 248 Chinese companies listed on the three largest U.S. stock exchanges (Nasdaq, New York Stock Exchange, and NYSE American) with a total market capitalization of $2.1 trillion. See https://www.uscc.gov/research/chinese-companies-listed-major-us-stock-exchanges.

role has substantially diminished. For missions that are considered strategically important, such as the development of chip fabrication equipment and vaccines, the Chinese state continues to rely heavily on SOEs or public research institutes. Second, the Chinese government plays a more active role in the capital market. To harness entrepreneurship and attract private capital into prioritized areas, the state actively supplies VC through guidance funds and continues to act as a gatekeeper of the domestic stock markets, giving preference to firms in strategically important industries. The U.S. government, on the other hand, does not control companies or impose sectoral criteria for access to capital markets.

But it would be a mistake to simply characterize the comparison between China and the U.S. as state-led versus free-market economies, as often done in public commentary (e.g., Kurlantzick 2012). While the U.S. government does not directly own or run high-tech companies, it has long played the role of a "hidden developmental state" (Block 2008). Initially, the American state's efforts were mostly driven by the desire for the most advanced military technologies, some of which were later spun off for commercial purposes (Weiss 2014). Starting in the 1980s, when the U.S. faced rising challenges from Japan and other countries to its industrial and technological leadership, it also became more active in using domestic and international measures to support its economic competitiveness (Fong 2000). To better understand the similarities and differences between high-tech in China and the U.S., it is useful to compare the state's role in three dimensions: capital for startups, investment in basic research, and market creation.

First, as mentioned above, the Chinese state is today playing a more active role in supplying capital—mostly indirectly—to new tech ventures than the American state. But historically, the U.S. federal government played a key role in fostering the VC industry. Prompted by the Soviet Union's successful launch of the Sputnik satellites in 1957, American policymakers rushed into action and created a series of programs to accelerate technological

advancements. One of the programs was the Small Business Investment Corporation (SBIC) initiative, which aimed to make more funding available for innovative startups (Weiss 2014). The initiative supported investment companies to fund startups via government-guaranteed low interest loans. While the SBIC initiative was criticized by the private sector for being rigid and by congress for fraud and waste, it accounted for the bulk of VC raised in the U.S. in the 1960s and helped to stimulate the growth of specialized intermediaries—such as law firms and accountants—in Silicon Valley and Route 128 that served the needs of entrepreneurial firms in the two major startup areas (Lerner 2012). Today, state capital accounts for a small portion of VC raised in the U.S., but various federal agencies continue to invest through their VC arms in startups whose technologies can be used for government or military needs. The most famous example is the Central Intelligence Agency-funded In-Q-Tel, which invested in a satellite mapping company that later became Google Earth.

Second, the U.S. government invests far more than its Chinese counterpart in basic research, which serves as the knowledge base for high-tech industries. While it is sometimes complained that Chinese government spending in high-tech "distorts" the market, in fact it is often dwarfed by U.S. government investment in basic research, not to mention that American corporations alone—enabled by large profits—spend huge sums in R&D. Take semiconductors. It is estimated that in 2019 the federal government invested $6 billion to support the industry (Nathan Associates 2020), which far exceeds the less than $700 million the Chinese central government spent per year on the two chip-related Major Projects.[13] In pharmaceuticals, the NIH had a budget of $39 billion in 2019, whereas the National Natural Science Foundation of China (NSFC) allocated 4.3 billion yuan ($660 million) to research in

[13] According to the official newspaper of MIIT, the central government allocated 32.8 billion yuan to Project 01 between 2006 and 2020. As Project 02 is similar in size, the two projects would cost the central government about 4.4 billion yuan annually. Even if spending by local governments and companies are taken into account, the yearly expenditure of the two projects fell far short of $6 billion. Yao Chuanfu, "Outstanding achievements for hegaoji Major Project (我国实施'核高基'科技重大专项成效卓著)," *People's Posts and Telecom (人民邮电)*, November 21, 2017.

medical sciences;[14] in fact, NIH's budget was larger than the entire budget of China's central government on basic and applied research, which was about $36 billion. The U.S. government has also tried to make sure that some of the R&D spending would benefit startups. Federal agencies with extramural research budgets of over $100 million are required to allocate over 3 percent of that budget to small, high-tech businesses.[15]

Third, the U.S. government is more active in creating the market for products developed by entrepreneurial tech ventures through government procurement and granting of exclusivity. Historically, the U.S. military through its defense contracts acted as the "biggest angel" of the chip industry in Silicon Valley (Leslie 2000; Lécuyer 2007). Today, 23 percent of federal contracts are mandated for small businesses.[16] Since the government is often more sensitive about performance than price, this is a particularly attractive market for startups developing advanced technologies. Given the enormous size of federal contracts—$586 billion in 2019—this is also a huge market for startups. It is this supportive stance toward entrepreneurs that made it possible for startups like SpaceX to emerge in cutting edge technologies. Apart from direct procurement, the state also grants extended market exclusivity for companies that develop special products such as "orphan drugs" for rare diseases. Chinese tech startups, on the other hand, have not been able to benefit as much from government procurement. The government has sourced chips mostly from SOEs, and, as we have seen, the vibrant fabless sector mainly supplies the consumer electronics market. Chinese drug companies have so far not been able to enjoy additional market exclusivity beyond the patent protection period.[17]

[14] NSFC, 2019 Statistics for projects funded by NSFC (2019 国家自然科学基金资助项目统计资料).
[15] The programs are Small Business Innovation Research and Small Business Technology Transfer. See https://www.sbir.gov/about.
[16] U.S. Small Business Administration, https://www.sba.gov/federal-contracting/contracting-assistance-programs.
[17] Government procurement is starting to play a more important role in areas where SOEs capabilities are weak, such as artificial intelligence (AI). Many of the Chinese government's public security AI contracts have been awarded to young firms. See Beraja, Yang, and Yuchtman (2020).

Apart from domestic measures, the U.S. government has actively used trade, foreign investment restrictions, and its influence over international intellectual property rules to sustain its leadership in high-tech. Taken together, it would be difficult to make the case that the American state is substantially less active than its Chinese counterpart and only relies on the market in promoting high-tech. This should not be surprising, as high-tech—for its economic and strategic value—is simply too important for any government to leave to market forces. Rather than statist versus free-market economies, what we have in China, the U.S. and the East Asian countries discussed earlier are in fact different ways of combining public and private efforts, which are partly a function of historical legacy and ideology. The dominance of large, diversified business groups in Japan's and South Korea's political economy, the lack thereof in Taiwan, and the socialist past in China have shaped these countries trajectories. On the other hand, a market fundamentalist ideology in the U.S. has prevented its state from participating in the economy in ways that some of the East Asian states did, such as extensive planning and coordination by the bureaucracy.[18] Yet, institutional legacies and ideology do not necessarily determine nations' trajectories in a path dependent fashion. In high-tech, countries have tried to emulate others' effective measures and experimented with new ones when faced with challenges. We have seen how Chinese officials drew upon the success of Silicon Valley to foster entrepreneurship and VC. The U.S. also once took a page out of Japan's playbook when it launched the public-private SEMATECH consortium to enhance chip manufacturing technology (Flamm 1996). In recent years, the U.S. government seems less shy to talk about how to be more proactive in high-tech. As China and the U.S. engage in an intensifying competition in technology, we may see more hybrid arrangements that seek to create synergy between public and private actors in both countries.

[18] Chalmers Johnson (1982) once referred to the American system as market rational, in contrast to Japan's plan rational system and Soviet Union's plan ideological system. Perhaps a more accurate characterization is that the U.S. system is to a great extent market ideological.

Limits and Future of China's Startup Boom

While the rise of tech entrepreneurship injected dynamism to China's economy, continued single-party rule raises questions regarding its future potential. The regime's stress on obedience and use of coercive control create anxiety and unease among tech entrepreneurs and have turned some into critics. To be sure, there is a wide political spectrum among tech entrepreneurs and venture capitalists in China. Some have become prominent defenders of China's political system. Perhaps the best known is Eric Li, a venture capitalist who attended Berkeley and Stanford and has close ties to VC in Silicon Valley (Sheff 2002). Li gave several widely circulated talks and commentaries in western media about the strengths of China's political system and is also a founder of a nationalist web portal. At the same time, other venture capitalists have been critical of the regime and a few well-known figures have turned opinion leaders on social issues or civil rights activists. In 2013, the government detained two prominent veterans who were outspoken on the internet—Wang Gongquan and Xue Biqun (also known as Xue Manzi). Due to their connections and influence in China's tech startup world, their detention caused substantial anxiety and resentment among Chinese entrepreneurs and venture capitalists.[19] The lack of the rule of law not only created uncertainty among local entrepreneurs but have also dissuaded some overseas Chinese from returning, especially some of the very best who have good opportunities of upward mobility abroad. As Zweig and Wang (2013) find, despite the government's great efforts in attracting overseas Chinese, many of the brightest have not returned. They note, "The very talented, who have numerous options both at home and abroad, are likely to opt for an environment

[19] Interview V2018-037. Wang was a partner at several leading VC firms and helped to fund some of the earliest returnee-founded startups. Xue was a cofounder of UTStarcom, a well-known returnee-founded startup, and a prominent angel investor.

that allows free thinking, debating and writing, and whether this can be achieved in China without significant political liberalization remains a major question" (613).[20]

In addition, the lack of formal political participation has led to the exclusion of labor and other important stakeholders. As a result, the benefits created by China's tech entrepreneurial boom have been narrow in scope and uneven in distribution. Successful tech companies are some of the best-paying employers and have certainly contributed to income growth, but this is often accompanied by long working hours. With weak labor laws that are often laxly enforced, tech companies widely practice what is known as "996," a shorthand for a 9 a.m. to 9 p.m., six-day-a-week work schedule. At less profitable companies, this practically involves overtime without proper pay. The rise of platform companies has also created millions of gig workers such as ride-sharing drivers and food delivery couriers, who work under the tight control of algorithms and performance evaluations. While workers face inadequate compensation and see their health and safety compromised, some tech entrepreneurs have become fabulously rich. Among the ten wealthiest business people in the 2020 *Forbes* China Rich List, four were founders of large internet platforms.

Furthermore, a political regime facing few lateral constraints leads to the perception that Chinese tech firms lack autonomy. With the advance of information technologies and the rise of data collection as an important business model, the issue has grown in prominence and created major roadblocks for some of the most successful Chinese tech companies with global ambitions, such as Huawei and TikTok. While oftentimes these firms' interests are not aligned with those of the state, they can be vulnerable to suggestions that China's undemocratic system gives them no choice but to comply. In other words, the authoritarian regime type has exacerbated the firms' commitment problem (L. Liu 2021). For instance, some U.S. senators, without evidence that TikTok has actually collected data for the Chinese

[20] On the limits of China's efforts to attract talent in high-tech, see also Simon and Cao (2009).

government, have named it as "a *potential* counterintelligence threat we cannot ignore," (emphasis added), because "[w]ithout an independent judiciary to review requests made by the Chinese government for data or other actions, there is no legal mechanism for Chinese companies to appeal if they disagree with a request."[21] Growing pressure from the U.S. government has forced TikTok's Chinese parent to take several costly measures and may eventually result in its sale of TikTok.

Thus, China's future political development will have a substantial impact on the potential and sustainability of the tech startup boom. Sustained authoritarianism, even equipped with an effective state, may dissuade many of the best talents and inhibit unorthodox thinking and daring explorations. These issues are also highly relevant for the question of whether China can build up capabilities in basic research, which serves as the knowledge base for cutting-edge industries such as biopharmaceutical. Indeed, the executive president of the China Pharmaceutical Innovation and Research Development Association (PhIRDA) has named basic research as the largest obstacle for China's drug innovation, "We can take a look at the world's top medical centers, research universities, and research institutes. How many do we have?"[22] To catch up, China will need to not only substantially increase its spending in basic research but also revamp its science and research system such that top talents could pursue lines of inquiries that are the most promising and rewarding. That a few returnee scientists recently left China for the U.S. again—reportedly due to better support for research in the latter—suggests much may need to be done.[23]

[21] Cotton, Schumer Request Assessment of National Security Risks Posed by China-Owned Video-Sharing Platform, https://www.cotton.senate.gov/?p=press_release&id=1239.
[22] "Interview with Song Ruilin: How to Enhance the Competitiveness of China's Innovative Drugs," *Caixin*, February 18, 2021.
[23] The scientist that received the most attention was Nieng Yan, who was once touted as a great example of the government's talent attracting efforts but recently moved back to Princeton, where she had studied and worked. See Stephen Chen, "Top Chinese researcher's move to US sparks soul-searching in China," *South China Morning Post*, May 9, 2017.

In addition, given the reliance of Chinese tech firms on various kinds of cross-border linkages, China would also need to carefully manage its relations with the U.S., which holds the central position in global networks of high-tech even though American firms may not be the technological leaders in every area. This dissertation has shown that although China has benefited substantially from integration into global networks, it has also been exposed to the vulnerabilities of being cut off from these networks by the U.S., which is both a hub and choke point by virtue of its control of key assets, knowhow, and infrastructure. The dilemma, as Segal (2006, 296) aptly puts it, is that "Beijing requires good, stable relations with Washington in order to achieve most of its major goals…but the United States is also the country most likely to be able to block the outcomes Beijing desires most." Recent actions by the U.S. government against Chinese tech firms have revealed U.S. centrality in these networks and how this can be "weaponized" (Farrell and Newman 2019). First, the U.S. can deny access to crucial technology by restricting export, investment, and collaboration with entities in the U.S., even the firms' own subsidiaries. The experience of Huawei well illustrates these capabilities. For instance, the Commerce Department has barred Huawei from purchasing U.S. products and cited the company as a national security threat, which prompted American universities to sever collaboration with the company. The trade restriction even applied to transactions between Huawei and its research subsidiary in the U.S., forcing the latter to suspend work and lay off most of its staff.[24] The Committee on Foreign Investment in the United States (CFIUS) has on several occasions thwarted Huawei's proposed investment in American firms. Notably, the U.S., through its central position in global production networks, has been able to bar non-American companies from supplying Huawei. In May 2020, the Commerce Department issued new rules aimed at restricting

[24] Jane Lanhee Lee and Sijia Jiang, "Huawei's U.S. research arm slashes jobs as trade ban bites," *Reuters*, July 22, 2019.

Huawei's ability to outsource chip manufacturing to third parties that use U.S. technology and software. As TSMC, Huawei's major foundry partner, heavily relies on equipment and software provided by American firms, this essentially prevented TSMC from serving Huawei anymore. In August, the restriction was expanded to all chips made by foreign manufacturers using U.S. technology, regardless of whether the chips were designed by Huawei or not. Given the dominant positions of American firms in equipment and design software, this would cut Huawei off from most chips it needed, including those made by Japanese and South Korea firms. As a result, Huawei was forced to divest a large portion of its cell phone business, which consumed a large amount of chips.

Second, the ability of Chinese students and researchers to study and work in the U.S. could be restricted. For instance, the Trump administration amended rules such that Chinese graduate students studying robotics, aviation, or high-tech manufacturing would be required to reapply for visas every year. It also eliminated an exemption for international employees from China and other countries, which meant companies would need to file applications for all future Chinese employees working with relevant technologies including chips and telecommunication (Burke 2021). Overzealous pursuit of economic espionage and trade secret theft cases by U.S. authorities—such as the Department of Justice's "China Initiative"—may also deter normal academic collaboration and exchange.[25]

Third, to raise capital and engage in cross-border transactions, Chinese tech companies would need the facilitation of the U.S. dominated global financial system. Those targeted by the U.S. government—such as Xiaomi and SMIC recently—could be put on the blacklist for allegedly having military linkages, which would prevent American investors from buying

[25] Launched in 2018, the "China initiative" has targeted scholars who have received research funding from China, particularly via the Thousand Talents Program. At a senate hearing, the top counterintelligence official at the Federal Bureau of Investigation directly linked talent recruitment to espionage, stating "These talent recruitment and 'brain gain' programs … encourage theft of intellectual property from U.S. institutions." Bill Priestap, Statement Before the Senate Judiciary Committee, Washington, D.C., December 12, 2018.

shares in these companies. Worse, they could be forced to delist their shares from American stock exchanges, which are still popular locations for Chinese tech companies to raise capital despite more friendly rules for startups at stock exchanges in mainland China and Hong Kong. [26] Chinese tech companies doing business overseas also need to be vigilant about U.S. surveillance through various "financial data panopticons," especially the Society for Worldwide Interbank Financial Telecommunication (SWIFT), a central institution in the international payment system (Farrell and Newman 2019). Huawei's experience is again instructive. Its Chief Financial Officer (who is also the founder's daughter), Meng Wanzhou, was detained in Canada after U.S. prosecutors accused her of bank fraud. At the center of the charge were transactions processed by HSBC for Skycom—a company that Huawei called a business partner and U.S. officials considered as an unofficial subsidiary of Huawei's—for its sales of equipment to Iran. Since HSBC processed the transactions through the New York-based Clearing House Interbank Payments System, it provided U.S. officials with the justification that Huawei violated U.S. sanctions barring any transactions with Iran involving American entities. But even if done differently, these transactions could hardly pass without detection by the U.S. due to its access to SWIFT data with European acquiescence. As two Bloomberg columnists put it, "Had HSBC settled Huawei's payment offshore, the U.S. could still have known—and found a way to punish it."[27]

Thus, the future of China's tech startup boom will depend on both development within China and its relations with the outside world. Despite the various limits, the rise of tech entrepreneurship in China has not only spurred economic and technological advance within the country but also helped to bring affordable products to Chinese consumers as well as those in the developing world. Given China's advantages in scaling up, there is also much

[26] Several prominent Chinese tech companies have recently withdrawn from the U.S. stock markets or pursued dual listing in Hong Kong as a precaution.
[27] Andy Mukherjee and Nisha Gopalan, "Can China Win the Financial Cold War?" *Bloomberg*, August 6, 2020.

potential for collaboration between Chinese and foreign tech companies in providing solutions to areas such as clean energy and drug innovation that may help deal with pressing global issues. In order that tech entrepreneurship in China can continue to produce the positive outcomes and realize the potential, continued domestic reform and positive interactions between China and the U.S.-led high-tech networks—despite competition and tensions that are perhaps inevitable—will be crucial.

Appendix

Chronology

Circa 1980

Businesses privately run by science and technology personnel began to emerge.

1983

Central leaders publicly expressed support to science and technology personnel who created privately run businesses.

The State Council initiated a study on how to respond to revolutions in new technology (新技术革命), which led to increased interest in high-tech hubs overseas including Silicon Valley.

1985

The central government formally allowed collectives and individuals to establish for-profit "scientific research or technological service organizations."

1986

China's first venture capital firm, China Venturetech Investment Company, was established by SSTC.

1987

The central government encouraged S&T personnel to start companies or to contract state or collective owned enterprises.

1988

A constitutional amendment formally acknowledged private businesses as "complements of the socialist public ownership."

The central government approved the creation of Beijing New Technology Industrial Development Experimental Zone, the nation's first high-tech zone, and launched the Torch Program.

1990

The People's Republic's first stock exchange was established in Shanghai.

1991

The high-tech zone program was expanded to more than two dozen cities across the country, and these zones were encouraged to set up venture capital firms.

1993

SSTC announced support to *minying* science and technology enterprises and called for enhancing the latter's access to finance.

IDG Capital, one of the earliest transnational VC firms to operate in China, began investing in local startups.

1995

The central government promulgated Decision Concerning the Acceleration of Advancement of Science and Technology (关于加速科学技术进步的决定), which praised *minying* science and technology enterprises as an animating force and pledged to develop venture capital.

1997

SSTC launched a study on establishing the venture capital system.

1998

A proposal to develop venture capital was designated as the top proposal at the annual session of the Chinese People's Political Consultative Conference.

1999

A constitutional amendment bestowed on private businesses the status of “an important component of the socialist market economy.”

The central government promulgated Several Opinions on Establishing a Venture Investment Mechanism (关于建立风险投资机制的若干意见), which encouraged non-state actors including foreign investors to engage in VC investment in China and encouraged tech startups to list on overseas stock markets to facilitate VC exit.

The central government created the Innovation Fund for Technology-Based Small and Medium-Sized Enterprises (also known as Innofund).

2000

The State Council introduced Several Policies Encouraging the Software and Integrated Circuit Industries (鼓励软件产业和集成电路产业发展的若干政策), which included several clauses supporting entrepreneurship and vertical disintegration.

Sina was listed on Nasdaq through the variable interest entity arrangement, which became the go-to solution for Chinese internet companies to access overseas capital.

2001

China joined the World Trade Organization.

2002

China Venture Capital Association, a trade group representing transnational venture capital and private equity firms, was established.

2004

The SME Board was launched at the Shenzhen Stock Exchange.

2005

The central government promulgated Interim Measures for the Administration of Venture Capital Enterprises (创业投资企业管理暂行办法), which allowed the creation of VC guidance funds.

Sequoia Capital, a renowned VC firm headquartered in California, established a fund dedicated to the China market. Multiple Silicon Valley-based VC firms entered China in the late 2000s.

2006

The National Medium and Long-Term Program for Scientific and Technological Development 2006-2020 was unveiled. The Program listed 16 Major Projects of strategic importance, including two on integrated circuits and one on innovative drugs.

The Partnership Enterprise Law was amended to allow limited partnerships.

2008

The Overseas High-Level Talent Recruitment Program, also known as the Thousand Talents Program, was launched.

2009

NDRC launched the Venture Capital for Emerging Industries Program (新兴产业创投计划) and announced the first batch of 20 VC funds, in which central and local governments invested over 2 billion yuan.

The ChiNext market was launched at the Shenzhen Stock Exchange.

2011

The State Council introduced a new set of policies for the IC industry, including the use of VC guidance funds to encourage entrepreneurship in IC.

2014

The State Council unveiled Outline of the Program for National Integrated Circuit Industry Development (国家集成电路产业发展推进纲要), which intensified policy efforts and introduced various new measures including the creation of a leading group for the chip industry and the multi-billion China Integrated Circuit Industry Investment Fund.

2015

The State Council launched the Mass Entrepreneurship and Innovation program (大众创业万众创新), as part of which several national level VC guidance funds were created.

The State Council launched the Made in China 2025 initiative, in which integrated circuit and biopharmaceutical were designated as prioritized sectors of the initiative.

A comprehensive reform of the drug approval system was launched.

2018

The U.S. government imposed an export ban on ZTE, which paralyzed the company.

The Stock Exchange of Hong Kong reformed listing rules to allow biotech companies with limited revenue to raise funds.

2019

The STAR Market was created at the Shanghai Stock Exchange.

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