Government Role in Fostering Emerging Technological Industries: A New Perspective for Industrial Policy Research

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Abstract: *Mainstream industrial policy research cannot fully explain how government interventions have helped China's mobile communications industry catch up with and overtake those of advanced nations. China's mobile communications industry made breakthroughs in 3G, caught up with advanced nations in 4G, and gained a leadership position in 5G due to the implementation and improvement of a strategy of industrial competition that accommodates mainstream standards and prioritizes the mid-band spectrum based on the integrated "technology, standard and industry" deployment system and swift decision-making. The introduction of a perspective of a strategy of industrial competition may supplement industrial policy research in the following ways: First, when the concerted actions of numerous innovators are important for industrial competition performance, an effective strategy of industrial competition can be devised and overall coordinated by the government provided that is compatible with the catch-up development of emerging technological industries. Second, an industrial policy becomes effective when it is complementary with the strategic factors for long-term industrial performance such as the strategy of industrial competition and avoids serious disruptions to market-based mechanisms.*

Keywords: *Government intervention, strategy of industrial competition, overall coordination, swift decision-making*

JEL Classification Code: L52

DOI: 10.19602/j.chinaeconomist.2023.09.02

1. Introduction

Emerging industries are catalysts for advances in technology and efficiency. By increasing manufacturing sophistication, they create dynamism for a country's long-term development. According to mainstream industrial policy research, government interventions in late-moving nations have worked well for traditional industries but less so for emerging industries; they are incompatible with emerging industries due to the latter's technological and market uncertainties[1]. It is asserted by US economists Acemoglu and Robinson (2012) in their renowned book *Why Nations Fail* that China could only surpass the United States in mature industries, not emergent ones. These arguments have been contradicted

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[1] For relevant research literature, please consult: Masahiko et al. (eds), *The Role of Government in East Asian Economic Development: Comparative Institutional Analysis*, Clarendon Press, 1998, pp. 5-18; Geng Chen, *The Rise and Fall of Development-Oriented Countries and Implications for China's Transition*; Lin et al., *Industrial Policy: Summary, Reflections and Outlook*, Peking University Press, 2018, pp.196-203; Jiang et al., *Understanding China's Industrial Policy*, CITIC Press, 2021, pp.338-341.

by China's advances in the mobile communications industry. In the context of China's mobile communications industry, the conflict between theory and reality presents an opportunity to expand the research in industrial policy. The identification of effective behavioral characteristics and boundary conditions of government interventions in specific industries is of utmost importance if China is to fully capitalize on its ultra-large market advantage and attain technological independence and superiority.

Regarding the mobile communications industry, China began from scratch in 1G, followed advanced nations in 2G, made breakthroughs in 3G, caught up to advanced nations in 4G, and is currently leading the world in 5G. The mobile communications industry is one of the few emerging industries in which China has achieved technological and market leadership. This exceptional performance came about with a technological paradigm and competitive environment distinct from those of other industries. In contrast to industries with a higher level of technological sophistication and maturity, such as high-speed rail, nuclear power, and LCD panels, mobile communications technologies are characterized by shorter iteration cycles (Lee and Lim, 2001) and an expanding technology frontier. According to Cooper's law, the development of fundamental theories in mathematics and physics has led to an exponential increase in the availability of the mobile communications spectrum. International organizations such as the International Telecom Union (ITU) and the 3rd Generation Partnership Project (3GPP) have developed a succession of communication standards that enable a new generation of mobile communications technology to emerge every decade or so. Technology iterations have expanded the technological scope and market opportunities for mobile communications. Some governments, including those of the United States, the European Union, Japan, and South Korea, have proactively intervened in the selection of technology paths and the standardization of mobile communications due to its strategic significance to national information security. Competition in the mobile communications industry has never been restricted to the commercial sector. The heterogeneous roles of governments in the competition of the mobile communications industry are significant determinants of the disparities in industrial performance between nations.

China's mobile communications industry is distinctive in terms of its technology paradigm, competitive context, catch-up mode, and development performance. Given such uniqueness, it is essential to identify the behavioral characteristics and boundary conditions of effective government interventions in the process of its industrial development in order to fill in theoretical gaps in the research on industrial policy.

2. Necessity of Introducing a New Theoretical Perspective for Industrial Policy Research

2.1 Gaps in Research on Current Industrial Policy

The effectiveness of an industrial policy mirrors the government-market relationship with regard to industrial development. It is a perennial research topic in industrial and developmental economics. Existing research on industrial policy can be roughly divided into three categories based on distinctions in problem orientation and theoretical perspectives: Institutional systems, policy capabilities, and selective industrial policy.

Research on industrial policy seeks to answer the question of how the institutional foundation of a nation's industrial policy influences the formulation and implementation of that industrial policy. Such research is exemplified by the development-oriented government theory. According to this theory, effective government interventions hinge upon a particular type of institutional foundation, and industrial policy tends to be formulated and implemented by a government authority comparable to Japan's Ministry of Economy, Trade and Industry or South Korea's Ministry of Economy and Finance (Öniş, 1991). Such institutions possess discretionary powers outside the political system, and their "embedded autonomy" in government-business relations enables them to maintain close contacts and interactions

with industry elites without surrendering their independence to the vested interests of businesses and other entities (Evans, 1995).

Research on industrial policy from the perspective of institutional systems focuses primarily on incentives in policy formulation and implementation, whereas research on industrial policy through the lens of policy capability explains the effectiveness of that industrial policy. Policy capability refers to the capacity of a government to mobilize the necessary resources to make and implement a policy decision[2]. Such research contends that an industrial policy cannot be discussed in isolation from government policy capability, as a government's desire to catch up with advanced nations, its industrial knowledge, and its ability to mobilize policy resources will lead to differences in the effects of an industrial policy across nations and industries (Evans, 1995). In addition, a government's policy capability is crucial to the efficacy of policy choice: A government may adopt sub-optimal industrial policy B instead of industrial policy A if the latter is too demanding of policy capability, even if it provides superior social welfare (Andreoni and Chang, 2019). Institutional factors - such as bureaucracies staffed with well-educated elites, as well as the incentive, organizational, and resource structures of government - determine policy capability on a fundamental level. In this regard, research on industrial policy from the perspectives of institutional systems and capabilities exhibits a degree of convergence.

The third perspective of research on industrial policy is the effectiveness of the selective industrial policy. This type of research examines the necessity and methods of selective industrial policies, such as investment subsidy, tax credit, market protection, and access control, in order to correct market failure. Research on selective industrial policy based on the neoclassical paradigm or the Austrian tradition takes the position that government intervention is ineffective for the following reasons: Government failure outweighs market failure in the process of industrial policy formulation and implementation (Jiang, 1996); picking winners is detrimental to market-based mechanisms (Jiang and Li, 2018); excessive selective interventions are unfavorable for businesses to identify information and conduct spontaneous market coordination (Aoki et al., 1998); "industrial policy is destined to fail" due to the existence of distorted incentives and the restriction of cognitive abilities (Zhang, 2017). A few studies from this perspective emphasize that selective industrial policies can be effective within a very limited scope. For example, Rodrick believes that through their entrepreneurial activities, leading companies reduce the cost of information discovery for other businesses, which justifies government subsidies for their information externalities (Rodrik, 2019).

Why have confrontation and conflict between pro-government intervention and anti-government intervention advocates become the unresolvable norm in research on industrial policy? This brings to mind a fundamental question: Is it necessary to explore and introduce a new perspective that is vital to industrial policy practice but overlooked in current research on industrial policy? The answer to this question will reveal how government interventions have aided China's efforts to catch up with advanced nations in the mobile communications industry. The author's long-term analysis of China's high-speed railway industry since 2015 and analysis of China's mobile communications industry since 2018 have revealed that the government has played a significant role in the technological catch-up of these industries. To fulfill a specific mandate, the government devised and implemented a series of "strategic operations" distinct from and in lieu of selective policy measures such as fiscal subsidies and tax credits. In introducing high-speed railway technology, for instance, the government made sure that the Chinese technology transferee must be able to manufacture commercial EMU trains and that the foreign technology transferor must implement the technology transfer contract, thereby increasing the effectiveness of the "market for technology" strategy for the high-speed railway. In the international

[2] Since this paper is concerned with the problem of industrial policy, it is focused on policy capability rather than government or state capability in a broader sense. For detailed discussions on the differences of policy, please consult Painter and Pierre, *Challenges to State Policy Capacity: Global Trends and Comparative Perspectives*, Palgrave Macmillan, 2004, pp. 1-18.

competition for mobile communications, the Chinese government has adopted an integrated "technology, standard, and industry" system in order to develop a comprehensive industrial ecosystem based on the Chinese TD-SCDMA and TD-LTE standards. However, these government interventions of non-selective industrial policy have not yet been incorporated into the scope of current research on industrial policy, which may explain the divergent opinions in the research on industrial policy.

Without opening the black box of government behavior or overcoming the narrow understanding of government interventions as selective industrial policies, it would be difficult to fathom how so-called good systems or robust policy capabilities translate into desirable industrial development results. The objective of research from the perspective of institutional systems exemplified by the development-oriented government theory is to characterize the institutional foundation for effective industrial policies. However, there is frequently a great deal of variation between countries' institutional foundations (Hall and Soskice, 2001), whose characteristics are debated among academics. Regarding the question of whether the Chinese government is development-oriented, the renowned China expert Naughton argued that China's is not the typical East Asian development-oriented government (Naughton, 2021). Other academics, however, view China as an example of a successful development-oriented government in East Asia (Knight, 2014). Given the diversity of institutional systems and the complexity of assessing institutional characteristics, research on government interventions from an institutional perspective and research on policy capability based on institutional analysis cannot reach generalizable conclusions unless government interventions are accorded central importance in the analysis.

Theoretically, research on a selective industrial policy often attributes industrial success to factors other than government intervention. The market-augmenting government and functional industrial policy theories, for instance, consider government-provided legal protection, fair competition, and the protection of intellectual property rights (IPRs) to be the primary determinants of selective industrial policies. China's success in catching up with advanced nations in terms of emerging industries and sophisticated product systems, such as mobile communications and high-speed railway, is largely attributable to the market's role in resource allocation. This is both a significant experience of - and the most important factor behind - China's economic achievements. Although market-based resource allocation is a prerequisite for efficient government operations, this does not imply that successful government interventions in particular circumstances can be ignored or viewed as exceptions to the general economic laws. Theoretically, opening the black box of "non-selective government interventions" provides an entry point for the conditional compatibility between government intervention and China's advances in the mobile communications industry. In this paper, discriminatory industrial policy instruments such as investment subsidies and tax credits are referred to as "selective industrial policies", whereas "non-selective government interventions" include the formation of an industrial competition strategy, industrial chain coordination, and the demonstrative effect of lead users. With the incorporation of non-selective government interventions into the analysis of industrial policy, we present a comprehensive industrial policy analysis framework encompassing "institutional foundation, policy capability, government interventions (non-selective government interventions and selective industrial policy), and development results".

2.2 Theoretical Perspective and Analytical Framework

Some research on industrial policy has identified the significance of non-selective policy instruments for the technological catch-up of IT industries, including mobile communications. Several studies have demonstrated that non-selective industrial policies and other comparable rational policies are essential for transforming government capability into corporate capability. These studies have elaborated on the theoretical mechanism by which generally rational producer industrial policies contribute to industrial development (Song, 2016). Innovative as these observations on the non-selective policies of government intervention are, such research may face obstacles when applied to the specific catch-up

development of China's mobile communications industry. Why is the United States disadvantaged in competing with China for 4G and 5G despite its adoption of extensive rational policies or non-selective industrial policies, preventing its corporate competitiveness from transforming into overall industrial competitiveness? Key to explaining these differences in the performance of mobile communications in China and the United States is the type of non-selective industrial policy, as well as the compatibility of that policy and technology paradigms in the context of industrial competition. Following this approach, this paper investigates non-selective government interventions from the perspective of industrial competition in order to fill a theoretical gap in the present research on industrial policy. In this paper, industrial competition policy is defined as a nation's distinctive approach to competition, which sets it apart from other nations. This encompasses various aspects such as the global standing of its technologies and products, the carriers or positions of key industrial resources and capabilities (Mowery and Nelson, 1999), and the dynamics of competition and cooperation between nations. The formation and implementation of industrial competition policy are influenced by government interventions. These interventions have the potential to exert a significant impact - either through their decisive nature or their enabling effect - as they expedite or facilitate the formulation of a comprehensive industrial competition strategy. The implementation of an industrial competition policy leads to alignment of actions among diverse economic entities within an industry, as well as synchronization of behaviors among industrial groups over time, thus serving as the prevailing rationale for industrial activities.

Industrial competition policy refers to a form of competition policy that operates at the industry level, and is distinct from corporate competition policy and broader industrial development policy. While an industry consists of myriad economic entities, an industrial competition policy is not merely a combination of individual corporate competition strategies. In certain situations, it may even conflict with the competition strategies adopted by dominant enterprises. In the context of the mobile communications industry during the 3G era, China pursued a strategic approach to enhance its industrial competitiveness. This approach involved the cultivation of domestic industrial chains by focusing on the development and adoption of the indigenous TD-SCDMA standard and network. While Huawei did engage in the development of relevant industrial chains during this period, TD-SCDMA did not constitute its principal target market. The competition strategy employed within a particular industry diverges from the broader national industrial development strategies, including import substitution and export substitution. The latter portrays a nation's comprehensive patterns of industrial advancement, which fall short in providing a complete explanation for China's attainment of the forefront global position in specific areas such as high-speed railway. Similarly, these patterns fail to account for China's global leadership in mobile communications technology. The industrial competition strategy diverges from conventional selective industrial policies in the following ways: While selective industrial policies may result in the discriminatory allocation of policy resources, industrial competition strategies encompass a nation's discernment of long-term prospects within a particular sector and the comprehensive measures undertaken to exploit such prospects. Selective industrial policies adopt an inward-looking stance in order to facilitate the transformation of the economic structure through an internal mechanism of picking winners. In contrast, industrial competition strategies take an outward-looking approach with an analytical framework to determine the strategic actions necessary to win out in international competition. In contrast to selective industrial policies, which are commonly found in development planning and policy documents, industrial competition strategies are more sensitive to the latest information, dynamic in nature, and tend to be more prevalent in non-textual formats, such as administrative mandates or industry consensuses.

Based on the observed trajectory of China's mobile communications industry, the formulation of a strategy of industrial competition appears to be influenced by government intervention across two dimensions: First, government interventions may have an important effect on the development of a strategy of industrial competition. The formulation and implementation of a strategy of industrial

competition may be undertaken by the government through formal administrative procedures. It is more likely, however, that this process of strategic planning occurs gradually through formal or informal interactions among stakeholders like government, businesses, research institutions, and private organizations. It results from collective interactions between the government and economic entities. The government's role in the coordination, implementation, and decision-making of a strategy of industrial competition grants it direct influence on the formation of the strategy from its capabilities and approach through to decision making. Second, the influence of government behaviors on the implementation of a strategy of industrial competition is directly linked to a country's distinct industrial organizational structure. The dynamics at play involve the interplay of competitive and cooperative interactions among government, businesses, intermediary organizations, universities, and research institutions. An industrial organizational structure that aligns with a technology paradigm and competition strategy will encourage innovators to collaborate and engage in technology learning. In theory, the actions and interactions of economic entities are subject to the influence of one or a blend of several coordination mechanisms[3], such as market coordination, coordination through intermediary organizations (Matsuyama, 1998), and government administrative coordination, when executing a strategy of industrial competition. Throughout the evolution of mobile communications, spanning from the first generation (1G) to the fifth generation (5G), governments across the world have actively intervened in order to foster industrial development. These interventions have been implemented through various coordination mechanisms, tailored to the specific needs and circumstances of each nation. The United States exhibited a notable characteristic of market coordination, whereas Europe was more dependent on intermediary organizations such as GSM and 3GPP, and administrative coordination assumed a more proactive role in China's case. The presence of diverse industrial organizational structures resulting from various coordination mechanisms served as a significant catalyst for the development of strategies of industrial competition and gave rise to disparities in the outcomes of their implementation[4].

3. Role of Government Interventions in Shaping the Competition Strategy for the Mobile Communications Industry

At the adoption of the reform and opening up policy in 1978, China's mobile communications industry was non-existent in 1G; afterwards it followed advanced nations in 2G, made breakthroughs in 3G, caught up to advanced nations in 4G, and is now leading the world in 5G. In the 1G era, the United States led the world in mobile communications technology, while China was still developing mobile communications industrial chains and completely relied on overseas manufacturers for the supply and deployment of network equipment. During the 2G era, Chinese companies entered the mobile communications equipment industry through the importation and absorption of foreign technology, although they lagged behind advanced nations in terms of technological sophistication. In the 3G era, China's indigenous TD-SCDMA technology survived international competition to become the No. 3 global standard, trailing only the US CDMA2000 and European WCDMA. With the TD-SCDMA standard, Chinese firms raised their domestic telecom equipment market share from less than 20% in the 2G era to almost 80% in the 3G era, while also gaining organizational expertise in standardization and commercialization. Because its commercial use was limited to the domestic market, the TD-SCDMA standard was sidelined worldwide.

[3] For instance, a committee comprised of entrepreneurs, experts, retired government officials, trade unions, and consumers actively participated in the formulation and implementation of Japan's industrial policy, balancing the interests of diverse stakeholders. See Suzumura et al., *Industrial Policy of Japan,* Academic Press, 1988, pp. 126-240.

[4] In fact, the model specification bias of a negative correlation between government and industry development performance is also likely to occur even in econometric research based on large samples because government interventions are suboptimal reactions to market failures rather than stochastic behaviors, and existing studies have explained such model specification bias as industrial policy failure. See D. Rodrik, "Where Are We in the Economics of Industrial Policies?" *Frontiers of Economics in China*, 14(3): 329-335.

China's efficient conception and implementation of an industrial competition strategy enabled its mobile communications industry to catch up and take the lead in the 4G and 5G eras.

3.1 From Breakthroughs in 3G to Neck-and-Neck in 4G: Formulation and Implementation of the Integrated Development Strategy

During the 3G era, both China's TD-SCDMA standard and the US WiMAX standard belonged to the time-division duplexing (TDD) multiple access technology path[5] and contended for the mainstream 4G standard. The Academy of Telecom Science and Technology under the former Ministry of Posts and Telecommunications (reformed in 2000 into the Datang Telecom Technology Industrial Group) created the TD-SCDMA standard in 1998. China did not have the capability to construct a complete set of communication systems at the time, nor did it have any experience competing in the global market for mobile communications standards. During the same time period, top ICT firms in North America such as Intel, Motorola, and Nortel Networks developed the WiMax standard, as they had strong technological capability and experience building global communication standards in both the 2G and 3G eras. The WiMAX standard boasted the advantages of high transmission rate, extensive coverage, and diversified service contents, thanks to technology developments in orthogonal frequency-division multiplexing (OFDM) and multi-input and multi-output (MIMO) antenna. However, the less favorable TD-SCDMA evolved into one of the two mainstream 4G protocols, TD-LTE[6], and was successfully commercialized globally at scale, with over 1.7 million TD-LTE commercial networks deployed worldwide. In contrast, WiMAX was limited to a relatively modest user base of 25 million, thereby prompting mainstream global communications carriers to discontinue its adoption. Compared to the dominant European WCDMA standard, both TD-SCDMA and WiMAX were late-moving catch-up technology standards. The distinction is that the Chinese government first pursued an integration strategy with mainstream standards, as opposed to the WiMAX camp's closed and non-compatible stance. This disparity is the fundamental cause of the divergent performance of different standards in later technological and market competitions. The Chinese government played a central role in formulating a strategy of industrial competition to "seek progress through integration" and helped persuade businesses to harmonize their strategies. It also facilitated strategic implementation in the subsequent competition of mobile communications industry standards between China and the United States. Except for convincing international organizations to embrace WiMAX as an international 3G standard, the deployment of a near-incompatible strategy with other international standards was solely a corporate decision. Wen Ku, director-general of the Department of Science and Technology at the then Ministry of Information Industry (now the Ministry of Industry and Information Technology, or MIIT), and Vice Minister Xi Guohua visited Intel and Motorola's WiMAX business managers in 2007 to discuss China-US cooperation on communication standards, which cooperation did not materialize because representative WiMAX enterprises were unwilling to compromise. As a result, the Chinese government turned to Europe with a strategy of integration based on non-principal compromises for the integrated development of China's TD and European LTE technologies.

The then Ministry of Information Industry took proactive measures to address the conflict of interest among companies involved in the integration strategy. China had at least two options before 3GPP became the global 4G communications standard in 2007. The first option was to stick to its own TD standard. As the primary developer of the TD-S CDMA standard, Datang Telecom was an adamant

[5] Time-division duplexing (TDD) is a technology that allows a mobile communications system to support multiple users at the same time. It is the most important basic technology in the mobile communications system and may generate critical basic patents, making it an important area of competition for mobile communications technologies between countries and technologies.

[6] A common international expression is LTE TDD, which is more often referred to in China as TD-LTE. These expressions are used interchangeably depending on the context.

advocate of the first option, which became a nonstarter for the European 3GPP. The second option was to move the timeslot allocation in the Chinese standard closer to the European-dominated LTE TDD on the basis of retaining TD-SCDMA's technological advantage. In the interest of advancing the evolution of China's TD-SCDMA toward 4G in the integration with the European standard, the then Ministry of Information Industry decided to go with the second option. It also requested Europe to accept some of China's core intellectual property rights in the LTE TDD standard in order to protect China's knowhow in the TD field. After proactive coordination and government-enterprise communication, the integration strategy became recognized by Datang Telecom and other stakeholders as conducive to the maximization of overall industry interests.

Unlike China, WiMAX encountered coordination failures in both the formulation of a strategy of industrial competition and its execution via industrial chain coordination. First of all, the WiMAX camp adopted a strategy of non-compatibility with European and Chinese standards. The non-compatibility stance, coupled with the absence of an independent evolutionary path[7], posed major challenges to the growth of WiMAX's user base (Shapiro and Varian, 1999). Without a substantial technological advantage over Chinese and European standards, WiMAX would struggle to attract a sufficiently large user base for commercialization. Secondly, the WiMAX technology fell short in terms of meeting the necessary technological benchmarks for widespread commercial use, primarily due to a conflict of interest that arose among the various businesses involved in the supply chain. Both China and Europe had embraced an envelope approach (Eisenmann, 2011), assimilating and incorporating WiMAX's core technologies. As a result, WiMAX failed to capitalize on the optimal timeframe for establishing itself as the prevailing technological standard during the 4G era. When WiMAX subsequently sought to integrate with China's TD standard, Europe expedited its TDD standard integration with China, leveraging Chinese core technology, in the interest of the European LTE standard's sustained development.

The presence of heterogeneous industrial organizational structures arising from diverse coordination mechanisms also contributed to the divergent outcomes observed in the China-US competition over technology standards. Within the framework of the synergistic "technology, standard, and industry" implementation system, telco operators, system and equipment providers, and instrument and component manufacturers engaged in synchronized R&D and investment activities along the TD technology pathway. This concerted effort facilitated the advancement of technological innovations and commercial applications. The conflict of interest and divergent behaviors among supply chain participants impeded the synchronized progress in WiMAX's technological performance and network development. The development of a commercially viable network technology system based on a mobile communications technology standard necessitates coordinated research and development across the supply chain. This intricate process involves conducting experiments, verifying results, performing test runs, making necessary modifications, and implementing improvements. Based on the integration of technology and industry development during the 3G era, the then Ministry of Information Industry took the initiative to create an IMT-Advanced implementation working group in March 2007. This initiative was a crucial component of the "industry, universities, research, and commercialization" partnership platform, which aimed to foster a robust 4G ecosystem. The establishment of this working group was supported by the "New-Generation Broadband Wireless Mobile Communications Network" introduced in 2006. This platform extended invitations to leading multinational corporations, including Ericsson and Nokia, to engage in the research and commercialization of Chinese standards through international collaboration. The primary objective of this platform was to foster an innovation ecosystem for 4G technologies encompassing standards, R&D, testing, and applications, as well as an industrial framework that

[7] The lack of phone number portability for 2G and 3G users transitioning to the WiMAX network implies that WiMAX did not enjoy the same advantages as European LTE and Chinese TD networks, which allowed for seamless migration of existing users from 2G and 3G networks.

included chips, terminal devices, systems, networks, and business services. In March 2008, the Ministry of Industry and Information Technology (MIIT) established a TD-LTE working group. This group, led by the Chinese Academy of Information and Communication Technologies (CAICT) and China Mobile, superseded the IMT-Advanced implementation working group. Its primary objective was to serve as a platform for conducting preliminary research on TD-LTE technology, as well as formulating and implementing related standards. The TD-LTE working group facilitated collaboration among more than 50 enterprises operating in various sectors such as system equipment, chips, terminal devices, and instruments and apparatuses. Their collective efforts were aimed at surmounting technological obstacles and expediting the preparedness of TD-LTE technology, products, and networking.

China's implementation of the "technology, standard and industry" synergic system not only bolstered its 4G technological prowess rooted in the TD-LTE standard, it also showcased its determination and dedication to investing in and advancing TD. Under the framework of the synergistic implementation system and in accordance with the national strategy of "moderately advanced information infrastructure deployment", telco operators, spearheaded by China Mobile, played a crucial role as early adopters (Von Hippel, 1986). This resulted in market commitment and stimulation of the industrial chain. China Mobile, with its knack for incorporating technology, establishing extensive networks, and devising solutions for various purposes, offered comprehensive usage scenarios for experimentation and validation for the TD-LTE standard. China Mobile implemented large-scale TD-LTE technology experiments by constructing over 1,000 base stations in seven cities across China. This initiative aimed to assess the actual networking capabilities of TD-LTE through comprehensive verification. The experiment was expanded to 15 other cities, further enhancing the scope of the research. Large testing platforms enabled network planning based on various usage scenarios and generated a demand for system equipment and components through network expansion, including chips for mobile devices. The coordination of platforms played a crucial role in preventing ill-advised and haphazard investments across various stages of the industrial chain. China Mobile, as the telco operator with the largest user base globally, consistently increased the sophistication of its TD-LTE technology and made notable improvements to auxiliary systems. These endeavors garnered support from foreign equipment vendors and operators, who had previously refused to participate in and endorse Chinese standards.

On the contrary, WiMAX encountered a predicament of collective irrationality, whereby major hardware manufacturers and mainstream operators declined to provide support due to the lack of compelling policy incentives from the US government to foster collaboration on the WiMAX standard. Qualcomm, the foremost hardware manufacturer in North America in terms of technological progress, was reluctant to endorse the WiMAX standard. With intellectual property rights and chips as its core competencies, Qualcomm's profit model revolved around the design and sales of communications chips, alongside the collection of licensing fees for intellectual property rights in connection with its underlying core technologies. Both the TD-SCDMA and 4G LTE standards relied on Qualcomm's CDMA technology and associated intellectual property rights. While Qualcomm's UMB did not achieve global recognition as the 4G standard, the company's fundamental interests remained tightly linked to the European and Chinese standards, rather than the WiMAX standard. Following unsuccessful negotiations between WiMAX and Qualcomm, the latter's 3G and 4G chips ceased to support WiMAX. Intel's failure to anticipate the swift expansion of the smartphone market resulted in a setback in its efforts to develop WiMAX smartphone chips. This setback exacerbated the deficiencies and imbalances within the WiMAX industrial chain. Given the freedom to select mobile communications standards, dominant US telco operators, namely AT&T and Verizon, demonstrated a preference for embracing the well-established European 4G standard. This decision was driven by their inclination to avoid assuming substantial technological and market risks associated with spearheading the widespread commercial implementation of WiMAX. Clearwire, a non-mainstream telco operator in the United States, along with small telecommunications operators in other developing countries, faced challenges due to their limited technological capabilities

and market scale, hindering their ability to foster the growth of the WiMAX ecosystem.

In 2010, Intel, the sponsor of the WiMAX standard, initiated the dissolution of the WiMAX division. Nortel Networks, which had made large bets on WiMAX, declared bankruptcy. In 2011, Clearwire, the largest WiMAX operator in the world, headquartered in the United States, partnered with China Mobile for the joint development of services and equipment based on China's TD-LTE standard, signaling the official dissolution of the WiMAX camp.

3.2 Spearheading 5G: Implementation of the Mid-Band Priority Strategy

The selection of a frequency band has a direct impact on the R&D and product development of each generation of dominant mobile communications technologies. It is of strategic significance for the technological and economic feasibility of subsequent commercial network deployment. Given the technological characteristics of mobile communications, the intergenerational evolutionary process from 1G to 5G is also a process of utilizing higher-band spectrum resources. Countries are faced with a choice of frequency bands with different levels of technological sophistication and economic cost. Requirements for 5G applications can be realized through mid-band (FR1: 450MHz-6000MHz) and higher-frequency millimeter wave (mmWave) (FR2: 24250MHz-52600MHz). In the long run, mmWave represents the future of 5G's evolution, but the two frequency bands have their respective strengths in the initial stage of 5G's development. Theoretically, mmWave boasts better technological performance, but involves much more complex technology development and a higher network development cost due to denser base station deployment.

The selection of frequency bands is not determined solely by exogenous technological characteristics, but also reflects differences in the development and network deployment of a country's mobile communications industry. China adopted a "medium-band first" strategy to develop mid-band technologies and networks to meet the needs of large-coverage and high-mobility usage scenarios and an mmWave network to meet high-speed and system capacity requirements. In contrast, the United States adopted high-frequency mmWave for the initial development of the 5G network and technology. In the first half of the 5G contest, China and the United States performed differently due to their distinct frequency strategies. China led the world in mid-band base station equipment performance, with a 70% global market share; it fostered a mid-band 5G supply chain encompassing systems, terminal devices, chips, critical components, and other major processes, and it created the most extensive and highest-quality 5G commercial network. The United States was forced to retreat to the mid-band spectrum after an unsuccessful attempt to deploy the mmWave network. As a result, it missed the window of opportunity for deploying mid-band technology and its concomitant industrial chain.

China's adoption of the strategy of mid-band prioritization was primarily driven by the following considerations: First, as emphasized by the interviewed experts, the Chinese government placed a high priority on network coverage, and the mid-band spectrum was better suited for network coverage. Second, mmWave was incompatible with the strategic orientation of China's industrial and innovation chains. China lagged far behind the United States in the early stages of 5G deployment in terms of mmWave power devices and the prototype verification system. The mid-band spectrum was more advantageous for China to use to develop an independent industrial chain as quickly as possible. China consistently pursued a strategy of integration with international mainstream standards and Europe also gave the mid-band spectrum priority. The preference in China for the 5G mid-band spectrum was based on a consensus reached by government departments and industry experts through numerous interactions over a number of years. The government is credited with adopting this frequency strategy. By assessing the technological and economic implications of the frequency paths, listening to the opinions of technology experts and industry insiders, and transforming existing strategies into detailed and effective policies and actions, the Chinese government laid the groundwork for China to emerge as a frontrunner in the initial phase of the 5G race.

The preference for mmWave by the US government is attributable to its industrial governance system and strategic deliberations. First, US satellite communications operators had already taken up a significant portion of mid-band resources for basic research and military communications. Consequently, the remaining bandwidth available for the 5G network was inadequate to guarantee extensive coverage and efficient data transmission. The reallocation of mid-band resources to the commercial sector could face substantial administrative resistance, which would result in a time-consuming and arduous process. Second, the United States sought to gain a competitive edge over China and Europe through the introduction of the more advanced mmWave technology. Given Qualcomm's superior baseband chipset for mmWave networks, the United States government anticipated securing a competitive advantage in the realm of 5G by directly embracing mmWave. Lastly, the United States' backward optical fiber infrastructure constrained strategic spectrum resource options available to the US government. While mid-band and 5G networks necessitate the use of optical fibers for data backhaul, mmWave technology does not rely on such fibers for its functioning. Furthermore, the optical fiber infrastructure in the United States faced significant limitations in providing extensive mid-band coverage, primarily due to the high costs associated with land acquisition. Consequently, American operators showed a preference for the mmWave alternative. The confluence of these factors prompted the United States government to embrace the mmWave rotor strategy during the 5G era. In the practical implementation of the mmWave network, operators encountered challenges pertaining to the subpar diffraction capabilities of the mmWave technology, thereby falling short of meeting the demands of commercial utilization. In this context, the Cellular Telecommunications & Internet Association (CTIA), in its report titled "A National Spectrum Strategy to Lead in 5G" published in April 2019, expressed the view that the United States erred by concentrating solely on commercializing the high-frequency spectrum during the initial phase of 5G implementation, without conducting any auctions for the mid-band spectrum. During a Senate hearing in January 2020, the Chairman of the US Federal Communications Commission acknowledged that the prioritization of mmWave technology over the mid-band network in the United States' 5G competition was a "fundamental mistake" (Rosenworcel, 2020). Following a period of five years on the wrong path, the United States has now started to shift back towards a mid-band trajectory.

The different choice of spectrum strategies made by China and the United States in the first half of the 5G race and the consequent differences in industrial performance can be attributed to China's integrated "technology, standard and industry" implementation system and the "market coordination system with separate departmental governance". China's spectrum strategy is characterized by an orientation of technological capabilities to integrated "technology, standard and industry" implementation. Specifically, the MIIT is responsible for the supervision and administration of the mobile communications industry and network development. The State Radio Administration of the MIIT is responsible for the division, allocation and assignment of radio frequencies. Such an administrative system is conducive to coordinating the use of spectrum resources with industrial development strategy and network development. The integrated 5G "technology, standard and industry" implementation system based on IMT-2020 could coordinate the distribution of spectrum resources with such considerations as compatibility between mobile communications and other wireless businesses, integration of China's advantageous technologies with international standards, and a competitive structure between telco operators[8]. More importantly, the Chinese government gave priority

[8] This frequency allocation approach was adopted throughout the development of China's mobile communications industry. During the 3G era, China Mobile enjoyed priority in the allocation of core frequency bands with wider bandwidths. This decision was made with the anticipation that China Mobile's technological prowess and market influence would contribute to the development of China's fledgling TD-SCDMA standard and industrial chain. During the 4G era, the Chinese government granted China Mobile the high-quality frequency resources in the 2.6GHz band, providing a bandwidth of 190Mbps. China's resource allocation has demonstrated its resolute determination and unwavering commitment to the development of the TD-LTE standard and the establishment of TDD as a global standard. However, it is worth noting that China Mobile's significant market influence has the potential to speed up the growth of various industries, both upstream and downstream, including the development of system equipment, terminal chips, as well as instruments and apparatuses.

consideration to whether the allocation program would promote the improvement of technological capabilities throughout the industrial chain. The 3.5GHz spectrum band that China allocated to 5G is a mainstream global frequency band and its most important test frequency band, hence the most mature technology and industrial chain. Following the logic of spectrum auctioning and market-based allocation in the United States, this spectrum band ought to be given to China Mobile, which had the greatest financial strength and the largest market share. However, the Chinese government decided to allocate this frequency band to China Unicom and China Telecom despite their less favorable technological and investment capabilities, leaving the less mature 2.6 GHz and 4.8 GHz frequency bands to China Mobile. This decision was motivated by the expectation to use China Mobile's superior technology and market influence to cultivate an industrial chain for the core technologies of those two frequency bands.

In contrast, the United States implemented a market-oriented coordination system with separate departmental governance for the management of frequencies. The government is responsible for clearly delineating the rights boundaries between departments in order to minimize the costs of interdepartmental coordination. In addition, the government should allocate frequency resources through auctions to telco operators who have the potential to maximize the utilization of these resources. Nevertheless, empirical evidence has shown that it is complex and time-consuming to coordinate numerous entities in the allocation and reallocation of spectrum. The oversight of spectrum allocation for commercial and federal public use falls under the purview of the US Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA), in their respective capacities. To tackle the issue of interference arising from the utilization of a spectrum by both government and commercial entities, the United States implemented the practice of cross-institutional coordination. However, while this practice is effective in regular circumstances, it lacks a clearly defined coordination mechanism and process for handling special events. The spectrum coordination among multiple entities or in cases of significant complexity would invariably result in a prolonged administrative process. In deploying the mmWave network, the federal government utilized mid-band resources not easily adaptable for commercial purposes. The process of reverting back to the mid-band spectrum, however, entailed a lengthy period of 3 to 5 years, involving interdepartmental coordination and auctioning procedures. The county-based spectrum authorization in the United States further intensified the fragmentation of spectrum resources, amplifying the expenses incurred by telco operators in consolidating spectrum resources across regions. In 2022, the United States concluded the long-awaited auction of mid-band bands ranging from 3.7 GHz to 2.2 GHz. This process was completed 18 months after China's commercialization of mid-band 5G technology.

4. Theoretical Analysis and Extended Discussions

4.1 Conditional Compatibility between Government Intervention and Catch-Up Development of Emerging Technology Industries

Industrial policy research based on the existing perspective generally holds a critical stance on government intervention in emerging technology industries. This is primarily based on two assessments of the technological and economic characteristics of emerging technology industries: First, there is a high degree of technological and market uncertainties; second, market trial and error on a mass scale have become the dominant evolutionary mechanism of emerging technology industries due to such uncertainties. The effectiveness of government interventions in the catch-up development of emerging technology industries, therefore, naturally becomes a question of whether uncertainties and market trial and error on a mass scale are compatible with government intervention.

The case against government intervention in the technology sector posits that, given the inherent uncertainty, businesses are better equipped than the government to gather precise information about technology and market dynamics. Nevertheless, as exemplified by the catch-up experience of China's

mobile communications sector, the formulation of an industrial competition strategy assumes paramount significance in propelling the advancement of nascent technology sectors. It is crucial to note, however, that the implementation of such strategy is not solely contingent upon governmental intervention within specific circumstances. While it is true that industrial competition strategies are typically released by the government, it is important to note that these strategies are often collaboratively developed by the government, technology experts, and industry leaders from prominent organizations such as Huawei, China Mobile, CAICT, and other leading businesses and research institutions. China's mobile communications industry encountered various uncertainties during its catch-up development, stemming not only from the emergence of new technologies but also from intense competition in the global market. However, the dynamic collaboration between the government and businesses - rather than the government assuming the role of decision-maker for enterprises - has led to the formulation of a resilient industrial competition strategy and has guaranteed the effective implementation of the comprehensive "technology, standard, and industry" framework. Another intriguing finding from research on China's mobile communications industry is that the industrial competition strategy often emerges through extensive debates and consensus-building between government authorities and the industry, rather than being conveyed through formal texts. In the early 1998, the former Ministry of Post and Telecommunications convened meetings to deliberate on the submission of China's mobile communications standards to the International Telecommunication Union (ITU). In January 2007, a workshop was organized by the then Ministry of Information Industry to deliberate on the potential integration of the frame structure with Europe, exploring the feasibility and strategies involved. In light of the evolving competitive landscape, the industrial competition strategy would undergo necessary adjustments. Following the unsuccessful negotiations between the then Ministry of Information Industry and representatives of WiMAX enterprises, a decision was made to undertake a complete integration with the European standard. In response to evolving technological capabilities and a shifting competitive landscape, the Chinese government implemented flexible adjustments and strategic allocations of optimal spectrum bands among the country's three telco operators. China's industrial competition strategy has demonstrated a notable degree of informality and adaptability, highlighting the significance of prompt decision-making grounded in straightforward principles within a rapidly changing landscape (Sull and Eisenhardt, 2015). This ability plays a crucial role in navigating uncertainty and surpassing competitors. In order to navigate a complex and competitive landscape, the Chinese government has adopted a straightforward decision-making principle. This principle aims to foster the growth of domestic technological capabilities while also promoting integration with internationally recognized standards. The government promptly recalibrated its approach to competition and collaboration with its rivals, while also reallocating policy resources among innovators to ensure a flexible adaptation between the industrial competition strategy and the competitive environment.

The second question pertains to whether extensive market-based trial and error are sufficient to prove government intervention wrong. Based on available research, it can be argued that government intervention tends to curtail competition, thereby hindering the diverse range of trial and error. However, the catch-up experience of China's mobile communications industry offers an alternative theory.

(i) Government intervention, while limiting the number of competitive players, may also boost competition by reshaping the competitive landscape of market participants. The Chinese government has astutely implemented regulations aimed at enhancing the competitiveness and quality standards within the mobile communications sector. For instance, the integrated "technology, standard, and industry" implementation system that has evolved since the 3G era encompasses a comprehensive range of technology and product testing systems. These include the external field performance test platform developed by CAICT and China Mobile's extensive networking performance verification platform. From a technological standpoint, these platforms have been specifically engineered to facilitate the verification and testing of various technologies. From an economic perspective, the primary objective

is to foster technology innovation competitions among telecom equipment manufacturers like Huawei and ZTE, as well as a balanced and equitable environment for foreign enterprises such as Siemens and Nokia, ensuring they have access to unbiased technology and product evaluations. Rather than imposing limitations on competition, these technology and product testing platforms have fostered increased involvement of foreign capital and competition driven by innovation.

(ii) Despite the emergent nature of emerging technology sectors, the implementation of large-scale trial and error may not be universally applicable to all facets of China's mobile communications industry development. The mobile communications industry in the country is primarily focused on indigenous technology standards, whose commercialization relies on acquiring underlying technologies and establishing a comprehensive industrial chain. In the realm of technological standards, it is imperative for telco operators, research institutions, and manufacturers of system devices, components, and test equipment to collaborate rather than pursue individualized trial and error. For the nascent mobile communications sector, China adopted a strategy of competition among diverse market entities. This entailed grappling with uncertainties arising from both technological advancements and market dynamics. Moreover, stakeholders across the supply chain exhibited a lack of incentive to make substantial investments in a novel standard. As a solution, the government would intervene to facilitate coordinated efforts among mobile communications innovators through administrative directives, large-scale infrastructure initiatives, and fiscal incentives. This approach would enable collective action, allowing the nation to bridge the gap and surpass leading countries in this field.

(iii) Under specific conditions, the competitiveness of emerging technology sectors, such as the allocation of mobile communications spectrum, may be adversely affected by inefficient trial and error processes or intense market competition. China has implemented a spectrum allocation system that is guided by the government. Based on the assessment of technological capabilities and the maturity of the industrial chain, the government has strategically distributed spectrum resources among various technology options and market participants. This allocation aims to enable the most technologically advanced telco operator to lead and support the development of the less mature industrial chain. Contrarily, the United States implemented a market auction mechanism for spectrum allocation, resulting in inefficiencies and strategically prolonging the reclamation of mid-band spectrum. Despite the system's potential to allocate spectrum resources to more efficient operators, it failed to incentivize operators to cultivate an industrial chain and develop capabilities.

Based on the above analysis, it can be inferred that the implementation of a well-crafted industrial competition strategy has rendered government intervention in China's mobile communications industry conditionally compatible with its catch-up development. The prevailing research on industrial policy has often classified these facts as "anomalies", as it tends to associate government intervention solely with targeted industrial policies like fiscal subsidies and tax preferences. However, the research fails to thoroughly examine the impact of non-selective government interventions on industrial competition strategies. In our survey, the respondents overwhelmingly highlighted the integral role played by the Chinese government in the catch-up development of China's mobile communications industry. They emphasized the significance of the integrated "technology, standard and industry" implementation system, as well as the effective industrial competition strategy. Rather than relying on selective industrial policies such as fiscal subsidies, these factors were deemed crucial in driving the industry's advancement. The realm of mobile communications network technologies encompasses a multitude of intricate industrial coordination endeavors, including but not limited to inspection planning, standard selection, and network deployment. The US industrial coordination mechanism has indeed fostered the development of cutting-edge mobile communications technologies. However, the conversion of these frontier technologies into broader industrial competitiveness and widespread network deployment has been hindered by two key factors: The erroneous selection of technology path and the excessive costs associated with frequency coordination. It can be argued US mobile communications firms

are individually very innovative; however, the overall industrial competitiveness of the sector is experiencing a decline due to shortcomings in industrial competition strategy and market coordination.

While the government has indeed played a significant role in shaping China's competitive strategy for the mobile communications industry, it is important to note that this conclusion may not necessarily be applicable to all other emerging technology sectors without any reservations. The efficacy of government intervention, as evidenced by empirical observations, is subject to certain limitations in its scope of application. First, the government's ability to effectively shape and execute the industrial strategy relies on two key factors: Insightful understanding and professional expertise. Moreover, it is crucial for the government to foster a collaborative and consultative relationship with diverse innovators, ensuring open lines of communication and opportunities for mutual learning. Second, the collaborative efforts of innovators play a pivotal role in the execution of industrial competition strategies. When comparing market-based mechanisms to government intervention, it is worth noting that the latter may be more adept at achieving "overall coordination" when guided by an industrial competition strategy. The justification for the overall coordination theory lies in the observation that when a significant number of players engage in coordination, two mechanisms can facilitate the convergence of multiple Nash equilibria. The first one is market coordination mechanism. With sufficient information, market participants adjust their strategies through various rounds of competition and develop a belief of convergence (Crawford and Haller, 1990). However, the degree of uncertainty may reach a significant threshold, such as when every advancement in mobile communications necessitates a reshuffling of the industrial competition dynamics. In this scenario, the likelihood of multiple market participants opting for the Nash equilibrium strategy diminishes significantly, and the process of achieving pure market coordination may result in substantial time and trial-and-error costs. At this juncture, it becomes increasingly efficacious to incorporate a third-party facilitator, such as the government, into the equation. Through the establishment of a credible commitment, a facilitator assists in the attainment of the optimal Nash equilibrium among all participants (Aumann, 1987; Govindan and Wilson, 2010).

Existing research on industrial policy has also underscored the significance of government coordination. Japan's post-war industrial policy practices often entail government coordination among different parties within the industrial chain (Song, 2016). However, it is important to note that these studies exhibit notable distinctions when compared to the well-coordinated approach employed by China's mobile communications industry, which encompasses "technology, standards, and industry" implementation. In this paper, we make reference to coordination activities as discussed in the existing literature. Specifically, our study examines the concepts of "regional coordination" and "overall coordination". Overall coordination, in the context of economic development, relates to the government's efforts to facilitate and promote sophisticated innovation endeavors and dedicated investment activities undertaken by innovators. On the other hand, regional coordination entails the government's coordination initiatives aimed at facilitating basic economic activities conducted by a restricted number of individuals within a specific geographical area[9]. Based on existing research, the presence of a robust input-output correlation among industries or the interconnectedness of upstream and downstream links within the industrial chain results in a reciprocal relationship between production and investment decisions, thereby engendering a detrimental "vicious cycle" of industrial development. In this scenario, should the government successfully identify the constraints posed by outdated upstream industrial technologies or the costs associated with the advancement of downstream strategic industries,

[9] The "Big Push" theory, as expounded by Paul Rosenstein-Rodan, highlights the inherent complementarity that exists among various industries. However, it is important to acknowledge that this theory fails to consider the limitations imposed by both capabilities and capital on the process of industrial development. The concept of the "Big Push" fails to provide a satisfactory solution to the challenge of achieving effective coordination between various industries and entities. Central to the issue of overall coordination lies the fundamental inquiry of how to facilitate synchronized efforts among a multitude of industrial entities amidst a backdrop of uncertainty.

it would make sense to implement measures such as price subsidies or technological advancements to increase the competitiveness of bottleneck industries (Liu, 2019). However, the existing research on industrial policy highlights the importance of government coordination in regional contexts. This coordination focuses on a limited number of subjects and relies on selective policy instruments within a relatively stable environment. Government coordination in China's mobile communications industry can be characterized as a comprehensive approach that involves a range of interventions and policy combinations aimed at supporting major innovators in a rapidly evolving environment. The differences between the regional coordination and overall coordination can be categorized into two distinct aspects: In the realm of industrial ecosystems, it is noteworthy that overall coordination encompasses a vast array of stakeholders. On the other hand, regional coordination is confined to a select few economic entities. Under China's "technology, standard, and industry" implementation system for the mobile communications industry, the government has effectively synchronized and managed the diverse components of the innovation and industrial chains. In contrast, regional coordination is applicable to traditional and heavy industries with a relatively straightforward input-output relationship[10]. Furthermore, regional coordination entails the implementation of a simple coordination mechanism primarily centered around price intervention. This approach is rooted in the notion that the government can generate a "Kaldor compensation" for industries that are lagging behind. Specifically, the government engages in a temporal redistribution of potential value that may be generated by strategic sectors in the future. This value is then advanced to uncompetitive upstream or conventional industries through fiscal policies, with the aim of fostering a virtuous cycle of industrial progress. China's overall coordination mechanism for the mobile communications industry prioritizes the selection of technology paths, early-stage market development, the establishment of a unified testing and validation system, and the formulation of standards. These interventions are not limited to selective industrial policies, but rather encompass a broader range of measures. Under the purview of industrial competition strategy, these endeavors collectively constitute a meticulously crafted "policy portfolio" or "policy pack". The effects of overall coordination are determined by the interplay of various interventions, rather than the intensity of individual policies[11].

For overall government coordination to succeed, it is essential to create a unified industrial competition strategy at the industry level and consistent investment activities throughout the industrial chain (Matsuyama, 1998). As an emerging technology sector, the biopharmaceutical industry, for instance, is characterized by highly differentiated technologies and products and expanding technology frontiers. Hence, unified technology standards and technology paths are not applicable to the biopharmaceutical industry, for which the industrial policy must focus on encouraging the diversified exploration of enterprises and research institutions, as stressed by Rodrik (Rodrik, 2006), instead of encouraging businesses to act in unison. Obviously, there are very specific situations in which government intervention is compatible with, say, the catch-up development of China's mobile communications industry, and serious deviation from any of the above conditions will cause government intervention to fail.

[10] The network development theory and the sectoral innovation system theory also give prominence to the connections between innovators in the government push of high-tech and emerging industries. However, such connections are still regional interactions between a few entities rather than concerted actions of overall coordination. See Block and Negoita, "Beyond Embedded Autonomy: Conceptualizing the Work of Developmental States," in Chu Yw. (eds) *The Asian Developmental State*, Palgrave Macmillan, 2016, pp. 57-72.

[11] Examining the distinctions between overall coordination and regional coordination, as commonly discussed in the context of non-selective industrial policy, serves to enrich the ongoing scholarly discourse on the whole-nation system. Current research posits that the whole-nation system represents a task-oriented framework mandated by the state, operating independently from the existing governmental organizational structure. However, our survey has revealed that within the same institutional framework, the special project related to the development of new-generation broadband wireless communications network has yielded varying outcomes when compared to other similar initiatives. It is imperative, therefore, to gain a deeper understanding of the theoretical implications of the entire whole-nation system. Based on the observed behavioral traits, an effective whole-nation system will prioritize the cultivation of a culture that values continuous and rigorous education, achieved through comprehensive coordination and unwavering dedication to substantial investments.

4.2 Discussions on the Effective Conditions of the Selective Industrial Policy

The effectiveness of selective industrial policy stands as a central concern in both Chinese and global industrial policy research, representing a highly contested topic in the field of economics. Critics have advocated for the adherence to the overarching trajectory of market-oriented reforms. Nevertheless, they fail to elucidate the empirical evidence unveiled in our particular case. Selective industrial policies - particularly those focused on major science and technology projects - have undeniably played a crucial role in fostering industrial chain coordination and advancing the technological development of critical components. The necessity for logically coherent theoretical explanations remains imperative when considering such a distinctive and significant phenomenon.

Selective industrial policy is instrumental for the implementation of the industrial competition strategy. Yet the majority of present research on industrial policy has focused on examining discrete and isolated instances of government intervention. This narrow approach has resulted in fragmented analyses of the broader issue of government intervention. The extent of government interventions far exceeds the limited scope of selective industrial policy instruments, such as fiscal subsidies and tax preferences, encompassing a wider range of complexities. Rather than focusing solely on the outcomes of individual initiatives, a comprehensive approach is required to assess a nation's industrial policy (Stiglitz, 2017). Several studies on industrial policy have acknowledged the significance of non-selective government intervention in various areas such as financing basic research, establishing technology alliances, implementing technology standards, providing infrastructure, and managing conflicts of interest (Chang and Andreoni, 2020). Similar to the use of targeted industrial policy tools, various government interventions continue to operate independent from one another. Based on the observations of China's mobile communications industry, it is evident that government interventions play a crucial role in fostering a comprehensive system that encompasses various aspects such as devising an effective strategy, establishing standards, conducting fundamental research and development, advancing critical technologies and test platforms, promoting cooperation, and stimulating market demand. In pursuit of advancing indigenous mobile communications technologies, the Chinese government has strategically adapted its policy portfolios to align with the evolving landscape of technology and international competition. The amalgamation of industrial competition strategy and diverse policies and interventions constitutes a strategically complementary policy framework in a multifaceted and holistic approach. The prevailing body of research on industrial policy concentrates on examining distinct policy instruments employed by governments, such as fiscal subsidies, or analyzing specific policy attributes like the level of intervention intensity and its impact on industrial development performance. The potential fallacy of establishing an erroneous causal relationship between industrial policy and development results lies in the negligence of the strategic complementarity between individual policy variables and other policy variables.

The effectiveness of selective industrial policy relies heavily on its impact on the strategic factors that drive long-term industrial development performance, especially in the context of industrial competition strategy and coordinated actions by industrial entities. When considering the interplay between selective industrial policy and other government interventions, particularly its alignment with the industrial competition strategy, it becomes simpler to elucidate the seemingly paradoxical phenomenon in which selective industrial policy has proven unsuccessful in the majority of emerging technology industrial sectors (as catch-up development in these sectors does not necessitate coordinated efforts across the industrial chain), but has been effective in China's catch-up development of the mobile communications industry, as selective industrial policy complements the industrial competition strategy. The subsidy policy has intensified corporate risk during the final phase of the solar energy industry's catch-up, leading to distortions in corporate investment behaviors (Geng, 2019). Conversely, the "new-generation broadband wireless mobile communications network", a National Science and Technology Major Project, has catalyzed the development of China's mobile communications industry.

Under the market-oriented approach, we may identify the essential conditions for selective industrial policy to yield positive results. First and foremost, it is imperative that any successful selective industrial policy does not undermine the fundamental workings of market mechanisms. In the long run, it is evident that no policy dividend would be sufficient to offset the detrimental effects on market mechanisms. It is important to acknowledge that the concept of "disruption" varies in intensity, and that any form of selective industrial policies is contrary to market mechanisms. The efficacy of a selective industrial policy can be assessed by weighing its costs against the benefits, as long as it does not significantly disrupt the functioning of the market mechanism. To minimize the negative impact of government intervention on market mechanisms, it is crucial for a well-designed selective industrial policy to minimize distortions to key market mechanisms, including competition and supply-demand pricing. This approach aims to reduce the costs associated with government intervention and its potential damage to market efficiency. In its efforts to catch up in the mobile communications industry, the Chinese government has fostered an expectation of market opportunities for both domestic and international enterprises. This has been achieved through the commitment to extensive network development using indigenous technology standards, as well as the provision of incentives to encourage fair competition and the expansion of the industrial ecosystem for manufacturers. In the course of our survey, certain respondents have indicated that the government and telco operators have exhibited a tendency to extend "preferential treatment" towards multinational corporations such as Nokia, as opposed to domestic enterprises, in testing and procurement. This approach is believed to be aimed at facilitating the integration of these multinational companies into the Chinese market. Regarding the pricing mechanism, the procurement price of telco operators is primarily determined by the product performance and price advantage offered by equipment and component manufacturers. Despite their discriminatory selective industrial policymaking, the National Science and Technology Major Projects have followed an integrated "technology, standard and industry" approach for the cultivation of competitive suppliers, user assessment of upstream suppliers, and informal interactions with innovators. Rather than disrupting market mechanisms, this approach has bolstered control over competition, fostered cooperation within the industrial chain, and prioritized the commercial orientation of research and development. The interplay between government guidance and market mechanisms has played a pivotal role in nurturing the development of China's mobile communications industry.

Selective industrial policy can be deemed effective when it serves as a facilitator for information dissemination and the implementation of a well-devised industrial competition strategy. From a broader perspective, the implementation of selective industrial policy can contribute to the advancement of strategic factors that undergird an industry's long-term growth and progress. Selective industrial policy, while not inherently a strategy for industrial competition, plays a crucial role in shaping the industrial competition strategy without seriously disrupting market mechanisms. Based on China's mobile communications industry's catch-up experience, it is evident that the government can spearhead the development of industrial chains through means other than selective industrial policy, such as the National Science and Technology Major Projects. Instead, selective industrial policy works with other factors such as market commitment to establish the foundation for comprehensive coordination. However, as a result of adhering to a consistent industrial competition strategy, these selective industrial policies have had a notably favorable impact on China's mobile communications industry in terms of catch-up development.

Selective industrial policy can be an effective form of government intervention as long as it satisfies certain necessary and sufficient conditions. This principle is crucial in refuting the logical fallacy of the argument against selective industrial policy. First, it cannot compromise the functioning of market mechanisms and should be strategically aligned with the factors that drive long-term performance within an industry. Not only have effective industrial policy interventions been observed in China's mobile communications industry, but extensive empirical evidence has also revealed instances where selective

industrial policy interventions have proven unsuccessful. Critics of selective industrial policy have failed to identify the necessary conditions for its effectiveness, thereby adopting an overly dismissive attitude that disregards its potential benefits. Meaningful and constructive industrial policy research should, therefore, be carried out based on the behavioral characteristics and boundary conditions of government interventions.

This paper presents a novel perspective on industrial competition strategy and overall coordination within the realm of industrial policy research. It elucidates the role of government intervention in fostering the catch-up process of China's mobile communications industry. Given the constraints imposed by a singular case study, it is necessary to acknowledge the inherent limitations in presenting and substantiating counterfactual hypotheses. Consequently, we are unable to definitively establish that government intervention is the sole trajectory for China to emerge as a global leader in mobile communications. Furthermore, this study failed to identify the specific industrial sectors in which overall coordination can be applied. According to my observations and reflections, it can be inferred that the industrial internet and high-speed maglev trains bear resemblance to the mobile communications industry due to their similarities as burgeoning technological sectors. In light of substantial investments and the need to establish a comprehensive technology architecture or standard across the industry, it becomes important for stakeholders to devise a competitive strategy within the context of significant technological and market uncertainties. Future research should present a long-term and in-depth survey on those sectors, as well as analyze case studies in the mobile communications industry, as an essential direction in expanding the conclusions of this study.

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