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The Challenges of Aligning Green Finance with SMEs under the Dual Carbon Goals and the Resolving Role of Supply Chain Finance

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Abstract:
In the context of global initiatives to address climate change and advance the agenda of sustainable development, the "carbon neutrality" objective is exerting a profound impact on socio-economic transitions. Small and medium-sized enterprises (SMEs), as a vital component of the national economy, play a pivotal role in the realization of the "dual carbon" goals. This paper examines the integration of green finance and supply chain finance as a mechanism for enhancing SME ESG performance and drive sustainable development by alleviating financing constraints and optimizing resource allocation. It analyzes the current development status and inherent challenges within the green finance system, outlines the structural barriers that SMEs face in green transformation, and constructs a theoretical framework for how supply chain finance impacts SME ESG performance. The study concludes that by leveraging the credit strength of core enterprises, mitigating information asymmetry, and enhancing supply chain coordination efficiency, supply chain finance can effectively channel green capital to SMEs and systematically elevate their ESG standards across environmental, social, and governance dimensions.

Keywords: Green Finance; Supply Chain Finance; esg; Green Transformation; Green Financial Derivatives

1. Introduction

In the context of global endeavors to address climate change and promote sustainable development, China's proposed "carbon peak and carbon neutrality" (hereafter referred to as the "dual carbon") goals are profoundly reshaping the development of the economy and society. Achieving this strategic transformation requires not only the leadership and exemplary role of large enterprises but also the extensive participation and green transformation of small and medium-sized enterprises (SMEs), a cornerstone of the

national economy. However, compared with large enterprises, SMEs confront significant challenges in balancing their sustainability objectives and business performance. For a long time, constrained by resource and scale limitations, SMEs have typically prioritized short-term profits, leading to their relatively weak position within the supply chain[1]. This disadvantage renders it challenging for them to impose effective green procurement requirements on upstream suppliers or to secure critical green technology and financial support from core enterprises functioning as "chain leaders." Consequently, they become trapped in a "high-cost, high-emission" business model, which severely impairs their capacity to achieve sustainable development[2].

To overcome this issue, financial support is crucial. As a key policy tool for directing capital toward green sectors, green finance should theoretically play a decisive role in helping SMEs overcome the financing bottlenecks during their green transformation. However, the current green financial system faces significant application challenges when serving SMEs: On the one hand, traditional green financial products (such as green bonds) often have high issuance thresholds and compliance requirements. This creates a mismatch for the needs of SMEs, which are characterized by small scale, frequent capital turnover, and strong demand for timely funding[3]. On the other hand, due to difficulties in identifying green standards and incomplete environmental information disclosure, there is severe information asymmetry between financial institutions and SMEs[4]. This not only increases the financing costs for SMEs but also raises market concerns about the risk of greenwashing, thereby reducing the effective allocation of green financial resources.

In this context, innovating financial models and effectively removing barriers that hinder the flow of green financial resources to SMEs have become a core issue to be addressed in theory and practice. Supply chain finance, as a financing model built on real transaction scenarios and the overall credit of the supply chain, offers a promising approach to solve this problem. By taking advantage of the credit of core enterprises and the information flow within the supply chain, it can effectively resolve the information asymmetry between financial institutions and SMEs, providing more targeted and accessible financial support for upstream and downstream SMEs in the supply chain.

2. Current Situation of Green Finance

As a crucial pivotal driver of the comprehensive green transformation of the economy and society, green finance has witnessed consistent advancement at both the policy and market levels in recent years. China has issued a series of top-tier guiding documents that position green finance as a key development orientation and emphasize adherence to the principle of "establishing the new before abolishing the old" to systematically coordinate financial support for green development and low-carbon transformation[5,6] .These policy guidelines provide clear direction for green finance to serve the economy, particularly SMEs.

In terms of market innovation, the green financial product system continues to thrive. Financial institutions are proactively developing a variety of products, including green bonds, transition finance, and carbon finance, while innovating product designs to support environmental protection initiatives. Some regions have also launched financial products linked to enterprises' carbon emissions, which effectively incentivizes SMEs to proactively reduce their emissions. Meanwhile, to address climate change-related risks, a range of innovative risk diversification tools are being piloted and promoted, assisting SMEs in managing operational disruption risks triggered by extreme weather events.

In terms of standardization, relevant authorities have been consistently promoting the unification of green finance standards and have established a comprehensive classification framework that covers the full scope of green projects. This initiative has effectively resolved the long-standing problem of inconsistent standards across different green financial products, thereby laying an institutional foundation for financial institutions to accurately identify green projects and for SMEs to access green financing efficiently. From a market standpoint, both the balance of green loans and the issuance volume of green bonds in China have maintained rapid growth, and several key indicators now rank among the highest globally[7green finance in China saw significant progress across several areas. Early in the year, the CPC Central Committee and the State Council issued the Opinions on Comprehensively Promoting the Construction of a Beautiful China,1 laying out key strategies for achieving a green, low-carbon economy across all sectors. In particular, it advocates the robust development of green financial systems, including green bond issuance, expansion of the national carbon market, climate finance innovation, and ESG information disclosure. It also supports creating standards and certifications for green products and a \"carbon inclusive\" mechanism for public participation. In response to this high-level directive, four ministries (PBOC, MEE, NFRA and CSRC].

In summary, while green finance has achieved a certain

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scale driven by policies and market innovations, the standardization, product innovation, and enhancement of inclusivity remain key priorities for its current advancement. For SMEs, leveraging green finance to overcome financing bottlenecks will be a core focus in their pursuit of sustainable development.

3. Development Dilemma of Small and Medium-sized Enterprises from the Perspective of Green Finance

For a long time, small and medium-sized enterprises (SMEs) have adopted extensive growth patterns due to their pursuit of short-term profits, resulting in a relative disadvantage in the supply chain. This makes it difficult for them to impose green procurement standards on upstream suppliers or obtain key technological and financial support from core enterprises. This situation further weakens their capacity for green transformation and environmental governance, making it challenging for them to meet the requirements of the "dual carbon" goals and constraining their sustainable development. The ESG (Environmental, Social, and Governance) concept, by focusing on non-financial performance indicators, helps align corporate environmental value, social value, and economic value [8] and provides a quantifiable and applicable framework for sustainable development [9]. After engaging in supply chain finance, SMEs can not only increase investment in fulfilling their environmental responsibilities but also leverage their supply chain achieve synergy with core enterprises, jointly address challenges, and improve their environmental, social, and governance performance, thereby enhancing their overall ESG levels.

However, green finance still faces several challenges in its development. On one hand, issues such as inadequate standard coverage and a homogeneous product structure persist. Current green financial instruments are still dominated by loans and bonds, with a shortage of customized, low-cost products tailored to the needs small and medium-sized enterprises (SMEs). On the other hand, SMEs commonly encounter difficulties in green certification and environmental information disclosure, which results in low approval rates for green loans and may even lead to the risk of deliberately fabricating a false “green and environmentally friendly” image. Moreover, the transmission of policies varies across regions and industries, making it difficult for some SMEs with slower green transitions to obtain effective financial support.

Based on these challenges, this paper will next focus on the ESG performance of SMEs, exploring how green finance influences their sustainable development pathways.

4. Green financial Bonds and Derivatives

4.1 SME Financing and Derivatives

Green finance plays an irreplaceable role in facilitating corporate green transformation. Funding shortages represent one of the key bottlenecks restricting small and medium-sized enterprises (SMEs) from pursuing green innovation[10and the need for ‘green’ innovations to improve resource productivity and reduce pollution. However, empirical studies investigating the nexus between green innovation systems and industrialisation in developing countries are limited. Based on nine semi-structured interviews and a survey of 117 firms, this article assesses sectoral systems of innovation in Ethiopia’s cement, leather and textile sectors, with a view to understanding their functioning toward supporting green industrialisation. Results revealed low rates of product and process innovations among firms in Ethiopia. The main inhibitors of innovation are high costs of technology, inadequate finance and limited information. Improving competitiveness is the main driver of firms’ innovation, while reducing environmental impacts and meeting environmental regulations were among the least important motivators. Moreover, interactions among firms, government and other actors encourage innovation. The study therefore suggests enhancing coordination among key actors, providing financial incentives for firms, and enforcing environmental regulations.”,”container-title”:”Journal of Cleaner Production”,”DOI”:”10.1016/j.jclepro.2017.08.067”,”ISSN”:”0959-6526”,”journalAbbreviation”:”Journal of Cleaner Production”,”page”:”503-511”,”source”:”ScienceDirect”,”title”:”Innovation for green industrialisation: An empirical assessment of innovation in Ethiopia’s cement, leather and textile sectors”,”title-short”:”Innovation for green industrialisation”,”volume”:”166”,”author”:[{“family”:”Wakeford”,”given”:”Jeremy J.”},{“family”:”Gebreeyesus”,”given”:”Mulu”},{“family”:”Ginbo”,”given”:”Tsegaye”},{“family”:”Yimer”,”given”:”Kassahun”},{“family”:”Manzambi”,”given”:”Ornélie”},{“family”:”Okereke”,”given”:”Chukwumerije”},{“family”:”Black”,”given”:”Mairi”},{“family”:”Mulugetta”,”given”:”Yacob”}],”issued”:{“date-parts”:[[“2017”,11,10]]}}}],”schema”:”https://github.com/citation-style-language/schema/raw/master/csl-citation.json”}]. As an effective financing tool, green finance can help SMEs adjust their intertemporal allocation of

funds, alleviate short-term liquidity pressures, and offer critical financial backing for green innovation. Various green financial products directly or indirectly facilitate enterprises' energy conservation, emission reduction, green financing, and green-oriented technological innovation.

Currently, financial institutions are proactively engaging in the innovation of, with a focus on aligning such products with the practical needs of SMEs. First, such products are typically characterized by moderate loan amounts, flexible repayment terms, and streamlined approval processes, where the evaluation primarily centers on an enterprise's green development potential and the environmental benefits of its green projects. Second, highly tailored financial derivatives and repayment plans can be customized in light of the specific challenges, risk profiles, and investment requirements, as well as cash flow situations of SMEs across different industries. Such instruments and plans can be flexibly adjusted in accordance with fund recovery cycles to mitigate enterprises' financial burdens (Table 1). Third, exploring the development of new models of green financial derivatives is of equal importance. By partnering with SMEs to issue joint green bonds, financial institutions can aggregate a portfolio of small and medium-sized environmental projects, enhancing the credit ratings and market attractiveness of these projects, thereby reducing financing costs and broadening financing channels[11]. Concurrently, financial institutions can provide supportive financial services—such as dedicated green credit facilities—to streamline approval procedures and enhance the efficiency of loan disbursement.

Table 1. Main product types of green finance and their application characteristics

Product Category	Field of Application	Challenges
Long-term Green Bond	Solar and wind energy	Large capital demand, long investment payback period, and strong dependence on a stable policy environment and electricity market
Green Venture Capital Fund	Research and utilization of new energy	High R&D cost and uncertainty in technological route, high risk of failure but significant social and environmental benefits upon success
Green Fund and Green Loan	Energy and water saving	High initial investment and long promotion payback period; large upfront equipment costs and high technological renovation expenses; long market promotion cycle requiring supporting fiscal subsidies or interest discount policies.
Environmental Equity Financial Instruments	Carbon emission trading and green certificate	Immature market pricing mechanism, limited liquidity and high entry barriers for enterprises. Lack of a well-developed regulatory and trading system for stable and efficient operation.
Green supply Chain Finance	Coordinated emission reduction across the supply chain	Reliance on the credit transmission of core enterprises; inadequate information-sharing mechanisms, difficulty of accurately tracing and quantifying environmental performance

Currently, China's green finance system and related legislative frameworks remain under development, confronting a multitude of structural challenges. On one hand, there exists an absence of effective alignment between existing green finance policies and the practical development needs of small and medium-sized enterprises (SMEs). Owing to significant information asymmetry between financial institutions and SMEs, the efficiency of green financial resource allocation is compromised—which impedes the effective advancement of the digital transformation process for the overwhelming majority of SMEs. The current certification requirements for green projects offer inadequate coverage to small and medium-sized business entities, and many enterprises, constrained by their own qualification levels and capacity, face difficulties in providing sufficient documentation to demonstrate the environmental benefits of their projects. This consequently leads to generally low approval rates for such enterprises' green credit applications. Furthermore, deficiencies in environmental information disclosure and internal monitoring mechanisms within SMEs result in some of the green funds already acquired failing to be effectively allocated to green projects or digital upgrades. This not only gives rise to concerns regarding the accuracy of environmental information disclosure but also further erodes the confidence of financial institutions in providing financing to SMEs.

It is noteworthy that the application of a single standard without differentiation in green finance practices, along with the imposition of strict credit constraints on SMEs that exhibit relatively slow transition progress, would compromise the inherent resource guidance and allocation functions of green finance. According to a 2023 survey by the Chinese Academy of Financial Inclusion, although most SMEs demonstrate a strong willingness to

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pursue low-carbon transition, green financial resources—including green credit and green bonds—continue to flow primarily to larger, well-qualified, and mature enterprises. Moreover, SMEs have extremely limited access to green funds via equity financing channels.

On the other hand, the alignment between China's green finance policy framework and practical development needs remains to be enhanced. Some policies have failed to fully deliver on expectations in the course of implementation, and relevant supporting mechanisms remain inadequately developed. The effective implementation of green finance policies is contingent upon cross-departmental and multi-stakeholder collaboration and efficient policy implementation. However, the current policy transmission process continues to confront institutional and systemic obstacles, including inadequate inter-departmental coordination and low levels of participation among market entities. This leads to a mismatch between the supply of green financial services and the practical needs of SMEs. In addition to insufficient regulatory enforcement during policy implementation and inadequate guidance and constraint mechanisms for SMEs, the overall effectiveness of these policies is further diminished—which hinders the process of utilizing green finance to advance digital transformation. Moreover, disparities in environmental regulation practices, economic development levels, and policy orientations across regions have led to substantial regional imbalances.

According to sustainable development theory, enterprises are required to balance profitability against environmental and social responsibilities in order to maximize their long-term value[12]. The concept of ESG has thus been developed. Existing research has demonstrated that ESG plays a positive role in enhancing corporate financing capacity, operational efficiency, and firm value [13], Such positive impacts have been encouraging a growing number of enterprises to proactively adopt ESG strategies. However, SMEs tend to overemphasize economic objectives while downplaying environmental and social responsibilities, which in turn results in an overall low level of ESG performance. Compounded by their weak position in the supply chain, they face difficulties in promoting upstream green procurement or obtaining technological and financial support from core enterprises, thereby further constraining their sustainable development capabilities. Therefore, this section aims to explore whether supply chain finance can improve SMEs' ESG performance and assist them in achieving sustainable development. It is worth noting that corporate ESG scores represent a weighted aggregation of environmental, social, and governance dimensions; thus, an improvement in any dimension serves to enhance the overall ESG performance.

With respect to environmental responsibility, sustainable development theory highlights the synergistic relationship among economic growth, social progress, and environmental protection, mandating that enterprises allocate resources in a rational manner and minimize pollutant emissions throughout the value creation process—so as to fulfill both environmental and economic responsibilities simultaneously. As market entities, enterprises tend to consume resources and generate pollution in the course of pursuing profits, thereby generating negative externalities [14]. Supply chain finance offers critical institutional and resource-based support for SMEs to fulfill their environmental responsibilities. On the one hand, specifically, unlike traditional financing, supply chain finance is anchored in authentic transaction-specific information, thereby helping to mitigate information asymmetry between relevant banks and SMEs, subsequently reducing financing costs, and improve the efficiency of green financing [15]. It directs financial resources toward green industries [16], thus effectively supporting green innovation and environmental investments for SMEs. On the other hand, supply chain finance enhances trust between upstream and downstream partners through specialized information-sharing platforms, promoting green collaboration and innovation [15],[17]. SMEs can leverage this collaborative mechanism to integrate external resources, enhance innovation capabilities, reduce the risks of green innovation through knowledge and technology spillovers within supply chain, and improve innovation outputs [18due to its sheer breadth and the inconsistent insights it offers. This study systematically addresses this issue by conducting a systematic literature review of articles on innovation in green products and processes, with the aim of enhancing conceptual clarity and consistency, thus, advancing theory and research. This study reviewed 195 articles relating to both green product and process innovation published during 1991–2016. The articles were analyzed in terms of key attributes of green product and process innovation using content analysis. Based on the analysis, this study identifies the key drivers and consequences, mediators and moderators and develops a conceptual framework of green product and process innovation. It also discusses the limitations and main theories of green innovation literature, and articulates potential paths for future research.",",-container-title":"Technology in Society","DOI":"10.1016/j.techsoc.2017.06.002","ISSN":"0160-791X","journalAbbreviation":"Technology in Society","page":"8-23",",-source":"ScienceDirect","title":"Drivers and conse-

quences of green product and process innovation: A systematic review, conceptual framework, and future outlook","title-short":"Drivers and consequences of green product and process innovation","volume":"51","-author":[{"family":"Tariq","given":"Adeel"},{"family":"Badir","given":"Yuosre F."},{"family":"Tariq","-given":"Waqas"},{"family":"Bhutta","given":"Umair Saeed"}],"issued":{"date-parts":[["2017",11,1]]}}}], "schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}], thereby further enhancing their ESG performance in the environmental dimension.

In terms of social responsibility, sustainable development theory advocates a win-win scenario between commercial profits and social value, namely, the principle of "balancing righteousness and profit". Although enterprises' fulfillment of social responsibility aims to build a positive corporate image, management still expects economic returns [19]. Notably, improving product quality is the most directly impactful social responsibility behavior on economic return, as it enhances consumer purchase intention and builds brand value. Supply chain finance, by optimizing the working capital liquidity of SMEs, helps improve product quality and thereby enhances ESG performance in the social dimension. First, supply chain finance can improve the financing environment for enterprises, securing funds for production and operation. Stable cash flow enables SMEs to purchase high-quality raw materials, upgrade production facilities, and provide more systematic employee training—thereby improving production standardization and quality control [20]. Simultaneously, the continuity of financial support reduces the risk of production interruptions, ensuring consistent product quality. Second, according to supply chain management theory, core enterprises can drive synergistic improvement of quality standards across the chain, thus creating a "quality contagion effect" [21,22]. Supply chain finance enhances risk-sharing and value co-creation between SMEs and core enterprises [23], which not only promotes the optimization of quality standards in SMEs but also drives quality improvement across the entire supply chain, helping them fulfill social responsibilities, and ultimately facilitating overall ESG performance improvement.

5. Conclusion

Achieving the "dual carbon" goals is a comprehensive systemic transformation involving the entire economy and society, and the wide-ranging participation of SMEs is critical to the success of this process. This study demonstrates that the green transformation challenges faced by SMEs are, in essence, a fundamental conflict between the traditional extensive development model and the modern sustainable development model. The core constraint lies in the significant structural imbalance between the scarcity of green innovation funds and the supply of green financial resources.

The core finding of this study is that green supply chain finance, as an innovative financing mechanism, enables the effective allocation of green financial resources to SMEs. By leveraging the credit of core enterprises, alleviating information asymmetry, and optimizing capital allocation efficiency, this mechanism not only directly alleviates the financing pressures on SMEs but, more importantly, activates the synergistic effects of the entire supply chain, providing a systematic pathway for enhancing the ESG performance of SMEs. Specifically, in the environmental dimension, continuous financial support and inter-chain knowledge and technology sharing jointly promote green technology innovation and pollution reduction and control. In the social dimension, improved financial conditions drive the enhancement of product quality and the protection of employee rights and interests. In the governance dimension, clear transaction processes and collaborative mechanisms within the chain promote the standardization of internal management systems in enterprises. Therefore, constructing a green financial service system centered on supply chain finance is a key measure to address the bottlenecks restricting the sustainable development bottlenecks of SMEs.

This research has implications for both policymaking and market practice. At the policy level, efforts should prioritize establishing a unified, standardized, and category-specific green finance system, incorporating transition finance into the overall framework, and refraining from imposing simplistic financing restrictions on SMEs. Simultaneously, support should be provided for the development of information platforms based on supply chain data, offering data support for financial institutions to conduct precise risk assessments and differentiated pricing, and effectively mitigating the risk of environmental information misinformation. At the financial institution level, financial institutions should break away from traditional credit models, actively developing green financial products deeply integrated with the supply chain, such as "green order financing" and "environmental benefit-linked loans," promoting a shift in financial service logic from reliance on entity credit to focusing on transaction data credit.

It must be pointed out that this is a preliminary study. The green transformation of SMEs is a multidimensional, dynamically evolving complex process. Future research

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could further analyze the different roles of green supply chain finance across different industrial sectors and regional contexts, and deeply explore the application potential of emerging technologies such as blockchain and artificial intelligence in enhancing the transparency and operational efficiency of the mechanism.

In summary, deeply integrating the concept of green finance into every sector of supply chain operations, transforming financial services from a constraint on the green transformation of SMEs into an effective tool that supports their practice of ESG principles and achievement of sustainable development, is not only a necessary requirement for promoting high-quality economic development but also an important pathway towards building a modern society in harmony with nature.

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