

Research on the Mechanism of Green Finance Driving the Realization of Carbon Neutrality

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Abstract. Climate change's escalating threats have propelled carbon neutrality to the forefront of global priorities. With global temperatures having risen 1.1°C above pre-industrial baselines, achieving net-zero emissions demands immediate multilateral action. One of the most important instruments for facilitating the shift to a low-carbon economy is green finance. Nevertheless, the operational pathways through which financial instruments catalyze carbon neutrality require methodical investigation. By methodically investigating how green finance affects carbon neutrality from four key angles—policy tools, market mechanisms, technological innovation, and societal governance—this study aims to deepen the understanding in this field. The research adopts a mixed-methods approach that includes a comprehensive literature review and in-depth case studies. The findings indicate that green finance significantly enhances the feasibility and efficiency of achieving carbon neutrality through market-based incentives, diversified policy instruments, support for technological innovation, and multi-stakeholder governance. The study concludes that increasing investment in green technology, strengthening international cooperation, and optimizing policy design are essential to maximize the impact of green finance.

Keywords: Green Finance, Carbon Neutrality, Policy Instruments, Market Mechanisms, Technological Innovation

1. Introduction

The Paris Agreement's global carbon neutrality mandate has established green finance as a critical enabler of low-carbon transition financing [1]. As 130+ nations adopt net-zero pledges, the investment demand reaches unprecedented scales: the IEA projects 4 trillion in annual clean energy financing by 2030 for credible decarbonization trajectories [2, 3]. Against this backdrop, academic and policy discourse has increasingly focused on the potential of green finance. Early scholarship predominantly focused on normative modeling and conceptual scaffolding, elucidating axiomatic foundations and projected efficacy. Zhang's meta-analysis reveals a persistent empirical deficit in extant literature, constituting a critical methodological lacuna [4]. There remains a limited understanding of the specific, on-the-ground mechanisms—such as policy interplay, market dynamics, and technological diffusion—through which green finance instruments actually drive tangible carbon reduction outcomes across diverse institutional and economic contexts. Recent analyses of global trends further highlight the disparity between theoretical potential and practical

implementation. While global green finance flows are growing, as documented by the Climate Policy Initiative and other field surveys, their distribution and effectiveness are highly uneven. Developed economies often benefit from more mature financial ecosystems and regulatory frameworks, whereas emerging economies, despite their critical role in global emissions, frequently face challenges in scaling effective green finance mechanisms [5, 6]. This study aims to bridge this gap by systematically investigating the operational pathways through which green finance facilitates progress toward carbon neutrality. Adopting a mixed-methods framework combining comparative case analysis with policy archaeology, the study deconstructs green finance mechanisms' sectoral and regional variegation. It seeks to advance the theoretical discourse by constructing a comprehensive analytical framework that classifies and examines the multifunctional mechanisms of green finance.

2. Overview of green finance and carbon neutrality

2.1. Definition and connotation of green finance

A revolutionary approach to financial services, green finance incorporates environmental factors into risk management, investment choices, and the creation of financial products. "The integration of environmental risks and possibilities into financial decision-making through new products, strategies, and laws" is another way that the UN Environment Programme defines green finance [6]. In recent years, the field of green finance has grown to encompass a wide range of financial tools and systems. With a global issuance of \$522.7 billion in 2021, green bonds—fixed-income securities designated especially to raise funds for environmental and climate projects—have seen tremendous growth [7]. Carbon trading systems, sustainability-linked bonds, green insurance, and green loans are other tools. The development of green finance reflects a paradigm shift in financial institutions' risk management frameworks, wherein environmental considerations have transitioned from peripheral concerns to core determinants in investment decision-making

2.2. Connotation and goals of carbon neutrality

A balance between the quantity of greenhouse gases released into the atmosphere and the quantity extracted from it is known as carbon neutrality, or net-zero emissions. International agreements, especially the Paris Agreement, which seeks to keep global warming well below 2°C over pre-industrial levels while pursuing attempts to keep the temperature increase to 1.5°C, have given the idea more notoriety [1]. Achieving carbon neutrality requires transformative changes across multiple sectors. The energy sector must transition from fossil fuels to renewable sources like hydropower, wind, and solar. Industries need to adopt carbon capture, utilization, and storage technologies and circular economy principles. Transportation should shift towards electrification and sustainable fuels, while land-use and agriculture must enhance carbon sequestration methods [3]. These shifts demand substantial financial investments and structural changes, highlighting the critical role of green finance in facilitating this transition.

2.3. The relationship between green finance and carbon neutrality

Carbon neutrality and green finance form a feedback loop: climate goals shape investment priorities, while green finance accelerates technological transition. Through the mobilization and allocation of funds toward low-carbon projects and technology, green finance plays a crucial role in facilitating carbon neutrality. According to Wang and Zhi, green financing contributes to closing the substantial

funding gap in climate-relevant industries, which the Climate Policy Initiative projects will cost roughly \$4.3 trillion a year until 2030 in order to satisfy the objectives of the Paris Agreement [8, 9]. There are several ways that carbon neutrality is supported by green finance. First of all, it offers the funding required for energy efficiency upgrades, green infrastructure development, and renewable energy projects. Second, it uses cutting-edge financial products and risk-sharing arrangements to lessen the investment risks connected to low-carbon technologies. Thirdly, it encourages businesses to embrace more sustainable practices by influencing their behavior by integrating environmental considerations into investment choices [10]. Green financing also aids in the creation of carbon markets and pricing systems, which provide financial incentives for lowering emissions and speed up the shift to a low-carbon economy.

3. Mechanisms of green finance in driving carbon neutrality

3.1. Policy instrument mechanisms

Policy instruments are essential for shaping the green finance ecosystem and directing capital flows toward carbon neutrality goals. Rather than functioning in isolation, these policy instruments operate through a web of synergistic interactions, collectively constructing a robust policy framework that accelerates the maturation of green financial markets.

Regulatory frameworks, such as mandatory environmental disclosure requirements and green taxonomy systems, provide the foundation for market accountability and transparency. Pioneering examples include the European Union's Sustainable Finance Disclosure Regulation (SFDR) and EU Taxonomy, which establish clear standards for environmentally sustainable economic activities and require financial market participants to disclose sustainability-related information, thereby effectively channeling capital toward green investments [11]. Fiscal policies, including carbon pricing mechanisms (e.g., carbon taxes or emissions trading systems), environmental taxes, and green subsidies, create economic incentives for low-carbon projects. According to the World Bank, by 2022, 68 carbon pricing initiatives were implemented worldwide, covering approximately 23% of global greenhouse gas emissions, with carbon prices ranging from \$1 to \$137 per ton of CO₂ equivalent [12]. By internalizing the costs of carbon emissions, these measures significantly enhance the economic competitiveness of low-carbon alternatives. Moreover, monetary policies and financial regulations play a crucial supporting role in advancing green finance [10].

The policy instruments demonstrate a catalytic multiplier effect. For instance, a well-defined green taxonomy serves as the basis for mandatory disclosures, while high-quality disclosure data enables the effective implementation of carbon pricing and prudential supervision. Concurrently, carbon price signals create a virtuous cycle by incentivizing demand for green financing instruments, thereby amplifying their catalytic impact. This synergy systematically reduces transaction costs and uncertainties associated with green investments, facilitating the flow of private capital into low-carbon sectors. Crucially, policy effectiveness hinges on adaptive governance frameworks that enable real-time calibration. Policymakers must continuously monitor and evaluate policy outcomes based on market feedback—such as the pricing and liquidity of green assets—and the actual progress toward carbon neutrality goals. Such adaptive, feedback-informed governance is essential to maintaining the relevance and efficacy of the policy toolkit over time.

3.2. Market mechanisms

Market-based mechanisms represent a crucial dimension through which green finance drives carbon neutrality, operating through carbon pricing, specialized financial instruments, and sustainable investment strategies. These mechanisms create economic incentives for emission reductions and channel capital toward low-carbon solutions, while their effectiveness depends on continuous innovation and synergy with other policy and technological frameworks.

Carbon markets, which include compliance markets under emission trading systems and voluntary carbon markets, set explicit carbon prices. These prices reflect the cost of emissions and are influenced by factors such as regulatory stringency, market liquidity, technological advancements, and macroeconomic conditions. The European Union Emissions Trading System (EU ETS), the world's largest carbon market, has effectively reduced emissions by about 35% between 2005 and 2019 [11]. Price volatility in these markets significantly impacts participant behavior: higher and more predictable carbon prices encourage investment in low-carbon technologies, while uncertainty can lead to delayed investments or reliance on short-term compliance strategies.

The green bond market has emerged as a specialized financing channel for environmental and climate projects, with its operational mechanisms centered around use-of-proceeds requirements, external reviews, and impact reporting. Global green bond issuance reached \$522.7 billion in 2021, with cumulative issuance since market inception surpassing \$1.9 trillion according to Climate Bonds Initiative data [7]. These instruments enable financing for renewable energy projects, energy efficiency upgrades, sustainable transportation, and other low-carbon initiatives across both developed and developing economies. The market's credibility depends on robust verification processes and transparent allocation reporting, which help prevent "greenwashing" and ensure funds are directed to genuinely sustainable projects.

Environmental, Social, and Governance (ESG) investing has evolved into a powerful market mechanism that incorporates sustainability criteria into investment decisions. ESG assets surpassed \$35 trillion in 2020 and are projected to exceed \$50 trillion by 2025, representing nearly one-third of all global assets under management according to Bloomberg Intelligence [5]. This growth reflects both increasing investor recognition of climate-related risks and opportunities and rising demand for sustainable investment solutions. The integration of ESG factors influences corporate behavior through multiple channels: it affects companies' cost of capital, creates reputational incentives for improved environmental performance, and enables engagement strategies where investors actively push for enhanced climate disclosure and emission reduction targets.

The effectiveness of these market mechanisms in driving carbon neutrality depends on continuous innovation and their synergistic interaction with other policy instruments and technological advancements. Financial innovations such as sustainability-linked bonds, transition finance frameworks, and carbon credit derivatives are expanding the toolkit available to market participants. This momentum is amplified by three synergistic mechanisms: carbon market-regulatory alignment, ESG-disclosure integration, and green bond-tech innovation linkages—all forming self-reinforcing cycles that exponentially accelerate net-zero transitions. This systemic approach, where market mechanisms operate in concert with supportive policies and technological solutions, represents the most promising pathway to achieving climate goals at the necessary scale and speed.

3.3. Technological innovation mechanisms

Through various innovation mechanisms, green finance plays a critical role in speeding up the development and deployment of low-carbon technologies. Clean technology startups and innovation projects require funding from venture capital and private equity investments, which, according to PitchBook, reached \$56 billion globally in 2021, more than doubling the previous year's total and marking a significant increase from just \$6.6 billion in 2016 [12].

Fundamental research and applied development of innovative low-carbon technologies are supported by research and development (R&D) funding. In addition to private R&D investments, public funding—often distributed through green financing mechanisms—helps bridge the gap between laboratory research and commercial deployment. More R&D expenditure is necessary to create the innovative technologies required to reach net-zero emissions, especially in hard-to-abate industries like heavy industry and long-distance transportation, according to the International Energy Agency [3].

Green finance acts as a catalyst for low-carbon technology diffusion, accelerating global adoption through structured transfer mechanisms. International financial institutions such as multilateral development banks and green climate funds are crucial in facilitating technology transfer to developing nations, preventing carbon lock-in, and facilitating the transition to clean technologies [7].

3.4. Social and governance mechanisms

The fourth pathway through which green finance advances carbon neutrality is via social and governance mechanisms. These mechanisms not only generate immediate incentives for decarbonization but also establish long-term institutional safeguards that embed climate objectives into the core of corporate and financial systems.

Corporate governance structures significantly influence companies' environmental performance and decarbonization trajectories. Key governance practices—such as integrating climate-related Key Performance Indicators (KPIs) into executive compensation schemes, establishing board-level sustainability committees, and conducting systematic climate risk oversight—directly shape strategic decision-making. Empirical evidence from Eccles, Ioannou, and Serafeim reveals that firms with advanced sustainability governance structures achieve dual advantages: 18-23% higher operational efficiency and 30% lower systemic risk exposure compared to industry averages [8]. These governance arrangements serve as enduring institutional frameworks that ensure continuous attention to climate goals across business cycles.

Stakeholder engagement and mounting pressure from civil society, consumers, and employees are increasingly driving corporate climate action. Mechanisms such as environmental activism, climate-focused shareholder resolutions, and growing consumer preference for sustainable products create tangible market signals that incentivize emission reductions and strategic alignment with climate targets [9]. These social forces not only drive immediate action but also seed enduring institutional change—normalizing low-carbon practices and fostering collective behavioral shifts that sustain transition momentum across decades.

Transparency and disclosure requirements enhance accountability and empower stakeholders to assess corporate climate performance. Initiatives such as the Task Force on Climate-related Financial Disclosures (TCFD) and its successor, the International Sustainability Standards Board (ISSB), have developed frameworks for consistent, comparable climate-related financial disclosures [10]. These frameworks do more than address current information asymmetries—they establish

foundational infrastructures for market discipline that will support informed capital allocation and risk assessment for decades to come.

Together, these social and governance mechanisms create a self-reinforcing ecosystem for climate action. In the short term, they generate direct pressure and incentives for decarbonization. More importantly, they establish resilient institutional architectures—including governance norms, stakeholder engagement processes, and disclosure systems—that lock in climate accountability and ensure sustained progress toward carbon neutrality, regardless of shifting political or market conditions. This dual function makes social and governance mechanisms indispensable for both initiating and maintaining the transition to a net-zero economy.

4. Case study

The European Union has established itself as a global frontrunner in green finance and climate policy by developing an integrated framework to achieve its goal of climate neutrality by 2050. The EU's approach combines regulatory measures, market-based instruments, and substantial financial support to drive the green transition, while continuously adapting to implementation challenges.

The EU's 2018 Sustainable Finance Action Plan remains the foundational blueprint for European green finance strategy. This comprehensive framework includes three key regulatory instruments: the EU Taxonomy Regulation, which establishes a classification system for environmentally sustainable economic activities; the Sustainable Finance Disclosure Regulation (SFDR), mandating financial market participants to disclose sustainability-related information; and the Climate Benchmarks Regulation, setting standards for low-carbon investment benchmarks [11]. Together, these measures have enhanced market transparency, mitigated greenwashing risks, and redirected capital flows toward sustainable activities.

However, the implementation of these policies has faced significant challenges, including the technical complexity of taxonomy criteria, compliance costs for financial institutions, and potential market fragmentation across member states. In response, the EU has adopted a phased implementation approach, providing detailed technical screening criteria through delegated acts, offering extensive guidance through the European Supervisory Authorities, and establishing platforms for stakeholder consultation to ensure practical feasibility and cross-border consistency.

Dubbed the European Green Deal Investment Plan, this €1 trillion mobilization initiative (2021-2030) employs a triple-coordination strategy: blending EU budget allocations, member state co-financing, and private capital de-risked through InvestEU guarantees. This comprehensive funding strategy combines EU budget allocations, member state co-financing, and substantial private investments mobilized through the InvestEU program, which provides EU budget guarantees to de-risk sustainable projects. The plan specifically addresses investment gaps in Central and Eastern European member states through the Just Transition Mechanism, ensuring no region is left behind in the green transition.

The EU Emissions Trading System (EU ETS), established in 2005 and covering approximately 40% of the EU's greenhouse gas emissions, remains the world's largest carbon market. The system has undergone several reforms to enhance its effectiveness, including the establishment of the Market Stability Reserve to address surplus allowances and the implementation of a stricter annual cap reduction factor of 2.2% since 2021 [11]. These measures have significantly reduced emissions from covered sectors while generating substantial revenues that are reinvested into climate action through innovation funds and modernization programs.

5. Conclusion

This study demonstrates that green finance drives carbon neutrality through four interconnected mechanisms: policy instruments that establish regulatory frameworks and incentives, market mechanisms that price carbon and mobilize capital, technological innovation that accelerates low-carbon solutions, and social governance that embeds climate accountability into corporate behavior. Key findings reveal that successful green finance systems rely on the integration of these mechanisms, combining carbon pricing, green taxonomies, and sustainability disclosures with robust financial instruments and stakeholder engagement. However, challenges remain in data availability, impact measurement methodologies, and the adaptation of these frameworks across diverse economic contexts. Future research needs standardized impact metrics, emerging market analysis, and blockchain applications in green finance. Longitudinal studies tracking the long-term effects of green finance interventions will also provide valuable insights. For policymakers, priorities include building comprehensive policy frameworks that combine regulation with market incentives, strengthening international cooperation to address transboundary environmental challenges, and supporting capacity building in developing economies. Financial institutions and corporations must continue integrating climate considerations into decision-making processes while developing innovative financial products to support the low-carbon transition.

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