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A Marxist Political Economy Analysis of China's Emission Trading Scheme in Supporting Dual Carbon Goals

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Abstract

Emission trading scheme (ETS) is a central market instrument for achieving China's goals of peaking carbon emissions and reaching carbon neutrality. This paper briefly summarizes the transition from regional pilot programs to a unified national market and assesses how the system currently operates. Despite its expansion, the market continues to face limited liquidity, weak price discovery, and problems in allowance allocation. The paper then uses Marxist political economy to examine how emission rights acquire value as tradable commodities, how carbon pricing shapes the behavior of capital, and how emission rights function as production factors in the development of new quality productive forces. It argues that carbon pricing can direct investment toward greener production, while allowance trading can improve price discovery, allocate abatement resources more efficiently, and provide financing for low-carbon investment. Realizing these benefits will also require closer coordination between public oversight and market incentives, including a gradual shift from emissions-intensity targets to an aggregate cap. This paper further identifies persistent tensions between government and market, capital accumulation and ecological limits, and economic efficiency and distributional equity. Finally, this paper concludes with proposals to improve the development of the ETS market. The analysis presented in this paper could possibly provide guidelines to strengthen the contribution of carbon trading to China's low-carbon transition within its socialist institutional framework.

Keywords

Emission Trading Scheme (ETS), Carbon Peaking and Carbon Neutrality, Marxist Political Economy, Carbon Market, New Quality Productive Forces

1. Introduction

Climate change is a shared challenge humanity facing today (Gupta, 2010; Lee et al., 2023). China has pledged to peak carbon emissions before 2030 and achieve carbon neutrality before 2060 (the "Dual Carbon" goals). In the report to the 20th National Congress of the Communist Party of China (CPC), General Secretary of the CPC Central Committee Xi Jinping has pointed out that "a green and low-carbon economy and society are crucial to high-quality development." The carbon emissions trading scheme (ETS) serves as a core market-based instrument for realizing these goals.

After over a decade of regional pilot programs, China launched its national carbon emissions trading market in 2021, starting with the power generation sector, and subsequently launched the national voluntary greenhouse gas emission reduction trading market in 2024 (Xu et al., 2024). In 2025, the General Office of the CPC Central Committee and the General Office of the State Council issued the Opinions on Advancing Green and Low-Carbon Transformation and Strengthening the Development of the National Carbon Market (*guanyu tuijin lvse ditan zhuanxing, jiaqiang quanguo tanshichang jianshe de yijian*) (Opinions on Advancing Green and Low-Carbon Transformation and Strengthening the Development of the National Carbon Market, 2025), marking the first central-level policy document dedicated to the carbon market (Zhu, 2025). It has been confirmed by many recent studies that the carbon market yields significant policy effects in driving corporate strategic transformation, reducing carbon emission intensity, and enhancing green innovation efficiency (Qin et al., 2025; Ren et al., 2022; Zhou et al., 2023). At the same time, low liquidity and limited price discovery continue to constrain the market, and quota allocation also remains underdeveloped, while the range of market participants and products is still narrow (Wang & Lv, 2026; Wang et al., 2025; Zhu, 2025).

These challenges and dilemmas are difficult to explain through neoclassical economics alone. Existing researches largely apply the Coase theorem, treating carbon emissions trading as a mechanism for internalizing externalities through the definition and exchange of property rights (Coase, 2013). In mainstream Western economics, climate change arises from the negative externalities of greenhouse gas (GHG) emissions and the failure of markets to account for their social costs. Carbon taxes and emissions trading are proposed as ways to incorporate these costs into economic decisions (Stern, 2008). Marxist political economy offers a different interpretation. It traces climate change to a global model of economic development driven by capital, rather than solely to missing or poorly designed markets (O'Connor, 1998; Xie et al., 2014). The pursuit of profit encourages the continued expansion of fossil fuel consumption, creating what Marx described as a "metabolic rift" between economic production and natural systems (popularized by John B. Foster) (Foster, 1999, 2013). From this perspective, carbon prices and capital flows reflect the wider dynamics of capital accumulation. This approach also helps explain the tensions that emerge when carbon markets are expected to support the Dual Carbon goals.

Applying the fundamental principles of Marxist political economy and drawing on the practical development of China's ETS, this paper systematically examines the ETS's current operational status and characteristics, while deeply exploring the pathways through which the carbon trading market supports the realization of Dual Carbon goals. It seeks to address the following questions: How is the carbon emission trading market created within the framework of the socialist market economy? How does it mediate the contradiction between social production and the ecosystem through the valuation and capitalization of carbon? What structural contradictions hinder its effective operation? Based on this analysis, the present paper proposes possible policy measures to improve China's ETS, aiming to provide theoretical support for advancing the low-carbon transition within the socialist institutional framework.

2. Current Status and Operational Characteristics of China's Carbon Emissions Trading Market

China's carbon market development has followed a "pilot-first, then nationwide" trajectory (Li et al., 2022; Wang & Lv, 2026; Zhang et al., 2025a). A carbon pricing mechanism with Chinese characteristics has been preliminarily established. The market is operating steadily with a positive outlook, and the effects of emissions reduction are gradually becoming apparent.

2.1. Institutional Framework and Top-Level Design

Since the introduction of the Dual Carbon goals, China has accelerated the refinement of its legal and regulatory framework for the carbon market. The National Development and Reform Commission (NDRC) has constructed a "1 + N" policy system for peaking carbon emissions and achieving carbon neutrality (Liu et al., 2025). The first central-level document on this subject, Opinions on Advancing Green and Low-Carbon Transformation and Strengthening the Development of the National Carbon Market, sets two key milestones for 2027 and 2030: by 2027, the mandatory carbon market is to essentially cover major emitting industries within the industrial sector, while the voluntary carbon market is to achieve full coverage of key areas; by 2030, a mandatory carbon market based on total quota control and a mix of free and paid allocation is to be largely established, alongside a voluntary carbon market characterized by integrity, transparency, standardized methodologies, broad participation, and international alignment (Zhou et al., 2026). The implementation of the Interim Regulations on the Administration of Carbon Emissions Trading (*tanpaifangquan jiaoyi guanli zanxing tiaoli*) has provided the first dedicated legal basis for the national carbon market (Interim Regulations on the Administration of Carbon Emissions Trading, 2024).

2.2. Development History: From Local Pilots to a Unified National Market

Since Shenzhen launched the first pilot in 2013, seven pilot ETS markets, including Beijing, Shanghai, Guangdong, Tianjin, Hubei, Chongqing, and Fujian (which is later added in 2016), were successively established (Li et al., 2022; Zhang et al., 2025a). The pilot markets differed in sectoral coverage, quota allocation, and the use of offset mechanisms (Li et al., 2022; Zhang et al., 2025a). Most covered high-carbon industries, including power generation, steel, and cement. Some also included construction and transportation. Allowances were generally allocated free of charge, although a small proportion was auctioned. This trial-and-error regulatory approach helped China build experience in carbon market governance. It also revealed considerable fragmentation among the pilots: trading remained limited, and carbon prices varied widely across regions (Wang & Lv, 2026; Wang et al., 2025). Pilot practices preliminarily validated the effectiveness of ETS in reducing carbon emission intensity and fostering green technological innovation. For instance, based on panel data from pilot provinces and cities, Chen et al. found that total carbon emissions in pilot regions fell by approximately 13.2% and carbon intensity by about 21.3% (Chen et al., 2025). A difference-in-differences (DID) study using panel data from prefecture-level cities, demonstrated that ETS pilots reduced carbon emissions by approximately 7.1% and carbon intensity by about 6.7% (Zhang & Sun, 2024). By investigating firm-level carbon emission data, Hu et al. also confirmed that ETS policy can significantly improve the quantity and quality (Hu et al., 2020).

In July 2021, the national carbon emissions trading market was officially launched. The initial phase covered approximately 2162 key emission units in the power generation sector, which encompass about 4.5 billion tons of carbon dioxide emissions and thus becomes the world's largest carbon market by covered emissions (Report on the First Compliance Cycle of the National Carbon Emissions Trading Market 2022, 2022). The compliance rate for the first compliance cycle reached 99.5%. In 2025, the national carbon market underwent its first expansion, incorporating three major high-emission industries sucha as steel, cement, and aluminum smelting, bringing the total number of key emission units to approximately 3300 and enabling the regulation of over 60% of the nation's total carbon emissions (Zhu, 2025). According to the 2026 work notice of the Ministry of Ecology and Environment (MEE), entities in the power generation, iron and steel, cement, and aluminum smelting sectors with annual direct emissions reaching 26,000 tonnes of CO_2 equivalent will be included in the list of key emission units subject to regulation, with quota allocation and offsetting mechanisms further refined (Notice on Effectively Carrying Out Work Related to the National Carbon Emissions Trading Market for 2026, 2026). Based on operational data from 4776 power generation units in China, Qin et al. showed that both the national and pilot carbon markets have significantly reduced carbon intensity, with the impact being more pronounced in the pilot markets (Qin et al., 2025).

2.3. Market Structure with Both Mandatory and Voluntary Mechanisms

China's national carbon market system comprises both mandatory and voluntary markets, which are interconnected through a mechanism for offsetting obligations via allowance surrender offset mechanism (Opinions on Advancing Green and Low-Carbon Transformation and Strengthening the Development of the National Carbon Market, 2025; Zhang et al., 2025a).

The national carbon emissions trading market requires key emitting entities to fulfill mandatory emission reduction obligations. As of August 22, 2025, the cumulative trading volume of allowances in the mandatory carbon market reached 680 million tonnes, with a total turnover of 47.41 billion yuan (Zhu, 2025). The annual turnover in 2024 hit a record high of 18.114 billion yuan, and the trading volume and turnover in the second cycle increased by 19% and 89%, respectively, compared to the first compliance cycle (Report on the Development of the National Carbon Market 2025, 2025; Zhu, 2025). The carbon price rose from approximately 48 yuan/tonne at the market's inception to around 80 yuan/tonne in 2024, surpassing the 100 yuan/tonne mark for the first time in April 2024 (Wang et al., 2025; Zhu, 2025).

The national voluntary GHG emission reduction trading market, China Certified Emission Reduction (CCER), was launched in January 2024, with the first batch of certified emission reductions registered and listed for trading in March 2025 (Zhou et al., 2026). As of August 22, 2025, the cumulative trading volume of CCERs reached 2.49 million tonnes, with a total transaction value of 210 million yuan (Zhu, 2025). In 2025, 12 methodologies for voluntary GHG emission reduction projects were released, covering areas such as afforestation carbon sinks and offshore wind power, and 33 projects were registered, representing an emission reduction volume of 17.7637 million tonnes (Zhu, 2025).

Regarding the relationship between local pilot programs and the national market, the *Opinions* explicitly state that no new local or regional carbon emission trading markets are to be established. Instead, the existing pilot markets remain testing grounds for broader market coverage and improved adjustment mechanisms. They also allow regulators to try new supervisory approaches and develop carbon finance products. In thi way, experiences from these experiments can then inform the unified national carbon market.

2.4. Operational Characteristics and Key Challenges

2.4.1. Insufficient Liquidity and Inactive Trading

Currently, compliance obligations account for most activity in the national carbon market. Trading remains subdued for much of the compliance cycle and rises sharply only as deadlines approach, showing a tidal pattern. The turnover rate during the first two compliance cycles was merely 2% - 3%, far below the approximately 500% level seen in the EU carbon market. Trading volume in the second half of 2023 accounted for 79% of the total volume for that cycle (Wang et al., 2025). Using the number of zero-trading days, trading volume, and market depth as liquidity indicators and exploiting variance ratio tests and logit models, Wang et al. (Wang et al., 2025) confirmed that liquidity has a significant positive impact on carbon market efficiency, and that the inefficiency of pilot markets stems largely from insufficient liquidity. A simulation study by Song et al. on China's power sector carbon market found that a 20% improvement in market liquidity could drive a 100% increase in demand for emissions reduction (Song et al., 2025).

2.4.2. Carbon Price Volatility and Undervaluation

Carbon prices in the national market fluctuate within the range of 40 - 100 RMB/tonne. An empirical analysis by Wu et al. (2024), based on a staggered DID model, indicates that a $1 increase in carbon price leads to a 1.69% reduction in CO_2 emissions and a $286 increase in per capita GDP (Wu et al., 2024). However, current carbon prices have yet to reach the level required to incentivize corporate investment in deep decarbonization technologies (Wang et al., 2025). Based on panel data from prefecture-level cities spanning 2007-2023, Pang et al (Pang & Han, 2025) found an inverted U-shaped relationship between carbon emission costs and green innovation, and the critical carbon price threshold for substantive green innovation is 16.62 RMB/tonne, beyond which the incentive effect diminishes. Compared to the EU ETS, China's carbon prices remain significantly low (Wang et al., 2025; Zhu, 2025).

2.4.3. Controversies Surrounding the Allowance Allocation Mechanism

Currently, free allocation is the primary method used, yet there are concerns regarding an oversupply of allowances. A plant-level assessment by Ma et al. found that current loose benchmarks would lead to a significant surplus of allowances. The market would only clear if benchmarks were tightened to the level of the top 2% in terms of efficiency (Ma & Qian, 2022). While free allocation reduces short-term transition costs for enterprises, it fails to reflect the scarcity of carbon emission resources and stifles market trading (Liu & Wang, 2025). An empirical research by Luan et al. also indicates that auctioning enhances corporate economic performance more effectively than free allocation (Luan et al., 2025).

2.4.4. Limited Diversity of Market Participants and Products

Current participants are restricted to regulated enterprises, while investors such as financial institutions have not yet been permitted to participate fully. Trading products are limited to carbon allowance spot contracts, with a lack of carbon financial derivatives such as futures and options. The limited range of products reduces liquidity, weakens price discovery, and leaves market participants with fewer tools for managing risk (Wang & Lv, 2026; Zhu, 2025).

2.4.5. Inadequate Legal and Regulatory Frameworks

China's carbon market is governed mainly through departmental regulations and policy documents. In the absence of a dedicated Climate Change Law or Emissions Trading Law, the existing rules lack a strong statutory basis and have limited deterrent force. Monitoring, reporting, and verification (MRV) procedures also remain inconsistent and insufficiently transparent (Liu et al., 2022). In 2022, targeted supervision and assistance activities by the MEE identified serious data falsification involving four institutions: CCEI, Zhongchuan Tantou, Qingdao Xinuo, and Liaoning Dongmei. The violations included altered coal quality test reports, inadequate verification, and fraudulent test reports (Report on the Development of the National Carbon Market 2025, 2025). These cases showed that weak oversight of emissions data can undermine the integrity of the carbon market.

3. The Essence and Mechanisms of Carbon Markets from the Perspective of Marxist Political Economy

Neoclassical economics explains carbon markets mainly in terms of externalities, but this perspective alone does not account for their dilemmas or potential. Marxist political economy offers a fuller explanation by examining how the logic of value and capital shapes these markets.

3.1. The Commodification and Valuation of Carbon Emission Rights: From Priceless to Priced

In Marxist theory, a commodity is a product of labor intended for exchange, and its value is determined by socially necessary labor time. As Marx wrote, "[Since] the earth is not the product of labour and therefore has no value" (Marx, 1992b). Yet under capitalism, land and other natural resources can be capitalized and assigned fictitious prices. Carbon dioxide is similarly not a commodity in itself. It becomes tradable only after the state defines carbon emission rights, limits their supply, and gives them a commodity form through institutional rules (Lederer, 2012; O'Connor, 1998; Xie et al., 2014). The state sets an overall emissions cap and initially distributes quotas among enterprises. Once these quotas become scarce, enterprises must purchase additional rights to emit, transforming what was previously treated as a public entitlement into a tradable asset. The compulsory definition of property rights is therefore a necessary condition for the creation of carbon commodities. Lohmann (Lohmann, 2012) describes carbon markets as neoliberal "crisis fixes" that reproduce the logic and vulnerabilities of financial derivatives markets. Through "radical disembedding" and the conversion of emissions into standardized calculations, carbon becomes an asset that can be traded and used for financial speculation. In Lohmann's account, this process treats carbon as an ideological fetish. It obscures the historical roots of global warming and separates the climate crisis from fossil fuel dependence and colonial exploitation. Carbon trading may then preserve opportunities for capital accumulation without producing the structural ecological changes needed to address climate change.

The value of a commodity reflects the social relations under which it is produced. In a carbon market, carbon does not derive its value from nature. Its value comes from the socially necessary labor involved in responding to climate change and meeting the Dual Carbon commitments. This includes the work required to establish carbon accounting systems, develop monitoring and verification technologies, and maintain the institutions through which allowances are traded

(Lohmann, 2009; Xie et al., 2014; Xu et al., 2023). The amount of labor and resources needed to reduce emissions differs among enterprises and regions. Using a directional distance function, Xue et al. estimated China's average marginal abatement cost at about 1093 yuan per tonne. The regional estimates were 854 yuan per tonne in eastern China, 1247 yuan in central China, and 1473 yuan in western China. Although costs remain higher in the west and lower in the east, the study also found signs of regional convergence (Xue, 2023). These differences provide the economic basis for allowance trading. Enterprises whose abatement costs are below the carbon price can reduce their emissions and sell the resulting surplus allowances. Enterprises facing higher costs can purchase allowances instead. Trading therefore shifts abatement toward enterprises that can reduce emissions at lower cost and distributes the overall cost among market participants (Fang et al., 2021; Peng et al., 2022; Stavins, 2003). From this perspective, the carbon price expresses the average social cost of emissions reduction. It also turns an environmental responsibility that enterprises might otherwise avoid into a monetary production cost. China's carbon market can thus be understood as a social process of pricing environmental capacity within the framework of socialist public ownership. By assigning a price to emissions previously treated as free, the market gives carbon emission rights a commodity form.

In Volume I of *Capital*, Marx argued that the commodity form conceals the social relations behind production. The social character of labor appears as an objective property of commodities, causing relationships among people to take the form of relationships among things (Marx, 1992a). Carbon markets reproduce this process in environmental governance. Decisions about who may use atmospheric capacity appear as price relationships between tradable carbon allowances. This carbon fetishism hides the distributive question underlying the market: how society's collective right to limited atmospheric environmental capacity is divided among enterprises and other entities.

Marx's concept of fictitious capital in Volume III of *Capital* offers a useful way to analyze the financial character of carbon assets (Marx, 1992b). Fictitious capital consists of ownership claims represented by securities. Its value is based on expected future returns rather than labor directly embodied in the asset. State-created carbon allowances have a similar character. Because allowances are not direct products of labor, their prices cannot be explained by the socially necessary labor time required to produce them. Prices depend instead on how market participants assess future carbon prices and allowance scarcity, as well as whether they expect the policy framework to remain stable. In this respect, carbon allowances resemble fictitious capital. Changes in carbon prices reflect marginal abatement costs, but speculation, policy expectations, and market sentiment also affect them (Wang et al., 2025). Burkett (1999) argues that ecological analysis is already present within Marxist political economy. Capitalism brings elements of nature into processes of commodification and capitalization repeatedly, and carbon markets are a recent example of this tendency.

3.2. Carbon Markets as an Institutional Response to Capital-Induced Carbon Lock-In

Marxist political economy places capital accumulation at the center of its analysis. Because capital depends on continual expansion, it seeks new sources of profit and new opportunities for investment (Marx, 1992b). Industrial capitalism has historically tied this expansion to the large-scale consumption of fossil fuels, making high-carbon production difficult to replace. Unruh (Unruh, 2000) describes this persistence as a self-reinforcing "techno-institutional complex." Long-term infrastructure investments create sunk costs that discourage technological change. Supply chains and market networks then develop around established industries, while laws, policies, and technical standards adapt to the same high-carbon model. Each part strengthens the others, keeping production and consumption dependent on fossil fuels. Enterprises can protect their profits by passing environmental costs on to society, leaving the public to bear much of the resulting climate risk. O'Connor calls this conflict between capital accumulation and the conditions that sustain production capitalism's "second contradiction" (O'Connor, 1988, 1998). Foster develops a related argument through the theory of metabolic rift. He contends that capitalism disrupts the material exchange between human society and nature, separating economic production from the ecological processes on which it depends (Foster, 1999, 2013).

Marx and Engels treated the conflict between capital accumulation and nature as a material problem. In the *Economic and Philosophic Manuscripts of 1844*, Marx wrote that "nature is man's inorganic body" (Marx, 2016). Human beings depend on nature for their existence, while their labor continually transforms it. Capital disrupts this relationship when the pursuit of accumulation turns nature into an apparently unlimited source of materials and energy. Engels focused on the consequences of this process in *Dialectics of Nature*: "Let us not, however, flatter ourselves overmuch on account of our human victories over nature. For each such victory nature takes its revenge on us" (Engels, 1960). He cited the desertification associated with agricultural deforestation in Mesopotamia and ancient Greece to show that interventions in nature can produce effects far beyond their intended purpose (Engels, 1960). In Volume I of *Capital*, Marx made the social dimension of this ecological damage explicit. He argued that capitalist industry and industrial agriculture deplete "the original sources of all wealth," namely "the soil and the labourer" (Marx, 1992a). Capital accumulation therefore places pressure on both natural systems and labor power. Carbon markets can be understood as an institutional response to this pressure. By making enterprises pay for the use of atmospheric environmental capacity, they impose a cost on activities that capital might otherwise treat as free and place a regulatory limit on unrestricted expansion.

Carbon markets can weaken carbon lock-in by requiring firms to bear part of the environmental cost of their emissions. These costs enter production expenses and influence how capital is allocated among different activities (Xie et al., 2014).

When high-carbon production becomes more expensive, its previous cost advantage declines and profit margins narrow. Firms then have a financial incentive to upgrade their production processes, use energy more efficiently, or purchase additional emission allowances. Firms that reduce emissions below their allocated quotas can sell the surplus. Carbon trading therefore raises the cost of continued high-carbon production while allowing lower-carbon firms to earn revenue from emission reductions.

Evidence from Chinese listed companies generally indicates that carbon markets encourage green technological innovation (Feng et al., 2024; Ren et al., 2022; Zhou et al., 2023). Using a DID model and data from A-share listed companies between 2010 and 2020, Feng et al. (2024) found that higher carbon prices increased corporate green innovation. The effects also spread across space, extending approximately 150 to 300 kilometers beyond the regulated area. Ren et al. (2022) reported a positive relationship between emissions trading and both the environmental and economic performance of firms. These effects, however, differ substantially across regions. Ren and Liu (2023) examined provincial panel data from 2006 to 2020 using multiperiod DID and synthetic control methods. Among the eight pilot regions, only Chongqing achieved both a reduction in carbon emissions and a Porter effect. Less developed regions obtained some economic benefits but did not experience a significant increase in green innovation. Regional differences also appear in innovation efficiency. Bai et al. (2023) used an SBM-DEA model and the synthetic control method to study 30 provinces from 2008 to 2020. They found that emissions trading improved green innovation efficiency through changes in industrial and energy structures, as well as through human capital and foreign direct investment. The size of these effects varied considerably among regions. From a Marxist perspective, this evidence can be understood as the law of value operating through carbon prices to redirect social capital away from high-carbon production. Qi et al. (2023) provide more direct evidence for this mechanism: firms covered by the pilot markets shifted investment toward low-carbon technologies and green innovation. Wang and Zhang (2024) identified another effect, finding that carbon markets improved corporate investment efficiency by reducing information asymmetry and agency problems.

Within China's socialist system, the carbon market is intended to correct some of the ecological damage produced by capital-driven development (Xie et al., 2014). The allowance cap sets a legally enforceable limit on emissions from covered enterprises. Requiring firms to surrender allowances also makes their use of atmospheric capacity a production cost, replacing its uncompensated appropriation with a regulated and priced right. Clarke (2020) offers a critical account of carbon trading under financialized capitalism. He views it as part of the monetization of nature and as an institutional response by capitalism to its own ecological crisis. In his analysis, the financialization of nature allows capital to ease these pressures temporarily while creating new opportunities for fictitious capital. Clarke therefore argues that a lasting solution requires ecological movements to join with class struggle in a transition toward socialism. China's carbon market differs from the model he criticizes because the state establishes its rules, sets the emissions cap, and defines its regulatory objectives. Its formal purpose is to protect the public environmental interest within a socialist institutional framework.

3.3. Carbon Emission Right as a Factor of Production and Green New Quality Productive Forces

As productive forces develop, the factors used in production also change. Carbon emission rights have emerged alongside labor, land, capital, and technology as a new factor for firms covered by emissions regulation. The introduction of carbon constraints changes firms' production decisions. Enterprises must account for their allowance holdings when selecting technologies and combining inputs, which encourages a shift from high-carbon production toward lower-carbon processes. In general, carbon emission rights perform three related functions. They function as commodities because they have both use value and exchange value and can be traded between market participants. They also operate as financial assets that can be banked, lent, or used as the basis for derivative instruments. At the same time, allowances act as a factor of production. Regulated firms must hold enough of them to cover their emissions and continue operating within the legal emissions cap.

Within the G-W-G' circulation of capital, carbon emission rights can circulate separately from physical production and become assets through which financial capital earns returns (Clarke, 2020; Vlachou, 2014). Without effective oversight, this process may draw funds away from productive investment and into speculative trading, increasing the risk of financial instability. Lohmann (2012) argues that carbon markets contribute to this problem by converting emissions into standardized financial commodities whose prices can become detached from the ecological damage they represent. The role of carbon finance under a socialist system depends on how it is regulated and where the resulting capital flows. Instruments such as carbon-backed loans and repurchase agreements can help firms finance green technologies when regulators keep them tied to emissions reduction and productive investment. A price on environmental capacity also increases the cost of carbon-intensive production, while improving the expected returns from renewable energy and energy-saving technologies. With these limits in place, carbon finance can direct social capital toward lower-carbon activities and support the development of greener productive forces.

Xi Jinping Thought on Ecological Civilization offers a theoretical basis for the socialist orientation of China's carbon market. The report to the 19th National Congress of the CPC called for efforts to "establish and practice the concept that lucid waters and lush mountains are invaluable assets," a principle widely known as the "Two Mountains (*Liangshan*)" concept. It rejects the assumption that environmental protection must come at the expense of economic development. Instead, it holds that ecological conservation can support development when environmental value is recognized in economic and policy decisions. China's carbon market puts this principle into practice. Its purpose extends beyond setting a price for carbon emissions. Within the socialist system, it also provides a means of coordinating development goals with environmental responsibilities. Carbon pricing requires emitters to account for some of the environmental costs of their activities, while emissions trading directs financial incentives toward lower-carbon production. The market thus gives economic expression to ecological value and applies the Two Mountains concept to the governance of carbon emissions.

The concept of new quality productive forces (*xinzhi shengchanli*) offers another way to understand the relationship between carbon markets and green productivity. It emphasizes technological innovation while treating green development as a condition of productive growth. Carbon pricing supports this process by increasing the cost of carbon-intensive production and improving the relative attractiveness of low-carbon technologies. The resulting price signals can influence investment decisions and encourage firms to direct more resources toward green innovation. The carbon market also broadens how productivity is assessed. Once ecological efficiency is included, a firm's capability to reduce emissions becomes part of its productive performance. Income from trading carbon assets may provide additional funding for research and development in green technologies. In the meanwhile, recognizing carbon emission rights as a factor of production brings ecological limits more directly into economic calculations. This reasoning is consistent with Marx's view that productive forces develop within natural constraints. In the Chinese context, it is presented as an extension of Marxist ecological thought under socialism with Chinese characteristics.

4. Inherent Contradictions in Carbon Market Operations and a Political-Economic Reflection

Carbon markets do not offer a complete or permanent solution to emissions reduction. Their reliance on market mechanisms creates structural tensions that can limit their effectiveness (Clarke, 2020). A clear understanding of these tensions is therefore essential for improving market design and strengthening the contribution of carbon trading to emissions reduction.

4.1. Contradiction I: Tension between Government Authority and Market Mechanisms

A carbon market relies on government decisions about its initial design and subsequent operation, even though it is intended to reduce emissions through market incentives. The difficulty of balancing these roles is particularly evident when regulators set the aggregate emissions cap. A loose cap creates an oversupply of allowances, weakens the carbon price, and gives firms little incentive to reduce emissions. A cap that is too strict, by contrast, can disrupt economic activity and place excessive compliance costs on regulated firms (Zhu, 2025). Plant-level estimates by Ma and Qian (2022) suggest that the current benchmarks are too lenient and will produce a substantial allowance surplus. Their findings indicate that the benchmarks would need to reflect the efficiency level of the top 2% of plants to create meaningful scarcity in the market.

Initial allowance allocation also involves a tradeoff between equity and efficiency because it determines who bears the costs of carbon regulation and who receives its benefits. Multi-agent simulations by Liu and Wang (2025) suggest that auctioning a limited share of allowances during the early stages of market development can contain transition costs while encouraging market participation. The same simulations indicate, however, that recycling auction revenue may distort incentives when policy requirements are stringent. Free allocation can ease firms into the carbon market and reduce opposition to compliance, but it can also protect the interests of high-emitting firms and weaken their incentive to cut emissions (Liu & Wang, 2025; Ma & Qian, 2022). Benchmarking raises a different allocation problem: the standards must be carefully calibrated. Wang et al. (2022) show that industry-specific benchmark coefficients influence firms' investment in emissions reduction. Appropriate coefficients depend on factors such as firms' abatement costs and consumer demand for low-carbon products. If the benchmarks are set poorly, firms may find that investments serving environmental goals undermine profitability, reducing their willingness to pursue further emissions cuts.

Carbon pricing also requires coordination between central and local governments and between public authorities and regulated firms. When the carbon price falls too low to encourage emissions reduction, the government must decide whether to intervene through price stabilization measures. Intervention may restore the price signal, but it also gives the state a more direct role in market operation and makes the boundary between public authority and market forces harder to define. In Marxist terms, this policy dilemma reflects the tension between the state's role as the collective capitalist and the pursuit of profit by individual firms within environmental governance (Li, 2025).

4.2. Contradiction II: Tension between Capital Accumulation and Ecological Limits

Carbon markets aim to make continued capital accumulation compatible with emissions constraints without requiring fundamental changes to existing modes of production. Marxist ecological critique questions whether this arrangement can succeed. Capital tends toward continuous expansion, but ecosystems have limited capacities to supply resources and absorb environmental damage. Carbon markets respond to this conflict by making emissions tradable. Critics therefore describe them as a form of green capitalism or carbon capitalism in which ecological crisis becomes another field for commodity exchange and accumulation (Clarke, 2020; O'Connor, 1998). O'Connor's theory of the second contradiction clarifies the underlying problem: capital accumulation can damage the environmental conditions on which production itself depends (Foster, 2002; O'Connor, 1988, 1994).

One criticism of carbon trading is that it allows firms to "pay to pollute." Large emitters with sufficient financial resources can purchase allowances instead of making substantial cuts within their own operations, leaving other participants to deliver a greater share of the required reductions (Magnetti et al., 2025). Evidence from the EU ETS shows that these decisions depend largely on relative costs. Companies with low marginal abatement costs generally reduce emissions and sell their surplus allowances, whereas those facing higher costs are more likely to buy allowances and continue emitting. Generous free allocations can weaken the incentive to invest in abatement even further (Nardone et al., 2025). The allocation process is also subject to political influence. Studies of the EU ETS find that large, politically influential emitters have successfully lobbied for more free allowances. This shifts part of the cost of emissions reduction to sectors outside the trading system and to the wider public (Alberola et al., 2008). An emissions cap may therefore control the aggregate quantity of carbon released while allowing particular firms, industries, or regions to postpone meaningful reductions.

The capacity of technological substitution to address ecological pressures also remains limited. Carbon markets generally reward innovations that lower emissions costs, but these innovations do not necessarily change the organization or scale of production. He and Dai (2025) identify a masking effect in assessments of green innovation. Aggregate results suggest that carbon trading promotes innovation, yet the gains are concentrated among firms with stronger technological capabilities. For most enterprises, the effect is statistically insignificant. Policy evaluations based only on aggregate outcomes may therefore overstate both the scale and reach of the market's influence on innovation (He & Dai, 2025). Foster (2013) argues that capital accumulation depends on the continued expansion of production, which eventually comes into conflict with ecological limits. Carbon trading cannot by itself reconcile this pressure for expansion with the finite supply of natural resources. A broader ecological transition would also require changes in production relations and consumption patterns that carbon pricing alone cannot bring about.

4.3. Contradiction III: Distributional Effects and Social Equity

Carbon markets redistribute costs and benefits across industries and firms, which means that poor design can deepen existing inequalities. The burden is especially uneven in regulated sectors such as heavy industry and chemical manufacturing, where carbon pricing directly raises production costs. For some firms, these costs can also strain cash flow and increase borrowing expenses. Zhou et al. (2023) find that the effect of carbon trading on green innovation varies significantly with firm size and political connections. Enterprises with different financial and technological resources are not equally able to absorb compliance costs or invest in cleaner production. If policy design fails to account for these differences, the carbon market may widen disparities between firms rather than support a broadly shared transition.

Carbon trading can also affect regional inequality because its costs and benefits extend beyond individual jurisdictions. Using a Spatial Durbin Model, Dai (2025) find that carbon markets have spillover effects on the equity of emissions distribution among provinces. Zhu et al. (2024) similarly report that carbon regulation can narrow regional development gaps, but does not eliminate the persistent core-periphery pattern. The distribution of costs and benefits may also differ. Zhang et al. (2025c) find little evidence of inequity in how compliance costs are allocated under China's carbon trading system, yet the benefits remain uneven, particularly when urban-rural differences in regional electricity consumption are considered.

Evidence from a multiregional computable general equilibrium model adds another dimension to this problem. Zhang et al. (2025b) find that the national carbon market has reduced carbon transfers through interprovincial and international trade. At the same time, its abatement effects differ markedly between northern and southern provinces, and the carbon terms-of-trade index shows clear regional variation. Firms in wealthier regions can meet their obligations by purchasing allowances or China Certified Emission Reductions from less developed regions. Such transactions may place a greater mitigation burden on poorer regions or encourage carbon-intensive industries to relocate there. Some scholars describe this unequal transfer of environmental costs as a form of ecological colonialism (Bachram, 2004).

The financialization of emission rights introduces a further risk, that is, carbon allowances and offsets can become objects of speculation. Lohmann (Lohmann, 2012) draws a structural comparison between carbon markets and financial derivatives markets. Both make uncertainty tradable and assign value to abstract claims that may become detached from underlying economic and environmental conditions. In his account, this separation can contribute to systemic financial instability. Huff (2023) develops a related argument through the concept of frictional commodities. Carbon offsets are neither conventional physical goods nor purely virtual assets. Their value links specific social and environmental conditions to an abstract claim traded in the market. As financial trading expands, speculation may push carbon prices away from actual abatement costs, increase volatility, and distort investment decisions. These risks support a cautious approach to carbon-market financialization. New financial products should be introduced gradually and selectively, with regulatory oversight focused on limiting speculation and keeping capital directed toward emissions reduction and productive investment.

These tensions are not peculiar to carbon markets. They arise whenever market instruments are used to pursue public environmental goals. Institutional design cannot remove them entirely, and attempts to establish a fixed equilibrium are unlikely to succeed as economic and environmental conditions change. Therefore, carbon-market governance requires regular adjustment of policy rules and regulatory boundaries. In China, those adjustments must reflect national conditions and socialist values while managing three persistent tensions: the respective roles of government and the market, the pressure for capital accumulation within ecological limits, and the distributional tradeoff between efficiency and social equity.

5. Pathways for the Carbon Trading Market to Support Dual Carbon Goals

The carbon market can contribute to China's carbon peaking and carbon neutrality goals only through coordinated action across several policy areas. This approach combines the price signals described by the law of value, the allocation of capital, and the institutional capacity of the socialist system.

5.1. Pathway I: Using Carbon Prices to Guide Capital toward Green Industrial Transformation

Carbon markets assign a monetary value to emissions and the costs they impose on society (Boyce, 2018). A clear and stable carbon price gives firms a basis for comparing the cost of emitting with the cost of investing in cleaner production. Expectations that the price will rise over time can also influence longer-term decisions about technology, energy use, and capital allocation. Wu et al. (2024) estimate that each \$1 increase in the carbon price is associated with a 1.69% reduction in CO_2 emissions and a \$286 increase in per capita GDP. Their results indicate that carbon pricing can support emissions reduction while remaining compatible with economic growth.

Once firms incorporate emission rights into production decisions alongside labor and raw materials, they have stronger reasons to manage carbon throughout the production life cycle. This can move them beyond minimum compliance and direct investment toward energy-efficiency upgrades, clean energy, and green research and development. The Porter Hypothesis provides one explanation for this response: environmental regulation can induce innovations that offset compliance costs and improve competitiveness (Porter & van der Linde, 1995). Evidence from China generally supports this mechanism, although the effects vary among firms. Using a difference-in-differences-in-differences model with data from Chinese A-share companies, Zhou et al. (2023) find that carbon trading improves green innovation efficiency, with stronger effects among small firms and in regions under greater policy pressure. Gong et al. (2025) show that higher and more stable carbon prices can increase total factor productivity by encouraging corporate green innovation. Based on green patent data from listed companies in heavily polluting industries, Liu and Li (2022) find particularly strong effects on invention patents, large firms, and non-state-owned enterprises. Cheng and Wang (2025) likewise report that carbon trading increases green innovation by encouraging research and development investment and strengthening environmental governance.

Carbon markets can reshape industrial investment by raising entry and operating costs in carbon-intensive industries, which discourages further investment in excess capacity. By contrast, low-carbon industries and clean energy producers may earn revenue from carbon assets and use it to finance further development.

These shifts can gradually redirect investment toward cleaner forms of production. Based on panel data from Chinese prefecture-level cities, the mediation analysis by Yang et al. (2025) finds that pilot emissions trading policies support urban green transformation through green innovation, industrial greening, and green finance.

5.2. Pathway II: Directing Capital through Three Carbon-Market Functions

Carbon value explains the incentive to reduce emissions. Carbon-market leverage concerns how those reductions can be achieved at lower cost. It directs capital through three related functions: price discovery, resource allocation, and financial intermediation. Price discovery begins with trading. As firms buy and sell allowances, the resulting carbon price incorporates their expectations about future abatement costs, allowance supply and demand, and policy changes. A stable and credible price gives regulated firms a basis for long-term investment decisions. It also provides policymakers with information they can use when adjusting emissions targets and reduction pathways (Wang et al., 2025; Zhu, 2025).

Resource allocation follows from differences in marginal abatement costs. Firms that can reduce emissions cheaply have an incentive to make larger cuts and sell their surplus allowances. Those facing higher costs can purchase allowances instead. In principle, this exchange directs reductions to where they cost less and lowers the overall expense of meeting the emissions cap. Wu et al. (2014) test this mechanism with a computable general equilibrium model that simulates changes in marginal abatement costs over time. They find that carbon trading reduces total abatement costs and allocates resources more efficiently than command-and-control regulation. The gains are not uniform across regions. Using a multiregional computable general equilibrium model, Zhang et al. (2025b) find that northern provinces achieve greater production-side reductions at lower marginal costs than other provinces.

Carbon markets can also connect emissions reduction with financial intermediation. Allowances and other carbon assets may be pledged as collateral or developed into products such as carbon futures and options (Niu & Geng, 2023). These arrangements can expand access to finance for low-carbon technologies and clean energy projects. Evidence from the national carbon market also shows that allowance scarcity can change firm behavior. Based on data from power-generation units, Lyu et al. (2026) finds that units facing allowance shortages reduced their carbon intensity by approximately 0.8% and their total emissions by 3.5%, with stronger effects after 2023. Carbon allowances can therefore acquire some features of fictitious capital: their expected future value can be used to support current investment. This financial role requires careful regulation so that capital remains connected to genuine emissions reduction.

5.3. Pathway III: Coordinating Government Oversight and Market Mechanisms

The state creates scarcity in the carbon market by setting the emissions cap and issuing allowances. Trading then determines how those allowances are distributed among firms and what price they command. Government and market functions are therefore closely connected. In China's institutional context, public oversight is also needed to keep market incentives aligned with emissions targets and socialist policy objectives. Without such oversight, short-term profit seeking may take precedence over environmental goals (Clarke, 2020).

The first task is to replace emissions-intensity control gradually with an aggregate cap, as proposed in the *Opinions* (Opinions on Advancing Green and Low-Carbon Transformation and Strengthening the Development of the National Carbon Market, 2025). Intensity targets restrict emissions per unit of economic output, which allows total emissions to continue rising during periods of rapid growth. They may improve efficiency without reversing the ecological metabolic rift between economic activity and natural systems (Foster, 1999, 2013). An aggregate cap addresses this limitation by placing a physical ceiling on total emissions. It therefore constrains carbon-intensive accumulation according to ecological carrying capacity rather than economic output alone.

Allowance allocation must evolve during the same transition. A hybrid system can combine free allocation with auctions, then increase the auctioned share as the market develops. Multi-agent simulations by Liu and Wang (2025) suggest that auctioning a small proportion of allowances during the early stages can limit transition costs and encourage market participation. Once the market matures, a larger auctioned share can strengthen incentives for technological progress and sustained emissions reduction. Wu et al. (2016) likewise find that a hybrid approach performs better than either complete free allocation or full auctioning.

Reliable data are equally important. The government is responsible for setting the cap, establishing market rules, managing risks, and enforcing compliance. Allowances have value only when emissions are measured consistently and reported accurately. Falsified data can therefore distort prices, weaken enforcement, and undermine confidence in the market. A rigorous MRV system should be supported by routine inspections and clear legal consequences. Regulators should also treat data quality and allowance surrender as regular components of compliance enforcement.

Financial innovation requires similar restraint. Carbon finance should help firms invest in decarbonizing the real economy. Allowing carbon assets to serve as collateral or form part of repurchase agreements can expand access to finance and reduce borrowing costs (Liu et al., 2026). Derivative trading that is detached from emissions reduction, however, can increase speculation and volatility. Regulation should therefore allow useful financial instruments while limiting activities that threaten market stability or divert capital away from low-carbon investment (Lohmann, 2012).

6. Conclusion

China's carbon market can contribute to green innovation, lower the total cost of reducing emissions, and support the transition of industry toward lower-carbon production. Its main instruments are straightforward: emission rights are assigned an economic value, and carbon prices influence where firms invest their capital. A Marxist political economy perspective, however, shows that this process is also shaped by conflicts between government planning and market incentives, capital accumulation and ecological limits, and economic efficiency and social equity. Carbon allowances occupy several roles at once. They are tradable commodities, financial assets, and inputs into production decisions. By defining and allocating these rights, the socialist state determines how access to limited environmental capacity is distributed and valued. The aggregate cap restricts carbon-intensive expansion, while the carbon price requires firms to account for part of the environmental cost of their emissions.

Further development of the market should focus on five areas. The first is stronger top-level design, particularly the transition to aggregate emissions control and the reform of allowance allocation. The second is better market operation. Greater liquidity and more reliable price discovery should be accompanied by price stabilization measures and carefully regulated financial instruments. The third is a firmer institutional basis, including national legislation, rigorous monitoring, reporting, and verification, and accessible judicial remedies. The fourth is closer coordination between domestic and international climate policy, including limiting the transfer of environmental burdens to poorer regions, linking domestic and international dual circulation, and strengthening China's participation in global climate governance. The fifth is distributional fairness. Regional compensation, clearer corporate responsibilities, and limits on excessive financialization can help prevent the costs and benefits of carbon trading from becoming more unequal. The contribution of carbon trading to China's carbon peaking and carbon neutrality goals will ultimately depend on how these institutional choices are made and revised over time.

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Author Contributions

T.Z. and X.F. conceived the central idea and overall intellectual framework of the article. T.Z. developed the main arguments and conducted the critical analysis and synthesis of the relevant literature. X.F. contributed to the interpretation of the broader theoretical and policy implications. T.Z. drafted the manuscript. All authors critically reviewed the arguments, contributed to the revision of the manuscript, and approved the final version.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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