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SPECIAL POLICY REPORT

Innovative Mechanisms of Sustainable Investment in Environment and Climate

2024

Innovative Mechanism of Sustainable Investment in Environment and Climate

China Council for International Cooperation on Environment and Development (CCICED)

New Paradigm of Green Finance: Great Potential in Capital Markets

Special Policy Study Report

CCICED

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Acronyms & abbreviations

AI	Artificial Intelligence
ALK	Alkaline Electrolysis
CCUS	Carbon Capture, Utilization and Storage
CPI	Climate Policy Initiative
CVC	Corporate Venture Capital
ESG	Environmental, Social and Governance
ESMA	European Securities and Markets Authority
EU-ETS	European Union Emission Trading Scheme
GP	General Partner
GPU	Graphic Processing Unit
GW	Gigawatt
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPO	Initial Public Offering
IRR	Internal Rate of Return
IVC	Independent Venture Capital
LBO	Leveraged Buyout
LP	Limited Partner
NEC	Nippon Electronic Company
OCC	Office of Comptroller of Currency
PBoC	People's Bank of China
PC	Personal Computer
PE	Private Equity
PLC	Programmable Logic Controller
RMI	Rocky Mountain Institute
SBIC	Small Business Investment Company
SBIR	Small Business Innovation Research
SoC	System on Chip
SOEC	Solid Oxide Electrolysis Cell
STTR	Small Business Technology Transfer
VC	Venture Capital
VLSI	Very Large Scale Integration

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Executive Summary

1. Background and Significance

After more than a decade of development, China has achieved remarkable success in its green transformation. This primarily related to two characteristics of green technology and the green industry as the manufacturing sector. First, the manufacturing industry benefits from economies of scale, and with its vast population and economic size, China has a scale advantage in developing manufacturing industries. Second, fossil fuels, being a natural resource endowment, have certain natural monopoly attributes, while the manufacturing industry is a highly competitive sector. Even market power formed by technological innovation is hard to sustain, and the shift from fossil fuels to clean energy would increase competitiveness in economic activities. The combination of scale advantage and intense competition has enhanced the efficiency of economic activities, and promoted the rapid development of China's green industry and placing it in a leading position globally. The green capacity accumulated by China and its low-cost green manufacturing are beneficial to the global green transformation and constitute a significant driving force for the global green transition.

However, relying mainly on expanded production capacity in existing mature technologies to drive the green transformation will face increasing challenges. There are three main reasons: First, as China is about to reach its carbon peak, carbon neutrality will become the main goal of the green transformation, which relies on emerging technologies still under development. Second, as demand for land resources in the green industry grows, diseconomies of scale could increasingly constrain the advantages of economies of scale. Third, amid the new geopolitical landscape, countries around the world are emphasizing security over economic efficiency, and protectionism and fragmentation of the global market could limit the scale effect of China's green industry.

In this new paradigm, the green transformation needs to rely more on breakthrough innovations, and the financial system serving the green transformation must make corresponding adjustments. Green technology innovation enjoys positive externalities brought by technological innovation, which means that both innovation and carbon reduction activities should bring additional benefits to society. Nevertheless, these benefits are not adequately compensated in market transactions. In other words, the market mechanism cannot fully incentivize enterprises to engage in green technology innovation. Only through the implementation of effective policy measures can market failures be corrected, allowing financial resources to flow into green technology innovation. The previous phase of the green transformation mainly focused on capacity expansion, with stronger

demand for incremental innovation. China's green finance sector for the most part had characteristics associated with policy finance. Green financial policies to correct market failures were mainly designed and implemented for debt financing. In the new phase of green finance, the support for breakthrough innovation should mainly rely on the capital market, where equity investment and financing are key to innovative finance.

So, specifically, how should the new phase of green finance better support breakthrough innovation in green technology? The answer to this question is helpful for China, as the country continues to promote green transformation to effectively achieve the dual carbon goals. In addition, it is of great significance for the high-quality development of China's economy and the construction of a financial system adapted to new quality productive forces.

2. Research Focus

Why should the capital market play a more significant role in the new phase of green finance? In the early stages of development of China's green finance system, clear policy tools such as the "Guiding Catalogue" (which defined the boundaries of supported industries and implemented precise financial support strategies) helped green debt financing achieve steady growth and gradual expansion. However, debt financing such as bank credit and green bonds has a lower risk appetite, which does not match the high uncertainty associated with breakthrough innovations. In contrast, the capital market has higher risk tolerance and greater patience towards investment return cycles. Moreover, the capital market is a decentralized investment and financing system, where the dispersed decision-making and behaviors of investors allow the market to provide financial support for innovative activities across various fields and technological routes. This helps build an innovative ecosystem in which different fields promote each other and different technological routes compete with each other. In light of this, the capital market has strong inclusiveness for financing different models of technological innovation. This is highly compatible with green technological innovation activities that have a high degree of uncertainty in their technological routes.

What are the unique advantages of the capital market for breakthrough innovations? The capital market has two unique advantages in promoting breakthrough innovations: ecological effect and screening effect. The ecological effect refers to the ability of the decentralized decision-making capital market to provide financial support for all fields. Compared to the science and technology financing models dominated by banks, the capital market is composed of many investors with different risk and investment preferences; it refers to a decentralized investment and financing system. Even if some investors avoid certain fields, there will be other investors

optimistic to invest. Thus, the capital market is more capable of providing financial support for all fields and is more conducive to forming an innovative ecosystem that is conducive to the development of breakthrough innovations. The screening effect refers to the capital market's greater ability to "bet on" the ultimately successful technological routes. The capital market is a decentralized investment and financing system composed of many investors with different risk preferences, investment preferences, and knowledge systems, which means that the it can provide financial support for all technological routes. In addition, investors in the capital market also act in a sense as consumers. The recognition of a specific technological route by investors largely reflects consumers' recognition of the technology and its products. This increases the probability of the capital market "betting on" the ultimately successful technological route.

What challenges does China's capital market face in supporting green technological innovation? Currently, both the equity market and the stock market[1] in China have some practical issues that limit their role in promoting breakthrough innovation in the green sector. In terms of the equity market, the domestic equity market is currently facing fundraising difficulties, with the green sector facing even greater fundraising pressure. Moreover, equity investors such as industry guidance funds prefer to invest in later-stage mature projects in the green sector and have short investment horizons, which is not conducive to supporting high-risk, long-term breakthrough innovation activities in the green sector. The stock market serves as the exit point for equity investments. As such, venture capital (VC) and other equity investors tend to support mature enterprises in the green sector while reducing investments in small and medium-sized enterprises engaged in breakthrough innovation. This is not beneficial for promoting continuous breakthrough technology innovation in green sector.

What role should the government play in the new phase of green finance? Given the uncertainty inherent in green technology innovation, it is necessary to construct a policy framework that can provide both "long-term stable expectations" and "technological inclusiveness" to support the development of green technology innovation. Such a policy system should be able to create long-term growth expectations, reduce innovation risks, and incentivize enterprises and research institutions to invest in the research and application of green technologies. This would ensure expectations of long-term returns for these fields, thereby achieving a win-win situation in terms of both environmental and economic benefits. At the same time, policy should also respect the autonomy and creativity of science, providing innovative enterprises or teams

[1] In this report, the “equity market” and “equity investment” refer to equity ownership other than the stock market, such as private placements, private equity, and venture capital.

with sufficient space for development, embracing the diversity of technological routes, and allowing a broad social group to complete the process of selecting the optimal technologies.

3. Policy Recommendations

To promote breakthrough innovation in green technology, it is necessary to address the dual externalities associated with green technology innovation. To this end, the green finance system needs to be improved in two ways. In the real economy, policies supporting green technology innovation should be based on "technological neutrality," shifting from the past focus on selecting specific technologies to a technology-neutral policy framework. This would lay the foundation for fully leveraging the ecological and screening effects of the capital market. In the equity market, it is necessary to accelerate improvement, fully utilizing its hub function, in order to support the urgent needs of green technology innovation.

3.1 Real Economy Policies: Creating Green Demand and Enhancing Green Returns

Adopt a "quantitative carbon reduction performance" model instead of a "procurement list" model in the bidding mechanism for green procurement. The role of green procurement in green transformation should be strengthened. Currently, China's green procurement system is mainly based on a government procurement list model, which makes it difficult to promote breakthrough innovations with high uncertainty. A more direct approach might be the "quantitative carbon reduction performance" model. Under this model, first, it is necessary to clarify the quantitative emission reduction targets and performance standards for green products, providing clear guidance and stable expectations for product suppliers and related investors. Second, it is important to encourage the use of competitive bidding mechanisms to continuously select and support the best green technologies. Third, it is vital to provide additional procurement price preferences for breakthrough technologies to promote continuous innovation by producers and to incentivize long-term investment, for instance, offering more procurement discounts for bids with carbon capture and utilization, carbon mineralization, or other technological breakthroughs, to producers to continuously innovate low-carbon solutions.

Establish a green performance auction fund connected to the financial market. To address the externalities and scale constraints in the green transformation, it is recommended to start from the supply side – i.e., combining government incentives with the pricing capabilities of the financial market and the flexibility and innovation of the private sector. Such a fund could be

established with public capital, and its operation could be divided into three stages. The first stage is that the green auction fund announces the amount of funds and duration for supporting green transformation projects. The second stage is that the fund accepts bids from companies for emissions reduction and funding needs. Based on the bids, the fund would provide a commitment to purchase carbon emissions reduction (or equivalent carbon emissions reduction of green technologies) for the most competitive green transformation projects, but without prepayment of funds. The third stage is that the auction-winning companies complete the green transformation projects within a specified period, and the fund would pay the bidding companies according to actual carbon emissions reduction or equivalent carbon emissions reduction of green technologies. If the carbon market price exceeds the purchase price promised by the fund, companies could also retain the right to sell carbon emissions reduction quotas in other markets. Establishing a results-oriented green auction fund would help to build an incentive-compatible relationship between green transformation and the financial market, expand the participation of the financial market in green transformation, and ensure the effective use of public funds, addressing challenges such as scale constraints.

Support the green technology innovation ecosystem by encouraging green technology incubation or acceleration projects, cultivating a team of green technology managers, and improving the green technology innovation service system. In addition to market support for needs at R&D and commercialization stages, the government should help with market applications of technology in the demonstration phase, testing the technological route's potential for commercialization. The focus should shift from supporting green technology to supporting the green technology innovation ecosystem. First, it is important to guide funds towards accelerators and incubators related to green technology. Second, it is necessary to accelerate the establishment the of professional talent pool for green technology transfer and transformation, cultivate domestic green technology managers, and gradually establish and improve the green technology transfer service system.

Promote the "two accelerations" in carbon market construction to reduce the green premium for innovative technologies. First, the government could accelerate the expansion of the carbon market by improving the carbon market infrastructure – i.e., the carbon emission accounting system – creating more demand for emission reduction technologies across industries. Second, the government could accelerate the establishment of a bidding mechanism for carbon quotas, gradually promote the increase of carbon prices, and use the revenue from carbon quota auctions to support green technology innovation. Currently, the overall carbon quotas in China's carbon market are still allocated free of charge. Drawing on the experience of the EU, it is necessary to gradually increase the proportion and industry coverage of paid allocation of carbon

quotas through a bidding mechanism. In addition, China can learn from the practices of developed economies by establishing a special innovation fund with the proceeds from the carbon market, to further increase investment in domestic green technology projects.

3.2 Capital Market Policies: Activating Patient Capital and Creating a Diverse Investment Ecosystem

Explore feasible paths for bank funds to support the development of the equity market in raising capital, and guide long-term capital such as funds from wealthy individuals and pension funds into the market. First, based on the reality that most financial resources in China are concentrated in the banking system, efforts should be made to explore new paths for orderly and moderate guidance of bank resources to support breakthrough innovation in the green sector through the capital market. The banking system needs to cautiously balance the benefits of innovation with financial risks when supporting the capital market and breakthrough innovation. Specifically, there are two approaches: One is to limit the scale of banks' participation in the equity market, and the other is to guide banks to participate more in relatively lower-risk mid-to-late-stage equity market investments (e.g., M&A). In practice, equity investment in the green industry can be piloted to gradually explore the appropriate scale of bank participation in green industry equity investment, and to encourage banks to participate more in green industry equity M&A, thereby enhancing equity investment in the green industry.

Second, the government could, starting from the static and dynamic wealth effects, guide the capital of affluent groups and long-term funds such as pension funds into the market. The key to enhancing fundraising in China’s equity market is to attract long-term funds such as those from wealthy individuals and pension funds, which is not only large in scale but also have a high-risk preference and long investment horizon, making them more suitable for supporting breakthrough innovation. Specifically, for high-net-worth individuals, the government could develop wealth management services such as private banking, and pilot green industry-related deductions that guide savings into long-term capital in the equity market through "inheritance tax and donation deductions". For pension funds, a prosperous stock market is needed to facilitate venture capital exit channels and improve the return on venture capital investment, thereby attracting pension funds to increase investment in the equity market and green industries.

Optimize the assessment methods for industry guidance funds in fund management, establish green venture capital plans, and value the positive role of foreign venture capital

and corporate venture capital (CVCs). First, to enhance the role of industry guidance funds[2] in green technology innovation, it is necessary to clarify their positioning in promoting innovation, optimize the assessment mechanism, respect the professional capabilities of market-oriented managers, and establish a reasonable responsibility determination mechanism to avoid lowering the risk preference of industry guidance funds due to excessive accountability. At the same time, it is recommended to increase the proportion of national-level funds and exploring the establishment of cross-regional integrated funds with green technology fields as a pilot to solve the market segmentation problem caused by reinvestment. Second, following the SBIC model in the US, a green venture capital plan needs to be created, with the establishment of a central green guarantee fund, providing financing guarantees for market-oriented funds focusing on green industry equity investment. Such measures would likely reduce the uncertainty of government funding, reduce government intervention in market-oriented general partners (GP) investment, and provide more investable funds for market-oriented GPs, thus to better support breakthrough innovation in green technology. The goal is to increase the intensity of financial opening up and attract high-quality foreign GPs to enter China's green equity market, which would likely improve the post-investment management capabilities of the domestic equity market. Finally, improve the conception of antitrust. The regulation of CVCs of large enterprises should shift from structuralism to behavioralism, by focusing on whether their capital expansion behavior involves non-competitive businesses, rather than simply considering them as monopolies because of their scale expansion. Leading firms in green industries should be encouraged to increase equity investment via CVC and other means, thereby better promoting breakthrough innovation in green technologies.

Create a favorable environment for green sector companies to go public and facilitate diversified means such as M&A. Firstly, the government could consider supporting and encouraging high-quality unprofitable enterprises in the green sector with opportunities to go public. It is a necessary prerequisite for enhancing the attractiveness of equity investment in green industries. Second, policymakers could explore gradually increasing A-share listed companies' participation in M&A transactions, and encourage listed green companies to integrate industry chain resources and improve operational efficiency through M&A. They could also encourage leading domestic and foreign equity investment institutions to set up M&A funds, and facilitate channels for venture capital and other equity investments to exit through M&A. Finally, it is recommended to promote market-oriented reform of stock exchanges by leveraging exchanges'

[2] China's industry guidance funds are policy-driven funds established by the government to guide investment through market-oriented operations with the aim of supporting the development of startup and technology-based businesses by leveraging government capital to attract more private investment into specific industrial sectors

information advantage and giving exchanges the autonomy to modify listing standards, in order to meet the financing needs of enterprises and the investment needs of investors, and enhance the inclusiveness of A-share initial public offerings (IPOs) in a bottom-up way.

Keywords: Green Technology Innovation, Capital Markets, IPOs, Guidance Funds, Innovation Ecology

1 Introduction

China's green transformation reflects, to some extent, the role of economies of scale and market competition in continuously reducing the cost of new types of energy. However, relying mainly on capacity expansion of existing mature technology industries to drive the green transformation will become increasingly challenging. There are three main reasons for this. First, as China's task of reaching its carbon peak, carbon neutrality will become the primary goal of the green transformation. Achieving carbon neutrality will rely on technological innovation. Second, as demand for land resources in the green industry expands, diseconomies of scale in land use will increasingly constrain the advantages of economies of scale. Third, amid the new geopolitical landscape, countries around the world are placing greater emphasis on security over economic efficiency, and the fragmentation of the global market could restrict China's green industry from fully leveraging economies of scale.

As the focus of the of green transformation evolves, green finance has also entered a new stage, focusing on breakthrough innovations in green technology. The biggest challenge in pursuing breakthrough innovations is the uncertainty of the technological pathways. For financial institutions, uncertainty translates to greater risk. Theoretically, a direct financing system based on the capital market has more capacity to bear risk and should be more efficient in matching capital with different risk preferences to the financing needs of different technologies. This makes it more suitable to support the next phase of technological innovation activities in China's green transformation. Therefore, the key issue lies in how to better enable the capital market to play its pivotal role and provide effective support for the new task of green technology innovation.

From a macro perspective, studying how China's capital market supports green technology innovation is of significance on at least two other levels. **First, from the perspective of China's promotion of high-quality development, the study of financial support for green technology innovation can provide important practical experience for the development of new quality productivity.** China's recently proposed concept of "new quality productive forces" aims to promote the optimization and upgrading of the economic structure and achieve high-quality development. Although the meaning of new productivity is still being outlined, one of its core features is the ability to promote sustainable economic and social development. The just-concluded third plenary session of the 20th CPC Central Committee identified technology innovation as the key driving force for the development of new quality productive forces. It also proposed "building a technological financial system that aligns with technology innovation,"[1] promoting the deep integration of technology and finance. This shows that a transformation of the financial system to better support disruptive innovation is a necessary requirement for China's transition to high-quality development, not limited to the green technology sector.

Second, from the perspective of the global push for a green transition, studying how China's capital market supports green technology innovation can provide more practical experience for capital markets in developing countries. On one hand, according to the International Energy Agency (IEA), nearly 35% of the cumulative carbon dioxide emissions reduction required by 2070 will come from technologies that are currently still in the early stages of development.[2] Without appropriate financial support, a global green transition could be difficult to achieve. On the other hand, according to Pitchbook, only about one-tenth of global private equity investment in the climate sector is in climate technology, and it is mainly concentrated in developed economies such as the US and Europe. China is one of the few developing countries with a relatively large-scale private equity market for climate tech investment. The capital markets of developed economies such as the US and

Europe are more mature and have greater influence on global private equity investment, and their financial systems in general have more experience in supporting disruptive innovations. However, for most developing countries, the Chinese experience is closer to their current circumstances and would serve as a better example for reference .

In 2023, the CICC Global Institute (CGI) and the US Natural Resources Defense Council (NRDC) formed a Sino-foreign joint research group to conduct a Special Policy Study under the theme of "Innovative Mechanism of Sustainable Investment in Environment and Climate". In 2023, the group focused on how sovereign asset owners could participate in sustainable investments through capital markets and guide more funds into fields related to the green transition. In 2024, the two parties once again turned their attention to the capital market, this time focusing on the tasks facing China's green transition—namely, promoting disruptive innovation. Specifically, the research group will focus on analyzing and reviewing: 1) The development process for China’s green financial system and alignment between financial support policies and the key challenges of low-carbon development; 2) clarifying the characteristics of green technology innovation and its policy support system, and analyzing the current specific demands for financial support in green technology innovation; and 3) exploring how to create an inclusive financial environment to support green technology innovation.

2 The New Focus of the Green Transition: Disruptive Innovation

China's achievements in its green transformation are mainly attributed to two factors. First, its large population and economy provide an innate advantage in terms of economies of scale for development of the manufacturing industry, especially when promoting mature technologies. Second, investment in the field of green technology has not led to market monopolies, ensuring that while capacity growth is maintained, market competition also remains vibrant. This advantage in economies of scale makes it possible for China's green industry to produce at low cost, and competition in the market reinforces this advantage. China's low-cost advantage in green capacity and manufacturing has played a positive role in promoting the global green transformation.

Nevertheless, relying on expansion of capacity based on existing mature technologies to promote the green transformation could face more challenges in the future. This is mainly due to three reasons. First, as China's carbon peak target is about to be reached, carbon neutrality will become a new goal in transformation. Realizing this goal requires the support of technological innovation. Second, as demand for land resources in the green industry increases, diseconomies of scale may become a factor. Finally, in the new geopolitical environment, countries pay more attention to security than to economic efficiency, which may lead to the division of the global market. This could adversely impact China's green industry's scale effect.

2.1 China Focuses on the Supply Side to Promote Green Transformation

The approaches to achieving the goals of green transformation vary among countries, particularly among major economies (see Figure 1). China and the European Union have similar size economies, and both have made significant emissions reduction efforts. However, the EU primarily focuses on the demand side, attempting to reduce the use of fossil fuels through carbon pricing to achieve a 43% reduction in emissions by 2030 compared to 2005. In 2023, the EU further raised its emissions reduction target to 62%, corresponding to a carbon price of EUR80–100 per tonne of CO_2, far exceeding China's carbon price[3]. China, on the other hand, mainly supports the development of green industries such as new energy vehicles from the supply side, with support measures that include government procurement, tax exemptions for purchases, and a whitelist for batteries. In the burgeoning energy storage sector, there are also policy incentives such as renewable energy storage requirements, time-of-use electricity pricing mechanisms, and electricity market mechanisms. The US's transformation policies lie between those of China and the EU, initially focusing on the demand side and now gradually introducing supply-side policies.

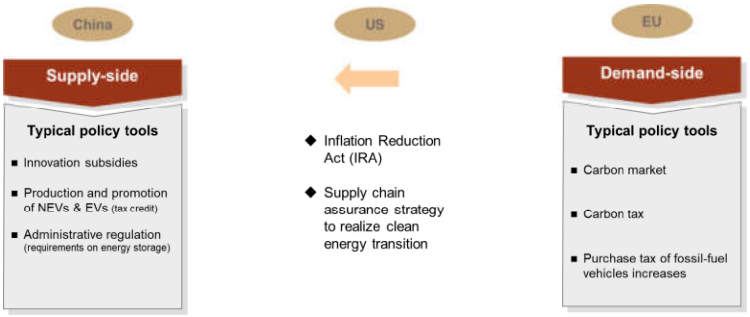

Figure 1 Two Pathways of Public Policy
Source: CICC Global Institute, "The Development of New Quality Productive Forces from the Perspective of Green Transformation: Economies of Scale, Overcapacity, and International Trade," May 2024

The different paths taken by China and Europe are both conducive to the global green transformation, but their industrial outcomes are starkly different. China's green electricity capacity, represented by photovoltaic and wind power, has grown rapidly, leading to a continuous decline in the price of green electricity in China. From 2009 to 2021, the central government subsidized on-grid electricity prices, and after 2021, local government subsidies replaced central government subsidies. To date, some of China's new energy power generation technologies have achieved grid parity, with unsubsidized generation costs now lower than those of coal-fired power. China's production capacity for new energy vehicles has also grown rapidly; BYD's annual production of electric vehicles has now surpassed Tesla's, ranking first in the world in 2023. In contrast, the development of the green industry in the EU has lagged. When measured by the cumulative installed capacity of new energy from photovoltaic and wind power, the EU has shrunk from nearly twice that of China a decade ago to only half of China's current capacity. Although the EU's high carbon prices have increased the cost of European manufacturing and boosted demand for green technologies, the market's high reliance on traditional vehicles has also significantly hindered the development and dissemination of new energy vehicle technology in the EU. The EU's demand for new energy and strong production capacity in China and the US has led to substantial imports of new energy products into the EU from these two markets.

2.2 Economies of Scale and Market Competition Effectively Contribute to Reduction of China's Green Premium

The success of China's green transition has, to a certain extent, demonstrated the role of economies of scale and market competition in continuously reducing the cost of new energy as part of the green transformation.

2.2.1 Green Economies of Scale

So far, China's green transition has primarily relied on the continuous expansion of production capacity through incremental innovative technologies. For mature technologies, expanding production capacity can effectively promote the reduction of the green premium. Economies of scale exist in the expansion of production capacity. Economies of scale are a common economic phenomenon in many manufacturing industries, where the cost per unit of product decreases as the scale of production and sales expands. This is

usually related to the large fixed capital investment required in manufacturing and the need for supporting infrastructure. At the same time, the accumulation of knowledge and human capital, as well as the industrial agglomeration that accompanies the development of manufacturing, have positive externalities. This allows larger-scale manufacturing enterprises to benefit more from the positive externalities accumulated in the existing economy. When green economy development is characterized by the expansion of production capacity in related manufacturing industries, economies of scale in the green economy become more pronounced.

China, with its vast population and economy, has a scale advantage in developing manufacturing industries. In the previous phase of the green transition, China fully leveraged its advantage in economies of scale in green manufacturing capacity expansion. Looking at wind power and photovoltaic technology as examples, both had dominant designs in the 1980s and began to be promoted in the European and US markets. In comparison, China was a latecomer in terms of technology and market application. In the photovoltaic sector, according to the International Energy Agency (IEA), R&D during the introduction phase of photovoltaic technology contributed more than 60% to the reduction of photovoltaic application costs. However, with the product design of crystalline silicon solar photovoltaic becoming standardized, the expansion of production capacity contributed nearly 50% of the cost reduction[4]. China began the "Golden-Sun Program" demonstration project in 2009 and introduced a benchmark feed-in tariff policy in 2011. Thanks to policy incentives, domestic photovoltaic installation capacity has significantly increased, driving the continuous expansion of domestic photovoltaic production capacity. The same is true for the wind power sector; between 2005 and 2009, the government required a 70% domestic content rate for wind power equipment, and starting in 2009, a benchmark feed-in tariff policy for wind power was implemented (see Figure 2), leading to a rapid increase in installed capacity. By 2023, the national installed capacities for photovoltaic and wind power reached 610mn kW and 440mn kW, respectively, becoming the second and third largest power sources after thermal power in China[5], with the total installed capacity of renewable energy surpassing that of thermal power. In the fields of lithium batteries and electric vehicles, China has achieved economies of scale through incremental innovation and production capacity expansion. Through substantial subsidies for new energy vehicles, China's electric vehicle production rapidly increased from only 150,000 units in 2015 to 4.5mn units in 2023, with lithium battery production capacity estimated to exceed 2,600 GWh in 2023[6].

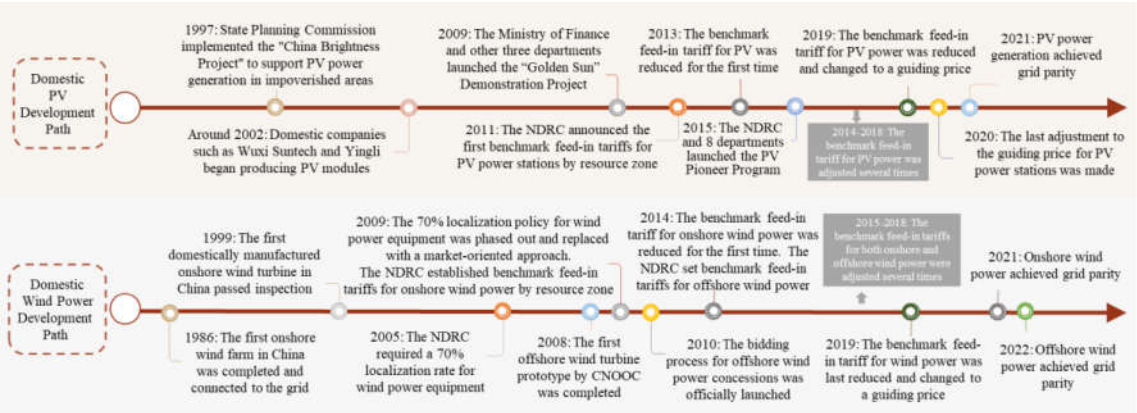

Figure 2 Development History of China's PV and Wind Power Industry
Source: International New Energy Network, International Energy Network, China Youth Daily, Polaris Solar PV Network, China Energy News, WindEurope, CICC Global Institute

2.2.2 The Power of Competition

Despite the substantial support provided by the government for the green industry, the market in China remains highly competitive. In technological fields such as wind and solar power, new energy vehicles, energy storage, and new material batteries, green investments in China have not led to market monopolies. This is largely due to three reasons.

First, the market in China is enormous, and is capable of accommodating and nurturing multiple enterprises and fostering intense competition. China ranks No.1 in the world in terms of macro investment. Although China's macro consumption rate is not as high as the global average, the large scale of its economy means that as of 2023, China still ranked No.2 in the world in terms of total consumption, ranking No.1 in goods consumption[7]. The vast investment and demand for commodities have given birth to a substantial domestic market for goods. No single green enterprise can achieve a monopoly over the domestic market, which forms the basis of the fierce competition in the green industry.

Second, local governments in China have strong motivation to spur economic growth and are extensively involved in formulating industrial policies for green transformation and engaging in green investments. As a result, there is a certain degree of redundant investment in China's green industry. This leads to a situation in which numerous enterprises exist within each industry, and local monopolies are not generally able to form, thus maintaining fierce market competition.

Third, China has an abundance of entrepreneurial spirit and accessible entrepreneurial resources. After more than four decades of reform and opening up, private enterprise plays a significant role in China's economy. Coupled with over two decades of deep exchanges and cooperation with international markets and multinational corporations following China's accession to the WTO, China possesses an ample supply of entrepreneurial spirit and talent. The relatively high macro savings rate and a robust banking system make it easy for entrepreneurs in China to secure funding. The higher education reforms at the turn of the 21st century led to the expansion of universities, which has created a large pool of highly educated talent in China over the past two decades, especially in fields such as science, engineering, and economic management, providing enterprises with abundant human resources.

These aforementioned reasons ensure that China's capacity expansion is accompanied by ample market competition. The country’s economies of scale make the low costs of its green industry possible, while the competitive pressures of the China market make these low costs a reality. The green capacity accumulated by China and its low-cost green manufacturing industry are beneficial to the global green transition and constitute a significant force in driving the global green transition.

2.3 New Task in China’s Green Transition: Disruptive Innovations in Technology

Over the past decade, the main driver of China's continuous green transformation has been the rapid development of green industries. However, the challenge of advancing green transformation primarily through the capacity expansion of existing mature technologies will become increasingly significant. After achieving peak carbon emissions, China's main task will shift to carbon neutrality, and the technologies required for carbon neutrality are mostly still in the early stages of development. According to the International Energy Agency (IEA), about 35% of global emissions reduction will need to rely on emerging technologies that have not yet

been commercialized, such as hydrogen energy and carbon capture, utilization, and storage (CCUS)[8]. The relevant emerging industries are still in the introduction phase, with their products and technological processes still facing considerable uncertainty and requiring a continuous trial-and-error process. In addition, green industries that are already in the growth phase also need continuous innovation and upgrading (even though their main technological pathways are relatively certain). For example, the large-scale development of wind turbines, the transition of photovoltaic modules from P-type to N-type technology, and the diversified development of power battery technologies such as solid-state batteries and lithium-sulfur batteries are all advancements that highlight the importance of technological innovation at this stage.

2.3.1 The New Main Tasks of Green Transformation Require Breakthrough Technological Innovation

China's green transformation has entered a new phase of development, characterized by the coexistence of the initial phase of emerging green technologies and the upgrading and transformation phase of mature green technologies. Compared to the previous phase, which focused on the expansion and large-scale application of mature green technologies, this new phase is centered around breakthrough innovation, thus emphasizing the importance of R&D investment. The necessity for green technology innovation stems from the current green technologies facing technological bottlenecks, resource constraints, and constraints related to achieving net-zero emissions.

First, existing green technologies such as photovoltaics (PV) are encountering development bottlenecks and require breakthroughs in energy efficiency limits. The current PV market is still predominantly based on first-generation crystalline silicon passivated emitter and rear cell (PERC) technology, with monocrystalline silicon PERC cells achieving a mass production conversion efficiency of 23.5%, which is close to the theoretical limit of 24.5%[9]. There are two major directions for breakthrough innovation in photovoltaic cells: Upgrading to crystalline silicon N-type cells through material replacement and the third-generation perovskite technology. Thanks to technological breakthroughs upstream and downstream i the photovoltaic industry chain, the photoelectric conversion efficiency of photovoltaic cells has increased from 23.2% in 2023 to over 26% in 2024, achieving a market transition from P-type to N-type, with conversion efficiency approaching the theoretical limit of 29.4%[10]. Another innovative direction for photovoltaic cells, perovskite cells, has even higher potential efficiency, which can exceed 50%, significantly higher than the 29% of crystalline silicon cells. However, they are prone to degradation and have poor stability, necessitating further R&D.

Second, relying only on clean energy technologies that are currently widely marketed will not be sufficient to meet the emissions reduction standards set out in the commitment target scenario to reach net-zero emissions. The IEA projects that by 2030, the majority of CO_2 emission reductions may be achieved through technologies that are currently marketed. However, looking ahead to 2060, about 40% of the emissions reduction will rely on technologies that are still under development[11]. Particularly in heavy industry and long-distance transportation, decarbonization will primarily depend on electrification, hydrogen energy, CCUS technologies, as well as advanced biofuels. To achieve net-zero emissions targets, IEA estimates that China needs to adopt these emerging technologies, which are currently in the prototype or demonstration stages, on a large scale after 2030:

(1) CCUS technology is the only practical way to significantly reduce greenhouse gas emissions from industrial processes, and is expected to contribute 10% of emissions reduction by 2070. The IEA has pointed out that to achieve net zero globally by 2070, in addition to energy restructuring, there will still be 2.9bn tonnes of CO_2 that cannot be removed from the industrial and transportation sectors, and which need to be stored and

consumed using CCUS[12]. Under China's 2060 carbon neutral scenario, the annual emissions reduction of CCUS is about 1.041bn tonnes, with a cumulative emissions reduction contribution of 14.6%[13].

(2) The application of hydrogen energy may cover 20% of the current global carbon emissions[14]. It can help decarbonize the steel, petrochemical, and transportation industries, industries in which it is difficult to reduce emissions, as well as serving as a carrier for long-term seasonal energy storage, increasing flexibility in the power system, and supporting higher renewable energy penetration. According to the China Hydrogen Energy Alliance, by 2025, the output value of China's hydrogen energy industry will reach Rmb1trn. By 2050, hydrogen energy will account for more than 10% of China's terminal energy system, and the annual output value of the industry chain will reach Rmb12trn.

(3) End-use electrification is also a crucial strategy for achieving net-zero emissions. Under China's committed target scenario, electrification will cover almost the entire energy system, contributing directly to 13% of the cumulative emissions reductions from 2020 to 2060, and indirectly reducing emissions by increasing energy efficiency. The share of electricity in terminal energy will increase to around 32% by 2030, over 55% in 2050, and more than 70% in 2060.[15]

The aforementioned three technological routes are still in their infancy, with no dominant technology yet established, and there is still competition among different technological pathways. Countries are actively engaged in research, demonstration, and application. In addition to these three key technologies, there are still a large number of emerging green technologies in the early stages of R&D that are awaiting technological innovation breakthroughs. According to the IEA's Clean Energy Technology Roadmap in 2020, the number of green technologies currently in the initial concept, small-scale testing, large-scale testing, demonstration, and early application phases far exceeds the number of green technologies that have already achieved mature application (see Figure 3).

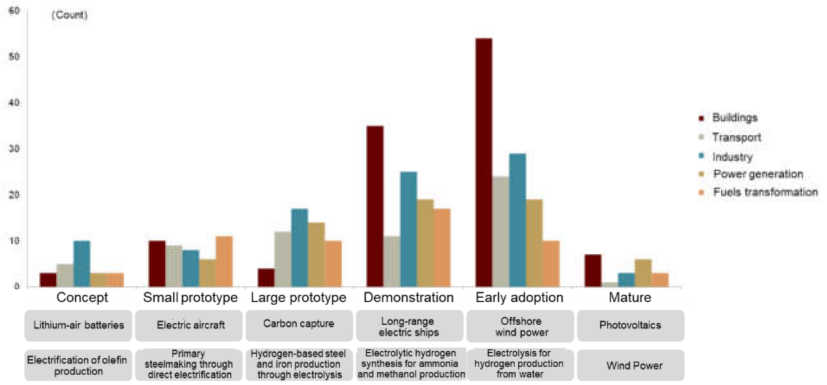

Figure 3 Number of clean energy technology analyzed in the ETP Clean Energy Technology Guide（2020）
Source: ETP Clean Energy Technology Guide Database, IEA, 2020, CICC Global Institute

2.3.2 The Economies of Scale in the New Energy Industry are Constrained by the Diseconomies of Scale Associated with Land Use

Land, as a factor of production, often exhibits characteristics of diseconomies of scale. It possesses natural exclusivity and competitiveness, and in production, it does not generate the positive externalities

typically required for economies of scale. More importantly, land is heterogeneous, varying in fertility[16] and in locational differences[17]. This heterogeneity leads to diminishing returns to scale for land, meaning that expanding production inevitably involves using less fertile land in unfavorable locations, resulting in a decrease in output per unit area or an increase in the cost per unit of product. This is the characteristic of land's diseconomies of scale. Under the influence of land's diseconomies of scale, economic entities of different spatial scales have asymmetry in their ability to achieve economies of scale. Larger economic entities have a greater capacity to achieve economies of scale. However, as the scale expands to a certain extent, this scale advantage will also be offset by the diseconomies of scale associated with land.

The green transition leads to a significant increase in the economic demand for land, and the characteristics of land diseconomies of scale are more pronounced in the green transition. Energy production requires land, and the energy power generated per unit area of land can measure the power density of different types of energy production. Since the power density of clean energy is significantly lower than that of fossil fuels, this means that the green transition requires more land for energy production. According to numerous studies[1], global energy production currently occupies 0.4%[18] of the land area. Even in the US, which has high energy demand, the fossil fuel extraction industry accounts for only about 0.5%[19] of the national land area. Some scholars estimate that if clean energy were to replace existing fossil fuels, the land required would account for at least 2.6% of the global land area, more than six times the current amount, almost equivalent to the land area of India[20]. At the same time, clean energy has certain requirements for natural conditions such as terrain, sunlight, and wind. Photovoltaic energy requires regions with abundant sunlight and contiguous areas. This conflicts with land use for food production and biodiversity protection[21]. Although China still has abundant unused land, since 2017, most of the new energy power installations have been located on land zoned for agriculture or industrial use[22]. China's clean energy also uses a significant amount of land types such as forest, wetlands, and shrub land, which is not conducive to biodiversity protection[23]. To reduce the diseconomies of scale associated with land, there is a greater need to rely on breakthrough innovations in green technology to improve efficiency.

2.3.3 Geopolitical Factors Limit the Scale Advantages of the Green Economy

In the new geopolitical landscape, countries around the world are placing more emphasis on security rather than economic efficiency, leading to a trend of deglobalization in the world economy. The US's promotion of reshoring and nearshoring of manufacturing has also reinforced existing trade barriers. The Russia-Ukraine conflict has further intensified the deglobalization of the world economy, with some countries showing a tendency to overemphasize security.

In this context, the green capacity advantage accumulated by China's green transition through fiscal support and policy-based credit may to some extent face a problem of insufficient demand. It should be noted that demand for green capacity stemming from the global green transition is far from saturated. However, due to the intensification of geopolitical risks, China's green capacity faces various barriers and additional costs in meeting demand from other countries for green products. This constrains the expansion of China's green capacity. For China to export green products, it will increasingly rely on breakthrough innovations in green technology to establish a competitive market position rather than relying on the scale advantages and low-cost advantages of manufacturing capacity expansion.

[1] Note: The required land area is the average of the optimistic and pessimistic scenarios in the article. The current total energy includes various types of fossil and clean energies, but there are differences in each year, which can be specifically referred to in the original text.

3 A New Stage of Green Finance: Enhanced Technology Finance Attributes

As the green transformation ushers in the new task of supporting breakthrough innovations, the green financial system that serves this transformation should also be adjusted accordingly. Theoretically, green technology innovation has positive externalities brought about by technological innovation, meaning that both innovative activities and carbon reduction efforts confer additional benefits to society at large, yet these benefits are not adequately compensated in market transactions. In other words, market mechanisms are insufficient for incentivizing enterprises to engage in green technology innovation. Only through the implementation of effective policy measures can market failures be corrected, allowing financial resources to flow into the domain of green technology innovation. In the previous stage of green transformation, which focused on capacity expansion, there was stronger demand for incremental innovations. China's green finance primarily exhibited policy-based financial attributes, and the green finance policies aimed at correcting market failures were mainly designed and implemented around debt financing. In the new stage of green finance, supporting breakthrough innovations should rely mainly on the capital market, with limited space for policy intervention in the capital market itself. This implies an enhancement of the innovative financial attributes of green finance.

3.1 Addressing Dual Externalities Requires Green Finance to Possess Dual Attributes

Green finance, as defined by the People's Bank of China (PBoC) and the United Nations Environment Programme (UNEP) in a 2015 report, is "a series of policies, institutional arrangements, and related infrastructure construction that guides social funds into the development of green industries such as environmental protection, energy conservation, clean energy, and clean transportation through various financial services."[24] This is largely in line with the G20's definition in 2016, which refers to green finance as "financial activities that can generate environmental benefits to support sustainable development."[25] In summary, green finance encompasses financial activity arrangements aimed at addressing climate change, environmental protection, and pollution prevention.

Green transformation has dual externalities, manifested as the negative externalities of carbon emissions and the positive externalities of green technological innovation during the transformation process. On the one hand, carbon-emitting economic activities benefit individuals while the resulting climate change and air pollution are costs borne by society as a whole. This negative externality means that the prices of goods and services formed by the free market do not align with social interests, as evidenced by the low market prices and high consumption of fossil energies. On the other hand, green technological innovation has positive externalities. Green technology innovation has a positive impact on the environment by promoting carbon emissions reduction and generates new knowledge through R&D of green products and services, leading to knowledge spillover effects that further drive social progress. The positive externalities of green technological innovation represent innovation bringing economic returns to investors and creating public value that is difficult to quantify for society. Since private investors cannot capture all the benefits of these positive externalities, the scale of their investment will be less than the socially optimal level. Therefore, during the process of converging

these externalities, from the phase of basic research to the commercial promotion of green technology innovation, the government needs to intervene by providing subsidies, tax incentives, regulations, and other means to establish a market environment, internalize these dual externalities, correct market failures, and attract more investors.

Addressing the externalities of carbon emissions requires reliance on the carbon market to convert the social cost of carbon emissions into user costs, encouraging economic entities to reduce energy consumption, and shift from fossil to clean energy. Additionally, industrial policies need to provide specific support to green industries, guiding capital flows towards green sectors and promoting the development of green industries. The reality is that China's carbon market is not yet well-developed and lacks vitality, with green finance primarily relying on a model of "fiscal support+ preferential loans" to achieve a bias in resource allocation towards green industries. Since this green transformation is mainly government-led, green finance is also policy-based finance. **To address innovation externalities,** green finance needs to exert its "technology finance attribute," that is, to build a technology finance model with the capital market at its core to promote breakthrough innovations in green technology. Given that breakthrough innovations in green technology are characterized by their disruptive potential, high uncertainty in development paths, and significant risk of failure, it is necessary to construct an inclusive policy framework to guide capital market support for green technology innovation. As breakthrough innovation in green technology plays an increasingly critical role in China's goals of reaching peak carbon emissions and achieving carbon neutrality, the technological characteristics of green finance will be gradually strengthened.

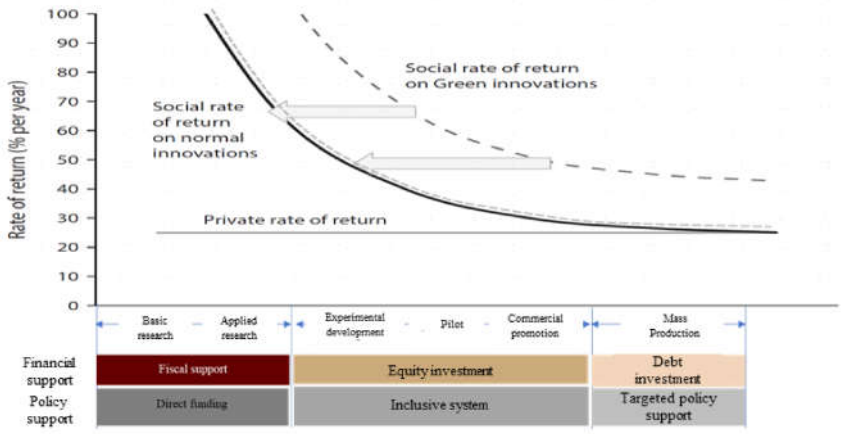

Figure 4 To address dual externalities, the financial sector in the field of green technology must provide comprehensive support throughout the entire chain

Source: CICC Global Institute

3.2 Capacity Expansion Financing Is Primarily Characterized by Its Policy-Based Financial Nature

When any industry enters the growth stage, it means that capital expenditure is accelerating, making this phase more sensitive to financing costs compared to other stages of the industry life cycle. This can be simply understood as a "capital shortage" period. As mentioned in the previous section, solar cells, wind power, new energy vehicles, lithium batteries, and other green industries in China have recently been in this growth stage. Therefore, the main task of green finance is to channel more lower-cost funds into these industries,

allowing these industries to expand their production capacity. To achieve this specific goal in industrial development, policies should provide clear direction for capital.

To guide the flow of capital, it is essential to first identify the sectors in which capital should be directed. In China's green finance policies, this is primarily achieved through the formulation of green project classification catalogues, which send clear signals to financial institutions, and by establishing incentive and constraint mechanisms based on these catalogs. Specifically, for green credit, the *Green Industry Guidance Catalog* (2019 Edition)[26], jointly issued by the National Development and Reform Commission and other ministries and commissions in 2019, makes energy-saving and environmental protection industry, cleaner production industry, and cleaner energy industry the central focus of the green industry. It also incorporates projects such as ultra-low emissions retrofitting of coal-fired power plants, clean utilization of coal, replacement of coal consumption with cleaner alternatives, and the production of gasoline and diesel products that meet China VI standards, thus providing positive guidance for the direction of green credit. As for green bonds, the release of the *Green Bond Endorsed Projects Catalogue* by the PBoC in December 2015 marked the official launch of China's green bond market. Subsequently, the *Green Bond Endorsed Projects Catalogue* (2021 Edition)[27], based on a four-tier classification, covers six major areas: Energy conservation and environmental protection, clean production, clean energy, ecological environment, green infrastructure upgrades, and green services. Moreover, it removed support for the clean utilization of fossil fuels, which had been included in the 2015 edition.

On the other hand, in order to enhance the transparency of the market and further strengthen the certainty of the green investment environment, China's green financial system also focuses on improving the norms in information disclosure, preventing the risk of "greenwashing", and assisting in the compliant and efficient use of green industry funds. For example, in 2012, the China Banking Regulatory Commission issued the *Green Credit Guidelines*[28], requiring financial institutions to regularly submit green loan data to the financial statistics monitoring and management information system. In 2018, the People's Bank of China issued the *Notice on Strengthening Supervision and Administration of Green Financial Bonds During Their Duration*[29], emphasizing the central bank's regulatory responsibility over green financial bonds during their term, and requiring financial institutions and the National Association of Financial Market Institutional Investors to take responsibility for information disclosure, updates, submission, and revision. In September 2021, the People's Bank of China issued the first batch of green finance information disclosure standards, namely the *Guidelines for Environmental Information Disclosure by Financial Institutions*[30]. These guidelines cover four types of institutions—commercial banks, asset management institutions, trust companies, and insurance companies—and set out a framework for information disclosure regarding service product innovation, risk management processes, and environmental risk assessments. They also specify the terms, frequency, and formats of disclosure, thereby providing support for standardizing green finance information disclosure.

3.3 To Finance Technology Innovation, the Attribute of Technology Finance Is Enhanced

3.3.1 Green technology innovation is highly uncertain

As mentioned earlier, green technologies that are in the early stages of development such as CCUS, hydrogen, and end-use electrification technologies will play an important role in the process of carbon neutrality

in China. However, early-stage R&D and selection of technologies require time. Due to the lack of established experience, clear and feasible technological pathways are not yet evident, which brings a high degree of uncertainty. Specifically, this uncertainty arises from three main factors:

First, technology routes are diversified, each with its own advantages and disadvantages in terms of subdivision criteria, making it difficult to judge which technology will be the first to make a breakthrough and bring the highest overall benefits in the future. Early-stage technology pathways present multiple possibilities. While the pros and cons of various technologies can be discussed on a theoretical level, predicting which path will yield the best overall results, succeed first, and scale up is challenging. At the same time, technological innovation itself has a high degree of uncertainty, making it difficult to predict when technologies will break through bottlenecks and realize qualitative changes. Green technologies often involve the combination of different technologies, and their interactions increase uncertainty in development. Synergy between technologies may occur, but mismatches can also degrade overall performance. For example, CCUS involves four aspects of technology: Capture, transportation, storage, and utilization (Figure 5). Theoretically, there are multiple technology routes to achieve the goals in each aspect, but most of the technologies have not yet been able to be popularized and applied. In terms of separation technology after capture, chemical absorption has been commercialized for decades, but no technological breakthrough has been achieved concerning the high energy consumption of solvent regeneration and high volatility. New technologies such as electrochemical and membrane absorption are being explored by various scientific research institutes. [31]These technologies are at various stages of R&D, each with pros and cons in terms of energy consumption, reaction conditions, durability, adsorption capacity, and application fields, making it difficult to determine which one is the best overall and deserves more attention and investment. Hydrogen energy presents similar characteristics: For hydrogen production, gray hydrogen technology is mature and low-cost, but fossil energy is scarce, emissions are high, and many impurities need to be purified; while "green hydrogen" based on zero-carbon electricity faces the challenges of low electrolysis rate and high cost of catalytic materials in electrolytic water hydrogen production and proton exchange membrane method. Meanwhile, blue hydrogen production leverages CCUS technology, and the intersection of technologies further complicates the prediction of technological routes develop.

Second, the initial costs of applying technology are high, which may include expenses for new materials, equipment, and infrastructure. The challenges in commercialization are significant, and the technology may struggle to mature through learning by doing, often remaining stuck at the prototype or demonstration stages for extended periods. This results in a prolonged duration of uncertainty. For CCUS, the high cost of equipment means that installing carbon capture devices could increase coal-fired electricity costs by Rmb0.26–0.4 per kWh under the current technological conditions, with each tonne of CO_2 absorbed raising coal power costs by Rmb140–600[32]. In terms of hydrogen energy, China's green hydrogen upstream production is concentrated in north China, northwest China, northeast China, and other renewable energy-rich areas, while the downstream demand is mostly distributed in east China, south China, and other economically developed areas. Hydrogen is flammable, explosive, corrosive, and brittle. As such, long-distance, high-security storage and transportation technology must be used to transport hydrogen. This ensures that hydrogen energy use is coordinated across regions. The end-use electrification also faces high costs. Electrification implies a comprehensive upgrade of new power systems, including generation, grid, load, and storage. The large-scale expansion and transformation of low-carbon electricity generation facilities, electricity infrastructure, and end-use electrification introduce complexity and high costs, potentially slowing down the adoption of green technologies. In this case, enterprises are caught in a technology adoption dilemma, and their willingness to

apply new technologies is negatively affected by high initial costs and uncertain returns. This hinders the scaling and industrialization of new technologies, preventing cost reductions through economies of scale and from gaining valuable experience. Consequently, these technologies may remain stuck in the "Valley of Death" at the prototype or demonstration stage, unable to undergo market testing to determine their feasibility (Figure 6).

Figure 5 CCUS Technology Routes (screenshot)

Source: IEA, China 21st Century Agenda Management Center, Global Carbon Capture and Storage Institute, Tsinghua University[33],YANG Pingjian et al. (2021),[34] CICC Global Institute

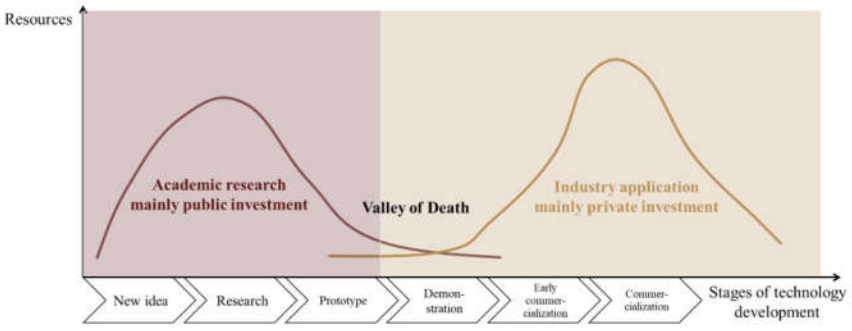

Figure 6 The "Valley of Death" for Technology Development

Source: CICC Global Institute

Third, the lag in institutional and market environments increases the uncertainty of green technology innovation. For instance, the development of CCUS technology relies on the profitability of reducing carbon emissions with this technology. Therefore, the certainty of CCUS technology development is

closely tied to the carbon price in the carbon market. According to the Intergovernmental Panel on Climate Change (IPCC), the scaling limit for CCUS technology is reached when the total cost of carbon capture and storage is between Rmb163–195 per tonne[35]. However, the current carbon market price in China is between Rmb70–100 per tonne[36], making it more economical for companies to purchase carbon emission rights directly rather than investing in CCUS projects. This reduces the incentive for large-scale adoption of CCUS technology. Similarly, there are bottlenecks in the electrification of end-use energy: Slow integration of renewable energy into the grid, insufficient electricity supply for trading due to incomplete market entry on the generation side, the absence of national-level electricity trading institutions, and the relatively slow development of a unified national electricity market. Therefore, the time lag in the construction and improvement of carbon and electricity markets makes it more challenging for technological progress to spontaneously and swiftly demonstrate clear prospects.

3.3.2 New green finance policies should ensure stability of expectations and inclusiveness of technologies

Due to the inherent uncertainties in the new task of green technology innovation for the green transition, it is necessary to establish a policy framework that provides both "long-term stable expectations" and "technological inclusiveness" to support the development of green technology innovation. Such a policy system should be able to: 1) Create long-term growth expectations, reduce innovation risks, and incentivize enterprises and research institutes to invest in the R&D and application of green technologies so that the track that receives investment has long-term income expectations, thus realizing a win-win situation for both environmental and economic benefits; and 2) it should also respect the autonomy and creativity of science, give sufficient space to the innovative enterprises or teams to develop freely, embrace the plurality of technology routes, and allow society at large to complete the process of selecting the optimal technology. Specifically:

First, the government should be able to send clear signals to the market that technology is expected to have stable demand in the long term. The production processes, application areas, and infrastructure requirements of technological innovation exhibit significant diversity and complexity. Each technological pathway carries a risk of failure, and this uncertainty often leads to insufficient investor willingness, necessitating government efforts to signal "stable expectations." Empirical research on M&A activities of listed companies in China confirms that government incentives for specific industries can effectively stimulate market dynamics and promote the flow of capital to these areas, which in turn leads to a boom in investment in the relevant industries.[37] Therefore, the government could use long-term strategies or purchase commitments to clearly indicate that these technologies will have stable market demand in the future, enhancing the certainty of future returns in the sectors receiving investment. This would strengthen investors' confidence in the growth potential of related technologies and attract their participation, creating fertile ground for technological competition.

Second, financial support should focus on longer-term returns rather than short-term profitability, so that there is sufficient space for various technologies to compete freely. Green technologies with both "technical feasibility" and "economic feasibility" often need to be screened over a long period of time before they can be realized, and this emphasis on the long term can provide more flexible room for technology innovation. The field of green technology innovation is full of unknowns and variables, and the uncertainty of

its technological development path and practical application scenarios requires us to adopt a multi-line parallel approach in our strategy. This diversified technology development strategy means that not all resources and hopes should be pinned on a single technology route or solution. Instead, exploration and experimentation of multiple technological ideas and application models should be encouraged and supported. In the long history of technological development, history has witnessed countless technologies from their birth to maturity and possible decline or transformation. Technologies that may have been disfavored because of their initial high costs and inefficiencies may, with continued innovation and improvement, become dominant forces in the marketplace. For example, the early steam engine was inefficient, but as the technology improved, the benefits of the steam engine continued to be realized, which ultimately drove the Industrial Revolution. This demonstrates that identifying and adopting the optimal technological path is a gradual process. If attention is only paid to short-term returns and avoid risks by funding only technologies with clear short-term profitability potential, the development of that particular path might be accelerated in the short run. However, the long-term opportunity cost could be the loss of a chance to discover a better technological route.

Third, from the perspective of the innovation chain, in the process of the diffusion of research and development results from scientific and technology innovation to industrial innovation, it is necessary for all types of institutions in the market to play a concerted role, that is, to build a more complete ecosystem. Promoting green technology innovation requires not only the use of financial institutions as financing intermediaries, but also the involvement of research institutions, universities, enterprises, and technology intermediaries, all of which should leverage their respective comparative advantages. Establishing an effective collaboration mechanism involving enterprises, universities, research institutions and financial institutions is essential to improving the efficiency of innovation. It is important to note that talent plays a crucial role in building a green technology innovation ecosystem. In this process, gender inclusivity should also be considered. According to a United Nations report published in 2019, women accounted for less than 30% of those engaged in scientific research and development globally.[38] Given that green technology innovation has significant spatiotemporal externalities and its ultimate users and beneficiaries are the entire human society, the underrepresentation of women in the use and participation of green technologies may lead to the selection of technological pathways that fail to maximize societal benefits. Therefore, more attention should be paid to employment opportunities for women in the green technology field, and their needs and perspectives should be more thoroughly considered in the design and deployment of green technologies.

4 Capital Markets: A Key Lever in the New Phase of Green Finance

4.1 Capital Markets Should Play a Greater Role in Green Finance

In China, the rapid growth of green capacity mainly relies on the strong support of debt financing centered on the banking system. This is a phenomenon that is closely related to the structure of China's unique financial system. China's financial system itself is dominated by banks, and the mode of support for the real economy is itself dominated by bank credit, bonds, and other debt financing tools, which is fundamentally different from countries such as the US (Figure 7). According to the Financial Statistics Report (2023) released by the PBoC, the cumulative increase in the scale of social financing for the whole year of 2023 amounted to Rmb35.59trn, of which RMB loans accounted for 62.4% of total social financing in the same period, government bonds accounted for 27%, corporate bonds accounted for 4.6%, and domestic equity financing for non-financial enterprises accounted for only 2.2%. Meanwhile, compared with other countries, the scale of China's stock market is small relative to the size of the economy. According to the latest data from Macro Micro, as of August 2024,[39] China's total stock market capitalization accounted for only 44.98% of GDP, much lower than that of the US (195.83%), Japan (158.65%), and India (125.37%) during the same period.

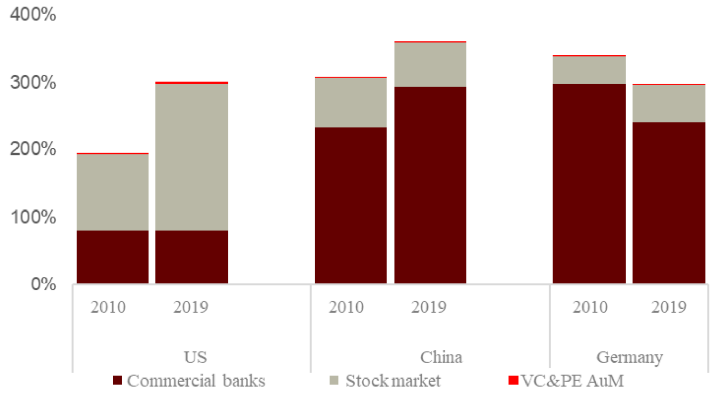

Figure 7 Financial Structure of China, the US, and Germany: Asset Size/GDP
Source: German Private Equity and Venture Capital Association, Japan Private Equity Association, Pitchbook, CICC Global Institute

As mentioned above, in the early stages of its development, China's green finance system has benefited from clearly defined development paths through policy tools such as the "Guidance Catalogue," which have clarified the boundaries for industry support and implemented targeted funding strategies. This has led to steady growth and gradual expansion in the scale of green bond financing. In recent years, China's green financial market, mainly consisting of "green credit" and "green bonds", has been expanding rapidly. In terms of market scale, China's green credit growth rate in 2023 consistently exceeded the growth rate of the total balance of loans from financial institutions. According to the PBoC, by the end of 2023, the balance of green loans in domestic and foreign currencies in China was Rmb30.08trn, ranking No.1 globally, with an average annual growth rate of over 20% over the past seven years. Additionally, the cumulative issuance of labeled green bonds in China exceeded Rmb3.4trn, ranking No.2 globally, with growth rates consistently

surpassing the general loan total growth rate since 2019. In contrast, according to Zero2IPO data[40], the cumulative amount of green industry investment in China's equity investment market from 2015 to 2022 was only Rmb569.2bn, showing a gap compared to the scale of bond financing. In terms of green finance resource allocation, China's green bond financing has strongly driven the rapid expansion of green industries. According to PBoC statistics, most of China's green credits have flowed into the category of "infrastructure green upgrading industry" covering green transportation, green energy infrastructure, and other fields, as well as the category of "clean energy industry", which includes solar energy and wind energy production (Figure 8). From 2020 to 2023, the growth rate of green loans in both the "infrastructure green upgrading industry" category and the "clean energy industry" category has exceeded 30%[41]. At the same time, more than half of the green bonds in 2022 went to the clean energy sector.

Debt financing, with its lower risk preference, large amounts of capital, and quick availability, aligns well with the characteristics of expanding green industries. On the one hand, as mentioned above, wind and solar technologies are relatively mature and are already widely applied and have a large market base. The performance, cost, and reliability of these technologies have been verified by the market, and the technologies have stable market demand, making the capacity expansion process relatively clear and predictable. Debt financing, precisely due to its lower risk appetite, is more suitable for supporting industries that have demonstrated clear market demand and more mature and stable technologies. On the other hand, green industries such as photovoltaic and wind energy have manufacturing attributes and are capital-intensive, requiring a large amount of capital to build infrastructure such as wind power stations, solar photovoltaic panels, and related grid support facilities. Debt financing tools, with shorter procedure cycles and the huge capital reserve of the banking system, can precisely and efficiently meet the expansion needs of these green production capacities.

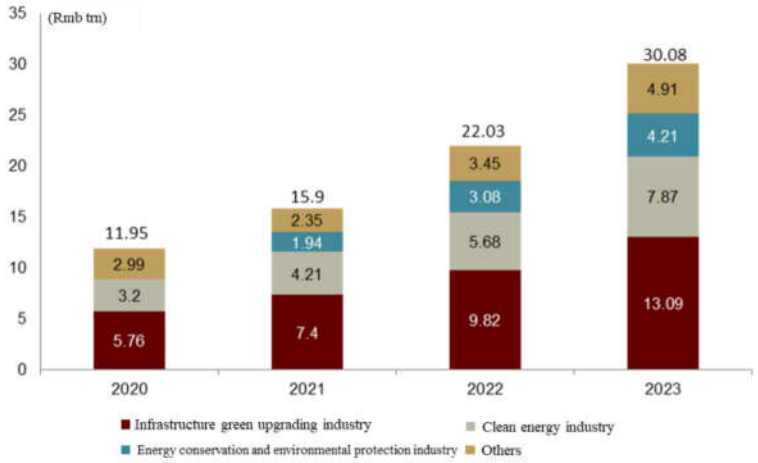

Figure 8 Balance of Green Loans in China (by Industry, 2020-2023)
Source: People's Bank of China, CICC Global Institute

However, the development of green finance needs to keep pace with the times, continuously innovating and improving financial products and services that match the corresponding stages of development. As the central role of green technology innovation in promoting green transition becomes more and more prominent, how to effectively deal with the 'uncertainty' in the process of technology innovation has become a new challenge for China. It has led to a gradual change in green finance – previously the main challenge was a "shortage of capital", whereas now it is a "lack of risk-takers". The traditional debt financing model is not sufficient to meet this new challenge, and its limitations are becoming more and more obvious, and it is no

longer sufficient to support the new round of demand for green development. **Green technology innovation urgently requires equity financing to take on a more core responsibility, thereby promoting the development of green technologies, accelerating their application, and injecting new vitality and momentum into the sustainable development of China's green economy.** The adaptability of equity financing in supporting green technology innovation is primarily reflected in the following three aspects.

First, the uncertainty of green technology innovation routes and the lack of collateral make equity financing more capable of bearing risks. From the viewpoint of industrial characteristics, most green technology innovation enterprises are small and medium-sized private companies with few tangible assets to offer as collateral, relying instead on intangible assets such as brand, technology, and intellectual property. The capital invested by equity investors focuses on the long-term value-added potential of the enterprise and its future rights to yields. This value-added potential is mainly based on the forward-looking and practical nature of technology development rather than on the value of the enterprise's existing assets, which is the focus of debt financing. From the perspective of technology development, as mentioned above, green technology innovation faces uncertainties such as multiple routes and short-term difficulty in judging comprehensive benefits. According to the National Intellectual Property Administration, in 2022, the industrialization rate of invention patents of Chinese startups was 22%, meaning only 22% of patents eventually result in products being produced and brought to market. Equity investors tend to take higher risks because they are concerned not only with the success rate of their investment, but also with the potentially relatively high return on investment once the project is successfully industrialized.

Second, green technology innovations have a long and uncertain road to commercialization, while equity financing has more patience for the return on investment. Early-stage technology innovation requires a lengthy process of route selection and gradual demonstration of economic potential. Historically, technologies such as PV, wind power, and nuclear power experienced development periods of around 20 years before commercialization (Figure 9)[42]. A report from Tsinghua University pointed out that the investment cycle of most green technology enterprises lasts 5–10 years[43], but the average term for traditional bank loans in China is only 2–3 years. Additionally, the issuance period for green bonds is also relatively concentrated in the 1–5 years range (Figure 10), making it difficult to match the R&D cycle of green tech innovation. In contrast, as equity investors usually seek long-term returns and are more willing to accept short-term uncertainty and volatility, they are able to give "patient" support to green technology innovation.

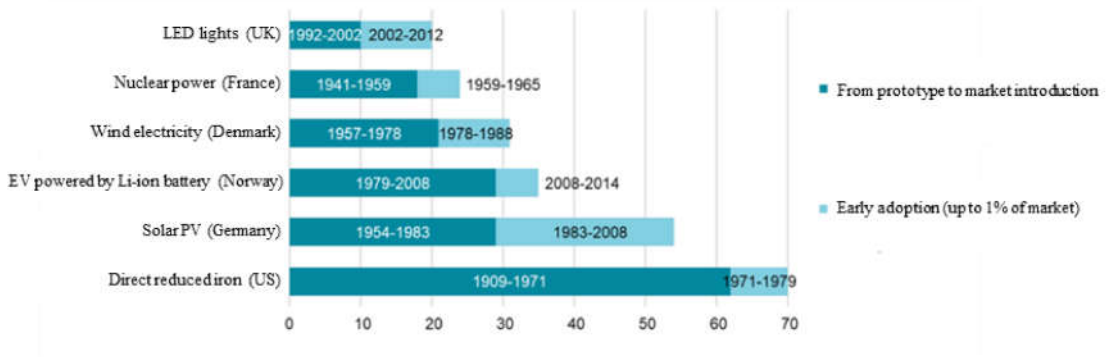

Figure 9 R&D and Commercialization Cycle of Typical Green Technologies
Source: IEA, CICC Global Institute

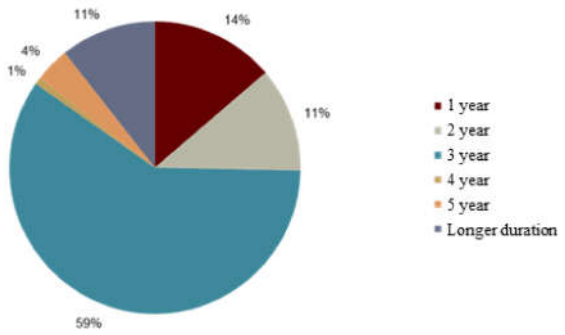

Figure 10 Maturity Structure Distribution of Labeled Green Bond Issuance in 2023
Source: Green Bond Environmental Benefit Information Database, CICC Global Institute

Third, equity investors are more diverse, which helps in the selection and application of green technology innovations. Technologies, products, and business models with a broad audience need to be fully competitive in a market economy, in which the "winners" of innovation emerge over the long-term evolutionary process, and should be chosen by the broad base of end-users.[44] Since the end consumers of green technologies like hydrogen energy and CCUS include a wide range of businesses and individuals, their preferences are diverse and often change. As a result, technological routes, products, and business models need to undergo a process of elimination to meet customer needs. The composition of participants in equity markets is more diverse and complex than in traditional debt markets. The main players in the debt market are usually banks, whose role in project selection and demand assessment is relatively limited. In contrast, equity market participants include not only private equity funds and other financial institutions, but also real enterprises behind industrial capital, government guiding funds, as well as angel investors, venture capitalists, and individual retail investors. Among such equity investors, there is no shortage of direct users of green technology innovations. They are able to approach investment from diverse perspectives, combining their specialized preferences, and through their investment activities, facilitate the rapid selection and optimization of green technologies. This process not only accelerates the matching of innovative technologies and market demand, but also ensures that the supported technological solutions can effectively meet the actual needs of end-users, thus enabling the success rate and market adaptability of technology innovation.

Therefore, the key to supporting green technology innovation lies in leveraging the central role of capital markets. With a higher tolerance for risk and a greater patience for longer investment cycles, capital markets are well-suited to fostering innovation. Additionally, their decentralized financing structure, characterized by distributed decision-making and investment behaviors, enables support across diverse fields and technology pathways. This dynamic fosters an innovation ecosystem in which various sectors mutually promote and compete with each other. As a result, capital markets' financing model is highly inclusive and aligns with the inherent uncertainties of green technological innovation pathways. In the following section, the study analyzes how the capital market can better support green technology innovation.

4.2 The Unique Advantages of Capital Markets: Ecosystem Effect and Selection Effect

The capital market has two unique advantages in promoting breakthrough innovation: The ecosystem effect and the selection effect.

The ecosystem effect refers to the fact that the decentralized capital market can provide financial support for all fields, which is conducive to the formation of an innovation ecosystem in which all fields promote each other and develop together. The fiscal-led and bank-led technology financing models are both centralized decision-making investment and financing models, and have the problem of being a single decision-making body, which means that these two models will inevitably support only a few fields because of the decision-making body's single risk preference, single investment preference, or cognitive bias. It is not conducive to the formation of an innovation ecosystem in which all fields develop together and promote each other. In contrast, the capital market, with its diverse investors with different risk appetites, investment preferences, and knowledge systems, offers a decentralized decision-making financing system, so that even if some investors exclude investment in certain fields, there are still other investors who are optimistic about these fields and invest in them, and thus the capital market is more capable of providing financial support to all fields equally, which is more conducive to the formation of an innovative ecosystem that is in turn conducive to the development of breakthrough innovation.

The selection effect refers to the capital market's superior ability to "bet" on successful technology routes. Even if a certain field is identified as important, there are often multiple technology routes in the field. Before the eventual success of a particular route, no one can accurately predict which route will succeed. In practice, when faced with the dynamic uncertainty of breakthrough innovation, the technology financing model led by the capital market demonstrates a stronger ability to bet on successful technological paths. This is due to two main factors: 1) Decentralized decision-making: The capital market operates as a decentralized financing system, consisting of numerous investors with varied risk preferences, investment preferences, and knowledge bases. This means that the capital market can provide funding for all technological paths. A large number of investors have made investments in various technological pathways within the current PV industry, including some niche technologies that are still in the early stages of research, which have also attracted some investors. In other words, the capital market's ability to bet on successful technological paths for breakthrough innovations is not due to the superior intelligence of investors but because the capital market invests in multiple technological paths. 2) Consumer representation: The success of a technological path often hinges on whether its products gain broad consumer recognition. Many investors in the capital market are also actual consumers, and their endorsement of a specific technological path reflects consumer acceptance of that technology and its products. As a result, technological paths supported by the capital market tend to have a higher success rate when launched in the market, thereby increasing the likelihood that the capital market will identify successful technological paths.

In short, the capital market promotes breakthrough innovation by leveraging its ecosystem and selection effects to build an innovation ecosystem that is conducive to mutual development across various fields and technology routes, ultimately achieving sustained breakthrough innovation capability. The capital market can be divided into two parts: The private equity market (referred to as the "equity market"[1]) and the public stock market (referred to as the "stock market").

[1] Venture capital (VC) can be defined in both broad and narrow terms: Broadly speaking, it includes equity investments by independent venture capital firms, government venture funds, corporate venture funds, and other institutions in non-listed companies. Narrowly speaking, venture capital typically refers to investments in startups, alongside angel investments in earlier stages and private equity (PE) investments in later stages. In this article, "venture capital" refers to its broader definition, which aligns with the broader concept of private equity PE investment. Similarly, "venture capital market" in this article also refers to the broad concept, essentially corresponding to the private equity PE market.

The core difference between the two lies in whether securities are publicly issued, leading to differences in regulatory stringency, information disclosure, investor composition, liquidity, etc. Generally speaking, due to their small scale and unstable profitability, it is often difficult for start-ups and SMEs to obtain financial support from banks and the public stock market. However, equity markets, primarily composed of PE, VC, and other professional investors, have a relatively high risk appetite despite the small size of their total capital, and are more willing and capable of supporting the breakthrough innovation activities of start-ups and SMEs with relatively higher risks but smaller funding needs for individual projects. That is, the VC market for unlisted enterprises is where breakthrough innovation happens.

Compared with the equity market, the stock market has a large number of investors and can provide a larger scale of capital, but it often has certain requirements for listed companies in terms of assets, earnings, and other financial indicators, and it is difficult for start-ups and SMEs to meet the relevant requirements for listing, meaning that the stock market is more capable of supporting the incremental innovation of large enterprises. In addition, empirical studies show that on the one hand, IPOs enhance the financial strength of enterprises, improves their ability to promote innovation through M&A, and helps to increase the number of innovations of enterprises after IPOs (Figure 11); on the other hand, enterprises face stronger external constraints after going public. For example, post-IPO, the likelihood of internal technical staff loss increases, high stock price volatility reduces the willingness to undertake high-risk breakthrough innovation, and stricter information disclosure requirements lower the expected returns from such innovations. Consequently, the proportion of breakthrough innovation decreases significantly after an IPO, while incremental innovation proportions rise.

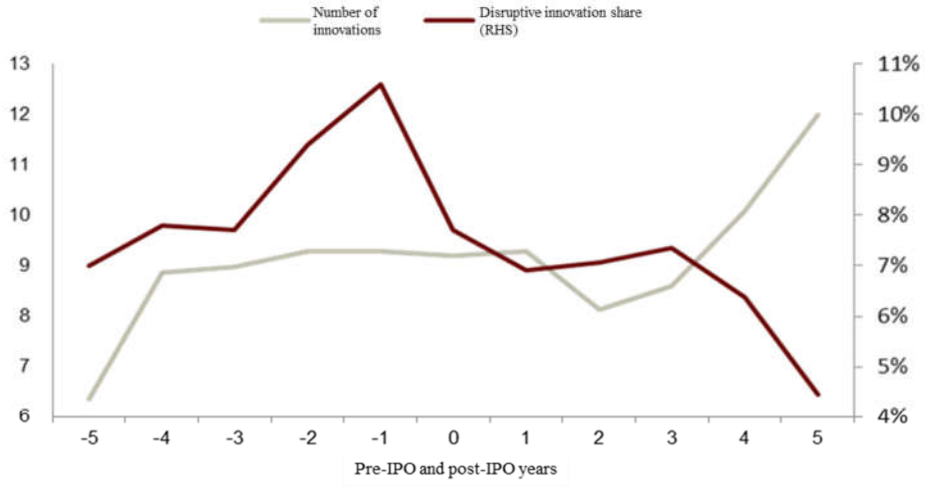

Figure 11 After IPOs, the Number of Innovations Increases, but the Share of Breakthrough Innovations Decreases

Source: Simone Wies, C. Moorman (2015)[45], CICC Global Institute

The reason why VC and other risk investors are willing to provide funding for high-risk breakthrough innovations by startups and small-to-medium enterprises is not to promote breakthrough innovation, but to ensure a smooth exit and achieve desirable returns on investment. Therefore, the availability of clear exit channels significantly impacts the willingness of risk investors to invest. Thus, the smoothness of exit channels significantly influences VC investors' willingness to invest. In practice, IPOs and M&As are the two most important exit methods for VC investors (Figure 12), and the smoothness of these two

exit channels is closely related to the prosperity of the stock market (Figure 13). On the one hand, a thriving stock market can accommodate more listed companies, offering greater opportunities for IPO exits. Statistical data shows that returns on investment through IPO exits are significantly higher than those through M&A. As a result, a booming stock market, by providing IPO exit channels and generating higher investment returns, enhances the willingness of VC investors to invest and increases the future capital available for new rounds of venture investments. On the other hand, studies on the US capital market reveal that listed companies are major players in the M&A market, with over 60% of M&A transactions involving US listed companies as acquirers. These companies frequently use stock as a payment method in M&A transactions. When the stock market prospers, the shares the target company acquires as part of the agreement should rise significantly. Being able to offer equity as payment offers listed firms an advantage when pursuing M&As. This facilitates VC investors' exits through M&A, as reflected in the high positive correlation between US VC M&A exit volumes and US stock market fluctuations. Therefore, creating a capital market-led technology financing system to promote breakthrough innovation in green technologies requires recognizing both the direct role of the VC market and the positive impact of the stock market in facilitating VC investors' exit channels. The effective interaction between the VC market and a thriving stock market can jointly promote breakthrough innovation in green technologies.

Figure 12 Proportion of M&A and IPO in US VC Exit Strategies

Data source: Pitchbook, Wind, CICC Global Institute

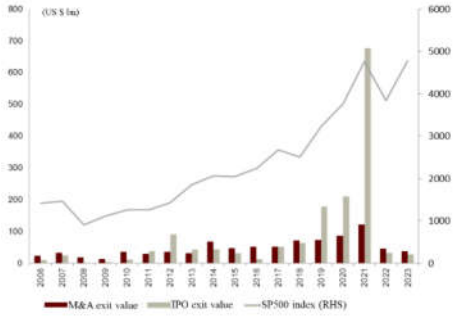

Figure 13 A Thriving Stock Market Facilitates VC Exit Channels

5 Challenges Faced by China's Capital Markets in Supporting Green Innovation

In recent years, both the VC market and the stock market in China have encountered several challenges. For example, difficulties in fundraising within the domestic VC market and a lack of diversity in investment entities and preferences have diminished the efficiency of promoting breakthrough innovation. More critically, the challenge in finding exit channels has intensified the trend of increasingly homogeneous investment preferences in the domestic VC market. This undermines the capital market's ecosystem effects and selection effects in promoting breakthrough innovation. Specifically, the current challenges facing the domestic capital market in supporting breakthrough innovation are as follows:

5.1 Fundraising Side: The Difficulty of Fundraising for Domestic Venture Capital is Becoming Increasingly Prominent

The domestic equity market is currently facing severe fundraising difficulties, which have diminished its ability to promote breakthrough innovation in the green sector. In 2018, funds raised for VC in China was US$131.4bn, but by 2022, it had decreased to US$52.8bn. In contrast, during the same period, US VC fundraising increased from US$71.8bn in 2018 to US$188.4bn in 2022 (Figure 14). Given that fundraising is a vital prerequisite for investment, the continued decline in fundraising in the domestic equity market limits the financial support available for the green sector, hindering its ability to support breakthrough innovation in this area.

Research shows that the "New Asset Management Regulations" are closely related to fundraising activities in the domestic equity market.[46] The 2018 new regulations on asset management explicitly state that "Financial institutions shall not provide channel services for other financial institutions' asset management products to circumvent investment scope, leverage constraints, and other regulatory requirements. Asset management products can reinvest in an additional layer of asset management products, but the funds receiving the investment can only reinvest in public securities investment funds.".[47] Although the "New Asset Management Regulations" have played a positive role in governing financial irregularities and preventing systemic financial risks, they will also likely affect the channels through which bank funds enter the equity market via trusts and other means.

Moreover, the A-share market for IPOs further influences equity investors' willingness to invest in the green sector. According to statistics from the Wind database, the number and financing scale of new IPOs in wind power, PV, and lithium batteries have continued to decline as a proportion of the total number and financing scale of A-share IPOs over the past three years. Since IPOs are the main exit channel for domestic equity investors, the difficulties in exiting through IPOs in the green sector further diminish equity investors' willingness to support early-stage small and medium-sized companies in this field. This situation places greater fundraising pressure on domestic equity funds and investors focused on the green sector.

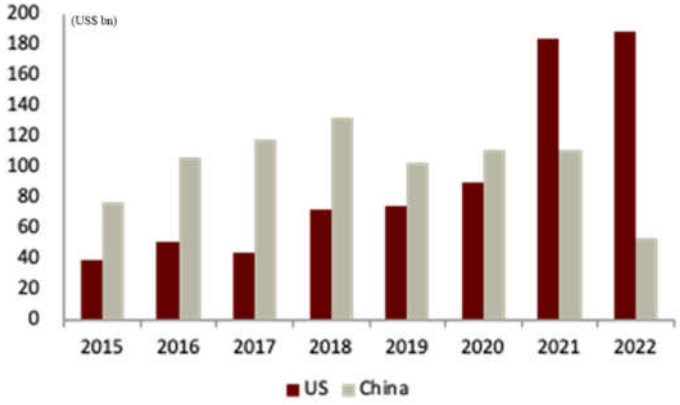

Figure 14 Annual Fundraising Amount Comparison Between China and US VC Markets
Source: Pitchbook, CICC Global Institute

5.2 Investment and Management Side: Investment towards Lower Risk and Shorter Time Horizons, with Management Capabilities Needing Improvement

In the context of the difficulties in fundraising, government-backed funds such as industrial guidance funds have become increasingly important for VC fundraising. For example, the proportion of industrial guidance funds[1] in the committed capital of domestic private equity funds was only 22% in 2017, but rose to 37% in 2023 (Figure 15). Considering that there are also many SOEs among industry capital investors, according to Zero2IPO's statistics on the fundraising amounts of domestic equity funds, government-backed funds may now account for more than half of the capital in China's VC market, with substantial contributions from local governments, which has significantly alleviated the difficulties in fundraising in the VC market.

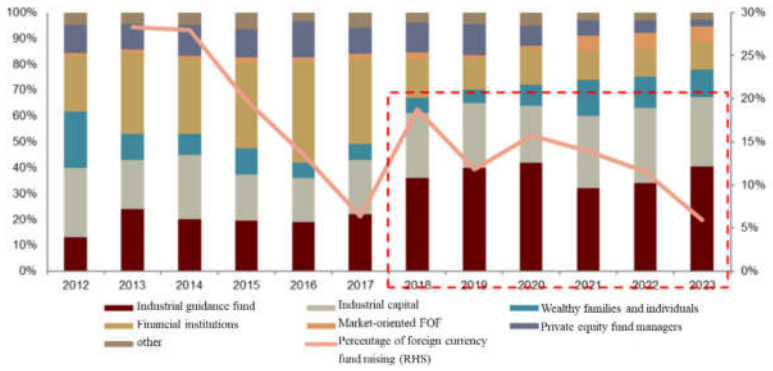

Figure 15 The Exit of Foreign Capital Since the Pandemic Has Exacerbated the Fundraising Winter in China's Venture Capital Market
Source: Zero2IPO, CICC Global Institute

[1] Besides government guidance funds, this category also includes government agencies and government-funded platforms. Given the similarities in their investment preferences and management models, they are collectively referred to as industrial guidance funds for the sake of simplicity.

However, industrial guidance funds also face some practical constraints in their investment and operational processes, which makes some of its characteristics unable to perfectly align with the need for promoting breakthrough innovation in the green industry. These constraints are reflected in several key aspects:

First of all, industrial guidance funds have strong demand for stability, which suppresses their risk appetite as they make investments, making them less conducive to supporting high-risk breakthrough innovations. Breakthrough innovation is a kind of economic activity with high levels of uncertainty, and the more disruptive and leading it is, the greater the risk for investors. Therefore, VCs typically do not achieve profitability through a high success rate of invested projects but rather through high returns from a few successful projects while bearing a high failure rate. However, industrial guidance funds, due to their public funding nature, neither pursue high returns from individual projects nor are willing to bear high failure risks. Notably, two factors have recently intensified the stability-seeking tendencies of industrial guidance funds in equity market: First, in the context of not yet having established a mechanism for clarifying the reasons for the failure of the projects seeking investment, the ever-increasing pressure of accountability has prompted the government to seek more stability in the limited partner (LPs). Second, along with the growth in the scale of industry-led funds, media attention on them is increasing, and the growing risk of negative public opinion related to failed investments is reinforcing the preference of industry-led funds for stability (Figure 16). As of 2021, 73.4% of industrial guidance funds' direct investment projects in the green sector were in the expansion and maturity stage, while 85.6% of total investment was in the expansion and maturity stage[48]. Additionally, among the green industry equity funds in which industrial guidance funds invest through sub-funds, growth funds and acquisition funds made up nearly 70% of the scale. This tendency to favor later-stage projects and sub-funds reflects strong demand for stability and a lower risk appetite among investors in the green sector.

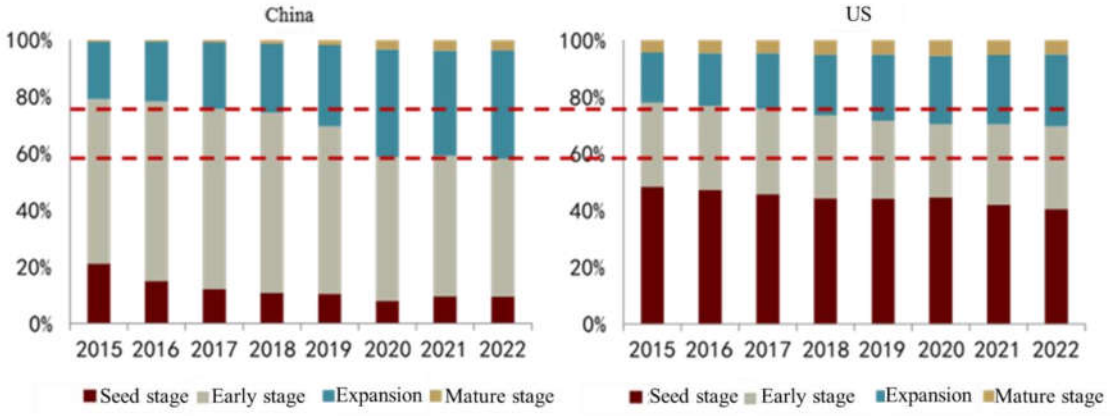

Figure 16 Increasing Preference for Stability in the VC Market with the Rising Proportion of Public Funds such as Industrial Guidance Funds

Note: Here, the proportion of investment counts is referred to, with the seed stage corresponding to the angel and seed categories in PitchBook investment types, the early stage corresponding to the early-stage VC category, the expansion stage corresponding to the late-stage VC category, and the mature stage corresponding to the venture growth category

Source: Pitchbook, CICC Global Institute.

Second, industrial guidance funds tend to invest in short-term projects that yield quick returns, which does not align with the long-term capital needs for breakthrough innovation in the green sector. Breakthrough innovation activities are usually characterized by high uncertainty and long R&D cycles, and thus require long-term funding support. The relative shortage of long-term funding is a significant shortcoming of the domestic equity market. The average holding period of VC projects, for example, during 2010-2023, was about 4.8 years

in the US and only 2.8 years in China. The reasons behind this are complex. Industrial guidance funds and other government funds have dominated China's equity investment market. Industry guidance funds tend to have a relatively short assessment period, while government funds are subject to the directives of local government officials who have brief tenures. All of these have imposed constraints on the investment of the industrial guidance fund. Specifically, in the green technology sector, according to statistics from the Zero2IPO database, the average holding period for venture capital investments in the clean energy sector (including four sub-industries: New energy, new materials, environmental protection, and other clean technologies) from 2010 to 2023 was 2.6 years. The average holding periods for new energy and new materials were 2.5 years and 3.6 years. This short holding period is detrimental to supporting breakthrough innovation in the green sector.

Finally, industrial guidance funds also have problems such as the level of operational specialization needs to be improved, strengthened market segmentation, and poor continuity of capital investment, which limit their function of promoting breakthrough innovation in the green industry. 1) Fund operation: It is not uncommon for staff representing government LPs to lack professional experience, leading to high communication costs between market-oriented (GPs) and government-backed LPs. A 2021 survey of 361 GPs found that excessive investment intervention by government LPs was considered the greatest disadvantage of government funds (Figures 17, 18)[49]. Additionally, some industrial guidance funds with direct management models face issues such as complex team structures, high proportions of functional departments, and lengthy investment decision processes with multiple levels of review. 2) Investment targets: Although many industrial guidance funds are established to promote technological innovation, their original intent is often to attract investment through equity financing. Consequently, these funds may impose rigid requirements on investment direction, geographic focus, and reinvestment ratios, which may exacerbate market segmentation risks and hinder the ability to leverage China's economies of scale to promote innovation. 3) Sustainability of funding: In the current context of high debt pressure on local governments, there is uncertainty regarding the amount of additional funds that can be invested in industrial guidance funds.

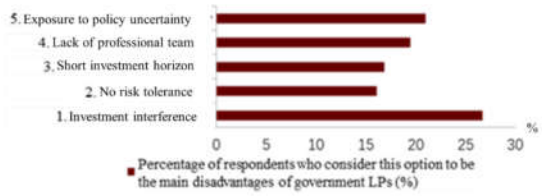

Figure 17 Major Drawbacks of Government LPs as Perceived by GPs.

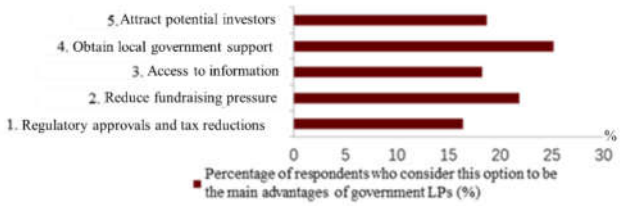

Figure 18 Major Advantages of Government LPs as Perceived by GPs

Source: Emanuele Colonnelli, Bo Li, and Ernest Liu. Investing with the Government: A Field Experiment in China. Journal of Political Economy, 2024, CICC Global Institute.

5.3 Exit Side: The Tendency of Investment Homogenization in the Equity Market

As mentioned earlier, promoting breakthrough innovation in the green sector through the capital market relies on effective interaction between the equity market and the stock market. For domestic equity investors, IPOs are one of the most important exit channels, IPOs are also an important lever for the capital market to promote breakthrough innovation in green technology by leveraging ecosystem effects and selection effects.

Faced with the "choke point" risks in certain areas such as semiconductors, the establishment of the Science and Technology Innovation Board in 2019 marked a proactive stance by the A-share market to support the listing of hard technology companies and to help China overcome these risks. Against this backdrop, the proportion of hard technology companies in A-share IPOs has been gradually increasing. Taking the semiconductor industry as an example, in 2019, there was one semiconductor company IPO in the A-share market, with total fundraising amount of Rmb2.8bn; this accounted for 0.5% and 1.1% of the total number and total fundraising amount of A-share IPOs that year. In contrast, in 2023, there were 23 semiconductor company IPOs in the A-share market, with total fundraising amount of Rmb70.8bn, representing 7.3% and 19.9% of the total number and total fundraising amount of A-share IPOs that year (Figure 19). The strong preference for hard technology companies in A-share IPOs has led to a growing concentration of domestic equity market investments in hard technology fields (Figure 20). According to statistics from Zero2IPO, the proportion of equity investment in hard technology sectors rose from 28% of the total annual investment in the domestic equity market in 2019 to 61% in 2022. In 2022, over half of the equity investment in hard technology was directed towards the semiconductor and electronic equipment industries. The data indicates that over the past few years, the domestic capital market has played a significant role in promoting the development of the hard technology industry and in resolving "choke point" risks. However, the continuous aggregation of capital market funds towards the hard technology sector has also led to the green industry equity market facing a shortage of incremental capital. This poses a challenge to the continuous achievement of breakthrough technological innovations in the green industry.

However, it is important to emphasize that there is no direct correlation between a company's current profitability and its future innovation capabilities. Major tech companies in the US such as Amazon, Tesla, and Meta were also unprofitable at the time of their IPOs. Moreover, considering that breakthrough innovation activities in the green sector often involve long R&D cycles, significant upfront investments, and difficulties in achieving early profitability or stable profits, it is common for companies engaged in such activities to be unprofitable. For example, the perovskite solar cell technology was first proposed in 2008, and there are currently several unlisted companies in China developing and applying this cutting-edge technology. However, due to challenges related to material stability, efficiency degradation, and lifespan, perovskite batteries have not yet seen widespread application, and most related companies remain unprofitable. Companies engaged in breakthrough innovation activities in the green sector may not yet be profitable and require financial support. Therefore, more efficient exit channels are needed to facilitate continuous breakthrough innovation and technological iteration upgrades in China's green industry.

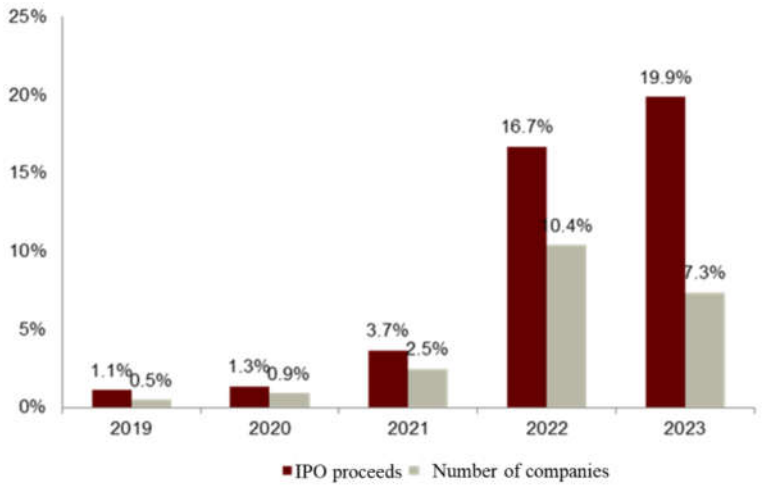

Figure 19 The Proportion of Semi-conductor and other Hard Technology Companies in A-share IPO Fundraising Has Increased in Recent Years.
Source: Wind, CICC Global Institute

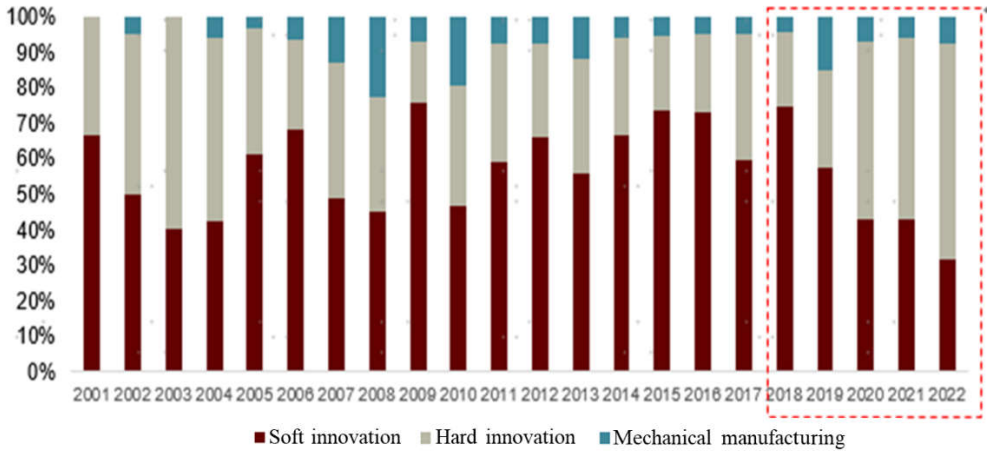

Figure 20 Domestic Equity Market Investments Increasingly Focused on Hard-Tech Sectors
Note: Hard technology mainly includes semiconductors and electronic equipment, clean technology, and biotechnology/healthcare; soft innovation mainly includes Internet, IT, telecommunications and value-added services, finance, and entertainment media.
Source: Zero2IPO, CICC Global Institute

6 Policy Recommendations

6.1 Real Economy Policies: Creating Green Demand and Enhancing Green Returns

Policies supporting green technological innovation in the real economy need to be based on "technology neutrality," which means shifting from a system that selects specific technologies to a technology-neutral policy framework, laying the foundation for the capital market to fully leverage its ecological and screening effects. Specifically, efforts should be made in two aspects: First, by playing an active role in fiscal policy, and second, by improving the carbon market pricing system. Before delving into specific recommendations, it is necessary to make the following clarifications: The construction and improvement of the carbon market is a complex project that needs to be advanced gradually, and its impact may be felt slowly. In contrast, fiscal policy can more directly support green technological innovation by creating market demand for green technologies through government procurement and direct subsidies. At the same time, China's general fiscal support measures for green technological innovation are already relatively comprehensive, including purchase subsidies for green products, financial assistance for trade-ins, and the Ministry of Finance's existing policy of Rmb40bn for green building procurement, all of which can play a role in promoting green innovation. The following will not elaborate further on these points. The policy recommendations in this article will focus on how fiscal policy can directly promote breakthrough innovation.

Recommendation 1: In the bidding mechanism for green procurement, adopt a "quantitative carbon reduction performance" model instead of a "procurement list" model

According to the World Bank, government public procurement directly or indirectly affects 15% of global greenhouse gas emissions[50], which is seven times the emissions of the entire aviation industry. Therefore, the role of green procurement in green transformation should be strengthened. Currently, China's green procurement system is mainly based a government procurement list model, and promoting breakthrough innovations with high uncertainty is challenging. A more direct approach might be the "quantitative carbon reduction performance" model. Under this model, first, it is necessary to clearly define the quantitative emissions reduction targets and performance standards that green products need to achieve, providing clear guidance and stable expectations for product suppliers and related investors. Second, it is important to encourage the use of competitive bidding mechanisms as the market ultimately needs green technologies that are both "technically feasible" and "economically feasible." Bidding encourages strong motivation for innovation by producers, and the government can use indicators such as "product life cycle carbon intensity" and "production costs" as bidding benchmarks, continuously selecting and supporting the best green technologies. Third, the government could provide additional procurement price preferences for breakthrough technologies to promote continuous innovation by producers and encourage long-term investment. For example, in New York State's "Low Carbon Concrete Leadership Act," bids with carbon capture and utilization, carbon mineralization, or other technological breakthroughs are given more procurement discounts, promoting producers' continuous innovation in low-carbon solutions.[51]

The Australian government's 10-year Low-carbon Power Purchase Agreement provides an excellent example (Box 1). By committing to purchase low-carbon electricity for 10 years, the government creates a predictable market environment for low-carbon electricity technologies, enhancing investors' confidence in the

long-term growth potential of the sector. At the same time, the government does not interfere with technological competition, avoiding preferential support for specific technologies, and instead fosters a fair environment for technological development. The government adopts a "results-oriented" approach, incentivizing competition among electricity suppliers through biannual power purchase auctions. In these auctions, the lowest bid is the criterion, ensuring that the most cost-effective and feasible low-carbon power technology prevails in the market. This approach not only promotes technological diversity but also ensures close alignment between technology advancement and market demand, providing strong market incentives for the continuous optimization and cost reduction of low-carbon power technologies.

Box 1 Australian Government's 10-year Low-Carbon Electricity Purchase Agreement Proposal[52]

In 2012, the Grattan Institute in Australia released a policy proposal suggesting the use of auctions for long-term government power purchase agreements to reduce the risks for companies that are demonstrating early-stage green technologies. This approach aims to promote competition among different technological pathways, achieving low-cost and efficient low-carbon electricity production.

Specifically, the government would first identify the types of technologies it wishes to support, such as PV, concentrated solar power, wind power, CCUS, etc. Then, every six months, the government would auction off 20-year electricity power purchase contracts by technology category for a total of 10 years. Bidding companies would offer their promised prices for producing low-emission electricity over the next 20 years, and the lowest bidder would win. After signing the contract with the government, the company would finance the project through the market. The government would not provide upfront payments or specify particular technology routes but would only pay for the electricity generated by the company based on two criteria: First, the difference between the contract carbon price and the actual carbon price. The contract carbon price is a predictable and guaranteed forward carbon price that changes over time according to the rules stated in the contract. When the market carbon price is higher than the contracted carbon price, companies must return the difference to the government. The second criteria is the green premium, which is the difference between the green electricity price promised by the successful bidder and the market price of electricity.

The purpose of setting technology categories is to create distinct bidding tracks without limiting the diversity of technology development. First, the government only specifies broad technology categories and does not use specific technology paths as criteria for selecting firms. Second, the auction includes two "open categories" and a "new entrants category" with demand and size as additional evaluation criteria to ensure that new technologies also have a chance to win. Third, the government constantly updates the scale of contracts in the technology categories and the categories themselves, reducing support for technologies whose costs consistently fail to decrease.

The advantage of auctions lies in introducing market competition which quickly reduces the costs and risks of applying new technologies. However, to achieve this, it is crucial to avoid lowball bids, moral hazard, and erroneously supporting projects that are able to sustain themselves, leading to inefficient resource allocation. To this end, the report recommends the following measures. First, enterprises face rigorous qualification assessments and are required to pay a security deposit. Enterprises must pass technical and business reputation assessments and, before submitting bids, must be certain that they will be able to obtain financing and cooperate with due diligence if they are successful in the bidding process. If a winning bid is below the government's initial project floor price, the company must pay a security deposit. Second, the contract may be terminated due to inaction of the enterprise. The government has the right to cancel the contract if the project is not successfully financed within three months of signing the contract, does not start construction within 12 months, or fails to provide low-carbon electricity for 24 months after the contracted date. Finally, projects are oriented to support commercialization. Government contracts do not target scientific research and theoretical exploration, nor do they support technologies for which adequate financing is already available. In addition, if the carbon price rises and the project becomes viable for independent commercialization, the government will reduce or terminate its support to ensure that resources are used efficiently.

The government payment model shares risk among multiple entities, accelerating the commercialization of early-stage technologies. First, the 20-year government purchase contracts provide long-term certainty for low-carbon power technologies, lowering financing barriers for companies. The market is

incentivized to invest in technologies with high short-term uncertainty but long-term potential for low-cost emissions reduction. Second, by raising the carbon price, the government reduces the credibility risk of the carbon market, preventing companies from favoring highly certain but less efficient mature technologies. Third, the government payment is results-oriented and is not involved in the intermediate stages, and projects are operated by market players. Project delivery, market, and technical risks are borne by developers and investors, preventing the government from investing in and operating suboptimal or incorrect technological routes due to a lack of ability to identify the best projects and commercial motives.

Recommendation 2: Establish a green performance auction fund connected to the financial market

Financial markets possess an inherent advantage in addressing the information asymmetry issues in the green transition, enabling more effective pricing for corporate green actions. Fully leveraging the role of financial markets can help make the green transition process smoother and more efficient. However, in reality, there is misalignment between financial markets and green transition policies in terms of incentive mechanisms, leading to an inability to effectively mobilize the enthusiasm of financial markets and resulting in low participation of financial markets in the green transition. To address this, it is recommended to use "green auctions" to tackle the externalities and scale constraints in the green transition by combining government incentives with the pricing power of financial markets and the flexibility and innovation of the private sector.

The Green Auction Fund, capitalized by public funds, can be operated in three stages. In the first stage, the Green Auction Fund announces to the public the amount of funds and the duration for projects supporting the green transition. In the second stage, the fund accepts bids from companies for emissions reduction and funding needs. Based on the bids, the fund commits to purchasing carbon emissions reduction quotas (or equivalent carbon emissions reduction by green technologies) credits for the most competitive green transition projects, but does not pre-pay funds at this stage. In the third stage, after the winning bidders complete their green transition projects within the specified period, the fund pays the bidders according to the actual carbon emissions reduction or equivalent carbon emissions reduction of green technologies, as committed. If the carbon market price exceeds the fund's purchase price, companies also retain the right to sell carbon emissions reduction credits in other markets.

Establishing a results-oriented Green Auction Fund helps align incentives between the green transition and financial markets, increases the participation of financial markets in the green transition, and ensures effectiveness in the use of public funds. It can also specifically help overcome challenges such as scale constraints. First, the green auction process can be led by financial institutions. Familiar with market operations, these institutions can use professional valuation methods to estimate funding amounts and durations, subject to market supervision, ensuring the standardization and efficiency of the auction process. Second, the market-oriented incentives of the Green Auction Fund can encourage financial institutions to provide early-stage funding support for auction companies, specifically addressing scale constraints. With the fund's payment as a guarantee, companies' R&D has a more certain future cash inflow, thus motivating financial institutions to finance companies through loans, venture capital, and other debt or equity financing methods, sharing in the success of the project. The involvement of specialized institutions like venture capital can also bring corporate governance experience and industry resources to companies, while various supervision methods can improve project success rates. Lastly, financial markets can provide efficient market pricing for companies' green transition outcomes. Whether it is the accounting of carbon emissions reduction or the market value estimation of green technologies, companies require third-party professional services and credibility endorsement. Greater market competition allows financial markets to provide more specialized services for these estimation activities.

In fact, there are already similar auction fund practices internationally. For example, the Pilot Auction Facility (PAF)[53] developed by the World Bank Group targets methane gas internationally. The project aims to stimulate investment in greenhouse gas emissions reduction while maximizing the impact of public funds and leveraging private sector financing. The main goal of PAF is to incentivize private sector investment and climate action in developing countries by providing a guaranteed minimum price for carbon emissions reduction credits. PAF achieves this by auctioning tradable put options, which give the holder the right, but not the obligation, to sell future emissions reduction credits to PAF at a predetermined price (the option "strike" price). If the carbon market price is higher than the strike price, option holders can choose to sell carbon credits to other buyers rather than PAF. If the market price is below the strike price, option holders have the right to sell emissions reduction credits to PAF at the strike price. PAF's options are tradable, allowing holders to transfer ownership, thus maximizing the likelihood of PAF achieving emissions reduction. PAF determines the value of price guarantees through online auctions in a competitive and transparent manner. The competitiveness of the auction reveals the minimum price required for the private sector to make emissions reduction investments. PAF has successfully held several auctions, including those targeting methane reduction projects at landfills, animal waste, and wastewater treatment plants, as well as auctions for nitrous oxide emissions from nitric acid production.

Recommendation 3: Support the green technology innovation ecosystem, by supporting green technology incubation/acceleration projects, cultivating a team of green technology managers, and improving the green technology innovation service system

As mentioned earlier, for breakthrough innovations, technologies may be stuck in the "Valley of Death" at the prototype or demonstration stages, unable to quickly pass market tests to determine whether the technology is viable. Therefore, in addition to incentives for basic R&D and market subsidies for the commercialization phase, fiscal policy should support the market application of technologies at the demonstration stage, promoting market tests to assess whether the technology paths have the potential for commercialization. There should be a shift from supporting green technologies to supporting the green technology innovation ecosystem. First, the government could consider guiding funds towards accelerators and incubators related to green technology. Currently, incubator platforms in the field of green technology innovation are still in the pilot phase. In 2022, China's first "dual carbon" incubator was established in the Changning District of Shanghai, and in May 2023, Shanghai Jiao Tong University, together with the Minhang District of Shanghai[54], jointly invested in the establishment of Shanghai DaLingHaoWan Technology Development Co., Ltd.[55], aiming to break the "last mile" of the transformation and application of scientific and technological achievements. Second, the government could accelerate the assembly of professional talent for the transfer and transformation of green technology, cultivate domestic green technology managers, and gradually establish and improve the green technology transfer service system. On the one hand, the fiscal sector can fund the training of green managers[56] in universities and enterprises; on the other hand, it can help the market establish third-party service companies related to the transformation of green technology, and open up market channels for the application and transformation of technology[1].

[1] Currently, the country has begun to focus on the challenges in the transition from green technology innovation to the commercialization phase. In July 2024, under the guidance of the China Association for Science and Technology and the Ministry of Science and Technology, the China

Recommendation 4: Promote the "two accelerations" in carbon market construction to reduce the green premium for innovative technologies

A more binding carbon market can drive a broader range of industries to apply green technologies more vigorously, accelerate the expansion of the carbon market, and expedite the construction of a carbon quota auction mechanism, which is conducive to achieving this goal.

First, accelerating the expansion of the carbon market creates demand for emissions reduction technologies across more industries. Initially, it is necessary to establish a comprehensive carbon emissions accounting system, and to develop and improve policy systems and management mechanisms for industry carbon control, corporate carbon management, project carbon assessment, and product carbon footprint, effectively connecting with the national carbon emissions trading market. At present, China is introducing relevant carbon accounting plans and is gradually improving the carbon emissions monitoring systems for various industries. Second, the scope of industries covered by the carbon quota trading market should be gradually expanded, thereby increasing the technological demand in high-energy-consuming industries. At present, three major industries—building materials (cement), steel, and non-ferrous metals (aluminum electrolysis)—are officially included in the scope of the national carbon emission trading market from 2024. Additionally, the linkage between the carbon market and the CCER mechanism can be strengthened with the improvement of CCER market trading policies, rules, and infrastructure construction, and the enhancement of regulatory efforts in the certification and publicizing of emissions reduction, hence stimulating more market entities to voluntarily undertake green technology innovation through voluntary emissions reduction projects.

Second, accelerating the establishment of a carbon quota auction mechanism will gradually promote the increase of carbon prices and support green technology innovation with the revenue from carbon quota auctions. Although the "*Interim Regulations on the Administration of Carbon Emission Trading (Draft for Revision)*[57]" has clearly stipulated that carbon quotas will gradually transition to paid allocation, and some places have already started pilot programs for paid allocation, the overall allocation in China's carbon market is still free. Drawing on the experience of the European Union, a carbon quota auction mechanism can be used to gradually expand the proportion and industry coverage of paid carbon quota allocation, allowing the price of carbon quotas to be determined by market supply and demand relationships, thereby enhancing the market efficiency of the carbon market. This mechanism compels carbon-emitting companies to engage more actively in technological innovation and facility upgrades in order to reduce the cost of purchasing quotas. Furthermore, China can learn from the practices of developed economies by establishing a special innovation fund with the proceeds from the carbon market, to further increase investment in domestic green technology projects

6.2 Capital Market Policies: Activating Patient Capital and Creating a Diverse Investment Ecosystem

As previously mentioned, when technological innovation becomes the new main task of China's green transition, equity financing needs to play a greater role; in particular, the capital market should perform its pivotal function effectively. However, compared to the banking system, there is a greater room for improvement

Electrotechnical Society organized and carried out the work of evaluating the capabilities of technology managers in the field of green technology.

in China's capital market, which requires accelerated construction and optimization in order to more effectively support the urgent needs of green technology innovation.

Recommendation 5: Explore feasible paths for bank funds to support the development of the equity market in capital raising, and guide long-term capital such as funds from wealthy individuals and pension funds into the market.

First, since most financial resources in China are concentrated in the banking system, there is a need to explore new pathways for guiding bank resources to support breakthrough innovations in the green sector through the capital market in an orderly and moderate manner. Since most of banks' funds come from a vast number of depositors, significant losses incurred by banks due to excessive participation in the equity market could potentially lead to systemic financial risks. Therefore, using banks to support the equity market and promote breakthrough innovations in the green sector requires a careful balance between innovation returns and financial risks. Limiting scale is an important way to balance these two aspects. Taking the US as an example, US regulatory authorities require that US bank investments in small business investment companies (SBIC) should not exceed 5% of the bank's capital and surplus. At the same time, when the sum of SBIC equity risk exposure and any other equity risk exposure of the bank exceeds 10% of the total capital, the amount of equity risk exposure that does not exceed 10% of the total capital is given a 100% risk weighting, and the remaining equity risk exposure is given a 300% or 400% risk weighting[58]. The aforementioned regulations effectively constrain the excessive expansion of financial risks associated with bank-related SBICs. In addition to limiting scale, encouraging banks to participate more in the later stages of the equity market, which are relatively lower in risk, such as providing diversified financial tools to support M&As and other low-risk equity investment activities, can also achieve a balance between innovation returns and financial risks. A typical case of banks participating in later-stage investments in the equity market is the leveraged buyout led by Blackstone in 2018, which acquired 55% of Refinitiv's equity, with approximately US$1bn of the US$1.1bn acquisition funds coming from syndicated loans provided by banking institutions such as Bank of America and Barclays[59]. For China, where financial products have moved away from guaranteed returns and have generally shifted towards net value-based management, , it is possible to leverage the advantages of bank wealth management subsidiaries in raising funds. On one hand, as part of pilot initiatives in green sector, the government could explore feasible ways for the banking system to moderately and orderly increase support for the domestic equity market. On the other hand, it's important to encourage banks to participate more in the green sector M&A market to enhance the activity of green sector equity transactions.

Second, starting from the static and dynamic wealth effects, the government shall guide the entry of funds from wealthy individuals and long-term funds such as pensions into the market. Over the past decade, domestic capital has become the main source of fundraising for venture capital in China. Therefore, the key to solving the fundraising difficulties also lies in how to attract domestic capital into the market. Considering banks should balance innovation returns and financial risks when supporting venture capital, and the constraints on the stage of intervention and the amount of funds, how to attract long-term funds such as funds from wealthy individuals and pensions into the market is a promising way for solving the domestic equity market fundraising difficulties. Research indicates that there is a close relationship between the willingness of long-term funds to invest and the static and dynamic wealth effects. The static wealth effect refers to the decrease in liquidity preference and the increase in risk preference and the scale of risk investment as investors' wealth increases under the principle of diminishing marginal utility. Based on empirical research on US individual investors from 2006 to 2018, it was found that for every 10% increase in income, there is a 1.5%

decrease in the degree of risk aversion.[60] Considering that donation funds also mainly come from wealthy individuals, funds from wealthy individuals in the US have always accounted for a high proportion of US venture capital fundraising, far exceeding other sources of funds such as insurance funds, foreign capital, and corporate funds. This means that to solve domestic equity market fundraising difficulties, China should build a friendly social environment that is conducive to equity investment by wealthy individuals. This could include actively developing wealth management businesses like private banking, exploring pilot schemes for donations in the green sector to offset taxes, and guiding the transformation of affluent family savings into long-term funds in the green industry equity market through an "inheritance tax + donation offset" approach. The dynamic wealth effect refers to the attraction of long-term funds such as pensions to venture capital because of the potential for substantial returns rather than because pensions are long-term funds. Empirical studies have also shown that the reason why US state and local pensions have increased their investments in alternative assets such as venture capital is mainly because these assets have higher risk-adjusted returns relative to stocks.[61] Research based on US private sector pensions from 1989 to 2008 indicates that the target of pension asset allocation is profit; otherwise, it will face the risk of not being able to pay pension benefits on time in the future. Therefore, if the capital market is not profitable, pensions will withdraw[62]. In other words, even from the perspective of pensions, whether they can play the role of long-term funds depends on whether equity investment can bring substantial returns, which largely depends on whether there is a prosperous stock market and smooth exit channels.

Recommendation 6: Optimize the assessment methods of industry guidance funds in fund management, establish green VC plans, and value the positive role of outstanding foreign venture capital and CVCs

First, optimize the assessment methods of industrial guidance funds to enhance their investment and management capabilities. To address the issues of low risk appetite and short investment horizon of industrial guidance funds, it is necessary to further clarify their role in promoting technological innovation rather than focusing solely on equity finance. The assessment requirements for industrial guidance funds should be refined. For example, a reasonable and clear responsibility determination mechanism for failed projects should be established to prevent excessive accountability from suppressing the risk appetite of these funds. Additionally, the current practice of annual performance assessment should be changed to focus on overall performance and long-term returns, evaluating from the perspective of multi-year average performance or full life cycle performance, thus providing flexibility for long-term investments. To tackle the low operational efficiency of industrial guidance funds, the proportion of government direct investment funds should be reduced, and the share of industrial guidance mother funds increased, making full use of the professional investment capabilities of market-oriented GPs. Their operational processes should respect the professional abilities of market-oriented GPs, ensuring a reasonable division of labor between market-oriented GPs and government LPs. To address the potential market fragmentation caused by industrial guidance funds, it is recommended to increase the proportion of cross-regional national funds and reducing the share of municipal and county-level funds when establishing them. For example, pilot cross-regional integrated industrial guidance funds could be established in developed areas like the Yangtze River Delta and the Pearl River Delta. This approach balances local competition and the advantages of scale to better promote technological innovation, reducing the risk of market over-segmentation due to excessive local investment. Once this model matures, it can be extended to more regions. In particular, considering the strong investment intention in green technology across regions and the manufacturing nature of the green technology sector, which

requires a complete industrial chain for healthy development, different regions can enhance overall efficiency through division of labor. Therefore, when exploring the establishment of cross-regional industrial guidance funds, green technology can be used as a starting point for pilot programs.

Second, create a green venture capital plan to establish a new model of effective cooperation between the government and market-oriented GPs to promote breakthrough innovations in the green sector. Drawing from the US experience, SBICs are an effective way for the government and social capital to jointly promote the development of SMEs. China can follow the US SBIC development model by establishing a green guarantee fund at the central government level. This fund can select market-oriented funds that meet certain criteria and focus on equity investment in the green sector, and provide financing guarantees equivalent to their fundraising amounts, thus amplifying the investable capital of market-oriented funds. Furthermore, to encourage market-oriented funds to invest early and in small projects, the screening conditions can focus on supporting funds with a scale of less than Rmb1bn, or stipulate that the government's guarantee for a single market-oriented fund does not exceed Rmb1bn. This model has four advantages: First, against the backdrop of fiscal revenue and expenditure pressure faced by governments at all levels, the sustainability of funds for industrial guidance in the future is uncertain. However, in this new model, the government's provision of financing guarantees to market-oriented funds helps them attract more social capital, providing more financial support for green equity funds without increasing government expenditure pressure. Second, shifting from direct government investment to government guarantee investment means less government intervention in market-oriented GPs, which is conducive to leveraging their professional capabilities in investment and post-investment management, and which enhances the overall investment and management efficiency of the domestic equity market. Third, in addition to the inherent desire for stability, another important factor leading to the preference of industrial guidance funds for mid-to-late mature projects is their large scale. Investing early and in smaller amounts would mean investing in a large number of enterprises or projects, which is not conducive to the management of industrial guidance funds. Therefore, to facilitate management, these funds are more inclined to participate in the investment of mid-to-late mature projects with high capital demands. In the new model, the government would set guarantee caps or fundraising caps for market-oriented funds to ensure that most guaranteed funds are small in scale and more willing to invest early and in small amounts, which is more conducive to promoting breakthrough innovations in the green sector. Lastly, the presence of government guarantees in the new model reduces the risks faced by investors in the equity market to some extent, hence attracting more investors. A richer variety of investors in the equity market is more conducive to the ecological and screening effects of the capital market, thus promoting breakthrough innovations in the green sector by building an innovative ecosystem that promotes and develops various fields and technological routes together.

Third, increase the intensity of financial opening up to attract high-quality foreign GPs to enter China's equity market. From the perspective of fundraising amount alone, foreign capital is no longer the dominant force in China's equity market. However, the impact of foreign capital withdrawal exceeds the role reflected by the proportion of fundraising scale, not only because the withdrawal exacerbates the fundraising difficulties in China's equity market on the margin but also because the US dollar funds that invest in China are basically experienced top institutions. Their withdrawal from China has had an adverse impact on the post-investment management capabilities and competitive landscape of the domestic equity market. Empirical research by the CICC Research Institute also confirms this point. Based on 8,071 VC exit cases from Chinese enterprises from 2001 to 2023, the CICC Research Institute compared the internal rates of return (IRR) of domestic and foreign GPs and found that under the same currency and equal investment scale, the return rate of

projects invested in by foreign GPs is significantly higher than that of domestic GPs in a statistical sense. Therefore, increasing the intensity of financial opening up and actively attracting foreign, especially US, excellent GPs to enter China may have limited effects on solving fundraising difficulties, but it is very beneficial for improving the post-investment management capabilities of the domestic equity market. In particular, considering that carbon neutrality is currently a global development consensus and a major trend for future development, and China is in a leading position in many fields of the green industry, China's green industry still has strong appeal for foreign equity investors. Equity investment in the green sector can be used as a starting point, and preferential policies that facilitate the cross-border flow of foreign capital, facilitate the industrial and commercial registration of foreign capital, and go to China to do business can be introduced to attract more excellent foreign VC to invest in China's green industry.

Fourth, optimize the concept of anti-monopoly and pay attention to the positive role of CVC in investment and management. Unlike independent venture capital companies (IVC), CVC refers to the VC subsidiaries or investment departments established by non-financial companies with their own funds. Since CVC funds mainly come from the company's own funds, as long as the company itself does not have survival issues, CVC is unlikely to face hard exit deadline constraints, thus having more significant long-term capital characteristics. More importantly, because CVC focuses more on serving the overall development strategy of the parent company when investing, and its investment direction also tends to be more inclined to start-ups related to the parent company's business, it can use the parent company's sales channels and other resources to empower the companies receiving investment, showing strong post-investment management capabilities. Research shows that start-ups supported by CVC obtain an average of 27% more patents and an average of 18% more citations in the three years before going public than those supported by IVC. In the four years after going public, the number of patents obtained by start-ups supported by CVC is 45% higher than those supported by IVC, and the number of citations is 13% higher on average[63]. However, in the past few years, affected by domestic anti-monopoly and the prevention of disorderly capital expansion policies, the activity of domestic CVC investments has significantly decreased. In this regard, for the anti-monopoly thinking of large enterprises' CVC, it may be necessary to abandon the structuralist market share perspective and pay more attention to the behavioral competitive perspective of anti-monopoly, i.e., not simply considering an enterprise as a monopoly just because of its scale or market share, but focusing more on whether the enterprise engages in unfair competitive practices. If an enterprise does not engage in unfair competitive practices or does not exert inappropriate influence on fair market competition, it should not be simply subject to anti-monopoly sanctions because of its external investments or scale expansion. Shifting from structuralism to behaviorism is also the experience of US anti-monopoly legislation over the past 100 years. In terms of green technology, leading companies in the green sector should be encouraged to actively participate in equity market investments on the basis of preventing the formation of monopolies and providing more financial and resource support for breakthrough innovative activities of SMEs in the green technology field.

Recommendation 7: Create a favorable environment for green sector companies to go public, facilitate diversified mechanisms such as M&As and promote the reform of the exchange company system

First, it is necessary to provide more opportunities for soft technology companies and unprofitable companies to list. On the one hand, considering the importance of green transformation, more opportunities for green sector companies to go public should be provided. This is a necessary prerequisite for encouraging VC and other equity investors to increase their investments in the green sector. On the other hand, green sector

companies engaged in groundbreaking innovation often face high initial investments, unstable profits, or even no profits. Judging a company's eligibility for listing solely based on current profitability may lead equity investors like VC to increasingly invest in mature, profitable companies, which is not conducive to the role of the equity market in early-stage and small-scale investments and promoting groundbreaking innovation. Diverse IPO standards for green sector innovation companies should be established, including R&D investment, revenue scale, and technological leadership, to give fair listing opportunities to high-quality, unprofitable green sector companies, which will also help attract more equity investment in green sector innovation companies.

Second, it is important to encourage listed companies to participate in M&A transactions, develop M&A funds, and build diverse exit paths. Apart from IPOs, M&As are also a vital exit channel for VC, especially as the pace of A-share IPOs has slowed significantly. It is important to recognize the significance of M&A exits for activating the equity market. Considering that listed companies and M&A funds are the main participants in M&A activities, to smooth the M&A exit channel, it is necessary to gradually explore and optimize the conditions for A-share listed companies to participate in M&A transactions, increase financing tools for listed companies' M&A transactions, and develop new M&A models like "PE + listed company" to enhance their ability and willingness to engage in M&A transactions. For example, A-share green sector listed companies can be used as pilots to explore and summarize better support for their participation in the M&A market, encouraging leading green sector companies to grow stronger through M&As, integrate industrial chain resources, and further improve their operational efficiency. Additionally, it is crucial to attract outstanding foreign M&A institutions to establish operations in China, set up foreign M&A funds, and encourage more domestic equity investment institutions to participate in M&A investments. Moreover, the development of the M&A market requires a series of supporting policies, such as simplifying antitrust review procedures to encourage leading companies to grow through M&A, improving social safety nets like unemployment insurance to provide a necessary social environment for M&A entities to improve the performance of acquired targets, and enhancing the functions of equity trading centers to promote the development of the private equity secondary market.

Third, emphasize the promotion of market-oriented reforms in stock exchanges to enhance their autonomy in increasing inclusivity from the bottom up. The US is a model for capital markets in promoting technological innovation, with its stock exchanges playing a significant role in promptly responding to corporate financing needs, driven by profit and competition incentives. Thanks to this mechanism, when the NYSE rejected "dual-class shares" in the early 1980s, NASDAQ was motivated to accept "dual-class shares" to support the listings of high-tech companies, contributing to the "new economy era" in the US. Currently, China's major stock exchanges are essentially public institutions, lacking the initiative and autonomy to increase inclusivity in response to market financing needs. The multi-tiered stock market, a product of top-down planning, is artificially segmented, with relatively low competition between segments, further dampening the enthusiasm of domestic exchanges to promptly and proactively respond to market financing needs. More importantly, market financing needs change rapidly, and exchanges can play a greater role in improving inclusivity to leverage ecological effects. In the future, emphasis can be placed on optimizing the institutional arrangements of domestic stock exchanges, thereby enhancing the inclusiveness of A-share IPOs from the bottom up in terms of institutional formulation.

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