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Re-engineering the Innovation Chain

How a New Phase of Government Intervention Is Transforming China's Industrial Economy

ABSTRACT Since 2020, China has dramatically increased the ambition, scope, and resources of its technology and industrial policy. Besides devoting more resources, the government has also expanded direct intervention in the economy, creating new organizational forms in order to link researchers, technology providers, and firms. This program aims to re-engineer the innovation chain—and with it, the entire industrial economy. The government intervenes by creating new organizations, remaking incentives of existing organizations, and serving as a compulsory matchmaker between different organizations and firms. These new organizational interventions increase the extent to which the government steers the overall economy and is leading Beijing to take an even more comprehensive and government-directed approach to technological and industrial development. KEYWORDS innovation, industry, technology, research, economics

KEY FINDINGS

- China's government is taking a more aggressive role in techno-industrial policy. Aiming for "science and technology self-reliance," the state intervenes to reduce dependence on foreign suppliers. These interventions are fundamentally reshaping the relationship between government and enterprise.
- Chinese policymakers have focused on strengthening connections within the innovation chain along which scientific discovery is transformed into economic value. To that end, the government is creating new organizations which unite scientific resources with commercial forces.
- As part of these efforts, "innovation consortia" are being organized to link actors behind a government-specified engineering or product target.
- Beijing understands that in industry, location matters. The government aims to build bridges within the innovation chain by placing firms and research institutes in close proximity to each other. With new industrial clusters, the government hopes to promote synergies through interactions among employees, technicians, and scientists.
- Chinese interventions in the innovation chain are inherently protectionist, designed to maintain the share of manufacturing in China's economy in opposition to market forces driving a post-industrial transition. This is based on security concerns and will impose significant economic costs on the country.
- Despite marking a fundamental shift in Chinese economic policy, the program that is emerging is weakly planned, scattershot, and incremental.

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INTRODUCTION

Beijing's policy shift to re-engineer the innovation chain emerged from a rethinking of development strategy that coincided with the strategic slogans of "dual circulation" and "new development paradigm" (新发展格局) in 2020. These slogans marked a realignment of innovation strategy, with much greater weight given to security. Similarly, the goal of "science and technology self-reliance" was written into the 14th Five-Year Plan in 2020, largely in response to the perceived U.S. challenge to Chinese technological advancement initiated by the serious sanctions imposed against Huawei in 2019.

These slogans and policy shifts were only gradually translated into a concrete program, delayed by COVID-19 and trade shocks in 2020 and 2021. Over the course of 2022 and 2023, however, the elements of a broad program have gradually been put in place. The new policy includes a dramatic increase in government-guided investment into priority sectors.

Data that cover government investment specifically are not available, but between 2019 and 2023, while total investment in all sectors grew just under 17 percent, investment in electric equipment and materials grew by a massive 115 percent, investment in computer and communication equipment increased by 79 percent, and investment in specialized production machinery grew by 50 percent. These are large sectors, and investment growth at this pace represents a massive resource commitment. This brief, however, focuses on an additional, less well-known aspect of Beijing's policy change: the expansion of direct government intervention in the economy to create new organizational forms.

PLUGGING GAPS IN THE INNOVATION CHAIN

Chinese industrial policy since 2006 has focused on promoting high-tech industrial sectors, which in turn has required substantial investment in scientific research and technology development. However, policymakers have grown impatient with the outcomes of these investments and have sought to translate research as quickly as possible into beneficial end products. Today, those efforts systematically emphasize strengthening connections within China's innovation chain.

The concept of the innovation chain is popular in China, and it provides simple but powerful insights into China's techno-industrial policies.[1] In it, innovation occurs when a scientific discovery—sometimes called an "invention" in the literature—is converted into an engineering achievement. Engineering achievements are then transformed into new products that produce economic value, referred to as "innovation."

It is possible for a large corporation to manage the entire innovation chain in-house—indeed, this was the norm in mid-20th century corporate America and Japan from the 1960s—but this is rarely the case today. Instead, the innovation chain has been sliced up and disaggregated among many specialized actors as the complexity of technology increases and transaction costs decline. Innovation chains, like supply chains, have become disaggregated and globalized.

In a complex innovation chain, two gaps frequently cause difficulties: that between scientific discoveries and feasible engineering solutions, and that between new technologies on the one hand and commercial products and businesses on the other (see Figure 1).

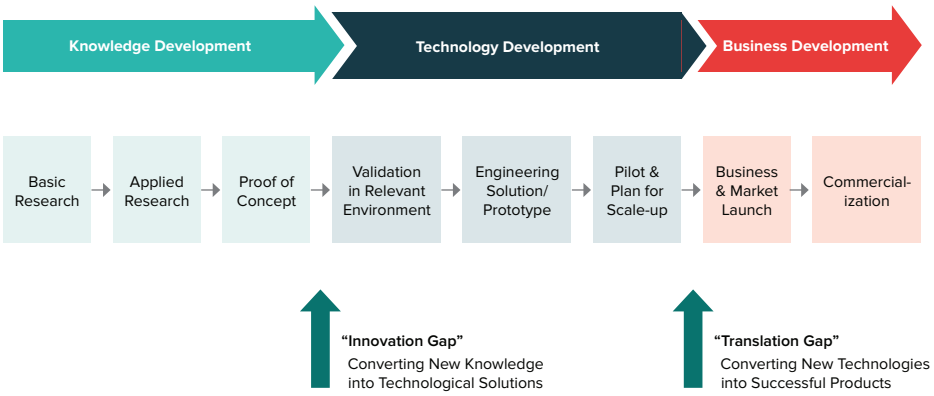

FIGURE 1. The Innovation Chain

It is hard enough to bridge these gaps when the innovation chain is internalized within a single organization, because the mindset, orientation, and incentives of actors differ across the various stages. The disaggregation of innovation chains means that these gaps may widen because of the distance between different organizations.

The urgency of filling gaps in the Chinese innovation chain is accentuated by China's new commitment to self-sufficiency. China grew explosively in the 1990s and especially the 2000s, in part because, under the conditions of advancing globalization, Chinese firms turned to international specialized suppliers for high-quality, low-cost technology inputs. Chinese chip designers were supplied by ARM and Synopsis, while Huawei turned to Bain, KPMG, and Qualcomm. Chinese start-ups relied on Walden International and other Silicon Valley venture capital firms not just for money, but for advice on business strategy and organization.

Now China has decided that each of these opportunities is also a vulnerability. Each of these high-quality specialized suppliers occupied a space between Chinese firms and, as a result, Chinese firms did not develop direct links with each other. If foreign firms were to withdraw or be evicted from China, there would be gaps in the supply chain. Chinese policy today seeks to bridge these potential gaps through innovation. Even though replacing Western firms does not depend on a completely new scientific discovery, it does require the replication or adaptation of technical processes mastered by Western companies within China. Following the same innovation chain concept, Chinese policymakers envision concentrating science and engineering resources to solve specific technical challenges in order to bridge gaps in industrial supply chains, especially high-tech ones.

China's approach is conceptually systematic and comprehensive. It aims to bridge all possible gaps in innovation and supply chains by intervening directly to bring scientific, technical, and commercial entities together in new organizations. However, the implementation of this approach is through a series of *ad hoc* practical efforts to achieve specific engineering goals.

This approach is reasonable, since each engineering challenge is unique in some way, and therefore each gap requires a unique bridging solution. Under Xi Jinping, the government has directly intervened to bring together new and existing actors within the

innovation chain through a wide variety of specific institutions. These include innovation consortia, new ways to incentivize existing institutions, nurturing new technological entities to fill gaps, and bringing firms and researchers together in high-tech clusters.

When the objective is an extremely high-priority engineering outcome, the result is a tightly organized mission-oriented consortium connecting research scientists and institutes with engineering facilities and production firms. More often, objectives are assigned to less tightly organized consortia where the constituent units retain their initial identity but are assigned new alliance partners, given new targets and incentives, and then mobilized toward a specific engineering outcome. The crucial commonality of these forms is that they unite scientific and research resources at the beginning of the innovation chain with businesses and end-use clients at the end of that chain, incorporating the entire process within a single organizational entity.

INNOVATION CONSORTIA LINK ACTORS FROM ACROSS THE CHAIN

The innovation consortium is the most important organizational initiative of the current program. There is a great deal of diversity among innovation consortia, but they all share distinctive features. All consortia are organized with a strong lead actor—typically a state-owned enterprise or research institute—and a specified engineering or product target from the central or local government. While membership is diverse, it always includes a research institute or lab and a company or end-user representative to unite the two ends of the innovation chain. Members sign contracts which specify goals, criteria, and rewards. Unique incentives for each type of actor are set in order to further the consortium's mission. Other market-friendly procedures outside the consortium are encouraged, including the subcontracting of tasks to small, specialized enterprises, and tendering specific engineering objectives for open bidding and solicitation.

There are two main types of innovation consortia: those which are predominantly research-driven and those which are predominantly economics-driven.

A research-driven consortium is generally led by a research institute or a national lab. The innovation consortium put together for the development of third-generation semiconductor materials provides an example of how research-driven consortia are organized.[2] It is led by the National Third-Generation Semiconductor Technology Innovation Center, which is part of the giant central government-run enterprise China Electronics Technology Group. The consortium has 21 participating entities, including nine state-owned and two private enterprises, along with two universities. The consortium's mission is to make breakthroughs in semiconductor technology. The enterprises feed practical information and market insights to the research institutes to assist those efforts.

Economics-driven consortia are exemplified by those pioneered in the prosperous and highly developed city of Suzhou in Jiangsu. By early 2023, Suzhou had 13 innovation consortia, most of which were led by enterprises. These consortia pursued diverse targets ranging from high-power semiconductor lasers to monoclonal antibodies and wearable technologies. The city government sponsors the organization of the consortium and usually entrusts its operation to the leading local enterprise in that area. The city's

motives mix economics and security. The aim to substitute high-tech imports is driven by perceptions that import dependence is fundamentally risky and creates a potential foreign chokepoint for a city's economic development.

There are a wide range of innovation consortia, and no official list of them has ever been published. Many locally sponsored consortia enjoy high priority official support, and many provinces have targeted the creation of a number of innovation consortia by 2025, including Guangxi (more than 20), Beijing (20), and Hebei (10). The wealthy coastal province of Zhejiang has targeted creating 50 innovation consortia by 2027. There are likely hundreds of active innovation consortia in China.

Huawei's Role in Innovation Consortia

Although shrouded in secrecy, there is no doubt that Huawei is running a large innovation consortium that is contracting with—and essentially taking over—a series of existing firms, including memory chip-maker Fujian Jinhua and start-ups like the automotive chip fabricator Pengxinwei. Huawei is receiving tens of billions of dollars in local government support for research and trial production. Huawei's coordination—with companies it controls and independents alike—ensures that successful engineering achievements will be quickly translated into an economically useful product.[3] The release of Huawei's Mate phone in the fall of 2023 with a 7-nanometer chip produced by the independent Semiconductor Manufacturing International Corporation (SMIC) shows the company's ability to achieve a high degree of coordination for an ambitious technology and innovation project.

CHINA IS MODIFYING INCENTIVE STRUCTURES TO STEER INNOVATION TOWARD NATIONAL OBJECTIVES

China hosts hundreds of research institutes, the majority of which are run by the government or state-run enterprises. An intensive effort is now being made to change the incentive system within China's research institutes to harness them toward specific government priorities.

This marks a major break in policy towards research institutes. Before 1979, intellectual resources were concentrated in elite government research institutions like the Chinese Academy of Sciences and the technical institutes of the industrial ministries. In many cases, this meant that the innovation chain was broken: brilliant research was carried out that was never translated into economically productive innovation. This changed after 1979, as the predominant approach became to give research organizations greater autonomy, including the freedom to set up profit-making subsidiaries. This provided incentives for researchers to directly commercialize products. Today, the approach is being changed once again, as most research institutes are now encouraged to commit to specific projects and engineering targets, including those embodied in new innovation consortia.

Clearly, the innovation consortium model will only work if elite researchers are committed to consortium goals. To ensure this commitment, performance indicators have been reset to increase the rewards for cooperation with manufacturers and achievement of specific technological objectives. The importance given to scientific publication as a success indicator has been drastically downgraded. Some of these institutions have

been rebranded as "new-style institutes." In these cases, research institutes commit to—and are rewarded for—specific technical targets and ambitious knowledge transfer goals.[4] This is a dramatically new approach to solving an old problem in China.

A parallel process is underway within state-owned enterprises (SOEs). For a decade, Xi Jinping has been restructuring the corporate governance system of state-owned enterprises to "embed the Communist Party" and make SOEs more responsive to political objectives.[5] Incentives have been restructured to compel central SOEs to pay attention to political and social goals. While traditional profit indicators have been downgraded, investments in research and development have been elevated as a regular success indicator. A recent talk by the head of the state-owned Assets Supervision and Administration Commission, the government agency that oversees central SOEs, gives a flavor of this realignment of priorities:[6]

> "Our overall requirement is to actively serve major national strategies and self-consciously serve the overall work of the Party and the country. Whatever General Secretary Xi Jinping requires, whatever the Party center arranges, whatever the nation needs, central state-owned enterprises must resolutely move in that direction . . . . [While] technological innovation is fundamental . . . sector control is [also] crucial, and we must actively cultivate leading enterprises in the value chain, [and] accelerate the building of a modern industrial system that is independent, secure, reliable, and competitive. . . . Security support is the bottom line."

NURTURING NEWCOMERS TO FILL GAPS IN THE INNOVATION CHAIN

Sometimes a gap in the innovation chain needs to be filled by a new organization or firm. While the Chinese government sometimes builds new organizations from the ground up, more often it seeks to nurture an existing firm that was born in the market economy. Two programs that seek to systematically fill gaps are the "Little Giants" and "Supply Chain Architects" (链主). The Little Giants program should be viewed as an "accelerator" for the development of existing small specialized manufacturing firms (although, with most having more than 100 employees, these firms would be classified as medium-sized in most countries).[7]

The program has already identified 12,000 Little Giant enterprises nationwide and arrayed them on a promotion ladder. The best firms qualify for subsidies and a fast track to listing on the Chinese stock market. It should be clear that the Little Giants program is specifically designed to fill the gaps potentially left by the retreat of international specialist firms from the Chinese economy. The innovation of Little Giants rarely involves science or technology that is new from a global standpoint, but commonly involves the effort to replicate in China international best practice in specific manufacturing areas.

The literature on global production networks (GPNs) lays out the crucial role that multinational firms serve as supply chain "architects" or flagship firms. These firms—Apple is the obvious example—structure global supply chains to lower their own costs and protect intellectual property. They profit by maintaining their own structurally

advantageous position within the GPN. China today seeks to systematically upgrade large domestic firms to enhance their ability to serve as supply chain architects. Indeed, the role of lead firms in the innovation consortia described earlier is closely related to the promotion of supply chain architects.

Huawei was already a modestly successful supply chain architect; the Chinese government now seeks to boost it to be the lead firm in an innovation consortium and a successful supply chain architect on a global scale. To a certain extent, the program to develop supply chain architects is the complement and mirror image of the Little Giants program. If specialized suppliers successfully proliferate, their transactions with assembly and manufacturing firms will be structured by supply chain architects. Both programs demonstrate the flexibility of Chinese government programs to re-engineer supply and innovation chains.

BUILDING BRIDGES THROUGH ZONES AND CLUSTERS

One of the key tasks of China's interventions is to build advanced manufacturing clusters. In industry, location matters. One way to enhance the connective tissue of the innovation chain is to place firms and research institutes in immediate proximity to each other, which encourages interactions among employees, technicians, and scientists. By creating new industrial clusters, Beijing intends to build bridges within the innovation chain and enhance synergies within.

Special zones and region-based economic planning have been part of the Chinese development model since the beginning of the reform era. Yet the current emphasis on clustering is qualitatively different: the relationships among firms within the cluster is the most important outcome for planners. All of the organizational interventions and modified incentives described earlier are applied actively in the new zones. In pursuit of clustering, policymakers are creating new organizations, modifying incentives, and upgrading organizations. Existing Hi-Tech Development Zones are being reinforced, given more executive authority, and directed to foster specific industrial sectors or sub-sectors.

Shanghai provides an extraordinary example of how industrial cluster policies have been integrated into an increasingly aggressive industrial policy. Shanghai is currently building a remarkable 53 specialized industrial parks, each with a very specific sectoral focus. Many are sub-clusters of the "three leading industries"—integrated circuits, biopharma, and artificial intelligence—which are expected to develop synergies from interacting with the multiple sub-clusters. Shanghai's government is not just intervening aggressively in the spatial organization of industry, it is also imposing cooperative relations on firms through their placement in specific zones. Fourteen research universities in Shanghai have been brought into formal relationships with specialized industrial parks.

POLICY IMPLICATIONS

Government interventions to close gaps in the innovation chain by creating new organizations and modifying existing ones reinforce and complement each other, creating a stronger cumulative impact. Officials at all levels have been given a mandate to intervene

actively and continuously in the operations of local firms. They have been given templates and instruments for action, and have been equipped with an urgent security imperative that makes their interventions practically irresistible to local actors in normal political conditions.

These measures signal a fundamental shift in the balance between government and business in the Chinese marketplace. An unprecedent effort by the government to directly shape the industrial economy is underway, for which nothing since the pre-1979 era of the command economy can compare. The new model goes beyond steerage and amounts to a direct re-engineering of fundamental organizations and relations among firms.

Yet the program is weakly planned, scattershot, and incremental, with local governments stepping up intervention in line with their own—rather than national—interests. Chinese sources constantly bemoan this fact and suggest the need for greater coordination and planning.

But China's seemingly haphazard approach may be a strength of the program. The fact that it is incremental and dispersed means that a multitude of failures and successes can be registered at the same time without derailing the progress of the manufacturing economy. Because China aims to enhance a vast array of technologies with multiple irreconcilable priorities, a broad and indiscriminating approach may in fact turn up lots of individual successes. Many of the micro-institutional interventions are compatible with a market economy.

There is a contradiction inherent in China's approach. To maintain China's status as an industrial superpower, Chinese planners are now opposing the market forces that have driven structural change, innovation, and prosperity. The justifications for this policy are not economic, but political. Xi Jinping is convinced that China's greatest source of influence is its massive industrial base. He also believes that this will be the source of current and future military prowess, and that it allows China to rebuff American technological and financial sanctions.

In essence, these policies are covert protectionism, driven by security concerns. Prices will increase for a whole range of imported goods and services, availability will decrease, and the costs to the overall Chinese economy will be very large. The policy will also degrade the quality of goods and services over time, as "good-enough" Chinese alternatives replace the best international products. The effects of protectionism will also be felt outside of China. As wages in China increase, production of labor-intensive goods such as shoes, garments, and toys are moving to lower-income countries, including Bangladesh, Vietnam, and Indonesia. Government interventions seek to keep these sectors in China through automation and intelligent manufacturing. This will obstruct the international migration of industries, which will be harmful to the economic prospects of low-income countries and inconsistent with China's advocacy of solidarity among developing countries.

It is far too early to tell if China's program can work. The substantial mobilization of resources—financial, technical, and human—in support of the state's goal will undoubtedly have some medium-term positive effects. However, there are already three fundamental contradictions on display in this effort.

First, there is a contradiction between the disarticulation of increasingly globalized supply chains over the past thirty years and the drive for integration and coordination in Chinese policy. China's effort to bridge gaps domestically makes sense from a security standpoint, but it is unlikely that China's emphasis on coordination, integration, and symbiotic relationships is compatible with the disruptive, cutthroat profit orientation that has driven the creation of modern industrial systems. There are certainly grounds for skepticism over whether China can close off the globalist element of a modern industrial system while reproducing all its complex elements in a government-dominated domestic economy.

The second contradiction is between the need to support basic research and the pressure to work toward targeted outcomes. The government is aware of this danger, and the new incentives for research institutes explicitly lay out a space for "curiosity-driven" research. But these initiatives are attempts merely to minimize the damage bound to result from a shift towards mission-oriented engineering targets.

Finally, there is a contradiction between centralization and the strengths of China's diverse ecology of regions, firms, and researchers that has until now produced a flexible and resilient innovation environment. China's innovative performance has been driven by the success of three regions with very different features: Beijing, with its strong human capital and government links; the Lower Yangtze, with its openness to foreign and especially Taiwanese investment; and Guangdong, with its practical and open orientation. Each region has been able to develop a distinctive policy regime and a innovation system. Now, China is attempting to integrate these regions into a grand national mobilization.

Clearly, each of these three tensions is an aspect of the fundamental contradiction between control and creativity. The expansion of central power could risk ultimately dragging China back to an era of excessive government intervention and stifled innovation. It is possible that the scope of efforts to encourage innovation have already expanded so much that they have become a kind of modified central planning with different priority initiatives stumbling over each other.

CONCLUSION

Since 2020, China has undertaken massive initiatives that have fundamentally changed its innovation system and industrial policy. They are focused on accelerating upgrades to existing organizations and on bridging the gaps within China's economic and technological systems. The volume of resources at the government's disposal, combined with its reasonable adaptive and incremental approach, means that we are likely to see some successful outcomes. With that, Chinese politicians will be able to defend their approach to their constituencies, especially with an appeal to nationalism and security.

Beijing is approaching its techno-industrial policies with politics and security front of mind. The economic impact of these moves, however, will almost certainly be negative, for China and for the world. The direct resource costs of these policies will be enormous.

In addition, there will be further indirect costs resulting from the adoption of an economically irrational program.

The misallocation of resources has already had a negative effect on China's economic development in 2023. In the long run, dissociation from global technological and economic processes will have an enormous cost, obstructing China's technological progress and economic development. It will even harm China's efforts to assemble new alliances of like-minded countries, to the detriment of its international soft power. China's adoption of these policies is creating an enormous lost opportunity by preventing China's deep integration with the world. ■

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NOTES

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2. Third-generation semiconductor materials, represented by Gallium Nitride (GaN) and Silicon carbide, are well-suited for power electronics, automotive components, renewable energy systems, electric vehicle charging, and even military applications, where efficiency and reliability are crucial.

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