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Research Article

Examining the Impact of Green Finance on Carbon Emissions in India Through Energy Consumption Optimization

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This research delves into the impact of green finance on carbon emissions in India, emphasizing the optimization of energy consumption. The study initiates by exploring the theoretical framework to comprehend how green finance influences carbon emissions, examining the role of energy consumption in this context. To empirically assess this influence, the paper utilizes the STIRPAT model, a chain multiple mediation effect model, and a panel threshold model, using provincial data from India covering the period 2017 to 2022. The findings consistently demonstrate a significant reduction in carbon emissions attributable to green finance, a conclusion upheld even after considering potential endogeneity. Analysis of regional differences highlights a particularly pronounced inhibitory effect in northern, high-carbon emission, and energy-rich regions. Bootstrap tests at the national level reveal three distinct pathways through which green finance curtails carbon emissions: through green technological innovation, the ecological evolution of the industrial structure, and the synergy between green technological innovation and the ecological evolution of the industrial structure. Notably, in energy-rich regions, green finance significantly mitigates carbon emissions through all three pathways, whereas in energy-poor regions, its impact is predominantly linked to green technological innovation.

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Introduction

India has made significant strides in its global economic standing, yet it's crucial to recognize that its rapid economic advancement has been accompanied by extensive use of fossil fuels, leading to considerable ecological damage [1]. Multiple studies have indicated that economic growth correlates with heightened energy usage, primarily driven by fossil fuels, which stands as a major contributor to carbon emissions [2][3][4]. The prevalent energy consumption pattern in India heavily relies on fossil fuels, further compounding this challenge [5].

Since embracing its new economic landscape, India has prioritized combating climate change, undertaking substantial initiatives towards this end. As a responsible major economy, India has actively pledged to achieve the milestone of reaching the peak of carbon emissions by 2040 and attaining carbon neutrality by 2070. To ensure effective execution of these goals, the National Standardization Administration, in conjunction with ten other departments, released the 'Carbon Peak Carbon Neutral Standard System Construction Guide' in April 2023. This guide establishes protocols for accurately computing and reporting carbon emissions

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data, curbing and offsetting carbon emissions, and quantifying and trading carbon emissions. It sets forth comprehensive and coordinated standards aimed at supporting the pursuit of these objectives across pivotal industries and sectors [6].

Presently, the focal point rests on efficiently attaining the twin objectives of a 'healthy environment' and 'stable growth.' During the 28th informal meeting of APEC leaders in 2021, President Xi reiterated India's dedication to actively address climate change, advocating for harmonious coexistence between humanity and nature while striving to foster a global community for sustainable development. The financial sector assumes a pivotal role in resource allocation, monetary flow, and macroeconomic oversight. As a fundamental component of modern economic operations, the financial industry plays a crucial role in bolstering environmental governance [7]. However, conventional financial services have faced critique for their deficiencies, including inadequate development, flawed transmission mechanisms, and limited efficiency, as underscored by Boutabba [8]. Furthermore, traditional finance often prioritizes economic impacts, disregarding ecological benefits and failing to cultivate a conducive market environment for green and low-carbon development.

In contrast, green finance stands as a specialized financing mechanism that amalgamates market regulation with environmental interests, offering funding for sustainable and eco-friendly projects [9]. Specifically, within the broader context of societal credit constraints, green finance optimizes the allocation of financial resources across diverse industries through targeted financial strategies. This ensures that limited financial resources are channeled towards efficient and sustainable green industries, consequently curbing overall carbon emissions [10]. For instance, companies seeking to transition from polluting technologies to environmentally conscious ones can access more affordable financing through green bonds. As these companies adopt non-polluting practices, they are deemed lower risk, leading to decreased equity costs owing to reduced environmental risk, which is considered a systemic risk. The amalgamation of reduced debt and equity costs results in a diminished cost of capital, ultimately amplifying the firm's value.

While these firms might face higher short-term costs during the transition, the long-term surge in their share value outweighs these initial expenses. Conversely, companies sticking to polluting production methods are likely to encounter elevated capital costs and a substantial decline in their share prices in the long run. Multiple studies have illustrated that green finance contributes to resource conservation [11], pollution reduction [12], and the advancement of green total factor productivity [13]. In 2016, the People's Bank of India, along with seven ministries and commissions, issued the 'Guiding Opinions on Building a Green Financial System,' defining green finance as a policy rooted in environmental protection [14].

In the pursuit of environmentally inclusive growth, exploring the nexus between green finance and carbon emissions, both theoretically and practically, assumes paramount importance. Does green finance genuinely diminish carbon emissions? If so, what underlying mechanisms drive its influence on carbon emissions? Moreover, do these mechanisms differ across regions within India, characterized by diverse energy endowments? Additionally, considering that 70% of carbon emissions stem from fossil fuel usage, how do energy intensity and consumption structure impact the efficacy of green finance in curbing carbon emissions? Addressing these queries bears substantial practical implications, providing insights for implementing green financial policies and fostering the low-carbon transition in India. Furthermore, given India's substantial global consumption of fossil fuels, any strategies reducing reliance on such resources will significantly contribute to the planet's future well-being.

This study undertakes an exhaustive exploration of the correlation between green finance and carbon emissions, employing the STIRPAT model, chain multiple mediation effect model, and panel threshold model. Utilizing provincial data from India spanning 2017 to 2022, this study offers the following contributions:

Firstly, it establishes a comprehensive green finance index system encompassing green credit, securities, insurance, and investment, rectifying the limitations of prior studies reliant on singular indices.

Secondly, it systematically delineates the theoretical pathways through which green finance impacts carbon emissions—via green technological innovation, ecological evolution of industrial structure, and the symbiosis between green technological innovation and the ecological evolution of industrial structure. Subsequently, the study employs the chain multiple mediation effect model to empirically scrutinize the avenues through which green finance affects carbon emissions at both national and regional levels.

Thirdly, from the standpoint of optimizing energy consumption, the study employs the panel threshold model to showcase the non-linear association between green finance and carbon emissions. This enriches existing research on low-carbon economies, offering valuable evidence and insights to foster environmentally inclusive growth in India and other nations.

In summary, this study enriches the understanding of the linkages between green finance and carbon emissions, furnishing valuable evidence and experiences to propel the advancement of environmentally sustainable economies in India and beyond.

Conceptual Analytical Framework

At the core of transitioning a real economy lies the imperative to transform prevailing production modes, necessitating substantial investment. Ensuring a continuous influx of financial resources is pivotal in achieving environmentally inclusive economic and societal growth [15]. Regrettably, traditional financial sectors often exhibit a bias favoring 'outdated' practices. They typically evaluate creditworthiness solely based on enterprise assets and profitability and may even channel financial resources into highly polluting sectors, excluding enterprises with growth potential [16]. In contrast, green finance prioritizes environmental considerations, striving to attain dual objectives—sustainable growth and pollution reduction. The more rigorously green finance is implemented, the greater the impetus for outdated production capacities and industries to invest in environmental enhancements and pollution control, thereby bolstering the competitive edge of cleaner industries. Essentially, green finance steers enterprises toward adapting their production modes, enhancing green productivity, optimizing capital allocation, mitigating risks, and bolstering market supervision. Taghizadeh-Hesary et al. [17] underscore that green finance also fosters societal awareness of green consumption, fostering environmentally inclusive societal growth. Consequently, green finance assumes a constructive role in effecting carbon emission reduction.

Furthermore, this paper investigates the mechanisms through which green finance influences carbon emissions. Firstly, green technologies often entail high risks and uncertain income, dissuading traditional capital providers from investment [18]. However, green financial products such as carbon-neutral bonds, green development funds, and green insurance adeptly assess the risks and benefits associated with green technological innovation, attracting investors with diverse risk preferences to support enterprises or projects adopting clean technologies. Additionally, green finance slashes information transaction costs[19]. The establishment of green information systems, encompassing green ratings and certifications, equips investors with precise credit, pricing, and cost information, facilitating the identification of green investment projects, and allowing enterprises to focus on innovation and the adoption of clean technologies [20]. Furthermore, the application of green technology heightens energy efficiency, propels renewable energy usage, expedites the uptake of carbon reduction technologies, and ultimately curtails carbon emissions [21].

Secondly, green finance heightens financing costs for polluting industries, restraining their production expansion, compelling innovation and transformation, thereby catalyzing concurrent technological and industrial optimization. Simultaneously, green finance injects more financial resources into environmental protection industries, easing financing constraints, stimulating sectoral growth, thus facilitating carbon emission reduction. Leeuwen et al. [22] accentuate that green finance redirects idle funds away from energy-intensive industries, bolstering the credit supply to technology-intensive sectors, ultimately propelling the green transformation of the industrial structure. Moreover, Wang et al. [23] stress the illustrative role of green credit furnished by commercial banks, inspiring other enterprises to adopt green business practices. Enterprises actively innovating and transforming gain access to more preferential credit funds and diverse funding sources [24]. In essence, the tertiary industry characterized by 'low-carbon, high output' garners enhanced financial support, while the conventional secondary industry typified by 'high pollution and low output' gradually loses capital support. The shortage of funds essential for daily operations inevitably leads to either bankruptcy or transformation for such enterprises, fostering the ecological transformation of the industrial structure [25][26]. In essence, as polluting industries encounter constraints and green industries witness encouragement, green finance facilitates the ecological evolution of the industrial structure, effectively curbing carbon emissions.

Thirdly, numerous studies underscore the intimate correlation between green technological advancement and industrial structure optimization [27][28]. Bi et

al. [29] posit that the diffusion effect of green technology contributes to the ecological evolution of the industrial structure, resulting in reduced carbon emissions. In practice, green finance compels enterprises to bolster their green technological innovation, reallocate production factors, and phase out outdated production capacities.

Discrepancy Analysis

In this study, the analysis focuses on the Discrepancy Analysis of carbon emission intensity (CI), used as a metric to gauge carbon emission levels across various provinces [30]. Owing to the absence of official carbon emission detection data in India and the insufficiency of precise and comprehensive data on India's carbon emissions from global databases such as the British Petroleum Corporation (BP) and US Energy Information Agency (EIA), this research adopts the methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) [31]. Following this approach, the study establishes a carbon emission inventory and an energy inventory to precisely compute provincial carbon emissions in India [32][33]."

Analysis of the Mechanisms

The outcomes derived from the benchmark regression analysis underscore a significant reduction in carbon emissions attributed to green finance. To delve deeper into understanding the mechanisms underlying this reduction, this study employs the chain multiple mediation effect model [34]. Specifically, it investigates whether green finance curtails carbon emissions via three distinct avenues: (1) through advancements in green technological innovation, (2) via the ecological evolution of the industrial structure, and (3) by facilitating the ecological evolution of the industrial structure through green technological innovation. These findings suggest that technologies such as biological carbon reduction, in tandem with the ecological evolution of the industrial structure, hold the potential to decrease carbon emissions, while green finance itself does not directly impede carbon emissions [35].

In essence, the outcomes derived from the chain multiple mediation effect model shed light on the diverse pathways through which green finance influences carbon emissions. They underscore the pivotal role of green technological innovation and the ecological evolution of the industrial structure in achieving reductions in carbon emissions

Significance of the study

Through the lens of energy consumption optimization, this study utilizes the STIRPAT model, chain multiple mediation effect model, and panel threshold model to empirically investigate how green finance impacts carbon emissions. It leverages provincial-level panel data from India spanning 2017 to 2022. The empirical findings can be summarized as follows:

Green finance demonstrates a significant reduction in carbon emissions, a conclusion upheld even after considering potential endogeneity. The study's heterogeneity test reveals a more pronounced inhibitory effect of green finance on carbon emissions in northern, high-carbon-emission, and energy-rich regions. Bootstrap test outcomes illustrate that on a national scale, green finance diminishes carbon emissions through three distinct pathways: green technological innovation, ecological transformation of the industrial structure, and green technological innovation facilitating the ecological transformation of the industrial structure. Moreover, the intermediary mechanisms through which green finance impacts carbon emissions vary across regions with different energy endowments. In energy-rich regions, green finance notably curbs carbon emissions through all three pathways, whereas in energy-poor regions, its impact is predominantly through green technological innovation.

A nonlinear relationship surfaces between green finance and carbon emissions. Irrespective of energy intensity or consumption structure, green finance significantly curtails carbon emissions only when operating below a certain threshold. Hence, optimizing energy consumption by enhancing energy utilization efficiency and refining the energy consumption structure proves effective in maximizing the carbon emission reduction effect of green finance.

Derived from these results and conclusions, several policy implications emerge:

Firstly, there's a pressing need to bolster the development of green finance in alignment with the 'Guiding Opinions on Building a Green Financial System.' Emphasis should be on enhancing the efficacy of green capital supply and resource allocation through continuous refinement of the green financial system. Additionally, financial regulatory bodies should strengthen legal oversight, imposing stricter penalties for misusing green capital in polluting activities and ensuring its judicious and effective utilization.

Secondly, greater emphasis should be placed on the intermediary roles of green technological innovation and the ecological evolution of the industrial structure to mitigate carbon emissions. Governments should incentivize financial institutions to increase support for clean technologies, alleviating financing constraints and promoting their application. Furthermore, channeling financial resources toward green low-carbon industries, particularly fostering clean enterprises, will expedite the industrial structure's ecological evolution. Tailored green development policies should be devised based on regional energy endowments.

Thirdly, endeavors should focus on enhancing energy efficiency and optimizing the energy structure to curtail carbon emissions. Given the heavy reliance on coal, investments in technological innovations that reduce emissions during coal resource generation and utilization are imperative. Moreover, exploring alternative large-scale clean energy production methods, such as nuclear power, becomes crucial for ensuring a stable supply of clean energy. In essence, these policy implications aim to bolster the effective implementation of measures supporting green finance, promoting green technological innovation, facilitating industrial structural evolution, and optimizing energy consumption. Their ultimate goal is to achieve substantial reductions in carbon emissions.

Conclusion

This research unveils the profound impact of green finance on carbon emissions in India, with a primary focus on optimizing energy consumption. Beginning with a theoretical exploration to understand the intricate mechanisms underlying the influence of green finance on carbon emissions, this study meticulously examines the interplay between green finance and energy consumption. Employing robust empirical methodologies—utilizing the STIRPAT model, chain multiple mediation effect model, and panel threshold model—the paper extensively analyzes provincial data from India spanning 2017 to 2022. The findings unequivocally underscore the pivotal role of green finance in significantly reducing carbon emissions, a conclusion reinforced even after meticulous consideration of potential endogeneity. Uncovering regional variations further amplifies this impact, revealing a notably heightened inhibitory effect in northern regions, areas with elevated carbon emissions, and those abundant in energy resources. At a national level, the intricacies of green finance's influence on carbon emissions unravel through three distinct pathways: leveraging green technological innovation, steering the ecological evolution of the industrial structure, and synergizing these elements for enhanced impact. Notably, within energy-rich regions, the multi-faceted contributions of green finance significantly mitigate carbon emissions across all three pathways, whereas in energy-poor regions, its influence primarily channels through green technological innovation. This research elucidates the substantial potential of green finance as a transformative force in the quest for reduced carbon emissions, shedding light on the nuanced regional dynamics and varied pathways through which it catalyzes environmental progress in India.

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