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Comprehensive Green Transformation of Society and the Economy

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Finance Drives the Low-Carbon Transition of High-Carbon Industries

Special Policy Study Report

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Executive Summary

1. Background and Significance

High-carbon industries generally refer to sectors that consume large amounts of fossil fuels and that exhibit high carbon emission intensity, primarily encompassing heavy industries such as building materials, steel, and chemicals. In recent years, production capacity across these high-carbon industries has gradually peaked. However, whether they can successfully transition to low-carbon development remains the core challenge throughout the green transformation process.

The core of green transformation lies in reducing the green premium—the difference between the cost of clean energy and that of fossil fuels. The persistently high green premium in high-carbon industries stems from three primary factors: First, these sectors show weak economies of scale, hindering R&D in low-carbon technologies and the reduction of clean energy costs. Second, China's current economic landscape features insufficient domestic demand, with high-carbon industries suffering particularly acute oversupply, and hence stifling low-carbon technological innovation. Third, amid new geo-politics and economic competition, unilateralism may weaken the impetus for global green transformation and transformation in high-carbon industries.

Similar to the overall green transition process, reducing the green premium in high-carbon industries involves two fundamental pathways: First, lowering the cost of using clean energy. This relies not only on the continuous upgrading of production processes within high-carbon sectors—such as electrification to reduce the difficulty and cost of using green electricity—but also on breakthrough technological innovations in clean energy industries such as hydrogen. . Second, increasing the cost of fossil fuel use through carbon pricing mechanisms (e.g., carbon markets and carbon taxes) or demand-side measures such as dual controls on energy consumption and carbon emissions. However, this process may trigger social risks such as unemployment and non-performing assets due to the exit of outdated production capacity.

In advancing the green transformation of high-carbon industries, finance can play a more important role in addressing the two major challenges identified above: First, insufficient momentum in technological innovation in high-carbon sectors makes reducing clean energy costs more difficult. How can finance support technological innovation in high-carbon enterprises? Second, as the cost of fossil fuel use rises, two major social risks escalate: Stranded assets and the need for a “just transition”. How can finance effectively mitigate these social risks?

2. Research Focus

Against the backdrop of high green premiums in carbon-intensive industries, intertwined with geopolitical competition pressures within the sector, we examine in this report how finance can play a role in addressing these challenges by focusing on two key pathways to reduce green premiums: Lowering clean energy costs and increasing fossil fuel costs.

For the pathway of reducing clean energy costs, promoting transition technology innovation using supply chain finance principles: Transition innovation encompasses both incremental improvements—such as energy-saving retrofits (e.g., efficiency enhancement, process optimization, waste heat recovery), fuel substitution (e.g., coal-to-gas switching), and waste recycling—and breakthrough innovations such as hydrogen applications and CCUS. Incremental innovation has already received significant attention within the existing transition finance framework (including transition finance taxonomies and transition plans) and is promoted through instruments like bank loans. However, breakthrough innovation often stems from specialized and agile SMEs, which often fail to secure necessary funding due to lack of collateral, and unstable cash flows. To resolve the financing predicament faced by SMEs and promote technological innovation in transformation, it is necessary to apply supply chain finance principles. Supply chain finance is a new financing model built on the credit and industrial advantages of the lead firms in the chain. The reason is that lead firms are not only the primary source of demand for low-carbon technologies and providers of key application scenarios, but also the standard-setters for low-carbon practices across the supply chain. They possess authentic supply chain transaction data as well as a deep understanding of the technical capabilities and creditworthiness of upstream and downstream enterprises, effectively alleviating information asymmetry. At the same time, their market dominance can provide SMEs with stable orders and cash flow security, thereby strengthening financial institutions' confidence in extending credit. Therefore, while green finance and other policy instruments incentivize lead firms in high-carbon industries to pursue green transition, it is also necessary to apply green supply chain finance principles to transform the green demand of leading enterprises in high-carbon industries into financing credit for SMEs. For example, financial institutions can be encouraged to recognize the green demand of chain-owning enterprises as a pledge, and to build a venture capital landscape with green CVCs as the core enterprise of chain owners. In this way, policy benefits can extend to SMEs across the supply chain and more effectively promote transition technology innovation.

For the pathway of increasing fossil fuel costs, the financial system should effectively support the phase-out of obsolete production capacity and mitigate the associated social risks, such as unemployment and non-performing assets. The first priority is to enhance the

management of stranded asset risks to improve capacity governance in high-carbon industries: China's high-carbon industries are highly dependent on coal and have relatively new assets. The base and speed of asset stranding during the low-carbon transition are both significant with high regional concentration, easily triggering localized economic and employment shocks. Facing the risks of "non-performing assets already formed" and "risks not yet materialized as non-performing assets," targeted measures are needed. First, resolve existing non-performing assets through debt restructuring, asset disposal, etc.; simultaneously, reduce incremental risks by promoting technological transformation and accelerating early retirements, among others, to prevent systemic financial shocks and enhance corporate transition resilience amid "anti-involution" normalized capacity governance**. Second, address challenges in relocation of workers to ensure a just transformation:** Financial institutions can assist in the relocation of laid-off workers through indirect and direct empowerment methods. Regarding indirect empowerment, financial institutions exercise stewardship functions such as reviewing enterprise relocation plans during pre-lending assessments and using results-oriented incentive and constraint mechanisms to link financing conditions with performance in equitable transitions, which would encourage enterprises to prioritize worker relocation. Regarding direct empowerment, financial institutions incorporate transition impacts into product considerations such as startup loans. By optimizing startup guarantee loan policies—expanding support targets, increasing loan amounts, lowering application thresholds—and leveraging digital technology to overcome cost and scale dilemmas, enabling precise marketing and risk control, and reducing service costs, financial institutions can provide strong support for laid-off workers starting businesses. Given that social risk mitigation shows significant positive externalities, conventional financial institutions often lack sufficient incentive to support such initiatives. Therefore, policy measures combining incentives and constraints are necessary to guide their involvement. Consequently, transition finance, in its role of supporting social risk mitigation, broadly falls within the realm of policy-driven finance.

3. Policy Recommendations:

First, encourage financial institutions leverage the "green demand" of chain-owning enterprises as a pledge for SME financing, thereby supporting SME financing and transition technology innovation. Green supply chain finance can be constructed in three steps. The first is to unify green certification for the assets of SMEs in accordance with the relevant standards. Second, the establishment of a data-sharing platform will be facilitated through the utilization of blockchain technology, thereby ensuring the traceability and verifiability of information. Third, innovate financial tools. For instance, package the green receivables held by SMEs from lead firms and issue green supply chain ABS to revitalize stock assets and expand financing channels.

Concurrently, the central bank provides financing for relevant projects, assigns favorable risk weights to green supply chain loans, and establishes credit and debt issuance facilities for participating core enterprises. This ensures that policy-based finance can be advantageous for supply chain SMEs.

Second, the establishment of a "green demand scenario + joint incubation" mechanism is initiated by the chain master enterprise. Chain-owning enterprises issue tenders for transformation projects, and the winning SMEs are awarded long-term orders and multiple rounds of investment by chain-owning corporate venture capital (CVC). In turn, chain-owning CVCs take the lead in forming an investment body jointly with government venture capital (GVC) and independent venture capital (IVC) to continuously inject capital. The policy is designed to expand the scale of the green demand scenario through the provision of research subsidies and refinancing, and to guide GVC to supplement capital in the capacity of a strategic limited partner (LP), thus forming a diversified pattern of venture capital and accelerating the landing of technology and the shaping of supply chain.

Third, support financial institutions' inclusion of carbon emission indicators as a consideration when providing M&A financial services. Policy initiatives can strengthen the role of carbon emission assessments in M&A activity: 1) Encourage commercial banks to implement comprehensive credit facilities for enterprises before, during, and after mergers and acquisitions (M&A), including carbon emission indicators in credit conditions; 2) support eligible high-carbon enterprises in raising M&A funds through issuance of stocks, bonds, convertible bonds, etc., and encourage financial institutions to innovate bond varieties; 3) actively explore new M&A financing models such as establishing M&A funds, using carbon emission improvement targets as key evaluation criteria for fund investments; and 4) promote breaking down barriers to M&A across regions and industries, unify administrative approval standards for M&A, and introduce carbon emission indicator assessments into the approval process.

Fourth, support financial institutions' development of debt swap instruments. The relationship between interest rates and the progression of decommissioning high-carbon assets is inversely correlated: Accelerated decommissioning results in a reduction of interest rates. This dynamic enables enterprises to receive compensation for the diminished revenue that accompanies the premature decommissioning of assets, which in turn is facilitated by a favorable financing cost structure. The government can reduce banks' funding costs and mitigate risks through a range of financial instruments, including refinancing, financial guarantees, and tax incentives. This policy intervention could enhance banks' willingness to participate in the green economy.

Fifth, financial institutions should be encouraged to incorporate an equitable transition into their financial products. The development of quantitative indicators and tools to incorporate

fairness considerations in high carbon business transformation programs is essential for effective decision-making. The provision of subsidies and refinancing (e.g., loans or bonds linked to employee targets) is necessary to support related products. The exploration of "transformation unemployment insurance" to cover the risk of income fluctuations arising from the redeployment of employees is also crucial.

Keywords: Transition finance, green technology innovation, supply chain finance, stranded assets, non-performing asset disposal, just transition

Acronyms & abbreviations

SLB	Sustainability-linked bond
CCUS	Carbon capture, utilization, and storage
GDP	Gross domestic product
LPR	Loan prime rate
BP	Basis point
AI	Artificial intelligence
IT	Information technology
SME	Small and medium-sized enterprises
ABS	Asset-backed security
CVC	Corporate venture capital
IVC	Independent venture capital
GVC	Government venture capital
WEF	World Economic Forum
IEA	Sustainability-linked bond
EVA	Economic value added
RAROC	Risk-adjusted return on capital
LP	Limited partner

Contents

Finance Drives the Low-Carbon Transition of High-Carbon Industries

High-carbon industries generally refer to sectors that consume large amounts of fossil fuels and that exhibit high carbon emission intensity, primarily encompassing heavy industries such as building materials, steel, and chemicals. In recent years, production capacity across these sectors has gradually peaked. However, whether they can successfully shift toward low-carbon development remains the core challenge throughout the green transition process. On one hand, the accelerated phase-out of certain inefficient production capacities is creating favorable conditions for green transformation. On the other hand, low industry profit margins make it increasingly difficult to increase capital expenditures, thus weakening enterprises' ability to develop low-carbon technologies. Further, shifts in the external geopolitical landscape have introduced new pressures on the low-carbon transformation of high-carbon industries. The shift in clean energy policy by certain countries may trigger a chain reaction in global green policy environment, reducing funding sources for transformative technological innovation. Against this backdrop, transition finance must play a pivotal role in providing sufficient capital to high-carbon industries and accelerating their green, low-carbon transformation.

1 The Economic Logic and Financial Responses to Green Transformation in High-Carbon Industries

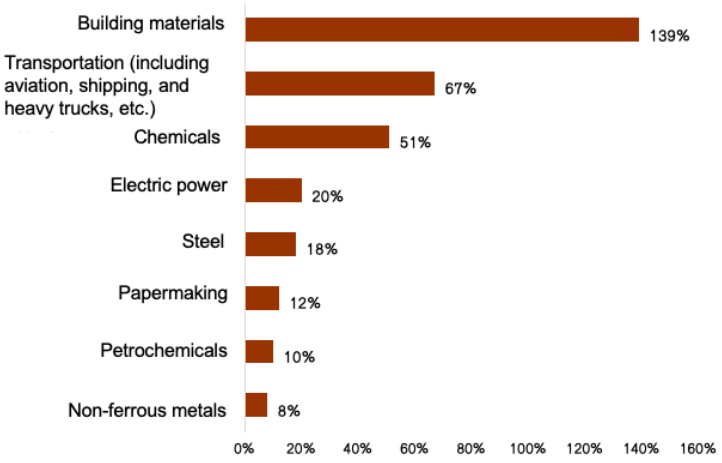
1.1: Three perspectives on understanding the elevated green premium in high-carbon industries

The core of green transformation lies in reducing the green premium—the cost difference between clean energy and fossil fuels. In the report “The Economics of Carbon Neutrality”, published by CICC Research and CICC Institute, green premiums were forecast across eight high-carbon sectors. Among them, the green premium for building materials (cement, glass, etc.) reached 139% (Figure 1), more than double the cost of using fossil fuels in their production. In recent years, the green premium has declined in sectors such as non-passenger transportation, chemicals, and power generation—now at 67%, 51%, and 20%, respectively—driven by the rise of new energy vehicles and renewable energy. However, these premiums remain elevated. Even relatively mature industries (e.g., non-ferrous metals, petrochemicals, papermaking, steel, and power) still carry green premiums ranging from 8–20%.

Why do high-carbon industries maintain such high green premiums? In the absence of public policy interventions such as transition finance, we examine whether green premiums in high-carbon industries would accelerate their decline or remain elevated from three perspectives.

Finance Drives the Low-Carbon Transition of High-Carbon Industries

Figure 1: Green premium levels in China[1] (by industry, 2021)

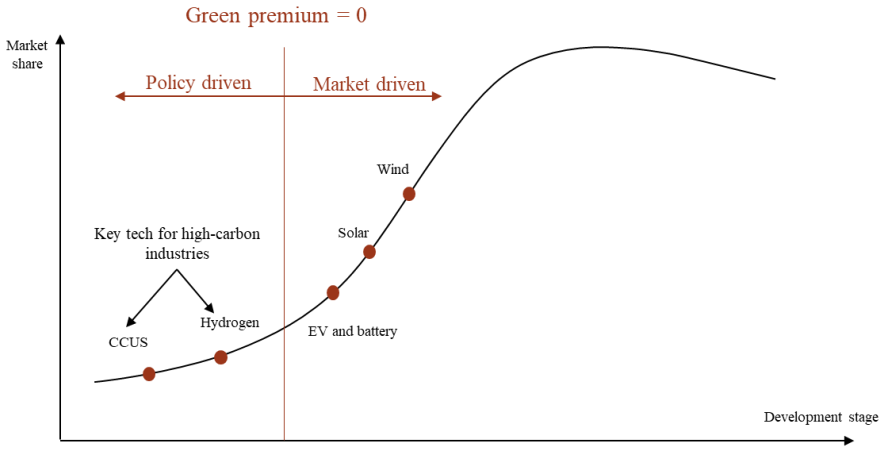


Source: CICC, Carbon Neutral Economics, 2021

First, high-carbon industries inherently exhibit weak economies of scale, hindering low-carbon technology R&D and clean energy cost reductions. Unlike manufacturing and the digital economy, high-carbon sectors such as building materials, steel, and chemicals exhibit weaker economies of scale. Expanding production capacity not only fails to yield proportional output increases but also generates negative externalities (e.g., pollution and carbon emissions). These industries often possess natural monopolistic tendencies, where individual firms require substantial scale and fixed investments, limiting overall market competition.

Under such conditions, the incentive for companies and industries to independently pursue low-carbon technology R&D is weak. In reality, technological progress in high-carbon sectors such as building materials and chemicals often lags that of clean energy manufacturing such as wind and solar power (Figure 2). Key technologies enabling significant reductions in green premiums—such as carbon capture, utilization, and storage (CCUS) and hydrogen energy—are in the nascent stage, lacking replicable experience and clear technical pathways. Concurrently, the lagging institutional and market environments heighten uncertainties in green technology innovation, hindering a rapid decline in green premiums for high-carbon industries.

Figure 2: Stages of development of major green technologies[2]

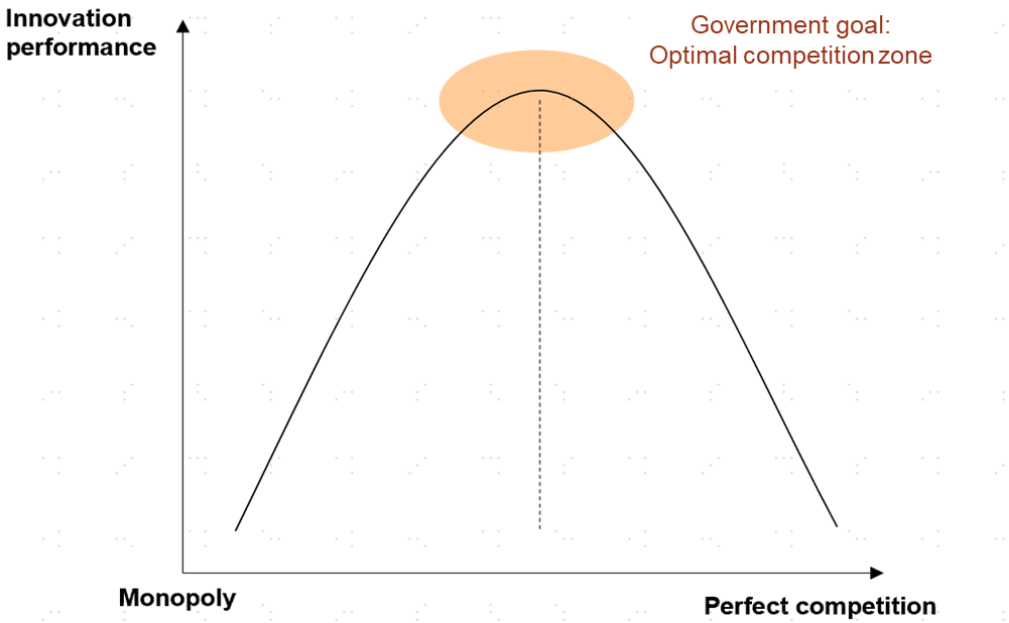


Source: CICC, Carbon Neutral Economics, 2021

Second, China's current economic environment features insufficient domestic demand, with oversupply particularly pronounced in high-carbon industries, thereby hampering low-carbon technological innovation. As the financial cycle enters a downturn, traditional high-carbon sectors such as steel and cement are experiencing shrinking demand. To compete for limited market share, some participants are resorting to irrational price cuts and delayed debt payments (Figure 4). This not only compresses profit margins for micro-level entities such as SMEs but also hinders technological advancement and green transformation at the macro level.

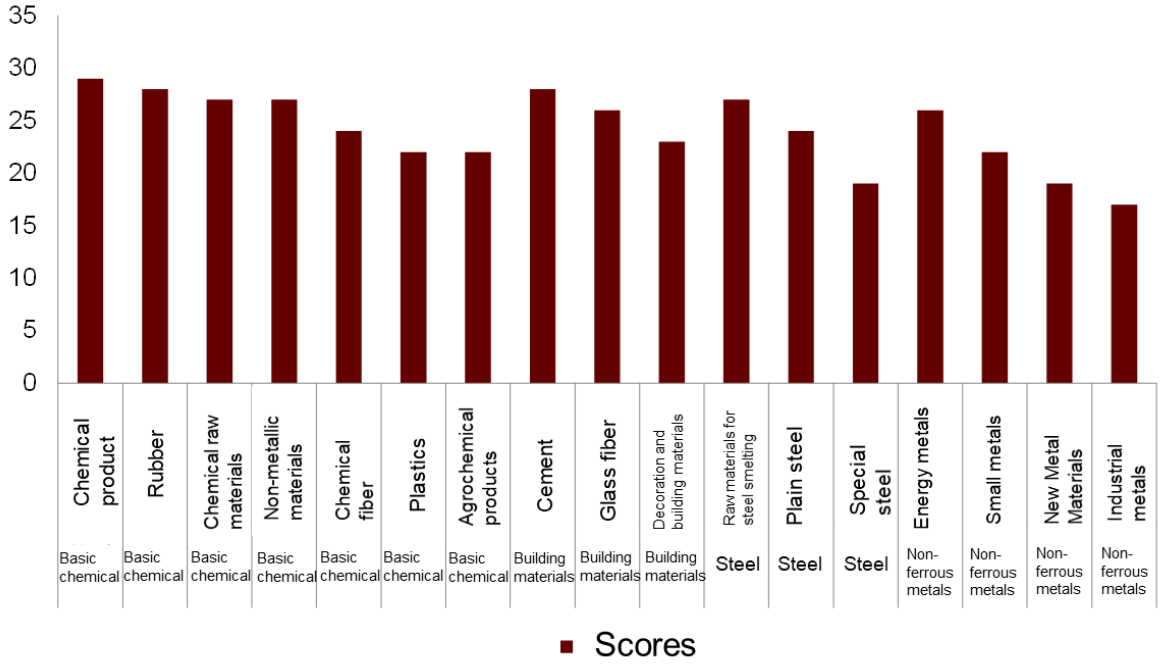
From an economic perspective, oversupply indicates underutilized resources or unfulfilled economies of scale—a critical driver of innovation. On the supply side, a nation's larger population and capital base translate to greater R&D investment and stronger innovation capacity. On the demand side, a larger economy creates a bigger domestic market, expanding the profit potential for innovation. If demand consistently lags behind supply, it not only leads to overcapacity and deflationary pressures but also makes it difficult to sustain production scale. This prevents the formation of a positive feedback loop between innovation and consumption, diminishing the expected returns on corporate innovation investments. Given that high-carbon industries inherently exhibit weaker economies of scale, oversupply further hampers efficiency gains and innovation improvements within the sector. Empirical studies reveal similar findings: A U-shaped relationship exists between competition intensity and innovation performance[3]. Excessive competition (potentially leading to oversupply) as well as a pure monopoly (potentially causing undersupply) hinder innovation. Only moderate competition fosters innovation by leveraging economies of scale.

Figure 3: Involutional competition is detrimental to innovation



Source: Shanhui Wang, et al, Research on Chinese Enterprise Technological Innovation and Product Competitiveness, 2013

Figure 4: Assessment of the potential for involutional competition in high-carbon industries



Notes: CICC Research Department's Macro Team utilized secondary industry-level data from listed companies between 2015 and 2024 to assess the likelihood of internalized competition within industries across four dimensions: Supply capacity (capital expenditure and inventory growth rate), competitive strategy (sales expenses and R&D investment), credit management (debt-to-equity ratio and accounts payable status), and revenue-profit metrics (revenue growth rate and net profit margin). Specifically, the historical percentile rankings for each sub-indicator across industries in 2024 were first calculated. Scores ranging from 1 to 5 were then assigned based on these rankings, with R&D expenditure ratio, revenue growth rate, and net profit margin receiving inverse scoring. Final scores were aggregated across sub-indicators, where higher scores indicate greater potential for internal competition (total score: 40 points; industry score range: 17–30 points). Results indicate that high-carbon industries exhibit a relatively high overall likelihood of internal competition. Particularly within basic chemicals—specifically, chemical products, rubber, and chemical raw materials—and construction materials (such as cement), certain sub-sectors may face severe internal competition (Figure 4)
Source: Wind, CICC Research

Third, under new geo-economic conditions, unilateralism may weaken the momentum for high-carbon industry transformation. Compared with industries such as wind power, photovoltaics, batteries, and new energy vehicles—which have already crossed the "valley of death" and entered rapid growth phases—high-carbon industries risk significant development setbacks if deprived of policy support. On one hand, the expansion of fossil fuel supply by certain countries, pressuring OPEC into increasing production, may drive down oil and gas prices. On the other hand, the shift in clean energy policy by certain countries may trigger a chain reaction by others, with the scaling back of clean energy policy support slowing the pace of cost reductions for clean energy. Recently, Germany drastically cut the budget for its "Clean Industry Plan" from EUR24.5bn to EUR1.8bn (a reduction of over 90%[4]), while multiple state governments in Australia have canceled or frozen support for flagship green hydrogen projects. These developments reflect declining willingness among some countries to invest in low-carbon technologies following the major policy shift.[5]

Beyond reducing inputs, the major policy shift may also undermine green trade protection systems such as the EU's carbon border adjustment mechanism (CBAM), weakening external market incentives for the green transition of high-carbon industries. While the EU CBAM could provide market momentum for the green transformation of exporting companies in high-carbon sectors, it and other green trade frameworks that seek to reduce carbon emissions are being stifled. For example, carbon emissions from imported goods to Europe scheduled for 2026 will be deferred until 2027 for charging purposes; importers whose annual cumulative

imports do not exceed 50 tonnes may be exempted from CBAM coverage[6]. As a result, exporters from China's high-carbon industries may see diminished returns for capturing market share in international markets through green compliance, potentially reducing their investments in energy conservation and carbon reduction.

1.2: Finance can support the green transition of high-carbon industries throughout the entire process

Similar to the overall process of green transition, reducing the green premium in high-carbon industries involves two fundamental approaches: 1) Lowering the cost of clean energy by promoting technological progress and green investment to reduce the supply costs of new energy sources; and 2) increasing the cost of fossil fuel use. This involves suppressing high-carbon activities on the demand side through carbon pricing mechanisms (e.g., carbon markets and carbon taxes), or through dual controls on energy consumption and carbon emissions. However, this process may lead to social risks such as unemployment as well as non-performing assets due to the exit of backward production capacity. It is important to emphasize that high-carbon industries such as steel and cement consume large amounts of fossil fuels as raw materials or fuel. Compared with general manufacturing, which relies more heavily on electricity in its energy mix, greater emphasis should be placed on increasing fossil fuel usage costs for these sectors.

Due to aforementioned negative externalities, the private sector has limited incentive to raise energy costs for high-carbon industries or promote low-carbon technological innovation. On the one hand, carbon emissions create negative externalities: Economic activities that generate carbon emissions benefit private entities, while the resulting damage—such as climate change and air pollution—is borne by society as a whole. These negative externalities distort market prices for goods and services, manifesting as low market prices for fossil fuels and high consumption levels.

On the other hand, green technological innovation possesses positive externalities. By promoting carbon reduction, it positively impacts the environment. It also generates new knowledge amid R&D and design of green products and services, creating knowledge spillover effects that further drive societal progress. These positive externalities mean green technological innovation not only yields economic returns for investors but also creates public value that is difficult to quantify. Since private investors cannot capture the full benefits of these positive externalities, their investment scale generally falls short of the socially optimal level. Therefore, during the convergence of externalities—specifically, the transition from fundamental R&D to commercialization—government intervention is necessary. Through subsidies, tax incentives, and regulatory frameworks, the government can establish a market environment that internalizes these dual externalities, corrects market failures, and attracts broader investor participation.

Financial policies can play a crucial role throughout the process of green transformation in high-carbon industries. This is primarily manifested in promoting low-carbon technological innovation and driving down the cost of clean energy. Amid new domestic and international market trends, high-carbon enterprises face accelerated profit declines. Leading firms exhibit low risk appetite and conservative investment, while SMEs, despite innovative vitality, face financing constraints—creating a mismatch in which companies with capital are not investing, while companies that want to invest lack the funds. This hinders breakthroughs in critical transition technologies. Crucial innovative financial instruments and institutional optimizations are

needed to build a support system commensurate with transition risks, transforming finance into a force that propels rather than constrains transformative innovation.

As the cost of fossil fuel use rises, two major societal risks—stranded assets and a just transition—are intensifying, requiring end-to-end financial support. On one hand, China's high-carbon industries exhibit two distinct characteristics: Production assets have relatively short lifespans, and production pathways rely heavily on coal-based fossil fuels. Compounded by the downturn in the real estate cycle, this will inevitably lead to capacity reduction and generate sizable stranded assets during the low-carbon transition. Shifts in international and domestic market dynamics may accelerate capacity clearance in high-carbon sectors, significantly hastening the pace of asset stranding. Simultaneously, China's high-carbon industries face multiple pressures including weak market demand and intense competition, potentially exacerbating worker unemployment and layoffs. This heightens the urgency of promoting a just transition, particularly in ensuring proper resettlement for workers displaced by industrial restructuring. Therefore, the financial sector must alleviate structural unemployment pressures through orderly capital support, risk mitigation, and transition incentives. It must also smoothly resolve systemic shocks caused by asset impairments, providing critical support for a stable socioeconomic transition to a low-carbon future.

2 Reducing Clean Energy Costs: Applying Supply Chain Finance to Accelerate Innovation in Transition Technologies

Transformation technological innovation is a key driving force for promoting the green and low-carbon transformation of high-carbon industries, but its development faces multiple practical challenges. High-carbon enterprises—affected by cyclical downturns in the industry and tightening carbon constraints—generally face profit declines, leading to a dual reduction in R&D investment capabilities and willingness to innovate. Structural contradictions in financial resource allocation are particularly prominent: Although leading enterprises enjoy financing convenience, their conservative risk appetite results in tepid investment in innovation. Meanwhile, SMEs with strong innovation intentions are constrained by a lack of financing channels, making it difficult to break through funding bottlenecks. This mismatch in financial resources hinders breakthroughs and applications in transformation technologies, necessitating innovations in financial instruments and institutional design to address critical blockages in technological innovation. It is crucial to ensure that finance becomes a catalyst rather than an impediment to transformation and innovation. Building a financial support system that matches the risk characteristics of transformation and innovation has become an important topic in achieving the dual carbon goals.

2.1: Why should high-carbon industry transition focus on breakthrough technological innovation?

When discussing the transformation of high-carbon enterprises, many industry observers first think of financial constraints, assuming they pose the biggest bottleneck for transformation. Generally speaking, the purposes of corporate financing include fixed asset investment, working capital replenishment, and technological innovation investment. For the transformation of high-carbon industries, the key use of funds is to innovate via technology and business models to truly solve the transformation challenges of high-carbon industries. New technologies can bring new supply, which in turn can create new demand. For example, in the steel industry, the transition from traditional blast furnaces to electric arc furnaces or attempts at hydrogen-based direct reduced iron (Hydrogen DRI) directly changes production methods and cost structures. The core of green and low-carbon transformation is continuously reducing the green premium.

The decline in green premiums mainly depends on two factors. First, the cost of using fossil fuels must increase. Carbon pricing mechanisms are a key factor; for example, carbon prices in the EU have stabilized above EUR80/tonne since 2022, significantly increasing production costs for high-carbon enterprises. However, limited carbon price levels only push companies to make incremental improvements in energy conservation and efficiency, which are insufficient to drive fundamental industrial upgrades. Second, and more crucially, the cost of green production must decrease. This can only be achieved through technological progress. For example, the levelized cost of electricity (LCOE) for photovoltaics has decreased by over 80% during the past decade, transforming solar power from being policy-dependent to market-driven. For high-carbon industries such as steel, cement, and chemicals, breakthrough technologies such as hydrogen are essential to making low-carbon products competitive in the market.

2.2: Challenges in financially supporting breakthrough innovations in high-carbon industries

Breakthrough innovations often do not originate from large enterprises, but instead from SMEs within the supply chain. According to OECD (2021)[7], SMEs play a key role in green and digital innovation, particularly excelling in disruptive technologies. Classic studies in innovation economics (Acs & Audretsch, 1990) also confirm that SMEs contribute disproportionately more to radical innovation than large firms[8]. Note: It is important to clarify that the term "supply chain" does not refer narrowly to upstream or downstream material or product relationships. For example, while iron ore is an upstream input for the steel industry and automobiles are a downstream application, these are not our focus in this discussion. The supply chain we refer to consists primarily of suppliers of technologies, equipment, materials, and services centered in key areas of energy consumption and carbon emission of high-carbon enterprises. For example, SMEs including energy-saving equipment manufacturers and carbon capture equipment developers in the steel production process are the main sources of breakthrough innovation.

In the green transformation of high-carbon industries, lead firms such as large state-owned enterprises (SOEs) or top-ranked industry names play a central role. They are not only the primary source of demand for low-carbon technologies and providers of key application scenarios, but also the standard-setters for low-carbon practices across the supply chain. The technological pathways, procurement preferences, and green transition pace of lead firms directly influence the entire supply chain's transformation progress. Therefore, financial support for the transition of high-carbon industries should not focus solely on individual enterprises, but rather must consider lead firms and their upstream and downstream partners collectively. By adopting a supply chain finance model, the leverage effect of capital can potentially drive decarbonization across the entire chain.

Although lead firms control financial and market resources, true technological innovation often stems from specialized and agile SMEs. Compared with incremental process improvements—such as energy efficiency retrofits (e.g., efficiency enhancement, process optimization, waste heat recovery), fuel substitution (e.g., coal-to-gas switching), and waste recycling—breakthrough low-carbon innovations (such as hydrogen applications and carbon capture, utilization, and storage) originate largely among SMEs. This reflects large firms' constraints from bureaucratic decision-making as well as their risk-averse tendencies (despite possessing stronger R&D capabilities), making them more inclined to adopt mature technologies and less willing to pursue breakthrough innovations that might disrupt their own market positions. In contrast, SMEs have strong incentives to use pioneering innovation to disrupt the existing competitive landscape and improve their market standing. Their rapid experimentation and flexibility make them key drivers of breakthrough technology iteration.Therefore, lead firms seeking to achieve their green transformation goals, a better strategy is to rely on SMEs within the supply chain to provide innovative solutions—requiring increased financing support.

However, SMEs within the supply chain often struggle to access financial services. Traditional financial institutions face inherent barriers in supporting SME financing: 1) Information asymmetry—banks find it difficult to assess the technical feasibility and market potential of SMEs; 2) lack of collateral—green technology R&D requires significant investment and long payback periods, which contradicts traditional credit risk assessment logic; 3) small individual financing amounts result in high service costs for financial institutions;

and 4) unstable cash flows do not align with banks' requirement for steady repayment capacity. Thus, even when SMEs possess innovation potential, they often fail to secure necessary funding, resulting in a dilemma where technology is needed and enterprises are motivated, but financing is absent.

Therefore, to resolve the financing predicament faced by SMEs, it is essential to move beyond the traditional financial perspective and instead leverage the industrial advantages of lead firms to build new financing models, such as supply chain finance. Lead firms possess authentic supply chain transaction data as well as a deep understanding of the technical capabilities and creditworthiness of upstream and downstream enterprises, effectively alleviating information asymmetry. At the same time, their market dominance can provide SMEs with stable orders and cash flow security, thereby strengthening financial institutions' confidence in extending credit. This supply chain finance model, grounded in established industrial relationships, can bridge the last mile in channeling funds to innovative SMEs. Based on this collaborative scenario, we systematically analyze how financial tools can empower lead firms to support SMEs and accelerate green technological innovation in high-carbon industries from two perspectives—debt financing (e.g., the construction of green supply chain finance systems by lead firms) and equity financing (e.g., industrial venture capital by lead firms).

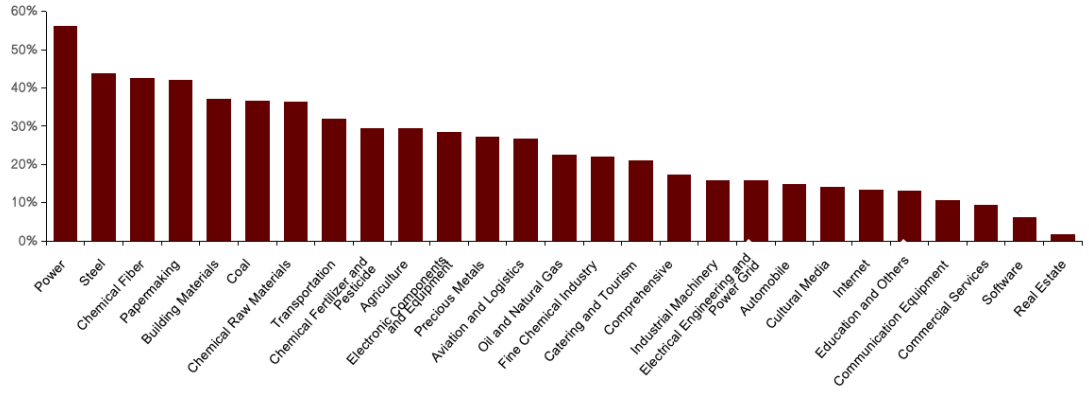
2.3: Breaking the deadlock in debt financing: Lead enterprise credit enhancement empowers supply chain technological innovation

2.3.1 Challenges for innovative financing of high-carbon enterprises by banks

First, incremental innovation is primarily driven by bank credit, but debt financing such as bank loans is ill-suited to support breakthrough innovation. Transition innovation encompasses both incremental improvements—such as energy-saving retrofits (e.g., efficiency enhancement, process optimization, waste heat recovery), fuel substitution (e.g., coal-to-gas switching), and waste recycling—and breakthrough innovations such as hydrogen applications and CCUS. However, while incremental innovation has already received significant attention within the existing transition finance framework (including transition finance taxonomies and transition plans) and is promoted through instruments like bank loans, breakthrough innovation has not been effectively supported by bank lending. First, compared with breakthrough innovation, incremental innovation activities generally have lower trial-and-error costs and investment risks, which are more in line with banks' risk appetite. Second, incremental innovation is typically based on established technology pathways with relatively clear market prospects. Banks can assess the feasibility of projects through industry experience, financial data, and other traditional risk-control tools, thereby reducing the problem of information asymmetry. Third, progressive innovation enterprises often already have a certain business foundation, can provide collateral or stable sources of repayment, and have relatively stable cash flow, which meets banks' credit approval requirements. In comparison with other industries, fixed assets in high-carbon industries account for a higher proportion of total assets (Figure 5), and bank credit can promote their progressive innovation. Recent years have seen a rapid growth in the scale of transformation loans linked to the carbon emission reduction performance of high-carbon enterprises. For instance, the number of loans linked to carbon emissions reduction and sustainability-linked loans at Societe Generale Bank increased by 94.50% compared to the end of the previous year, and financing increased by 325.71%[9].

Figure 5: Average Proportion of Fixed Assets to Total Assets by Industry (2020–2023)

Finance Drives the Low-Carbon Transition of High-Carbon Industries



Source: Wind, CICC Global Institute, CICC Research

However, in contrast to incremental innovation, it is often challenging for debt financing, such as bank loans, to support breakthrough innovation. This is because breakthrough innovations tend to be riskier, have longer cycles, and more volatile cash flows, which do not match the risk appetite and maturity of debt financing. Furthermore, breakthrough innovations are more likely to occur in start-up SMEs, which, according to one study, have 16 times more patents per capita than large firms in the field of green technology. At the same time, SMEs' green technology patents are cited by other patents 2.5 times more often than those of large firms, which suggests that their technologies are more original and influential[10]. However, breakthrough innovation in SMEs is characterized by higher uncertainty and information asymmetry, in which traditional modes of debt financing (e.g., credit and bonds) play a relatively limited role, and thus capital investment in breakthrough innovation activities is often insufficient.

In terms of information asymmetry, it is the creditor who is disadvantaged when it comes to information about the financed project. In the traditional model, creditors address this problem by collecting collateral. The presence of collateral reduces uncertainty regarding returns, and even if the project fails, the creditor can recover some of the funds by selling the collateral. However, SMEs often lack collateral, particularly since they tend to have more intangible assets than established large firms with substantial fixed assets. Moreover, R&D activities are highly uncertain, and the results of R&D do not necessarily take the form of intangible assets such as patents. Therefore, the lack of collateral restricts SMEs' access to finance. The high risk resulting from the uncertainty surrounding breakthrough innovation does not align with the risk appetite of traditional financing models. In the case of bank credit, for example, public deposits form an important part of banks' liabilities, and risky loans on the asset side create a risk mismatch. Furthermore, debt financing such as credit requires repayment of interest in instalments over time, whereas SMEs often lack stable operating cash flows.

Second, when supporting the technological innovation of high-carbon enterprises, commercial banks will face constraints relating to the "two highs and one surplus" (high pollution, high energy consumption, and overcapacity) loan assessment. Specifically, these restrictions can be traced back to the "Key Evaluation Indicators for Green Credit Implementation" document issued by the CBRC in 2014. This document outlines the situation of loans in the "two highs and one surplus" industries (including balances, percentages, growth rates, non-performance rates, etc.) and requires banks to assess their own green credit implementation and submit the results to the CBRC. The "two highs and one surplus" loan restriction policy emerged when China's economy entered a new stage of economic growth. The state gradually promoted supply-side structural reform

and optimized industrial structure. The loan restriction policy can help eliminate backward production capacity and upgrade the industrial structure of the "two highs and one surplus" industries through credit policy. It can also guide the flow of credit resources into the development of the green economy and high-tech industries. However, the problem is that, although the policy document's statistics are for loans to the "two highs and one surplus" industries after deducting the transformation and upgrading portion, some banks tend to take a "one-size-fits-all" approach without requesting specific projects. This makes it difficult for high-carbon enterprises to obtain funds for transformation and upgrading[11].

How can the contradiction between financial transformation and the restriction of loans to the "two high and one surplus" industries be solved? The key is to implement a differentiated credit policy to maintain pressure. At an aggregate level, in order to optimize industrial structure and develop new productivity, it is still necessary to reduce the total amount of loans to the "two highs and one surplus" industries. However, at a structural level, it is necessary to provide more loan support to high-quality, high-carbon enterprises that can undergo transformation, while continuing to restrict and suppress backward production capacity that cannot. Therefore, in addition to aggregate control, encouraging banks to adopt a list system can effectively encourage credit resources to favor headline enterprises in the industry.

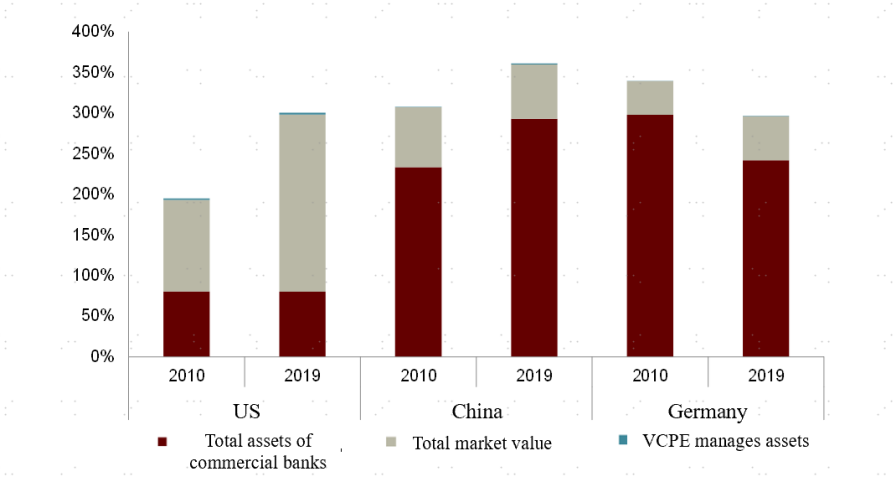
Finally, the lack of a nationally unified catalogue of transition finance means that the cost of defining transition finance operations for financial institutions is high. The low-carbon transition of high-carbon enterprises involves relevant professional knowledge, difficulty in obtaining data, a high risk of false transitions, and technical challenges for banks. Additional requirements, such as certification, labeling, and transition plans, lead to high costs for banks when defining transition finance. Banks are also forced to seek third-party certification bodies. Therefore, a nationally unified catalogue of transition finance needs to be introduced as soon as possible. However, due to the wide variety of products and significant technological differences in some high-carbon industries (e.g., the fine chemicals industry), even after its introduction, the transition finance catalogue may not comprehensively cover the baseline and target values of carbon or energy intensity for each sub-segment of the project. Therefore, it is still necessary to encourage local financial institutions and enterprises to address the gaps in transition finance standards in practice.

Chongqing Changfeng Chemical is a prime example of a company that has taken the initiative to customize its financial standards for production processes. In its case, this has involved the production of aniline from phosgene gas, a unique process that is not replicated elsewhere in the country. During this period, Changfeng Chemical has also actively participated in the trial project to establish transition standards for the fine chemicals industry. As part of this process, the firm has completed transition standards for aniline, benzophenone, tetrabutyl urea, salicylonitrile, and neutralizing agent products, including the baseline and target values of energy consumption per tonne of product. The completed sections have been put into trial operation in Chongqing. The Bank of Chongqing issued a transformation credit loan of Rmb10mn to Changfeng Chemical through its customized transformation financial service program. The loan interest rate is linked to the energy intensity of the product. When Changfeng Chemical reaches its transformation target value, it will be eligible for a 20bp interest rate reduction preference. This is expected to reduce the financial cost by hundreds of thousands of RMB at a time, when combined with the transformation loan subsidy policy[12]. As demonstrated by this case, there are still sub-segments of high-carbon areas that require attention from local banks, enterprises, and other institutions. To address the gaps in transition standards, the policy sector must provide encouragement and support.

2.3.2 Promoting green supply chain finance to play the role of credit enhancement for chain owner enterprises

China's financial system is dominated by banks, and the primary support for the real economy is provided through bank credit, bonds, and other debt financing instruments. This differs fundamentally from the systems in place in the US and other countries (Figure 6). According to the 2024 Statistical Report on the Increment of Social Financing Scale released by the People's Bank of China (PBoC), the total increase in the scale of social financing for the entire year of 2024 was Rmb32.26trn. Of this, RMB loans accounted for 52.9% of social financing in the same period, government bonds accounted for 35%, corporate bonds accounted for 5.9%, and domestic equity financing for non-financial enterprises accounted for only 0.9%[13]. In comparison with other countries, the size of China's stock market is relatively small in relation to the size of the economy. According to the latest data from Macro Micro, as of August 2025[14], China's total stock market capitalization as a percentage of GDP was 60.5%, which is significantly lower than that of the US at 213.04%, Japan at 174.68%, and India at 122.82% over the same period.

Figure 6: Financial Structure of China, the US, and Germany: Asset Size/GDP



Source: German Private Equity and Venture Capital Association, Pitchbook, CICC Global Institute

In this context, is there an innovative form of finance that can make full use of the capital advantages of the banking system and effectively solve the financing difficulties faced by SMEs due to insufficient collateral and low credit ratings? Supply chain finance can offer a viable solution. By leveraging the creditworthiness of key industrial chain enterprises, enhancing trade background scrutiny, and establishing a closed-loop capital management system, we can achieve the seamless integration of business, logistics, capital flow, and information flow through the utilization of big data and blockchain technology. By leveraging big data and blockchain technology to streamline “business flow, logistics, capital flow, and information flow”, the four flows are seamlessly integrated, leading to a substantial reduction in information acquisition costs and verification complexity in traditional credit processes. This addresses the issue of information asymmetry, enabling precise channeling of bank funds to SMEs at various points in the industrial chain while mitigating risk and ensuring the efficient allocation of financial resources. At this juncture, the chain master enterprise in the supply chain (typically the core enterprise of the industrial chain) can assume a pivotal role in providing

credit support for upstream and downstream SMEs, thereby facilitating their access to debt financing. Supply chain finance is based on the business relationship between SMEs and chain master enterprises, leveraging the implicit endorsement of core enterprises as a means of credit enhancement. Specifically, chain-owning enterprises primarily enhance credit for SMEs in three ways: First, by confirming accounts receivable and extending their own credit to suppliers (e.g., bill discounting and factoring financing); second, by providing direct or reverse guarantees to reduce the credit risk of financial institutions; and third, by sharing their supply chain transaction data to help banks more accurately assess the operating conditions and repayment ability of SMEs. This supply chain finance model, grounded in real trade experience, effectively addresses the financial challenges faced by SMEs while fostering enhanced industrial chain collaboration, thereby creating a mutually beneficial environment. Therefore, the interest rate for SME supply chain finance is typically within the range of 8–15% per annum, depending on the enterprise's size and its position in the supply chain. Historically, some SMEs experienced limited or no access to bank financing, relying instead on social financing, which often entailed financing costs exceeding 20%[15].

More importantly, supply chain finance is highly compatible with the green transition process. Compared to traditional supply chain finance, lead firms with intentions for low-carbon transformation can more easily leverage their market influence to shape a green and low-carbon supply chain during the transition process—such as requiring upstream and downstream transport companies to use green transportation equipment more extensively, opting for renewable electricity when purchasing power, or increasing procurement of green energy sources like hydrogen. Take Chongqing Jiulong Wanbo New Material Technology Co, for instance. The company is the world's largest alumina producer in terms of single-unit production capacity, and its comprehensive energy consumption and emission levels are still far lower than those of its domestic counterparts[16]. As a core enterprise of the industrial chain, the company is committed to its own green and low-carbon transformation, while also leveraging its market bargaining power and scale advantage to promote the green transformation of upstream supply chain enterprises. In the field of shipping, Jiulong Wanbo New Material Technology Co is facing a transport demand of over 10mn tonnes of bauxite per year. In order to address this demand, the company is encouraging upstream shipping enterprises to gradually adopt LNG and other clean energy ships. This initiative is being supported by a transformation of loans and financial subsidies, as well as other policy incentives. It is encouraging to see that a number of shipping enterprises have already taken the initiative to purchase new energy ships or implement low-carbon transformation[17]. In the land transport sector, Chongqing Jiulong Wanbo New Material Technology Co is committed to reducing its environmental impact by transitioning its transport fleet to electric lorries. To support this transition and address any concerns regarding charging, the company has invested in its own power plant to provide reliable charging services. This “technology demonstration + commercial support” model has generated significant demonstration and spillover effects, leading neighboring transport enterprises to follow suit and accelerating the promotion of electric trucks in the local area. Consequently, commercial banks are well-positioned to offer financing services to both chain owners and their upstream and downstream SMEs. For instance, the Chongqing Rural Commercial Bank Wanzhou Branch issued a Rmb1.5bn transformational loan for the construction of the modern production line of Chongqing Jiulong Wanbo New Material Technology Co, and also placed Rmb500mn and Rmb600mn in loans for the enterprises supplying electricity and equipment to Jiulong Wanbo New Material Technology Co, in order to safeguard the construction of this energy-saving and high-efficiency project[18].

Finance Drives the Low-Carbon Transition of High-Carbon Industries

Green supply chain finance is a credit tool that is expected to solve the two major problems of SME financing and green upgrading of supply chains at the same time. At present, the development of green supply chain finance in China is still in the exploratory stage, and a unified institutional definition and normative framework has yet to be formed at the national level. In the current market, financial institutions primarily promote green supply chain finance through three aspects[19]. First, the focus will be on supporting the green industry chain and providing supply chain financial services to enterprises at all levels. Second, the emphasis will be on promoting the production of green products, with order financing being directed towards supporting green building materials enterprises in purchasing raw materials and ensuring that the funds are used for the production of green building materials. The third option is to integrate the assessment of environmental performance into the supply chain finance process. This would involve offering customers with excellent environmental performance preferential interest rates, extended deadlines, fast-track approvals, and other incentives. Green supply chain finance encompasses a variety of operational models, with green order financing, green receivables financing, and green inventory pledge financing being the primary ones (Figure 7). However, when compared with traditional supply chain finance, green supply chain finance has some additional risk points, including the greenwashing or pseudo-transformation behaviors of the financing entities, the difficulty of auditing and assessing green bills and green products, and the great influence of fluctuations in carbon prices.

Figure 7: Operation mode and risk points of green supply chain finance[20]

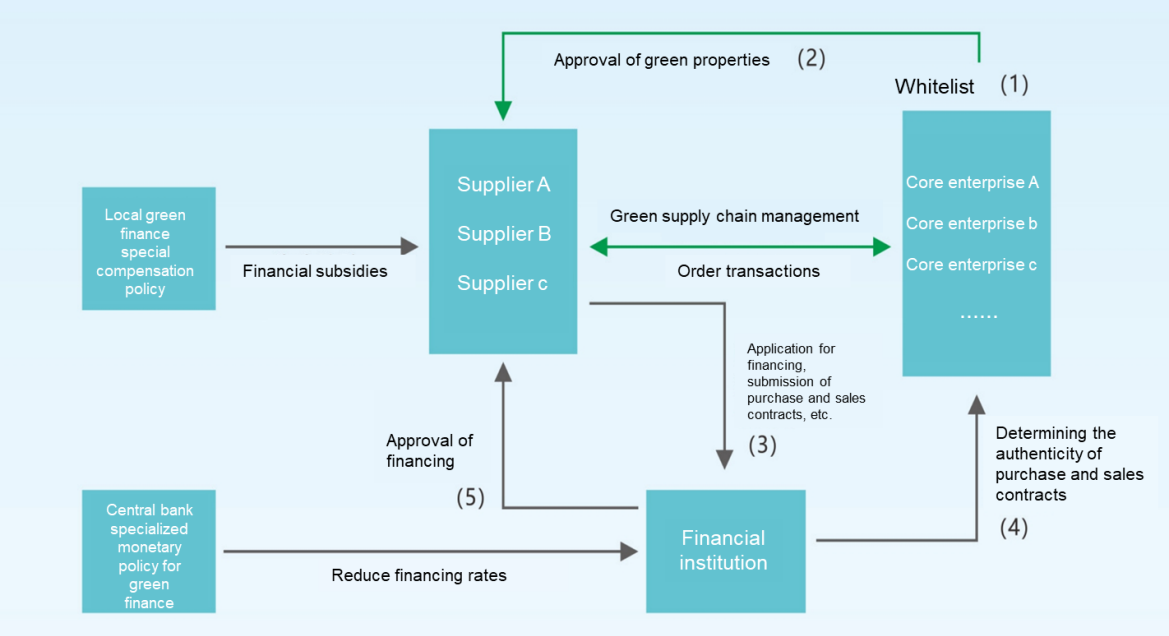
Mode of operation	Risk points
Green Receivables Financing: Upstream SMEs can apply for financing on the basis of receivables formed between them and green core businesses	Financing subjects green washing behavior, green bills audit
Green Production Order Financing: Using order financing to support green production activities by SMEs upstream of the supply chain	Green production compliance, green product price volatility risk
Green Purchase Order Financing: Using order financing to support downstream supply chain SMEs in their green procurement activities	Financing subjects green washing behavior, product green assessment
Green Inventory Pledge Financing: Supply chain enterprises can apply for pledge financing on the basis of inventories with green attributes	Financing subjects green washing behavior, product green assessment
Pledge financing for emission rights: Upstream SMEs can apply for pledge financing on the basis of emission permits and guarantees from core enterprises	Pledge rate of emission rights, uncertainty of emission rights prices, honoring of core business guarantees

Source: Shi Jinzhao et al. (2025) Green Supply Chain Finance Theory Review and Prospects, CICC Global Institute

Therefore, in order to establish sustainable supply chain financing, it is essential to transform the "green demand" of leading enterprises in high-carbon industries into financing credit for SMEs. This process can be divided into three steps: First, it is essential to unify green certification. With reference to the "Green Supply Chain Finance Service Guidelines for the Greater Bay Area (Automobile Manufacturing Industry)", issued by the Guangdong Green Finance Committee, a set of special green supply chain index evaluation systems can be formulated for the main enterprises of the high-carbon industry chain. A whitelist of enterprises can be selected for inclusion in the core of green supply chain finance. SMEs in the upstream and downstream of the supply chain of whitelisted enterprises can directly apply for green supply chain financing from the cooperating financial institutions (and can obtain preferential treatment in terms of interest rate, credit limit, and term, etc.) without having to review their green qualifications. This mode of "one-time audit, chain sharing" has the potential to streamline green certification processes, address the challenges faced by numerous

SMEs, and address the high costs associated with green certification. This, in turn, could enhance financing efficiency and lower the financing threshold for SMEs. Ultimately, the supply chain can provide SMEs with "green labels" for their inventory, orders, accounts receivable, and other underlying assets, confirming that their technologies or products meet green and low-carbon standards (Figure 8).

Figure 8: Green Supply Chain Finance Schematic[21]



Source: Greater Bay Area Green Supply Chain Finance Service Guide (Automobile Manufacturing Industry), CICC Global Institute

The green supply chain indicator evaluation system is a comprehensive framework that encompasses various dimensions, including green strategy, green manufacturing, green procurement, green logistics, green recycling, and information disclosure. A thorough evaluation will be conducted to ascertain the inclusion of a high-carbon core enterprise in the whitelist, using a combination of quantitative and qualitative methods to ensure a multifaceted and objective assessment. In the evaluation process, it is also necessary to combine the existing policy standards, such as the Green Low Carbon Transformation Industry Guidance Catalogue (2024 Edition), the Green Financial Support Project Catalogue (2025 Edition), the Green Supply Chain Management Enterprise Evaluation Indicator System (2023), and the List of Evaluation Criteria for Green Factories at the National Level (2024), with the relevant high-carbon enterprises on the list of Green Supply Chain Management Enterprises at the national level.

Figure 9: Design of Green Supply Chain Indicator Evaluation System for High Carbon Enterprises

Primary Indicators	**Secondary Indicators (Qualitative)**	**Secondary Indicators (Quantitative)**
Green Strategy	Green supply chain management target-setting and management	-
Green Manufacturing	Whether advanced low-carbon processes are used (e.g., hydrometallurgy, CCUS)	Comprehensive energy consumption and carbon intensity Proportion of clean energy use

	Whether the product meets green standards (e.g., green steel, low-carbon cement) Whether it has passed a cleaner production audit	Proportion of recycled material use
Green Procurement	Whether to establish a green access mechanism for suppliers Whether to obtain green supply chain certification Requirement of carbon footprint data from suppliers	Percentage of suppliers using energy-efficient and environmentally friendly processes and equipment Recycling procurement rate Scope 3 carbon emissions (emissions generated by suppliers and customers in the enterprise value chain)
Green Logistics	Green Transport Program Green Warehousing Program	Percentage of New Energy in Transport Vehicles Carbon Emission Intensity of Transport and Storage
Green Recycling	Construction of recycling system Construction of waste residue or waste heat recycling system	By-product recycling rate (e.g. steel slag, red mud) Coverage of waste material recycling outlets
Information Disclosure	Whether a carbon footprint tracking system is in place Data collection, information disclosure, and regular publication of ESG reports	Completeness of carbon emissions data disclosure (e.g., coverage of key indicators)

Source: Ministry of Industry and Information Technology (MIIT) Green Supply Chain Management Evaluation Indicator System for Enterprises, Greater Bay Area Green Supply Chain Financial Services Guidelines (Automobile Manufacturing Industry), CICC Global Institute

Second, break down data silos. Relying on digital technologies, a green supply chain financial data sharing platform has been built to achieve traceable, verifiable, and low-cost disclosure of green asset information, so that financial institutions can be "visible and trustworthy". For instance, in 2023, Chongqing Municipality issued the "Chongqing Green Finance Service for Green Automotive Supply Chain Guidelines (Trial)". These guidelines propose using the Yangtze Green Finance Connect—a comprehensive big data platform for green finance—to intelligently identify enterprises and projects for inclusion in the "Chongqing Green Automotive Supply Chain Customer (Project) Database". Once identified, this information is then shared and pushed to all financial institutions through the same system[22]. More importantly, in recent years, the rapid development of blockchain technology—with its characteristics of immutability and traceability—has provided efficient and trustworthy support for data circulation in green supply chain finance. Taking China Enterprise Cloud Chain as an example, the company has actively explored an integrated "supply chain finance + green finance" model. By leveraging blockchain-based products such as cloud credit, cloud leasing, and cloud notarization, it has significantly improved the efficiency of green supply chain financial services, accelerating processing from the previous T+3 to T+0, enabling banks to disburse loans in seconds, thereby precisely supporting green industries such as energy conservation, environmental protection, and clean energy[23].

Third, innovative financial instruments. On the credit side, core enterprises provide guarantees or payment commitments, and banks issue low-cost green supply chain loans to SMEs. For instance, Industrial Bank has been a pioneer in China in issuing the Green Supply Chain Finance Business Guidelines, and has launched supply chain finance products such as buyer's credit for green equipment and green products, factoring, and pledge financing for receivables[24]. On the securitization end, green receivables held by SMEs can be packaged and issued as green supply chain ABS to revitalize stock assets and expand financing channels.

For instance, Ouyeelf Financial Services, a supply chain financial service platform under China Baowu Steel Group Co. Limited, launched the "Green Tongbao" product based on the accounts receivable electronic debenture voucher product "Tongbao", which is labeled with "green" tags based on the combination of trade background information by the carbon financial service platform based on big data, blockchain, and other technologies. Upon receipt of the "Green Tongbao", suppliers can obtain corresponding financing support from designated financial institutions, and the cost of financing can be reduced by 20–100bp compared with that of ordinary "Tongbao"[25].

2.3.3 Policy finance needs to benefit SMEs in the supply chain

High-carbon enterprises are confronted with numerous risks in their technological innovation activities. From a technological standpoint, the returns on energy efficiency improvements and the cost of retrofitting may not meet expectations. From a market perspective, limited premiums for low-carbon products make it challenging for firms to fully recoup their investments. From a policy standpoint, fluctuations in the carbon price and changes in regulatory standards may compromise the economics of technological iteration. Public policy plays a key role in enabling governments to socialize and transfer risk across generations, as well as to internalize the double externalities of low-carbon technological innovation, a process which involves the role of policy finance.

At the policy level, financial institutions should be encouraged to recognize the "green demand" of chain-owning enterprises as a pledge, so that policy-based finance can benefit SMEs in the supply chain and promote supply chain-wide innovation. Specifically, the central bank can use refinancing tools to provide financial institutions with low-cost funds to support supply chain finance projects that comply with green and low-carbon technology standards and receive green purchase orders from chain-owning enterprises. The banking group of CICC's research department evaluated the economic efficiency of green loans using economic value added (EVA) and risk-adjusted economic return on capital (RAROC) indicators. The analysis revealed that the economic benefits obtained by commercial banks from conducting green loan business demonstrate higher economic efficiency compared to general public loans. A key factor contributing to this disparity is the carbon emission reduction support tool, which mitigates the capital cost of green loans for banks[26], underscoring the significance of policy interventions in promoting sustainable finance. The 2024 Opinion on Accelerating Comprehensive Green Transformation of Economic and Social Development proposes an extension to the implementation period of carbon emission reduction support tools until the end of 2027. It also calls for the study and formulation of financial standards for the transformation, and the provision of reasonable and necessary financial support for the green and low-carbon transformation of traditional industry sectors[27]. This suggests that there will be an increased focus on policy support for transformational finance activities in the future. Secondly, consideration could be given to offering banks preferential risk weights for green supply chain finance loans, with a view to reducing their capital consumption. Finally, core enterprises that actively participate in financing green technology for SMEs should be facilitated in terms of bank credit and debt issuance and financing, so as to increase the motivation of core enterprises to participate.

It should be noted that with the rapid development of supply chain finance in recent years, the current supply chain finance field has exposed multiple chaotic phenomena that need to be regulated. Firstly, some chain owners abuse their dominant market position by deliberately prolonging the accounts payable cycle of their upstream small and medium-sized suppliers (e.g., from 90 days to 180 days), and then

provide financing services to these suppliers through the associated supply chain finance platform. This exacerbates the cash flow tension of SMEs and ultimately benefits the chain owner's own price wars and volatile competition. In essence, it has become a means for chain-owning enterprises to exploit SMEs while simultaneously engaging in their own price wars and volumetric competition. The scale of non-interest-bearing liabilities (e.g., accounts payable, other payables) of some chain-owning enterprises greatly exceeds the scale of interest-bearing liabilities (e.g., short-term and long-term borrowings). Enterprises can substantially reduce their financial expenses by taking up the funds of suppliers[28]. Secondly, the risk of credit over-expansion by core enterprises has become a key concern, with the potential to generate systemic financial risks. Some chain master enterprises have been found to amplify credit leverage through various means, including providing fraudulent credit endorsement in the form of implicit guarantees for financing purposes to upstream and downstream enterprises, as well as forming a large number of off-balance-sheet liabilities. These practices may lead to an increase in financial risks along the supply chain once the financial condition of the core enterprise deteriorates or cash flow is strained. Finally, supply chain information service platforms have been found to charge unreasonable fees to SMEs, which raises their transaction costs. The existence of these problems means that supply chain finance, which is designed to solve the financing difficulties and information asymmetry of SMEs, is instead having a negative effect on their cash flow and may create new risks. In order to regulate the development of supply chain finance, the People's Bank of China and five other departments issued the Circular on Regulating Supply Chain Finance Business and Guiding Supply Chain Information Service Institutions to Better Serve SME Financing Matters[29] in 2025, which proposed to encourage the development of diversified supply chain finance modes. It encourages commercial banks to actively explore supply chain de-core modes, to reach supply chain enterprises in a more direct service manner, and to make use of supply chain “data credit” and “object credit” to provide supply chain finance services[30].

The future development of green supply chain finance also needs to follow the innovative direction of “no departure from the core”. This concept means not completely relying on the core enterprise, but reducing dependence on its credit, while strengthening the application of “data-based credit” and “asset-based credit”. This enables commercial banks to reach SMEs along the supply chain more directly through proactive service models.

This can gradually reduce the traditional reliance on credit endorsements, guarantee mechanisms, and confirmation documents from core enterprises, while preserving the collaborative advantages of the supply chain system. The key to this transformation lies in the construction of a multi-dimensional, data-driven risk control system. Through the integration of real-time transaction data, logistics information, warehouse receipt dynamics, and other digitized assets generated by each link in the supply chain, combined with internet of things (IoT) equipment tracking and blockchain depository technology, financial institutions can directly carry out accurate assessments and dynamic monitoring of SMEs' inventory turnover, receivables quality, order fulfilment ability, and other operational elements. Relying on the real trade background of the supply chain, it ultimately provides sustainable financial support for SMEs directly based on the supply chain, but without over-reliance on the main credit of core enterprises. It should be emphasized that today, AI large models are capable of detecting fraud and false information, such as counterfeit bills or greenwashing, thereby continuously enhancing financial institutions' ability to deliver green supply chain financial services and manage related risks.

2.4: Breaking the deadlock in equity financing: Chain leader CVC innovates venture capital model

2.4.1 Capital markets support breakthrough innovation

In contrast to incremental innovation, the high uncertainty, high risk, and long cycle characteristics of breakthrough innovation make equity financing preferable to debt financing, and capital markets can play a greater role. According to research by the IEA, approximately 35% of global emissions reductions are set to come from emerging technologies that are not yet marketable, including hydrogen energy and CCUS[31]. These technologies are critical for achieving deep decarbonization in sectors with high carbon emissions, such as heavy industry. The relevant emerging industries are still in the development stage, and their products and technological process routes are still subject to large uncertainties and need to undergo a continuous trial-and-error process. Conversely, breakthrough innovation signifies the pioneering exploration of cutting-edge technological domains. From the perspective of science and technology finance, the development of breakthrough innovation implies that the financial system, while providing financing, also needs to undertake the functions of screening and supervision, managing risks, and promoting transactions, and the capital market also has more room to play in this regard. As the depth and breadth of the US stock market leads other countries, and the NASDAQ market has been particularly influential in promoting science and technology innovation in the US, venture capital in both digital and biotechnology fields has been instrumental in promoting innovation and achieving lucrative returns.

A well-developed capital market is the result of institutional design and is also in a constant process of evolution. The US stock market is in a process of continuous evolution, and the trading mechanism of the world-famous NASDAQ market today was established in the early 1970s. The institutional framework of China's capital market is undergoing continuous enhancement, with a recent focus on promoting innovation. In 2019, the Shanghai Stock Exchange set up the Science and Technology Innovation Board and registration system pilot. The same year, it launched the comprehensive deepening of the reform of the New Third Board. In 2020, the GEM Board of the Shenzhen Stock Exchange implemented the institutional reform centered on the registration system. In 2021, it set up the Beijing Stock Exchange, among other initiatives. The overarching aim of these developments is to develop a multi-layered capital market and enhance the ability of the capital market to serve science and technology innovation.

However, promoting the registration system is a systematic project. A practical issue that needs to be addressed is how to manage the pace of listings under the registration system. It is generally accepted that when stock market valuations are low, the willingness of high-quality companies to go public will be reduced. Market incentive constraints will therefore lead to a slower pace of IPOs. Conversely, information asymmetry can give rise to the so-called adverse selection problem, where the market is unable to effectively differentiate between high-quality and low-quality companies, resulting in the listing of more low-quality companies. A key factor contributing to adverse selection is the relatively minor penalties for fraudulent behavior. The key to enhancing the caliber of listed companies lies in the enhancement of information disclosure quality, not only through the implementation of regulations, but also by means of the imposition of stringent penalties on rule violators and the provision of incentives to whistleblowers. The root of fraud lies in the absence of balanced information, making it challenging for external parties, including regulators, to access relevant corporate information.

Establishing incentives for individuals in possession of pertinent insider information to come forward is crucial in addressing this issue. Furthermore, it is essential to establish and enhance the Chinese version of the class action system. The Supreme People's Court has issued a set of guidelines titled "Provisions of the Supreme People's Court on Several Issues Concerning Representative Litigation in Securities Disputes". These came into effect on July 31, 2020. The aim of these guidelines is twofold: Firstly, to reduce the cost of defending rights and secondly, to facilitate the initiation of and accession to lawsuits by investors. The latter is key to improving the efficiency of initiating lawsuits in the implementation process.

In order to thrive, capital markets for innovation require more than a strong stock market; effective interaction between the equity and stock markets is also essential. The development of diversified equity financing is also an important part of the capital market's function in science and technology finance. In the context of private equity and venture capital, there are two aspects that require particular attention. First, the long investment period inherent to equity financing services means that innovation is limited. The expected return period of venture capital is a mere five to seven years at the longest, and public market investors have even less patience, while it often takes 15–20 years from the start of research to the realization of commercial returns due to the time it takes for technological advances to be commercialized. Public market investors have a negative view of listed companies that increase investment in challenging R&D. In the clean energy sector, there is a notable mismatch between venture capital investments that seek early exits and long-term investments that require patience. According to data from Preqin and Zero2IPO Database, the average duration of venture capital investments in China is significantly shorter than in the US, at 3.3 years compared to 8.2 years[32]. Second, the ability of equity financing to deliver quality listed companies to the stock market has declined. A significant aspect of this is the question of "where have the unicorns gone". In 2016 and 2017, China outperformed the US in terms of the number of new unicorn companies formed each year, with a significant lead over India. However, following 2018, the US has significantly outpaced China, while India is rapidly catching up with China. While there are cyclical factors at play, with the US stock market showing signs of improvement in recent years while China experiences slower growth, it is also important to consider whether there are underlying structural issues contributing to this disparity. Drawing from the experience of mature capital markets, the development of diversified equity financing requires the mobilization of entrepreneurs, wealthy groups, and philanthropic funds, which have a stronger incentive to explore projects in the private sector.

In terms of policy support, the government's industrial steering funds have seen significant growth in recent years, but certain issues remain. For example, current industrial guidance funds and other equity investors tend to favor later-stage, mature projects in the green sector and often have relatively short investment horizons. This preference is not conducive to supporting breakthrough innovations in green fields, which are typically characterized by high risk and long development cycles. Therefore, it is necessary to optimize the performance evaluation mechanisms for industrial guidance funds and establish dedicated green venture capital programs. Policymakers should also recognize the positive role of high-performing foreign venture capital firms and CVC. These issues are discussed in detail in the 2024 CCICED report "New Paradigms in Green Finance: Enhancing the Core Function of Capital Markets".

2.4.2 Building a venture capital landscape with green CVCs as the core enterprise of chain owners

In contrast to IVC, CVC refers to non-financial enterprises that establish venture capital subsidiaries or investment departments with their own funds to make non-controlling equity investments

in start-ups. As CVC funds are primarily derived from the enterprise's own funds, the enterprise's survival is a key factor in determining the absence of significant investment exit constraints. In comparison to IVC, where the upper limit of the survival period is typically 10 years, the demand for exit is less urgent in the case of CVC. Furthermore, in contrast to the pursuit of maximizing the financial return of IVC, CVC's primary focus is on achieving the parent company's strategic objectives. This approach is indicative of a more patient capital, and CVC is better positioned to invest in innovative projects characterized by long R&D cycles and high uncertainty. This patience leads to a willingness to use lower discount rates and a higher valuation of the present value of the future earnings of the invested projects, meaning that CVCs are usually involved in larger single investments.

More importantly, for the invested enterprises, CVC can effectively enhance their innovation output and probability of commercial success. The reasons for this are as follows: First, CVC is able to offer portfolio companies the parent company's complementary technologies, sales channels, application scenarios, and other resources, with stronger complementary and synergistic effects. Second, CVC's empowerment process is less dependent on the management activities of the investee company, so it intervenes less in the operation and management of the investee company than IVC and is able to encourage the enthusiasm of the management team of the investee company. Third, CVC has a tendency to view investment as an experiment rather than an asset management activity and has a greater tolerance for the failure of portfolio companies. The study shows that compared with IVC-backed startups, CVC-backed startups obtain 27% more patents and 18% more citations on average in the three years before going public; in the four years after going public, CVC-backed startups obtain 45% more patents and 13% more citations on average[33].

For chain-owning firms, CVC can also be beneficial in terms of enabling large firms to break free from internal R&D path dependency and acquire disruptive innovations. Large technology enterprises are well-placed to innovate, as demonstrated by quantitative indicators such as the number of researchers, the scale of research investment, and the accumulation of intellectual property rights. However, the complex internal structures and resource bases of large enterprises can sometimes hinder the full release of internal R&D capabilities, meaning that these capabilities are often better suited to incremental innovation. Consequently, large enterprises may seek to acquire disruptive innovations from external sources. While external M&A can facilitate rapid transformation, there is a risk of transmitting the challenges associated with large enterprises to the acquired enterprise. Additionally, the uncertainty surrounding disruptive innovation through external M&A can lead to a higher opportunity cost. When considering the full picture, CVC can be regarded as a method of innovation development for large chain-owning enterprises that offers a favorable risk-benefit ratio when it comes to acquiring disruptive innovation.

For instance, China Baowu Group's Baowu Green Carbon Private Equity Fund is the largest carbon-neutral thematic fund in China. It is committed to opening up the path of low-carbon development in the iron and steel industry for China Baowu, and helping its iron and steel ecosystem to achieve the goal of carbon neutrality. The fund's strategic investment approach encompasses two key tracks: Carbon emission reduction and carbon sequestration. In the area of carbon emission reduction, the fund prioritizes large-scale implementation of clean energy sources, including photovoltaic, wind, hydrogen, nuclear, and hydropower technologies. In the domain of carbon sequestration, the fund places emphasis on technologically advanced CCUS solutions[34]. Through systematic investment strategies, it fully supports the green and low-carbon transformation of the industrial chain. SINOPEC has made an investment in Shanghai Heavy Energy, with a view to supporting its industry chain structure across the board in the fields of hydrogen production equipment, fuel cells, and hydrogen-

electricity synergistic application. Meanwhile, SINOPEC's Enzer Fund has made an investment in the enterprise Hydrosys, a developer of hydrogen storage, transportation, and addition technology, with a view to promoting the localization of core enterprises in the field of hydrogen energy and the construction of a hydrogen refueling station network.

2.4.3 Policy should be implemented in a precise and targeted manner, with emphasis on two key dimensions: Broadening the scope of application and strengthening capital input

The core enterprise is the chain owner, and a mechanism is created that incorporates "green demand scenario + joint incubation by diversified capitals". This mechanism is designed to enable the rapid shaping of the green technology supply chain from Zero to One—that is, the creation of entirely new capabilities. Firstly, the chain master enterprise "makes the requirement". Chain master enterprises have developed "green demand scenarios", which are lists of transformation projects and technology bids that can be implemented, based on their own green and low-carbon transformation goals. SMEs that succeed in bidding can not only secure long-term orders but also gain access to the multi-round investment channel led by the CVC of the chain owner. The next stage of the process is the joint incubation of multiple capitals. The CVC of the chain owner will take the lead in forming a joint investment body with GVC and IVC to provide continuous capital injection and counselling to successful projects, thereby reducing the risk of technology iteration and market expansion of SMEs.

Policies have been "precisely trickled down" in two key areas. Firstly, the objective is to create more application scenarios of green technology and provide targeted support. This includes green refinancing from the central bank, research subsidies, and experimental demonstration funds for the new construction or expansion of the green demand scenarios of chain master enterprises. The aim is to expand the market scale of emerging green technologies. In contrast, we are encouraging GVC to participate in co-investment as a strategic LP, forming a venture capital pattern led by CVC+IVC and complemented by GVC strategy. This will amplify the leverage effect of financial funds and accelerate the application of green and low-carbon technologies and the shaping of the supply chain.

3 Raising Fossil Energy Costs: Policy-Backed Finance Needed to Manage Transition-Induced Social Risks

3.1 Carbon market mechanisms and administrative measures are two levers for increasing fossil energy costs

Raising the cost of fossil fuels to promote green transition primarily relies on two key policy levers in practice: Carbon market mechanisms and administrative directives and control measures. Carbon pricing involves government-guided assignment of social costs to carbon emissions, essentially a policy solution devised to address market failures. Indeed, numerous enterprises are spontaneously utilizing price signals to guide internal green transitions. For instance, several Fortune 500 companies and major financial institutions have begun incorporating carbon emission costs into decision-making through internal carbon pricing schemes, demonstrating the broad applicability of carbon pricing as a market signal. Administrative measures, however, are more direct, involving mandatory government intervention through regulations, standards, and prohibitions. China has introduced multiple robust measures in this regard to facilitate the transformation of high-carbon industries. Examples include strictly enforcing pollutant emission standards, workplace safety regulations, and product quality benchmarks, legally shutting down non-compliant enterprises[35], mandating the phasing out of outdated processes and equipment within specified timeframes, and implementing dual controls on both energy consumption intensity and total volume[36].

However, both approaches face practical challenges: On the one hand, given the substantial existing capacity in China's high-carbon industries, the carbon market requires an accurate price signal to effectively drive their transformation objectives. Yet China's carbon price often remains insufficiently high. In 2024, the average price of carbon market allowances stood at Rmb91.8/tonne, representing a 43.4% increase from 2023[37]. Nevertheless, this remains below the global average carbon price of US$32/tonne[38]. Moreover, the market is still in its initial expansion phase, failing to adequately reflect the societal cost of carbon emissions or provide sufficiently strong economic incentives to drive deep decarbonization and technological innovation. Conversely, carbon market mechanisms suppress output and consumption by raising production costs; higher carbon prices lead to greater economic contraction[39]. Similarly, aggressive administrative measures (such as large-scale shutdowns) may inflict significant macroeconomic shocks, adversely affecting sectoral output, local fiscal revenues, and employment stability in the short term.

Returning to the transition process within high-carbon industries themselves, as traditional fossil fuel-related industrial activities gradually contract, both employment and income will progressively decline, and associated assets will depreciate. This gives rise to risks of stranded assets for enterprises and risks of a just transition, including reduced labor income and even unemployment. Meanwhile, the carbon market elevates corporate operational costs, while administrative measures accelerate capacity elimination. **While hastening the low-carbon transition, these factors amplify both the aforementioned social risks, rendering the task of managing social risks considerably more arduous.**

3.2 Addressing stranded asset risks in high-carbon industries requires financial engagement

Stranded assets are defined as assets that have suffered unexpected or premature write-downs, depreciation, impairment, or even conversion to liabilities before the end of their expected economic lives due to external factors such as policies, regulations, technological innovations, market changes, and shifts in social norms[40]. The primary reason for the stranded assets in the process of the green transition of high-carbon industries is that, as the global response to climate change continues to advance, countries have introduced increasingly stringent carbon emission reduction policies. These policies have prompted the accelerated adjustment of the energy structure, the original reliance on fossil fuels, and other traditional high-carbon models of the assets. The assets are unable to adapt to the new low-carbon standards and market demand, and face the early elimination of the situation or a significant decline in the value of the assets. If such stranded assets are formed within a relatively short period of time and on a large scale, they may pose risks to the normal operation of the country, industries, and enterprises, and affect the advancement of green and low-carbon transformation.

3.2.1 What risks can the accumulation of stranded assets trigger?

China's heavy industry sector is characterized by two key features: First, the relatively short useful life of production assets, and second, the production path that is generally highly dependent on coal-based fossil energy. The inherent properties of these high-carbon assets indicate that a large number of stranded assets will be formed in China's high-carbon industries during the process of low-carbon transformation, thereby increasing the pressure on the country to prevent and handle stranded risks. With regard to coal dependence, from 2021 to 2023, an average of 90% of the iron and steel industry's capacity was based on the blast furnace-converter production path, with only 10% using the electric furnace steel process[41]. This proportion is far below the global average of 29% and the EU standard of 45%. Relevant studies show that in 2023, the cement industry still relied on fossil fuels for 90% of its energy needs, and carbonate decomposition emissions in the production process accounted for 60% of the total[42]. The chemical industry primarily utilizes fossil fuels as its primary energy source and raw material, and includes a substantial coal chemical sector. The electrolytic aluminum industry is highly reliant on coal power, particularly for power generation from captive power plants. The high coal dependency of these industries poses a significant challenge in terms of supply chain management. The transition to a low-carbon economy could potentially result in a situation where production equipment and raw materials are stranded due to their dependency on coal.

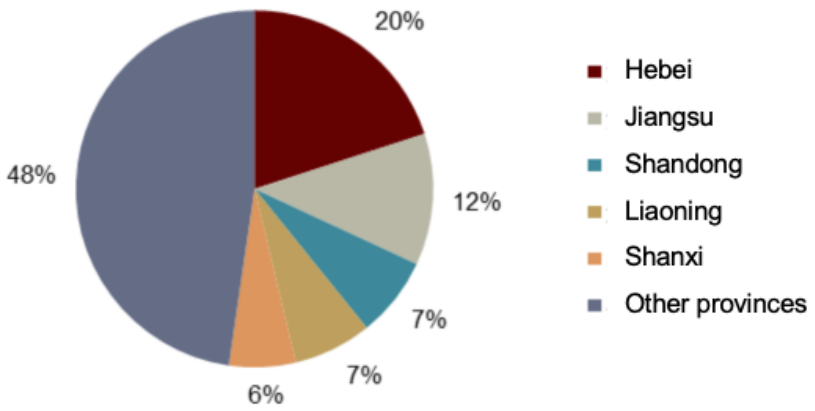
From the perspective of asset service life, the average operational lifespan of domestic blast furnaces in the steel industry is only 13 years, whereas their designed service life can reach up to 40 years[43]. In the cement industry, approximately 90% of production facilities were constructed within the past two decades, with 40% built in the last 10 years, and the standard design life of these facilities is generally four years[44]. In the chemical industry, the average service life of methanol production equipment is eight years, while that of ammonia synthesis equipment is 16 years—both significantly below the conventional lifespan of over 30 years. Similarly, the average age of coal-fired power plants in China is 13 years. Although the operational lifespan of these plants has been extended to 25–35 years due to early decommissioning and replacement with more efficient capacity, it remains notably lower than the global average of 40–50 years[45]. These assets, which have not yet reached the end of their designed service life but failed to meet low-carbon requirements, are associated with relatively low

annual depreciation provisions. As a result, they face potential risks of significant depreciation or premature retirement due to policy changes and market shifts driven by low-carbon transformation, further intensifying the pressure of managing a large volume of non-performing assets.

Currently, there is widespread concern about stranded asset risks in three areas. **First, whether the nationwide accumulation of stranded assets could trigger systemic financial risks.** To analyze this issue, we can seek answers from historical events that have triggered economy-wide systemic financial crises. Historical experience demonstrates that financial crises are sudden and systemic in nature. For instance, during the 2008 subprime crisis, the risk associated with financial derivatives rapidly disseminated across the global financial network, precipitating a bank run and a sudden cessation of credit, which ultimately culminated in a debt crisis that engendered a deflationary spiral within the real economy[46]. Corporate entities found themselves unable to meet their debt obligations as their earnings diminished, compelling them to divest their assets at depressed prices, thereby further exacerbating the downward spiral in asset and price values. This self-reinforcing negative cycle has the potential to elevate the national non-performing asset rate[47]. In contrast, the transition of high-carbon industries is a gradual, policy-guided process driven by technological substitution, and the economic impact of technological change is continuous and manageable[48]. The transition of high-carbon industries proceeds gradually under policy guidance, and the economic impact brought by technological change is continuous and controllable. Taking the replacement of the traditional coal industry by new energy technologies as an example, this process is more of a continuous accumulation of “slow variables”, rather than the “fast variable” shocks triggered by sudden funding chain ruptures as seen during financial crises.

Second, regional transition challenges and decline risks. As discussed above, we believe that stranded high-carbon assets indeed require greater vigilance regarding regional risks. China's high-carbon industries, including coal and iron and steel, demonstrate notable regional concentration, with certain regions exhibiting a high degree of reliance on these sectors for their economic viability and employment opportunities. In the case of iron and steel, for example, Hebei is the largest province in terms of steel production capacity, accounting for 20% of crude steel production in 2024 across all provinces in the country (Figure 10); from January to May of this year, Hebei's steel industry output accounted for 21.51% of the national total and generated 30.39% of national profits[49]. From the perspective of industrial development in Hebei province, iron and steel represent the first pillar industry. In 2023, the value added by the local iron and steel industry accounted for 26.45% of the province's industry above designated size, achieving direct employment of nearly 400,000 people[50]. Shanxi's situation in the coal industry is similar. In 2024, the total raw coal output of enterprises above a designated size in Shanxi province was 12,687,380 tonnes, accounting for approximately 26.7% of the national output in the same period[51]. From the perspective of Shanxi province's industrial structure, the coal industry contributed significantly to the economy in 2023. Specifically, the industry's added value accounted for 61.8% of the regulated industry's share and 26.5% of the province's GDP[52]. If high-carbon assets in the region are stranded on a large scale, it may lead to a sudden drop in the solvency of local enterprises, which will then be transmitted through channels such as upstream and downstream supply, directly pushing up the non-performing loan ratio of banks in the region. This process could potentially trigger a chain reaction: Asset quality deterioration could prompt banks to tighten credit to local enterprises, leading to challenges in enterprise financing and production contraction. This, in turn, could intensify the downward pressure on the regional economy, resulting in a local cycle of “rising non-performing rate - credit contraction - economic recession”.

Figure 10: The proportion of steel production in each province in 2024



Source: CEIC, CICC Global Institute

The third is the risk caused by improper disposal of non-performing assets by enterprises. Concurrently, the issue of stranded assets is gradually gaining prominence in the transition from high-carbon to low-carbon industries, and the risk of non-performing debt and equity should not be underestimated. From an enterprise financing perspective, the transformation of high-carbon enterprises often necessitates substantial capital investment to update equipment and research and develop low-carbon technology. However, the transition process of operational risk increases, profitability is expected to decline, and profit margins are compressed. These factors are compounded by the high carbon industry in recent years, which has experienced a low degree of growth and difficulty in generating revenue. Enterprises are facing an increased risk of default. In order to mitigate this risk, banks and other financial institutions are expected to tighten loan conditions, increase interest rates, or reduce the number of loans available. This will exert pressure on the enterprise capital chain. If the chain is broken, the enterprise will be unable to pay debts on time, which will result in an increase in bank bad debt and the formation of non-performing debt. For instance, Datang Baoding Huayuan Cogeneration Limited Liability Company, which was included in the thermal power de-capacitation program, was closed in September 2018 and ultimately filed for bankruptcy and liquidation. This resulted in the risk of recovery of Datang Power Generation's claims against it[53]. Consequently, high-carbon enterprises may also develop non-performing claims, such as bad bank debts and supplier arrears, due to broken capital chains and declining business conditions during the transition process. Conversely, enterprises themselves can develop non-performing equity due to substandard operations, diminishing equity value, impaired shareholders' rights and interests, and a decline in the attractiveness of equity in the market. For instance, in recent years, as polysilicon production continued to outgrow demand, some companies have been obliged to sell their holdings at low prices as a result of deteriorating market expectations. This has led to a significant depreciation of their equity value[54].

3.2.2 "Anti-involution" will further highlight the importance of risk management of stranded assets

On July 1, 2025, the sixth meeting of the Central Financial and Economic Affairs Commission listed "governing enterprises" low-price, disorderly competition in accordance with laws and regulations, guiding enterprises to improve product quality, and promoting the orderly exit of backward production capacity' as one

of the six key directions for advancing the development of a unified national market. People's Daily and Qiushi Journal have published a series of articles emphasizing that “involutional competition” has become a prominent issue in current economic development. Industries including photovoltaic glass, cement, construction, automobiles, and steel have introduced measures and commitments to reduce or limit production and shorten payment cycles, and comprehensive efforts to address “involutional competition” are underway. “Involutional competition" reflects homogenized and disorderly market rivalry, whose economic consequence is that, under limited resources, enterprises engage in excessive investment without necessarily improving output efficiency, leading to overall distortions in resource allocation. Underlying causes include market coordination failures (such as blind investment and redundant construction in popular sectors), structural imbalances in market power (for instance, lead firms or platform enterprises squeezing upstream and downstream suppliers, disrupting normal market competition), as well as local protectionism and market fragmentation, all of which impair normal market competition and clearance mechanisms.

The current round of “anti-involution” initiatives is driving capacity governance toward greater normalization and institutionalization. Unlike the 2016 supply-side reform, which primarily targeted “capacity reduction” in upstream heavy industries, this round significantly expands the scope of governance—covering not only upstream and midstream raw material industries but also strategic emerging industries such as new energy. In terms of implementation targets, the focus has shifted from small, scattered, and disorderly enterprises—such as unsafe "rebar" steel producers and small illegal coal mines in the past—to large SOEs and leading private firms with scale advantages. These enterprises typically possess strong employment absorption capacity, high levels of market-oriented operations, and active technological innovation. This structural shift necessitates more refined policy implementation—relying on market-based and rule-of-law approaches such as strengthened anti-monopoly enforcement, improved industry standards, and guidance for industry self-regulation, rather than simple administrative shutdowns.

The July 2025 Political Bureau Meeting identified the construction of a unified national market as a key mechanism to address involution, emphasizing the need to standardize subsidy practices in local government investment promotion and curb disorderly capacity expansion at the source. This shift in governance approach not only avoids the market volatility caused by campaign-style regulation but also marks a transition in China's capacity governance—from short-term interventions toward establishing long-term, sustainable mechanisms—seeking a more balanced and enduring equilibrium between maintaining fair market competition and preserving industrial vitality[55].

We believe that “anti-involution” will inevitably lead to the phasing out of certain high-carbon backward production capacities, thereby exposing these high-carbon assets to the risk of being stranded. Specifically, high-carbon assets facing higher stranded risks are primarily concentrated in three categories: Backward production capacities with low energy efficiency and poor environmental performance, over-capacities that exceed registered or approved levels, and outdated facilities.

First, there is the issue of backward production capacity with low energy efficiency and high emission intensity. The elimination of production capacity with low energy efficiency and high emission intensity is a key measure for the implementation of the “dual-carbon” target. By upgrading energy efficiency and reducing carbon emissions, the greening process of key industries can be accelerated, thus laying the foundation for carbon neutrality. Energy conservation and carbon reduction upgrades can effectively lower

enterprise energy costs, enhance market competitiveness, and mitigate the risk of stranded high-carbon assets in the future, thereby ensuring a smooth industrial transition. Additionally, the elimination of outdated production capacity will create room in the market for advanced green technologies, and promote the development of new energy, energy conservation, and environmental protection industries, as well as cultivate new momentum for economic growth. Consequently, through technological transformation and capacity optimization, we can promote the upgrading of high-carbon industries to transform them into high-end, intelligent, and green industries, and achieve high-quality development. As outlined in the Action Program on Energy Conservation and Carbon Reduction for 2024–2025, by the end of 2025, the proportion of production capacity exceeding the energy-efficiency benchmark in high-carbon industries such as iron and steel, oil refining, ethylene, synthetic ammonia, calcium carbide, electrolytic alumina, cement, ceramics, and more, will need to surpass 30%. Furthermore, production capacity falling below the energy-efficiency benchmark will be required to undertake energy conservation and carbon reduction technological reforms or face elimination and withdrawal from the market[56]. This suggests that outdated capacity within high-carbon industries will be phased out.

It should be noted that, in practice, some enterprises are unable to eliminate outdated production capacity due to the high costs of energy-saving equipment, the current pressure to operate, financial liquidity difficulties, and other factors. There is a lack of understanding on how China can incentivize companies to become more energy-efficient. A result of this is that high-energy-consuming equipment has been ordered by China even though they are not compliant.[57] This has a detrimental effect on the progress made in improving overall energy efficiency, whilst also resulting in energy wastage and environmental pollution. Therefore, in the process of implementing policy, it is necessary to strengthen supervision and law enforcement through regular inspection, information technology monitoring, and other means. This will ensure that production capacity is utilized on time and in an orderly manner, and will effectively promote the green and low-carbon transformation of the industry. Furthermore, financial subsidies, tax incentives, and other incentives should be considered to reduce the cost of transformation for enterprises.

Second, the actual production capacity exceeds the recorded capacity. In recent years, China has continued to strengthen the control of production capacity in some high-energy-consuming industries, requiring strict control of new production capacity and the strict implementation of capacity replacement policies. However, for some of China's high-carbon industries, actual production capacity has for a long time exceeded the designated capacity level. This imbalance may lead to safety hazards and pollution risks, and may exacerbate the fierce competition and overcapacity in the industry. In the cement industry, for example, the national cement clinker capacity utilization rate is projected to be less than 53% in 2024, significantly below the national average industrial capacity utilization rate of 75.1% and the 73.7% target set by the State Council's Guiding Opinions on Resolving Serious Overcapacity Contradictions[58]. In this regard, the Ministry of Industry and Information Technology revised the issuance of the *Cement and Glass Industry Capacity Replacement Implementation Measures (2024 version)* in October 2024. The measures included tightening cement replacement requirements, improving the capacity of approved production methods, and other measures. These measures were designed to promote the unity of field production capacity and actual production capacity, and to optimize the industry's layout and structural adjustment[59]. In July 2025, the State Administration of Market Supervision issued the *Implementation Rules for Cement Production License (Draft)*. According to these new regulations, enterprises are required to complete the declaration of capacity rectification by the end of 2025. Notably, the rules now

explicitly include the government's approval of production capacity as a mandatory requirement for production licenses[60]. Meanwhile, the China Cement Association has issued the *Opinions on Further Promoting Anti-Internalization and Stable Growth for High-Quality Development of the Cement Industry*, requiring enterprises to conduct a comprehensive verification of the discrepancies between registered and actual capacity of their clinker production lines, complete the required procedures within the specified time frame, and carry out production in compliance with registered capacity limits[61]. These policy measures are expected to standardize industry practices, curb unregulated expansion of production capacity, and assist the cement industry in overcoming internalization challenges, thereby promoting high-quality and sustainable development.

Third, outdated facilities. This category is primarily concentrated in the petrochemical and chemical industry, where the number of recent safety incidents has increased. The petrochemical sector has been in a prolonged downturn, and amid intense industry competition and growing profit pressures, enterprises have reduced supply and inventory through shutdowns or production cuts in recent years. This may pose certain risks to the operation of chemical facilities, leading some companies to cut safety investments and thereby increasing safety risks[62]. Against this backdrop, in 2025, five national ministries including the Ministry of Industry and Information Technology issued the *Notice on Conducting Inventory Assessment of Outdated Petrochemical and Chemical Facilities*. The assessment targets production facilities that have reached their design service life or have been in operation for over 20 years. The evaluation covers key aspects such as compliance with safety production standards, whether the facility is classified as obsolete, conformity with energy consumption limits and pollutant emission standards, and whether energy efficiency meets minimum benchmarks[63]. This inventory assessment covers a broad scope, involving most sub-sectors of the chemical industry. In the past, comprehensive inspections were challenging due to the large number of specialized sub-sectors, each requiring the establishment of baseline energy efficiency standards and advanced benchmarks. We believe this policy precisely focuses on facility age as a key indicator, as outdated facilities often carry higher safety hazards and suffer from low energy efficiency. Upon completion of this assessment, it will provide a critical lever for addressing issues such as “involution-style” competition or the orderly exit of backward capacities.

Considering the risk of stranded assets that “anti-involution” may pose to the above-mentioned high-carbon assets, the importance of stranded asset risk management for high-carbon enterprises is further highlighted—particularly the need for finance to effectively support enterprises in diversifying and mitigating such risks.

3.2.3 How finance supports enterprises in diversifying and mitigating stranded asset risks

Although we have identified stranded asset risks at both the regional and enterprise levels in previous sections, when exploring how finance can play a role, since the transformation risks at the regional level are caused by the accumulation of stranded asset risks of key enterprises and their industrial chains in that region, **we will focus on how to support enterprises in resolving related risks.**

For enterprises, stranded asset risks can be categorized into those **related to assets that are already non-performing,** and those **related to assets that have yet to become non-performing. Risks related to non-performing assets** refer to assets whose economic value drops significantly due to changes in the external environment (such as policy adjustments, technological advancements, shifts in market demand, etc.) and are no longer able to generate the expected returns as originally planned. These assets have suffered unexpected or

premature impairment, depreciation, or even been converted into liabilities, and must be recorded as losses on the balance sheet. These assets are no longer capable of generating sufficient cash flow to cover their operating costs or repay debts, leading the enterprise to face financial difficulties. Its main features include poor financial performance, asset impairment, debt default risk, etc. It may be necessary to reduce losses through debt restructuring, asset sales, legal proceedings, and other means. **Risks related to assets that have yet to become non-performing** refer to assets whose economic value has declined due to changes in the external environment, but have not yet reached a situation where they are unable to generate expected returns. Although these assets can still generate certain returns, their future earnings are uncertain and may face the risk of becoming stranded due to further policy changes, technological advancements, or shifts in market demand. These assets have not yet become non-performing assets, but there is a potential risk of economic value loss. Enterprises need to enhance the competitiveness of these assets through technological innovation, asset transformation, market expansion, and other means. It is also necessary to closely monitor policy changes and promptly adjust asset operation strategies to ensure that assets comply with new policy requirements. With reasonable financial support and strategic planning, these assets have the potential to transform, enhance their economic value, and even become new growth points for enterprises.

- **Disposing of non-performing assets to revitalize enterprise transformation**

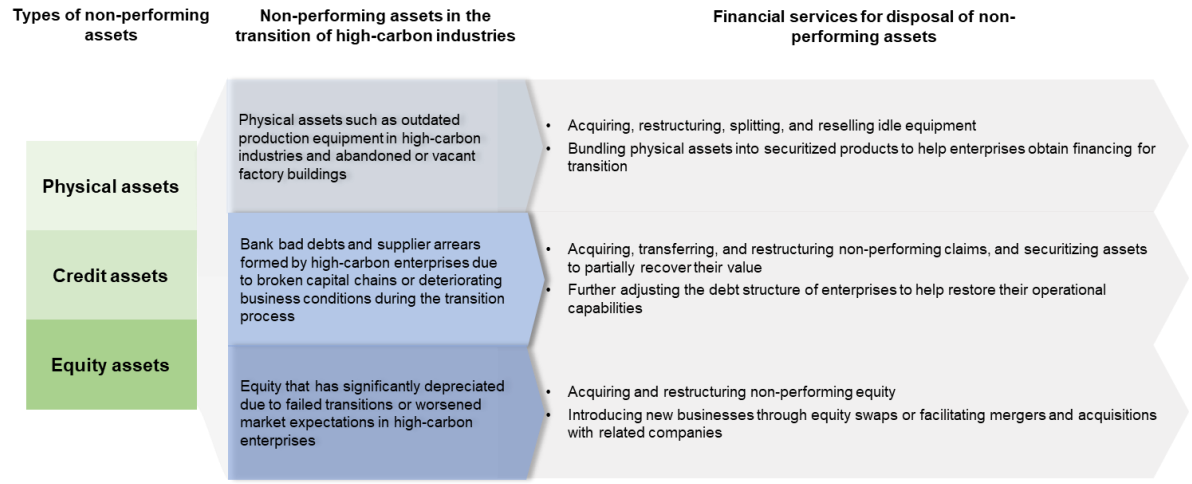
Finance can provide a range of diversified and specialized services to support high-carbon firms in resolving non-performing assets in transition (Figure 11). The non-performing assets formed during the transition process of high-carbon industries can be categorized into three types: Physical, debt, and equity.

In terms of physical asset disposal, for abandoned, outdated plant assets that do not meet environmental standards and idle equipment, these physical assets can be packaged into securitization products through a series of operations such as acquisition, restructuring, splitting, and resale. In the event of non-performing claims, financial institutions are at liberty to implement such measures as acquisition, transfer, debt restructuring, and asset securitization. This approach enables them to realize the recovery of the value of non-performing claims and thereby reduce the debt burden of enterprises. Conversely, asset securitization facilitates the circulation of non-performing claims within the capital market, thereby expanding the avenues for value recovery.

In terms of debt restructuring for enterprises, financial institutions can leverage their professional strengths, conduct in-depth analyses of the operating and financial conditions of enterprises, and customize debt restructuring programs for them. For example, they can coordinate the interests of different creditors and promote operations such as debt-to-equity conversion to reduce the asset-liability ratio of enterprises and help them restore their operating capacity and get back on the track of healthy development. In the Chinese context, the strategic withdrawal of production capacity in the iron and steel, coal, and other industries has been achieved through a range of financial restructuring measures, including debt-to-equity swaps. These measures have effectively reduced the leverage ratio of enterprises and enhanced their market competitiveness.

In terms of non-performing equity, the company has the capability to implement acquisition and restructuring strategies. New business opportunities are presented in the form of equity swaps, or the company and its affiliates are encouraged to pursue M&A to integrate resources and optimize their business structure. During Japan's industrial transformation, many companies upgraded their business operations and optimized their industrial structures through equity-level activities.

Figure 11: Types of non-performing assets in the transition of high-carbon industries and the financial services approach corresponding to their disposal



Source: CICC Global Institute

M&A and restructuring services not only address the non-performing equity formed during the transition of high-carbon enterprises but also facilitate the re-concentration of resources through M&A by large enterprises within the industry, thereby assisting in restoring the transformation capabilities of these enterprises. For example, Volkswagen, a global automotive giant implementing an aggressive electrification strategy (Together 2025+), invested approximately EUR1.1bn through targeted private placements and agreement transfers to become the largest shareholder of Guoxuan High-Tech (holding 26.47%). At that time, due to the significant monopoly effect in China's power battery industry, Guoxuan High-Tech faced enormous competitive pressures, technological iteration challenges, and declining gross profit margins[64]. After acquiring the equity, Volkswagen directly gained access to Guoxuan High-Tech's R&D achievements and production capacity in lithium iron phosphate (LFP) batteries, laying a solid supply chain foundation for Volkswagen's electrification strategy in the Chinese market while helping Guoxuan High-Tech secure stable orders and funding, enabling it to recover from operational difficulties and enhance its industry standing.

In China, M&A activities among enterprises hold significant importance for promoting industrial upgrading and optimizing resource allocation. However, they currently face numerous challenges. From a financial perspective, companies typically encounter multiple funding requirements during M&A processes: On one hand, acquirers must pay high equity premiums or asset prices and bear various costs incurred during transactions. On the other hand, to achieve strategic goals such as rapidly acquiring licenses and expanding product lines, the corresponding liquidity funds need to be reserved. These combined needs often require substantial funding support for M&As, yet current financing channels still face many practical issues to resolve. Some companies rely excessively on debt financing to complete acquisitions, such as Xiang Torch Auto Group, whose debt-to-equity ratio reached 560.72% due to continuous acquisitions (in 2004), with short-term loans amounting to Rmb3bn, severely eroding operating cash flows under heavy interest burdens[65]. Moreover, regulatory constraints on cross-industry M&As have weakened the acquisition motivations of listed companies, especially traditional companies needing transformation[66]. The newly issued M&A regulations in September 2024[67] may effectively unleash the role of M&As in optimizing resource integration in high-carbon industries.

In this regard, at the policy level, financial institutions should be supported in developing diversified M&A financial tools combining "loans + bonds + funds" to provide comprehensive financial support for accelerating the process of large enterprises merging and integrating smaller ones. Meanwhile, in the process of financial support for corporate M&A and restructuring, the role of finance in promoting "low-carbon transition" must be fully leveraged, and targeted support mechanisms should be built through multi-dimensional measures. Specifically, efforts should focus on two fronts: Optimizing financing services and innovating mechanisms.

In terms of financing services, commercial banks should on one hand be encouraged to provide integrated credit support throughout the entire M&A process (pre-, mid-, and post-transaction); on the other hand, qualified high-carbon enterprises should be actively supported in raising M&A funds through diverse capital market instruments such as stocks, bonds, and convertible bonds.

Regarding mechanism innovation, new financing models—such as establishing specialized M&A funds—should be actively explored, while setting up constraint mechanisms linked to low-carbon targets, embedding indicators such as carbon reduction progress into credit approval and bond issuance criteria to strengthen the stewardship function of financial support in low-carbon transitions.

To ensure the implementation of these measures, enhanced policy coordination and support are needed: The central bank could use monetary policy tools such as relending and rediscounting to provide liquidity support to financial institutions; government departments could use fiscal policies such as tax incentives to further incentivize financial institutions to participate in supporting the M&A activities of high-carbon enterprises, thus forming a cohesive policy synergy.

It is important to note that the disposal of non-performing assets is not merely a matter of selling the assets, but rather a strategy to achieve "value-added" asset disposal through financial and government operations[68]. The "root sculpture theory" of non-performing assets suggests that investment banking tools should be used to continuously enrich and enhance the intrinsic value of non-performing assets, transforming "withered tree roots" into "works of art". The objective is to maximize the recovery value. Common value-added disposal methods include asset restructuring, debt-to-equity conversion, and securitization of non-performing assets. For instance, Yongtai Energy had a high gearing ratio due to rapid business expansion, which eventually triggered a bond default. In this context, financial institutions assisted Yongtai Energy Group by selling non-core assets and implementing diversified debt restructuring measures such as debt extensions and debt-for-equity swaps, helping the company secure cash flow to support the development of green transition initiatives. Meanwhile, the government established special funds to alleviate the company's short-term liquidity pressures, stabilize capital markets, and manage creditor expectations, thus effectively boosting market confidence. This ultimately facilitated Yongtai Energy Group's successful transformation, serving as a model case of financial sector involvement in corporate non-performing asset disposal (Box 1).

Box 1: Wing Tai Energy Debt Restructuring Case[69]

As the largest privately listed energy company in Shanxi Province, Yongtai Energy Group Co., Ltd. had a long-term gearing ratio of over 70% from 2015–2017 due to the rapid expansion of its coal and petrochemical business, the lack of attractiveness of equity financing in the traditional industry, and its over-reliance on debt financing. In 2018, it was bond default of Rmb15bn, on top of Rmb35bn of maturing debt, triggering a systemic debt crisis. At the same time, the impact of corporate refinancing channels had been significantly reduced by deleveraging policy tightening and financial regulation. It was therefore difficult to

alleviate the pressure of debt through new financing. During the period under review, adjustments to coal production capacity resulted in a further contraction of cash flow. A number of factors had a negative impact on the company's capital chain, which was on the verge of breaking. This led to stagnation in its own operations and had an effect on the transmission of regional financial risk. The stability of the energy industry in Shanxi, and by extension the country as a whole, was under threat. It was imperative that the risks were addressed and to reinvigorate development momentum through debt restructuring and transformation initiatives.

In this context, Yongtai Energy proactively sought support from the financial sector and initiated a series of strategic transformations. First, the Group successfully alleviated short-term liquidity pressure by divesting Rmb23bn of non-core assets. The divested assets were utilized for debt servicing and liquidity supplementation, thereby significantly reducing the risk of default and securing a period for restructuring. Second, in August 2018, Yongtai Energy and Beijing Energy Group reached a restructuring cooperation agreement through the injection of assets to obtain liquidity support, and to build a green transformation support system with the resources of strategic parties. This strategic capital injection into the transformation of core resources was a key step in the process. Third, Yongtai Energy implemented a diversified debt restructuring strategy to optimize its financial structure. The company adopted a rollover policy for bonds that included three years of deferred repayment of the principal and an interest rate of 4.75% per year. It also provided options for debt-to-equity conversion and encouraged the participation of ICBC investment and other institutions in this process. The result of these measures was the conversion of Rmb4.8bn of debt-to-equity, which greatly reduced the pressure of debt.

The government and public finance also played a key supporting role in restructuring, effectively advance the realization of transition. The Shanxi provincial government and relevant departments took the lead in coordinating the restructuring work. This included setting up a creditor committee of financial institutions, guiding creditors to take concerted actions, avoiding the spread of risks caused by disorderly disposal, and creating a stable external environment. At the same time, they introduced policies to optimize the market environment, reduced the difficulty of financing for private enterprises, and set up a special fund of about Rmb5bn for private enterprises to provide financial support to ease the pressure of debt on enterprises, including Yongtai Energy. In terms of public finance, the creation of a special support fund provided direct financial assistance to alleviate the short-term debt burden of enterprises. It also improved the credit system of private enterprises to enhance credit support, indirectly reduce financing costs, improve financing efficiency, enhance the ability of enterprises to repay their debts, and provide a solid guarantee for the success of the restructuring.

In terms of transformation effectiveness, Yongtai Energy's transformation achieved a double breakthrough in finance and the industry. Yongtai Energy implemented a series of initiatives to optimize its financial situation. As a result, the asset-liability ratio decreased from 72.3% in 2018 to 58.6% in 2023, representing a reduction of 18.9%. Investment in green transformation significantly improved, with green R&D funds increasing from Rmb23mn in 2018 to Rmb124mn in 2023, an increase of 439%. Furthermore, the "vanadium ore-electrolyte-storage system" industrial chain was successfully built, and the transition from traditional energy to green industry was realized. The installed capacity of new energy sources was projected to reach 1.2GW by 2023. The company successfully established the industrial chain for a vanadium ore-electrolyte-energy storage system, marking a significant transition from traditional energy sources to green and low-carbon alternatives.

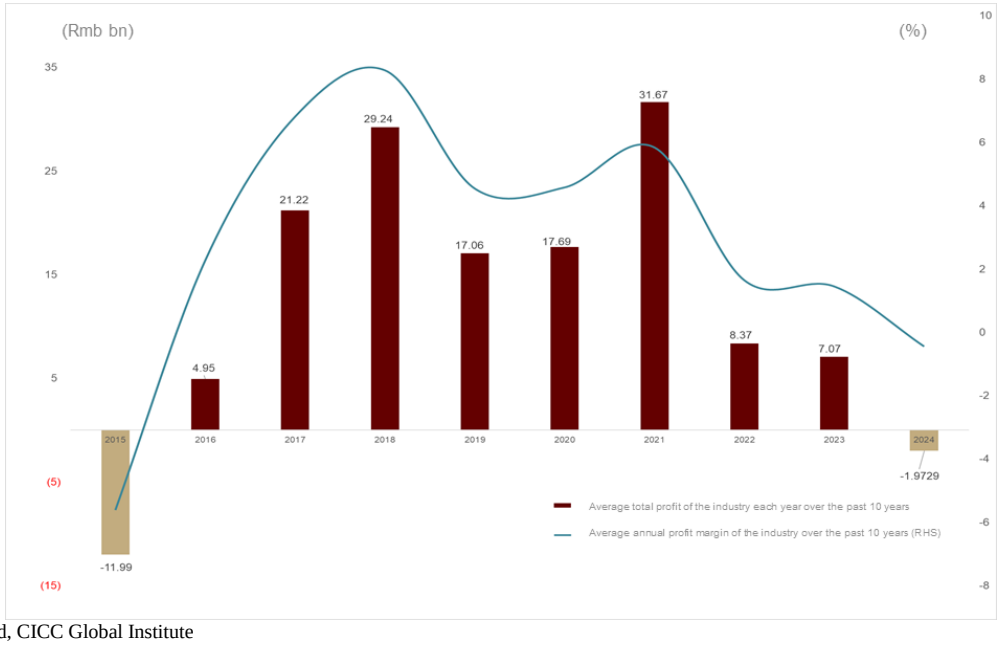
The Yongtai Energy case demonstrates the effectiveness of "government, enterprise, and bank coordination" in resolving systemic debt crises. The enterprise reshaped its foundation through asset disposal and strategic capital attraction, the government constructed a risk prevention and control and policy guarantee mechanism, and the financial institutions innovated debt restructuring tools. Simultaneously, this exploration offers a reference point for highly indebted enterprises in traditional industries. These enterprises can consider the disposal of non-performing assets as an entry point. By linking financial, monetary, and industrial policies, a virtuous cycle of "risk resolution - structural optimization - transformation and development" can be established. As enterprises are fundamental units of the real economy, facilitating their breakthroughs and revitalization will then promote high-quality transition of the overall socio-economic system.

- **Restoring profitability outlooks to accelerate retirement of stranded assets**

For risks that have not yet become non-performing assets, industries such as steel and cement—facing numerous challenges under current economic conditions, with weak overall market conditions and

declining profitability—still need to proactively accelerate the retirement of high-carbon assets to avoid future risks. Taking the steel industry as an example, data from the China Iron and Steel Association shows that in 2024, domestic steel markets were affected by multiple factors including a clear decline in domestic demand, strong growth in overseas demand, a slight reduction in output, and persistently high raw material prices. This intensified competition among enterprises, causing average domestic steel prices to fall by 8% and industry profits to remain slim (Figure 12). In 2024, China's total crude steel production reached 1.01bn tonnes, down 1.7% YoY, with apparent crude steel consumption estimated at 892mn tonnes, a 5.4% decrease[70]. Looking at listed company performance, among 25 listed steel enterprises that disclosed their 2024 results before February 2025, only two reported profit growth, while the majority experienced declining earnings or losses, with 12 companies reporting wider net losses compared to 2023[71]. Even after the "anti-involution" rectification in the first half of 2025 led to some recovery in profitability, the average profit margin for the steel industry in the first half of 2025 was only 1.97%[72], indicating that the contradiction between strong supply capacity and weakening demand persists. The cement industry is similarly bleak. Wind data shows that in 2024, among 18 A-share listed cement companies, 10 reported YoY declines in net profit[73] (Figure 13).

Figure 12: Average total profit and average profit rate of listed companies in the steel industry each year over the past 10 years



Source: Wind, CICC Global Institute

Figure 13: High-carbon industries such as steel and cement are all in a cyclical trough

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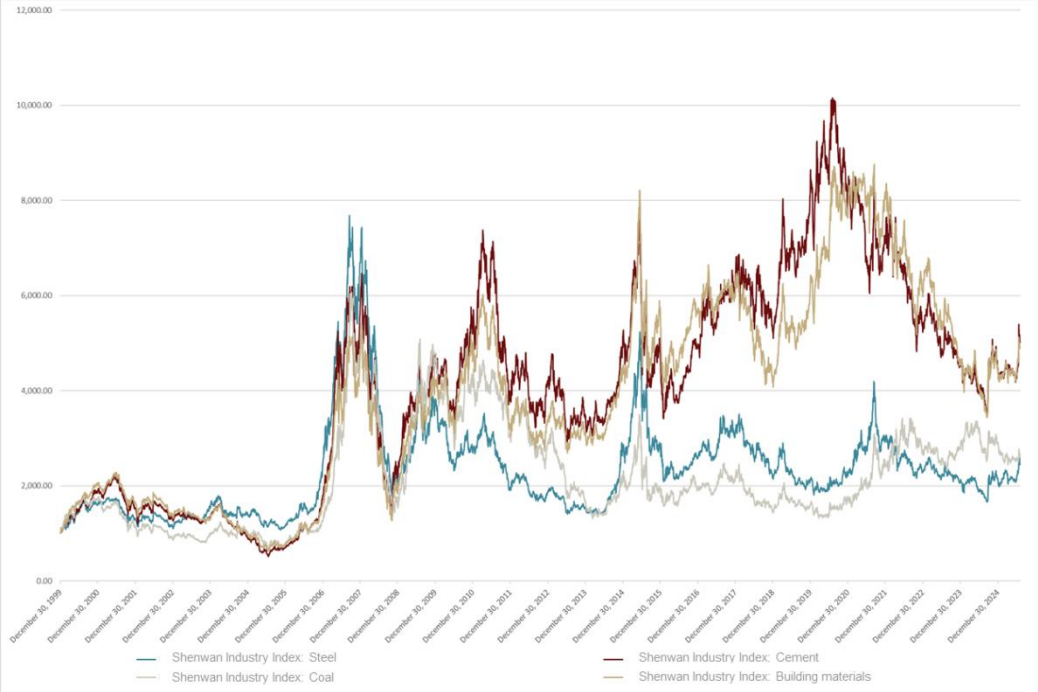

Source: iFinD, CICC Global Institute

High-carbon industries mostly belong to the manufacturing sector, where production equipment and facilities form the foundation for high-carbon enterprises' normal operations and cash flow turnover. Under the constraints of dual carbon goals, these enterprises face significant transformation pressures. If related equipment has to retire prematurely due to failing to meet environmental standards, it can severely impact the enterprise. For instance, steel company equipment typically require 20 years to recoup investment costs and generate profits. However, stringent carbon emission limits under dual carbon goals may force such equipment to retire after only 10 years of use, meaning the equipment will not produce the expected returns for the remaining 10 years. Moreover, steel companies must invest extra funds in purchasing new equipment or upgrading existing facilities, undoubtedly increasing their cost burden and further pushing an already struggling industry into a deeper predicament. Therefore, under the constraint of recent operational difficulties, the willingness of companies to undergo low-carbon transitions is often insufficient.

To address this, during the low-carbon transition of high-carbon industries, systematic policy incentives and diversified financial measures should be utilized to assist enterprises in retiring stranded assets in a scientific and orderly manner, providing profit compensation for premature retirement, and thus achieving a smooth transition. On the policy front, a supportive system with dual approaches needs to be established: On one hand, clear incentive mechanisms should be set up, using fiscal subsidies and tax benefits to guide enterprises to proactively accelerate the elimination of outdated equipment and capacity that do not meet environmental standards, promoting green renovation or compliant exit of existing assets; on the other hand, focus should be placed on maintaining operational stability during the transition period by optimizing credit policies to reduce financing costs. Interest rates could be inversely linked to the pace of high-carbon asset retirement—faster retirement leads to lower interest rates. Low financing costs can compensate for the loss of income from early asset retirement, alleviating financial pressures during asset replacement and business transition phases, and creating favorable conditions for new business structures and capacity upgrades. For example, Indonesia's energy transition utilizes preferential loans and non-preferential loans within the Energy

Transition Mechanism (ETM), "differentiated funding instruments" to accelerate the retirement of coal-fired power plants. It also leverages the Just Energy Transition Partnership's (JETP) "phased investment strategies" to build a clean energy system, supplemented by government policy guidance, serving as a model for energy transitions in developing countries.

Box 2: Indonesia's Energy Transition - The Case for Accelerated Coal Power Phase-Out[74]

Indonesia's energy sector has historically relied on coal, with statistics indicating that coal accounted for 39.69% of the country's primary energy consumption in 2023. This has led to notable levels of carbon emissions, with fossil fuel-related emissions reaching 675mn tonnes in the same year. Notably, the power sector's share of carbon emissions has been increasing annually, accounting for 33.43% of total emissions in 2023. However, Indonesia is committed to achieving net-zero emissions by 2050. By the end of 2050, the share of renewable energy will be increased to 31% and the share of coal will be reduced to 25%. At present, the share of renewable energy is only 13.29%, which indicates a significant gap with the target. As such, the energy transition must start as soon as possible.

In this context, Indonesia has been implementing significant reforms through the JETP and ETM mechanisms. First, ETM actively promotes the early retirement of coal-fired power plants by designing differentiated financing and operation programs for PLN Indonesia Power and independent power producers (IPPs). For power plants owned by PLN, it provides US$200mn in concessional loans and US$1mn in grants. For independent coal-fired power plants, it provides US$400mn in non-concessional loans and US$100mn in concessional loans. With regard to the "Cirebon-1" IPP, the planned transaction structure comprises three main aspects: 1) Adjust the power purchase agreement (PPA) to reduce the power supply duration between IPPs and PLN. 2) Sign a cooperation agreement specifying that PLN, the Indonesian government, and the Asian Development Bank (ADB) will jointly oversee the decommissioning of power plants following the termination of the PPA. 3) Establish a tripartite agreement to ensure that, upon repayment of new loans, IPPs, the Indonesian Investment Authority (INA), and the ADB will collaboratively advance the decommissioning process. During this process, the ADB will initially repay existing debts and replace them with low-interest new loans, while the INA will acquire equity to balance shareholder returns. Regarding PLN-owned power plants, the government and the ADB have established an US$851mn financial intermediary loan (FIL), which consists of two main components. The first is the Accelerated Coal Retirement Fund (ACRF), which provides debt financing to support the early retirement of coal-fired power plants operated by PLN. This fund primarily focuses on investing in the Energy Transition Mechanism National Platform (ETMCP) plan of PT Sarana Multi Infrastruktur, implementing the "asset spin-off scheme" for coal-fired power generation, or providing financing to investors or special purpose companies (SPVs) for asset separation and reuse, as well as shortening the PPA duration. Alternatively, it may involve directly acquiring majority equity in power plants to facilitate early decommissioning. The second component involves a US$1mn grant to support the ADB in developing the "Implementation Guidelines for the Just Transition Framework," ensuring a standardized and equitable exit process.

Second, the JETP focuses on five key areas: Transmission line and grid infrastructure development, early retirement and management of coal-fired power plants, accelerated development of dispatchable and variable renewable energy sources, supply chain strengthening, and phased clean energy system construction. Prior to 2030, the initiative will primarily emphasize the integration of renewable energy and grid infrastructure, including the expansion of transmission circuits, acceleration of wind and solar project development, optimization of grid operations, integration of island energy systems, and an increase in the share of clean energy in overall power generation. After 2030, the focus will shift toward the gradual phase-out of coal-fired power plants, with renewable energy serving as the primary source of reliable power supply. Concurrently, efforts will be made to advance technological innovation in energy storage and smart grid systems to reduce costs, enhance efficiency, and establish a solid foundation for sustainable and green development. Currently, 400 priority projects have been identified, with plans to add approximately 75GW of new renewable energy capacity over the next 15 years.

The Indonesian government also plays a pivotal role in the energy transition process by clarifying strategic directions through policy adjustments and validating implementation pathways through practical pilot initiatives, thereby providing strong top-level support for the transformation. To ensure progress, the government integrates policy reforms with pilot project development, which has led to the advancement of the coal phase-out timeline from 2056 to 2040, the revision of power planning regulations to mandate that 75% of new installed capacity originate from renewable energy sources, and the launch of pilot programs such as the "Solar Islands" initiative.

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Under the impetus of a series of mechanisms, the transformation has achieved initial breakthroughs. ETM enabled the Yining No.1 coal-fired power plant to bring forward its retirement from 2042 to 2035, and the Queenstown Power Plant plans to retire in 2037. JETP facilitated the expansion of the power grid and accelerated the development of wind and solar projects, gradually increasing the installed capacity and power generation share of renewable energy, laying a practical foundation for the emission reduction targets.

Overall, Indonesia's energy transition has solved the problem of coal-fired power plant retirement through the "Differentiated Funding Tools" of ETM, constructed a clean energy system with the "Stage-by-Stage Investment Strategy" of JETP, and combined with government policy guidance, providing a phased and multi-level practical sample of a funding-matched approach for energy transition in developing countries. Although it still faces challenges such as funding gaps and policy implementation, the feasibility of the path has been verified through project implementation. In the future, it will be necessary to continuously deepen international cooperation and mechanism optimization to promote the net-zero goal from planning to full implementation.

3.3 Policy-based financial support for just transitions

The core objective of a just transition is to minimize the social equity impacts as high-carbon enterprises undergo transformation. A key task involves properly resettling employees who are laid off due to this transition. In this process, the primary responsible parties are the enterprises themselves and local governments, with resettlement funds typically sourced from the operational funds of the enterprises, as well as fiscal allocations or central transfer payments from local governments. As such, the involvement of general market-oriented financial institutions tends to be indirect, possessing characteristics of policy-based finance.

To explore the role of finance in the employee resettlement process, it is first necessary to clarify the basic connotations and main tasks of employee resettlement. Employee resettlement refers to a series of measures taken by enterprises facing major changes such as transitions, restructuring, or layoffs, aimed at safeguarding the legal rights and interests of affected employees and assisting them in achieving a smooth transition. Specifically, the resettlement process usually progresses along the path of "enterprise first, then society," divided into two stages: Internal resettlement and social resettlement.

Internal resettlement is primarily led by the enterprise, utilizing its own resources to optimize and adjust internally, aiming to convert employees locally wherever possible. The main tasks during this stage include internal job transfers, retraining and skill enhancement, supporting internal entrepreneurship, implementing flexible employment arrangements, and executing internal retirement plans, all designed to mitigate the impact of job adjustments through internal mechanisms. When an enterprise's absorption capacity is insufficient to resettle all employees, social resettlement mechanisms need to intervene.

Social resettlement is led by the government and related social institutions, focusing on helping laid-off workers reintegrate into the labor market through public policies and resource allocation. Tasks include providing systematic re-employment support, organizing vocational skills training, expanding employment channels, offering entrepreneurial guidance and financial support, and building a diversified employment service system to facilitate re-employment or career transformation for employees.

From the perspective of funding requirements, both internal and social resettlements involve two types of core funds: Safety-net funds and developmental funds. Safety-net funds are mainly used to ensure the basic living standards and social insurance rights of laid-off workers, covering unemployment benefits, living allowances, and social insurance premium subsidies, serving as a foundational safety net. Developmental funds

focus more on future potential, used for issuing economic compensation, conducting vocational training, providing startup capital for entrepreneurship, and employment incentive subsidies, aimed at supporting employees in enhancing their employability or achieving self-employment. It is worth noting that the concept of a just transition must fully incorporate a gender dimension. At the 23rd Conference of the Parties (COP23) to the United Nations Framework Convention on Climate Change, a gender action plan on a just transition was adopted[75]. This plan aims to integrate a gender perspective into activities such as financial allocation, technology development and transfer, and capacity building, thereby promoting the formulation of gender-sensitive climate policies. Research from both the International Labor Organization (ILO) and the Intergovernmental Panel on Climate Change indicates that women often face heightened vulnerability in low-carbon transitions due to limited access to resources, insufficient education, and lack of decision-making power[76]. Transition strategies that neglect gender equality not only fail to achieve a fair transition but may also exacerbate social inequalities. Therefore, in terms of a social safety net, governments may consider providing additional subsidies specifically targeted at women. Financial institutions and governments can jointly establish dedicated green funds for female entrepreneurs or offer corresponding financing incentives to enhance the economic resilience and transition adapt ability of women. Based on these resettlement tasks, **the areas where financial institutions can directly participate are mainly concentrated in supporting entrepreneurial financing within re-employment assistance, particularly through guaranteed loans for startups.** These measures aim to lower the threshold for entrepreneurship, reduce start-up costs, and increase the success rate of new ventures, thereby aiding laid-off employees in achieving re-employment. **For other resettlement aspects, financial institutions primarily play an indirect role.** For instance, they can use preferential funding as an incentive to encourage enterprises to address the issue of laid-off worker resettlement, avoiding shifting the problem onto society and reducing the burden on government fiscal funds—a quasi-fiscal approach. Financial institutions can also collaborate with the government to guide enterprises in formulating reasonable resettlement plans, ensuring that the rights of laid-off employees are protected. Through direct and indirect participation, financial institutions can effectively support the resettlement of laid-off employees, promoting social fairness and a smooth economic transition.

It is worth noting that whether directly or indirectly involved in the resettlement of laid-off employees, financial institutions need to accurately identify those affected by the transition and implement corresponding support measures accordingly. This process follows a logic similar to inclusive finance: Financial institutions need to accurately identify target client groups for inclusive financial services at a lower cost but must also bear higher risks. This is because such client groups typically have a short credit history or limited credit records, leading to greater funding deployment costs and risk control challenges for financial institutions when providing support. Below, we will draw on the logic of inclusive finance to separately discuss how financial institutions can directly and indirectly participate in supporting the resettlement of laid-off employees.

3.3.1 Indirect empowerment: Actively leveraging the due diligence management functions of financial institutions

Currently, in both international and domestic transition finance practices, a common approach regarding employee resettlement is to link relevant requirements with the financial services available to the funded enterprises. In regions where transition finance practices have been implemented and where enterprises are required to develop transition plans, companies are further mandated to incorporate employee resettlement into these plans.

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In practical operations, **how financial institutions fulfill their due diligence management functions is crucial**. There are currently two main areas of specific practice: The first is the "pre-grant assessment" mechanism, which means that before disbursing financing, financial institutions rigorously review and approve measures for preventing unemployment risks and employee resettlement plans developed by high-carbon transitioning enterprises (usually reflected in the company's transition plan). After financing is granted, regular tracking and monitoring are conducted to dynamically understand the progress and effectiveness of these measures. The second is the "result-oriented" incentive and restraint mechanism, that is, financing is initially provided as agreed, and then incentives such as preferential interest rates are offered to enterprises that successfully achieve just transition goals by linking financing conditions with just transition performance indicators. Conversely, penalties are imposed on enterprises that fail to meet just transition requirements.

Regarding pre-grant assessment, the city of Huzhou in China has introduced the "Huzhou Financing Subject Just Transition Evaluation Method (Trial)", which establishes a relatively complete implementation framework for financial support of just transitions, providing valuable reference for practical operations[77]. The assessment content by banking institutions mainly focuses on whether enterprise transitions lead to more than a 10% reduction in staff or a decrease in employee income, while also examining whether the company has formulated effective employee skill training and enhancement programs. To enhance policy effectiveness, Huzhou has established a mechanism combining incentives and constraints. Enterprises performing poorly in just transition are required to make improvements, which are included as prerequisites or financing management requirements in credit schemes. Excellent performers receive expedited channels and differentiated pricing as incentives. This local practice provides a valuable reference for building a just transition financial support system in China.

In the domain of innovative financial products linked to outcome-oriented just transitions, the practice of the Scottish National Investment Bank (SNIB) in conjunction with the Scottish Just Transition Fund is particularly noteworthy. During the support of a Scottish energy company's transition from oil and gas operations to renewable energy, SNIB issued just transition-linked loans. This not only effectively accelerated the company's energy transition but also successfully controlled the risk of unemployment during the transition process, providing a replicable financing model for similar transition projects[78] (Box 3).

Box 3: Case of Aurora Energy Services' Just Transition-Linked Loan

As the global energy structure rapidly shifts toward renewable energy, Scotland, a region historically concentrated with traditional energy industries, faces significant challenges. Oil production from the North Sea has been continuously declining from its peak, and natural gas output is also on a downward trend. This has led to a substantial reduction in energy sector revenues and triggered the loss of a large number of associated jobs. The urgent need for energy transition, combined with the economic and employment shocks caused by the decline of traditional energy industries, compels Scotland to complete a structural shift toward renewable energy while ensuring economic stability and full employment. Aurora Energy Services took on the critical mission of driving regional energy transition under this backdrop.

To address these challenges, the Scottish National Investment Bank (SNIB) and the Scottish Just Transition Fund jointly provided an innovative financial solution by establishing a GBP20mn blended loan—GBP10mn from the Just Transition Fund and another GBP10mn from SNIB. The agreement clearly stipulated that Aurora Energy Services must achieve its transition from oil and gas operations to renewable energy according to a defined schedule: If the transition accelerated, the loan interest rate would decrease accordingly; if progress lagged, the rate would increase. This financing mechanism not only provided the enterprise with essential long-term capital while ensuring a balanced risk-return profile, but also accelerated the restructuring of the energy mix through market-based incentives.

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The loan agreement innovatively embedded a set of social equity key performance indicators (KPIs) to ensure that transition outcomes would be quantifiable and traceable. The agreement focused not only on the speed of business transformation but also anchored core equity metrics such as the number of permanent employees in "fair transition jobs" to ensure career continuity for oil and gas workers, the proportion of apprentices and interns to address skill gaps among youth and vulnerable groups, and the share of revenue from renewable energy to guarantee substantive business transformation. These indicators were audited regularly by independent agencies, forming a closed-loop management system from target setting to outcome verification, transforming the concept of "just transition" into concrete action guidelines.

Moreover, the project's blended financing structure overcame the bottleneck of transition funding through strategic advantages. The GBP10mn in public capital from the Just Transition Fund significantly reduced the overall project risk premium, alleviating investor concerns about transition timelines and return uncertainties. The GBP10mn in commercial capital from SNIB introduced market-based risk assessment mechanisms. This "government-guided, market-operated" model met the enterprise's long-term funding needs while avoiding the inefficiencies associated with pure fiscal subsidies, offering a replicable financing paradigm for similar transition projects.

Notably, large state-owned financial institutions in China are going beyond merely exercising stewardship responsibilities in supporting employee resettlement—they are also pioneering direct support mechanisms. For example, in 2023, the Postal Savings Bank of China successfully launched the country's first just transition loan, disbursing a Rmb100mn loan to Jinneng Holding Coal Industry Group Co., Ltd. A portion of the loan funds were used during the company's low-carbon transition to provide employees with job rotation training and operational qualification training, enhancing their professional skills, labor capabilities, and employability, thereby achieving a just transition of the workforce[79].

3.3.2 Direct empowerment: Incorporating transition impact into entrepreneurial loan products

China's financial institutions began directly supporting laid-off workers in entrepreneurship as early as 2002, primarily to address the impact of layoffs resulting from SOE reforms. At that time, small loans originally intended for rural households were extended to urban unemployed individuals[80], providing guaranteed microloans of around Rmb20,000 with a loan term not exceeding two years to encourage self-employment and entrepreneurship among laid-off workers. The guarantee fund was established by the government and entrusted to guarantee agencies. The "Management Measures for Small Guaranteed Loans for Laid-off and Unemployed Persons" listed 19 micro-profit projects eligible for full interest subsidies from the central government. In 2005, China further provided preferential loans of up to Rmb1mn with fiscal interest subsidies and fee subsidies to labor-intensive small enterprises that absorbed re-employed personnel[81]. By 2007, China's "Employment Promotion Law" legally solidified the policy of small credit support for employment-challenged individuals.

After over a decade of practice and continuous reform, the small guaranteed loan policy was officially renamed the "Entrepreneurship Guarantee Loan" in 2016. This expanded the scope of support, increased individual loan limits to Rmb100,000 with a three-year term, and raised the loan limit for small and micro-enterprises to Rmb2mn[82]. In 2023, the "Measures for the Administration of Special Funds for Inclusive Finance Development" (Caijin [2023] No.75) further optimized the policies for entrepreneurship guarantee loans, arranging for fiscal rewards and subsidies, lowering the application threshold for small and micro-enterprises, reducing counter-guarantee requirements, and allowing local adjustments to increase loan amounts, interest subsidy ratios, and adjust interest rate caps based on actual conditions. The upper limit for personal

entrepreneurial loans is Rmb300,000, typically with a three-year term; for small and micro-enterprises, it does not exceed Rmb4mn, with a two-year term, and an interest subsidy ratio of 50%, with interest rates across regions ranging from LPR plus 50bp to 250bp.

Despite various practices undertaken by China's financial sector to support laid-off workers in entrepreneurship, challenges such as high service costs, insufficient credit information, and significant risk levels remain. High service costs are mainly reflected in three aspects: 1) Meeting the service needs of dispersed clients often requires substantial human resources investment, including sales personnel and account managers, leading to higher labor costs; 2) due to the lack of stable income and complete credit records among laid-off workers, identifying and managing credit risks is challenging, resulting in higher risk control costs; 3) although the operational and maintenance costs for opening and maintaining accounts are roughly the same for each client, the contribution of laid-off workers in terms of loan scale and interest returns is relatively low, making the unit revenue limited.

Leveraging digital technology for online microloans has become a common practice in the industry, breaking through cost and scale constraints to achieve a balance between affordable loan costs, sustainable business models, and fair opportunities[83]. In marketing and front-end services, digital technologies significantly reduce customer acquisition and service costs through digital channels and intelligent customer service. For example, Ant Financial integrates data from sectors like ride-hailing and catering to assess borrowers' economic conditions at a lower cost than traditional home visits and avoids favoritism that could lead to overlooked assistance. In 2015, the Ministry of Civil Affairs' Social Assistance Department collaborated with Ant Financial on a social assistance fund management system, efficiently querying and managing approximately 70mn low-income beneficiaries and about Rmb20bn annually in central government funds[84].

In the application and data mid-platform layer, financial institutions use large-scale data analysis to achieve precise marketing and full-process risk control, reducing reliance on collateral. Ant Financial constructs comprehensive credit profiles using hundreds of data points such as consumption levels and regional characteristics to accurately identify users' repayment capacity and creditworthiness. Its digital risk control system employs a "monitoring-warning-intervention" closed-loop management to dynamically adjust credit lines, maintaining a non-performing loan ratio of 1.78% in recent years.

In back-office operations, financial institutions can leverage more efficient IT infrastructures like cloud computing and distributed architectures to reduce overall operational costs. For instance, WeBank's annual per-account IT operation cost is only Rmb3.6 (excluding labor), far below the Rmb20–100 range for traditional banks and US$10–60 for international banks, effectively supporting its services to micro and small customers[85]. Digital technologies also help financial institutions expand their reach through scenario-based finance by embedding services into diverse scenarios via partnerships with vertical industry players to deeply engage customers.

Regarding support for structurally unemployed populations affected by energy transitions, digital technologies can facilitate the construction of green inclusive financial service platforms. These platforms integrate information from governments, enterprises, and banks on personnel and business registration, enabling "shared, co-collected, and co-used" data, providing accurate customer acquisition and risk control data support for financial institutions, and forming a digital, replicable model for green inclusive loan recognition. **Additionally, financial institutions can extend lifecycle services through digitalization.** For example, they

offer account settlement, trade financing, and other financial services to enterprises, along with special rights such as subsidy applications and legal services. For individuals, they provide online financial literacy training to enhance the financial management capabilities of laid-off workers, offer financial planning services through digital tools to help them navigate difficult periods, and provide products like work injury insurance and corporate property insurance for those transitioning to re-employment or running small businesses, effectively boosting entrepreneurial confidence.

4 Policy Recommendations

Recommendation 1: Encourage financial institutions to acknowledge the "green demand" of the primary enterprises in the supply chain as a commitment, thereby facilitating the extension of policy-based finance to SMEs in the supply chain and promoting supply chain-wide innovation.

The key to developing green supply chain finance is to transform the "green demand" of leading enterprises in high-carbon industries into financing credit for SMEs. This process can be broken down into three steps: First, unifying green identification. According to the 2025 Edition of the Catalogue of Projects Supported by Green Finance, SMEs in the supply chain and their underlying assets, such as orders and receivables, will be designated with "green labels", thereby confirming that their technologies or products comply with green and low-carbon standards. The subsequent step involves overcoming data barriers. Relying on blockchain and other digital technologies, a green supply chain financial data sharing platform has been set up to realize traceable, verifiable, and low-cost disclosure of green asset information, so that financial institutions can be "visible and trustworthy". Third, innovative financial tools. On the credit side, core enterprises provide guarantees or payment commitments, and banks issue low-cost green supply chain loans to SMEs. In terms of securitization, green receivables held by SMEs are packaged and issued as green supply chain ABS, with the aim of revitalizing stock assets and expanding financing channels.

Furthermore, it is recommended that policy-based finance in the area of green low-carbon initiatives should be utilized to support SMEs within the supply chain. Specifically, the central bank can use refinancing tools to provide financial institutions with low-cost funds to support supply chain finance projects that meet green and low-carbon technology standards and have received green procurement orders from chain-owning enterprises; give preferential risk weights to banks' green supply chain finance loans and reduce capital occupancy; and facilitate the granting of bank credits and the issuance of debt financing to core enterprises that actively participate in the financing of SMEs in the area of green technology.

Recommendation 2: Supporting the chain master enterprise as the core enterprise, and the mechanism of "green demand scenario + joint incubation" is created with a view to facilitating the rapid formation of the green technology supply chain from zero to one.

First, the primary enterprises of the chain "make the requirements". In accordance with their own green and low-carbon transformation objectives, chain-owning enterprises have been responsible for the design and publication of "green demand scenarios". These scenarios are defined as a list of transformation projects and technology bids that can be implemented. SMEs that succeed in bidding will receive long-term orders and access to multiple rounds of investment led by the chain owner's CVC.

Second, the concept of "joint incubation" by multiple capitals is introduced. The chain master CVC assumes a leadership role in establishing a collaborative investment entity with GVC and IVC, with the objective of providing uninterrupted capital infusion and advisory services to successful projects. This initiative is undertaken to mitigate the risks associated with technological iteration and market expansion for SMEs.

Third, policies deliver targeted support at two critical junctures. On the one hand, it has been argued that the phenomenon under discussion serves to amplify scenarios. In order to facilitate the emergence of new or expanded green demand scenarios for chain master enterprises, a range of measures are being implemented. These include research subsidies, experimental demonstration funds, green performance auction funds linked to carbon reduction volumes[86], central bank green refinancing, and other targeted support, the purpose of which is to expand the market scale of emerging green technologies. Concurrently, capital is being added to the effort. It is recommended that GVC be encouraged to participate in the joint investment body as a strategic limited partner, forming a "CVC+IVC-led, GVC-supplemented" venture capital pattern. This would amplify the leverage effect of financial funds and accelerate the launch of green and low-carbon technologies and supply chain formation. The plan could be piloted in designated pilot zone(s) and upon maturation of the experience, they may then be replicated and promoted nationwide.

Recommendation 3: Support financial institutions in incorporating carbon emission metrics into M&A financial services.

To enhance the role of large enterprises in driving innovation and low-carbon transitions among SMEs, and to alleviate the pressure of stranded assets formed under the constraints of industry competition and low-carbon transitions, it is crucial to promote the M&A processes between large high-carbon enterprises and SMEs. This can be achieved by guiding financial institutions to embed carbon emission performance constraints into M&A financial services. Specific measures include:

1. Encouraging banks to provide comprehensive credit lines covering pre-, during, and post-M&A phases, incorporating carbon emission metrics into their credit conditions. Leverage policy incentives such as central bank refinancing to guide banks to support domestic and cross-border M&A projects aligned with low-carbon transition goals through M&A loans and syndicated loans both domestically and internationally. Financial institutions can offer loan extensions and preferential interest rates based on the carbon reduction performance of merged entities.

2. Supporting qualified high-carbon enterprises to raise funds for M&A activities through issuing stocks, bonds, convertible bonds, etc., while encouraging financial institutions to innovate bond products. For instance, introduce specialized bonds linked to multiple indicators such as the reduction in carbon emission intensity post-merger and the progress in adopting low-carbon technologies. Ensure that these funds not only facilitate industrial consolidation but also contribute to achieving carbon reduction targets.

3. Actively exploring new financing models for M&A such as setting up M&A funds, and using carbon emission improvement targets as an important criterion for funds to evaluate investment targets. Central and local governments can play a guiding role by co-funding M&A fund pools alongside leading high-carbon enterprises and financial institutions. Offer tax incentives to funds investing in M&As that significantly reduce carbon emissions, attracting private capital participation in green mergers.

4. Making efforts to break down the barriers to M&A among regions and industries, and unify the administrative approval standards. Include carbon emission assessments during the approval process for M&A applications in high-carbon sectors such as energy and industry. Consider the expected carbon reduction potential and disclosure of post-merger carbon reduction targets as part of the approval criteria. Establish joint

regional and sectoral approval mechanisms to improve the efficiency of reviewing high-carbon enterprise M&A projects. Additionally, support relevant high-carbon industry associations in setting up M&A information platforms to publish reports tracking post-merger carbon emission performance, enhancing market supervision of corporate low-carbon transitions. This fosters a fair, transparent, and low-carbon-oriented market environment, contributing to the establishment and enhancement of a unified national green and low-carbon market.

Recommendation 4: Support financial institutions to develop debt swap instruments and promote early decommissioning of stranded assets in high-carbon sectors.

In the context of the low-carbon transition, high-carbon industries are required to divest high-carbon assets at an early stage, which can compromise their capacity to generate the anticipated future returns. Concurrently, high-carbon enterprises continue to predominantly depend on debt financing, such as bank loans. The decline in industry growth and the reduction in asset profitability have substantially constrained their external financing options. Consequently, financial institutions can design debt swap tools linked to the progress of decommissioning high-carbon assets. Specifically, the interest rate of the debt swap instrument is inversely proportional to the decommissioning progress, wherein the faster the decommissioning, the lower the interest rate. Consequently, diminished financing costs can be utilized to compensate enterprises for the forfeiture of anticipated returns due to the premature decommissioning of high-carbon assets. In order to enhance the willingness of financial institutions to participate, it is recommended that the government provide targeted support to financial institutions through monetary policy tools such as refinancing and rediscounting, as well as fiscal policies such as financial guarantees and tax incentives, with a view to reducing the cost of bank funds and mitigating risks.

Recommendation 5: Promote the inclusion of "just transition" in the financial products of financial institutions for transition.

First, financial institutions should be guided in the development of quantitative indicators and due diligence management tools. Financial institutions are encouraged to develop quantitative indicators of "just transition" linked to transition finance services, or to set binding clauses in the terms of investment to fulfil due diligence management functions. When financial institutions are considering the possibility of offering transformation financing to high-carbon enterprises, it is important that they take the enterprise's "transformation plan" into account. This is because the plan can serve as a useful reference point. In order to encourage or require financial institutions to take this into account, it would be advisable for them to incorporate considerations of fair transformation in their investment decision-making frameworks.

Second, the promotion of the development of relevant financial products through policy support is essential. Financial institutions are using subsidies and other means to promote the development of financial products linked to just transition. For instance, a certain degree of refinancing and rediscounting support will be given to sustainable development-linked loans or bonds developed by financial institutions that link the cost of financing to the target number of employees of the enterprise. Furthermore, subsidies or tax breaks will be given to investment institutions that support the technological upgrading and transformation of high-carbon enterprises

through equity investment, while at the same time requiring, in the terms of the investment, that the enterprise commit to retaining its core employees or providing training for job switching.

Third, financial institutions are encouraged to explore the development of innovative financial products. Such products could include “transition unemployment insurance” to cover the risk of income fluctuations due to the transition, provide more comprehensive protection for enterprise employees, and facilitate a smooth transition for high-carbon enterprises.

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