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Original Paper

Drivers of Economic Growth and Structural Change in China under the Carbon Peaking and Carbon Neutrality Goals

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Abstract

Through a literature review and theoretical analysis, this paper examines how the reconstruction of the production function during the low-carbon transition shapes the drivers of economic growth and structural change in China. It also explores the new theoretical perspectives required, and the challenges encountered, in pursuing the "dual carbon" goals of carbon peaking by 2030 and carbon neutrality by 2060. The study finds that the production function is being reconfigured through the reallocation of factor inputs, the introduction of directed technological progress, policy guidance, and adjustment of the industrial structure. By developing low-carbon industries—including clean energy, green manufacturing, and environmental services—and by accelerating the rise of emerging industries while upgrading traditional ones, China's economic structure is undergoing a transition toward lower carbon intensity and higher technological content. Technological innovation, green finance, carbon emissions trading, and international cooperation are identified as the key pathways through which China can realize its carbon neutrality goal. The paper concludes with policy recommendations aimed at supporting the joint pursuit of growth and decarbonization.

Keywords

carbon peaking, carbon neutrality, production function, green transition, economic development

1. Introduction

Against the backdrop of intensifying climate change and mounting environmental pressures, carbon neutrality has become a shared goal across nations. As the world's largest developing country and the largest emitter of greenhouse gases, China has formally committed to peaking carbon emissions before 2030 and achieving carbon neutrality before 2060. These goals—known in Chinese policy discourse as the "dual carbon" targets—carry profound implications not only for environmental protection but also for the trajectory of economic development and the underlying structure of the national economy.

This paper aims to clarify, through theoretical analysis, how the low-carbon transition reconstructs the production function and, in turn, alters the drivers of economic growth and structural change in China. It further considers the new theoretical questions raised by the carbon neutrality target and the policy challenges associated with achieving it. The remainder of the paper is organized as follows. Section 2 reviews how the production function is reshaped under low-carbon constraints and analyzes the new drivers of growth and the corresponding structural changes. Section 3 discusses the theoretical and empirical challenges arising from the carbon neutrality agenda. Section 4 puts forward policy recommendations. Section 5 concludes.

The paper differs from existing work in two respects. First, while a substantial literature has examined the technological, financial, and regulatory dimensions of China's low-carbon transition in isolation, fewer studies provide an integrated theoretical account that links the reconstruction of the production function, the redirection of growth drivers, and the evolution of economic structure within a single analytical frame. Second, by combining insights from endogenous growth theory, environmental economics, and the Chinese policy literature, the analysis seeks to identify the channels through which a binding emissions constraint can simultaneously reshape factor allocation, innovation incentives, and industrial composition. The contribution is therefore primarily synthetic and conceptual: the paper aims to clarify how diverse strands of theory can be brought to bear on a uniquely large-scale national decarbonization commitment, rather than to offer new empirical estimates.

2. Theoretical Analysis under the Carbon Neutrality Goal

2.1 The Impact of the Low-Carbon Transition on the Production Function

The traditional production function takes capital, labor, and technological progress as its main variables. The low-carbon transition requires that carbon emissions be incorporated as an additional, binding constraint. Under this revised framework, both capital allocation and labor allocation are shaped by emission limits, while the direction of technological progress shifts toward energy efficiency and low-carbon innovation. Firms are pushed to reduce the carbon footprint of production, which in turn alters the path and pattern of economic growth.

Two adjustments at the level of factor inputs are particularly important. First, the energy mix moves from fossil fuels toward clean sources such as solar, wind, and hydrogen. This shift lowers the carbon intensity of output and, by raising overall energy efficiency, reduces the energy required per unit of GDP. Second, technological progress takes on a directional character: research on, and adoption of, low-carbon technologies—including both new energy technologies and the retrofitting of conventional industries—become the primary engines of productivity gains.

It is worth noting that the carbon constraint differs in important respects from the conventional resource constraints embedded in classical production theory. Capital and labor constraints typically operate through observable market prices and respond elastically to investment and demographic change. The carbon constraint, by contrast, is partly imposed exogenously by policy, partly endogenous to global climate outcomes, and binding in a quantity sense rather than only through prices. This hybrid character means that the elasticity of substitution between dirty and clean inputs takes on first-order importance: when substitution is feasible, output can grow even as emissions decline; when it is not, the constraint translates directly into a reduction in achievable output. Recognizing this asymmetry is essential for any meaningful integration of carbon variables into the production function.

These changes can be expressed by introducing carbon-related parameters into the production function. One formulation incorporates a carbon abatement cost elasticity ψ that captures the cost of emission reduction:

$$Y_t = z_t^{\psi} \cdot A_0 \cdot D_t \cdot n_t \cdot k_t^{\beta} \cdot G_t \cdot \mu_t^{\gamma},$$

where z_t denotes carbon abatement intensity, A_0 the technology level, D_t labor productivity, n_t the share of R&D personnel, k_t capital, G_t energy intensity, and μ_t the energy mix. An alternative formulation directly embeds CO_2 reduction effects:

$$Y_t = A \cdot k_t^{\alpha} \cdot L_t^{\beta} \cdot (1 - \varphi_t)^{\psi} \cdot E_t^{\gamma},$$

where E_t is energy input and φ_t is the rate of emissions reduction. These specifications make explicit that output depends not only on conventional inputs but also on the cost and effectiveness of carbon abatement.

Policy and institutional design also enter the production function indirectly. Stringent environmental regulation, fiscal incentives, and support for innovation alter both the relative price and the relative productivity of clean and dirty inputs. Industrial restructuring—reducing the share of high-emission, energy-intensive sectors and expanding low-carbon ones—further changes the composition of inputs that enter the function.

Endogenous growth theory provides a useful framework for connecting these mechanisms. Acemoglu et al. (2012) show that, when clean and dirty inputs are sufficiently substitutable, temporary policy interventions can redirect innovation toward clean technologies and sustain long-run growth. Aghion et al. (2016) provide complementary firm-level evidence from the auto industry, demonstrating that higher carbon-related fuel prices induce a shift of innovation toward clean technologies. Taken together, these adjustments imply a deep restructuring of the production function: factors are reconfigured, technological progress is redirected, policy is internalized, and industrial composition shifts—jointly producing a model of sustainable growth.

2.2 Drivers of Economic Growth

Under the carbon neutrality goal, the drivers of economic growth differ fundamentally from those of the high-emission industrialization model. Growth must increasingly rely on clean energy, green technology, and sustainable production patterns, with technological innovation and well-designed policy serving as the central drivers.

Technological progress is the cornerstone. The development and diffusion of clean energy technologies—solar, wind, and hydrogen—reduce dependence on fossil fuels and curb greenhouse gas emissions. Complementary green technologies, such as energy-efficient equipment and resource-recycling processes, raise the productivity of existing inputs and steer industrial upgrading. Through innovation, firms can simultaneously cut costs, lower emissions, and capture new markets, turning environmental constraints into a source of competitive advantage.

Government policy and market mechanisms operate jointly to support this transition. On the policy side, environmental regulations, emission standards, fiscal incentives, and targeted subsidies channel investment toward low-carbon technologies and projects. On the market side, the establishment of a carbon trading system turns emissions rights into a tradable commodity, providing firms with both an explicit price signal and an economic incentive to reduce emissions. Competition among firms further drives efficiency gains and the adoption of cleaner production methods.

Two complementary logics underpin this policy mix. The Pigouvian approach internalizes externalities through corrective taxation—most directly through carbon taxes—and works best when the marginal social cost of emissions can be reasonably well estimated. The Coasean approach, embodied in cap-and-trade arrangements, instead defines property rights over a fixed quantity of emissions and lets the market discover the efficient price. China's evolving policy toolkit combines both elements: administrative quotas and emission caps establish quantity ceilings, while pilot carbon markets and differentiated electricity pricing provide price-based signals. The interaction between these instruments shapes the effective marginal cost of carbon faced by firms, with important implications for the pace and direction of innovation.

Green investment serves as the channel that links these forces to real economic activity. Capital flowing into clean energy, low-carbon technology, and environmental services not only accelerates the development of these sectors but also creates new growth poles. The expansion of green finance—green bonds, green funds, and dedicated lending facilities—broadens the financing channels available to low-carbon projects and amplifies the macroeconomic impact of policy support. Drawing on Chinese city-level panel data, Li et al. (2024) show that green finance and green innovation jointly inhibit carbon emissions, with effects moderated by environmental regulation and the level of marketization.

The rise of low-carbon industries embodies these forces in tangible form. Renewable energy, energy-saving and environmental protection technologies, new-energy vehicles, and green building have generated substantial employment and output, while reducing reliance on traditional high-emission sectors. International cooperation reinforces these domestic drivers: technology sharing, joint research, and harmonized standards facilitate faster diffusion of low-carbon solutions across borders, while multilateral frameworks contribute institutional support to global decarbonization.

2.3 Evolution of the Economic Structure

The low-carbon transition has profound implications for economic structure, working through the energy mix, industrial composition, technological capability, and the interplay between policy and markets.

The most visible change occurs in the energy mix. The share of high-emission sources such as coal and oil is gradually declining, while clean energy—solar, wind, and hydropower—is expanding rapidly. Large-scale investments in wind and photovoltaic generation have begun to reshape provincial-level energy structures and lower the carbon intensity of the power supply. This transition both reduces emissions and improves overall energy productivity.

Industrial structure is being reshaped in parallel. Energy-intensive and pollution-heavy industries face stricter regulation and rising abatement costs, while green manufacturing and environmental services are expanding. Through process innovation and equipment upgrading, the manufacturing sector is achieving higher efficiency at lower emissions, supporting both productivity growth and structural upgrading. As Zhang et al. (2010) note, technological progress and the diffusion of green technologies are the primary engines of this transformation.

Emerging industries provide a further dimension of structural change. New energy, new materials, and new-energy vehicles have grown rapidly, becoming new sources of economic momentum. Yuan (2010) documents China's progress in clean technology adoption, an area in which the country has built substantial capability. These industries combine high technology content with relatively low environmental impact, fitting naturally into a low-carbon growth model.

Structural change of this magnitude does not occur frictionlessly. Existing capital stocks, occupational specializations, and supplier networks embed decades of fossil-fuel-oriented investment, generating path dependence that slows reallocation. Workers in shrinking industries may face skill mismatches with the expanding green sectors, while regions with concentrated exposure to high-emission activities risk localized declines in employment and tax revenue. Recognizing these frictions is essential, because the aggregate gains from a low-carbon transition can mask substantial distributional consequences during the adjustment period. A successful structural shift therefore requires not only the expansion of new sectors but also active policies for retraining, regional support, and the orderly retirement of legacy assets—features that bear directly on the political feasibility of the transition.

Supportive policy and active markets are jointly responsible for these structural shifts. Environmental regulation, fiscal incentives, and the development of carbon markets push firms toward cleaner production, while price signals and competition determine where capital and labor flow. Regional coordination is also evolving: eastern provinces leverage their technological and capital advantages to develop high-end green manufacturing, while central and western regions exploit their resource endowments to expand clean energy and ecological agriculture, contributing to a more balanced national pattern of low-carbon development.

3. Emerging Issues and Challenges

The pursuit of carbon neutrality raises new questions for both economic theory and policy practice.

First, several conventional theoretical assumptions become untenable. Standard growth models often abstract away from binding environmental limits, treating environmental costs as ex-post externalities rather than as intrinsic constraints on factor allocation. Under a binding carbon constraint, however, scarcity and environmental cost must be internalized. The assumption of technological neutrality also becomes problematic, since the direction of technical change—toward clean or dirty production—has first-order consequences for emissions and welfare.

Second, theoretical construction needs to be advanced in several directions. Production functions must explicitly incorporate carbon constraints and study their effects on growth and resource allocation. New growth models are required to analyze the contribution of green innovation and low-carbon industries to long-run growth. A comprehensive evaluation framework is also needed to assess the joint economic and environmental effects of carbon policy.

Third, empirical analysis faces practical hurdles. Reliable, harmonized data on emissions, energy use, and green innovation remain limited. Conventional econometric techniques may not adequately capture the complex dynamics of low-carbon policy, calling for new methods and interdisciplinary collaboration with environmental science and engineering.

Fourth, the transition raises a non-trivial intertemporal trade-off. Stringent emission reductions in the short run typically impose higher abatement costs on firms and may temporarily dampen investment in carbon-intensive sectors that still account for a sizeable share of output. The long-run benefits—avoided climate damages, technological leadership in clean industries, improved public health—accrue over decades and are diffused across many beneficiaries. Reconciling these horizons requires both credible policy commitment, so that firms invest in long-lived clean capital, and well-designed transitional support, so that short-run dislocations do not erode social and political support for the broader transition.

Finally, policy design itself is challenging. Achieving carbon neutrality requires a coherent package—covering emissions trading, green finance, R&D incentives, and industrial policy—that balances growth and environmental objectives, mobilizes firms and households, and aligns with the rules of international trade and finance. Maintaining policy consistency over a multi-decade horizon, while adjusting to changing conditions, adds further complexity.

4. Policy Recommendations

Several policy directions follow from the analysis. First, sustained public investment in green technology research and development should be paired with stronger intellectual property protection and demonstration projects that lower commercialization risk in energy, transport, and manufacturing. Targeted support for early-stage clean technologies—where private incentives alone tend to underprovide R&D—is particularly important, as these technologies often face long development timelines and uncertain returns that discourage purely private investment.

Second, green finance should be expanded along multiple dimensions. Regulators can encourage banks and institutional investors to broaden green credit, green bonds, and dedicated green funds, while developing transition-finance instruments that support carbon-intensive firms credibly committed to decarbonization. Standardized disclosure rules and a unified green taxonomy would reduce greenwashing risk and improve the allocation of capital toward genuinely low-carbon projects.

Third, the national carbon emissions trading market should be deepened through rigorous monitoring, gradually tightened cap trajectories, transparent quota allocation, and broader sectoral coverage. A predictable carbon price signal is essential for long-horizon investment decisions, and complementary measures—such as benchmarking against international peers and gradual integration with cross-border carbon pricing arrangements—can strengthen its effectiveness without compromising domestic policy autonomy.

Fourth, industrial policy should accelerate the upgrading of high-emission sectors through performance standards, tax incentives, and targeted subsidies for low-carbon retrofits, while supporting the expansion of emerging green industries. Coordinated transitional support—retraining programmes, regional development funds, and time-limited adjustment assistance for affected workers and communities—can mitigate distributional costs and preserve political feasibility, an aspect often underemphasized in technical analyses of decarbonization.

Fifth, China should engage actively in international climate cooperation, contributing to global governance frameworks and benefiting from cross-border exchange of technology, finance, and best practice. Strengthened cooperation on monitoring methods, data standards, and joint research can amplify the gains from domestic policy action and reduce the risk that unilateral measures generate competitiveness concerns or trade disputes.

5. Conclusion

Realizing China's carbon peaking and carbon neutrality goals demands a deep transformation of its growth model, supported by theoretical innovation, rigorous empirical analysis, and coherent policy design. The reconstruction of the production function, the redirection of growth drivers toward clean technology and green investment, and the structural shift toward low-carbon industries together form an integrated framework through which growth and decarbonization can be reconciled. Continued progress in technological innovation, green finance, carbon markets, and international cooperation is needed to translate these long-term commitments into a durable model of sustainable development that aligns environmental and economic objectives.

Several directions warrant further research. Empirical work could quantify the elasticity of substitution between clean and dirty inputs at the sectoral level in China, refining the parameters of the production functions developed here. Comparative studies across emerging economies pursuing analogous decarbonization strategies would help isolate the role of institutional and policy variables. Finally, integrating distributional analysis into macro-level transition models would provide a more complete picture of the welfare consequences of pursuing carbon neutrality at scale, and would help identify the policy combinations most likely to sustain political support for the transition over its multi-decade horizon.

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