

A Review of the Carbon Trading Market and Influencing Factors of Pricing in China

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Abstract. This paper presents a comprehensive analysis of the development and pricing mechanisms of China's carbon trading market, exploring their interconnections with multiple influencing factors to address the need for a holistic understanding of carbon market dynamics. It begins by reviewing fundamental theories of carbon trading and examines the practical evolution of China's carbon market through segmented time-series analysis. Employing a systematic literature review, the study identifies critical determinants of carbon pricing—such as national policy frameworks, shifts in energy structure, and significant international events including the U.S. withdrawal from the Paris Agreement—and assesses their individual and interactive impacts. The results underscore that carbon market behavior is governed by a complex, multi-dimensional logic, which cannot be adequately captured through single-factor explanations. By integrating theoretical foundations, empirical observations, and multi-factor interactions, this study offers novel insights into carbon price formation and contributes to a more nuanced understanding of the complexities inherent in China's carbon trading system.

Keywords: Carbon Trading Market, Carbon Price, Influence Factors.

1. Introduction

Over the past century, human activities have caused more greenhouse gases (GHGs) in the atmosphere. This has led to growing environmental, political, and economic impacts from climate change. Therefore, countries and international groups are taking action [1, 2]. Now, over 70 countries have promised to reach net-zero GHG emissions (or carbon neutrality) by 2050. They are also working harder to meet international climate commitments under the Paris Agreement [3]. China, the world's largest economy, has seen its total carbon emissions rise quickly in recent years. It has become a key task to balance economic growth and environmental protection, and to speed up progress toward the carbon peak and carbon neutrality goals [4]. In this situation, studying China's carbon trading system is strategically important for improving the carbon market.

Moreover, China's domestic carbon trading market is still in the early stage of development. There are many problems emerge, such as unbalanced development among different pilot markets, inadequate trading laws and regulations, and unstable carbon prices [5]. Since the trading price of carbon emission rights is a key indicator for the stable development of the carbon market, analyzing the various factors affecting its pricing is of great significance.

However, China's domestic carbon trading market is still evolving rapidly, and technology developed—such as the enhanced flexibility in mechanism design and the improved energy structure. It has also altered the significance of traditional influencing factors. Earlier studies often focused on regional pilot markets or specific economic indicators, failing to account for the integrated effects of nationwide market mechanisms, updated regulatory frameworks, and the growing influence of green financial instruments. Moreover, many existing models overlook the role of corporate compliance costs under the new allocation rules and the impact of renewable energy integration on price volatility.

Given these limitations in previous literature regarding the influencing factors of carbon emission rights pricing, this paper will integrate recent policy developments and expands the analysis to include a broader set of contemporary determinants. This paper first reviews the basic theories of carbon trading and introduces China's practice in the carbon trading market after these theories were proposed. It analyzes the development of China's carbon trading market through time segmentation

and uses a pie chart to more clearly illustrate the market's evolution from local exploration to gradual expansion. Next, by referring to previous literature, it elaborates on the factors affecting the pricing of carbon emission rights and presents its own perspectives based on the impact of the U.S. withdrawal from the Paris Agreement on prices. Finally, it analyzes the future trends of carbon emission rights prices, which may serve as a reference for subsequent research.

2. Literature Review

2.1. Basic Theories of Carbon Trading

In economic theory, carbon emissions arise from two fundamental issues: the tragedy of the commons, wherein firms overutilize atmospheric common resources to the detriment of public welfare, and negative externalities, whereby polluters do not bear the full social costs of emissions, leading to market failure as environmental damages remain unpriced [6].

Two classical approaches address these externalities. The Pigouvian solution advocates policy intervention through taxes or subsidies to internalize external costs, aligning private incentives with social marginal costs and thereby incentivizing emission reductions [6]. Alternatively, the Coase Theorem emphasizes the definition of property rights, proposing that clearly allocated emission entitlements can become tradable commodities, enabling market mechanisms to achieve cost-effective resource allocation [6].

These foundations gave rise to emissions trading theory. Under this framework, governments establish caps on total emissions, allocate initial rights, and permit firms to trade allowances [6]. This market-based mechanism reduces abatement costs economically while balancing efficiency and equity considerations [6]. The sulfur dioxide trading program under the U.S. Clean Air Act Amendments provided empirical validation of this approach, paving the way for the adoption of carbon markets worldwide—such as the EU Emissions Trading System (EU ETS)—and establishing carbon pricing as a cornerstone of climate policy [6].

These theoretical and practical developments form the conceptual basis of contemporary carbon trading mechanisms. The following section examines the evolution of China's carbon market and analyzes key determinants of carbon pricing, thereby contributing to the construction of a more robust and effective carbon market system.

2.2. Carbon Trading Market in China

2.2.1 Development history

The development of China's carbon trading market has evolved through two distinct phases. The initial phase was predominantly shaped by the Clean Development Mechanism (CDM), under which China emerged as the global leader in registered CDM projects, leveraging international cooperation to reduce greenhouse gas emissions at a relatively low cost [7]. Following this, the market entered a second phase focused on establishing a domestic emission rights trading system. In 2008, the National Development and Reform Commission (NDRC) initially proposed the development of carbon trading pilots, marking a critical transition toward a nationally regulated carbon market framework.

In November 2011, the NDRC formally authorized the establishment of carbon emission trading pilots in seven provinces and cities: Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, and Shenzhen [7]. Shenzhen pioneered this effort by launching the first official pilot market on June 18, 2013. By the end of July 2014, all seven pilot markets had commenced operation, forming an experimental foundation for a nationwide carbon trading system [7]. These pilots varied in design and scope, providing valuable empirical data and operational experience that informed the subsequent development of China's unified carbon market. This phased approach reflects a strategic shift from international offset mechanisms to a domestically driven cap-and-trade system, illustrating China's incremental policy learning and institutional capacity building in carbon market governance.

2.2.2 Institutional evolution

From the perspective of institutional evolution, the construction of a unified national carbon market is a long-term process, divided into four stages. The first is the preparation stage, aiming to complete the construction of a local carbon emission quota cap-and-trade system by the end of 2015 [7]. The second is the improvement stage (2016-2020), which targets the completion of a national-level quota trading system and the transition from intensity targets to total amount control targets [7]. The third is the expansion stage (2020-2030), with the main goals of establishing a national carbon trading system under absolute quantity control and maturing institutional, regulatory, and market operations [7]. The fourth is the deepening stage, aiming to build a national trading system under absolute quantified emissions, with the capacity to connect with other countries and play a leading role in the international carbon market [7]. At present, China's carbon market has developed from local pilots to a unified national market and is gradually transitioning to integration with the global market, but it is still in the experimental phase overall [7].

During the local pilot phase, various regions carried out basic work such as formulating local laws and regulations, clarifying total control targets and scopes, and establishing a greenhouse gas Measurement, Reporting, and Verification (MRV) system. This formed a pilot system consisting of six modules: total target and scope, quota allocation and management, MRV system, implementation mechanism, trading system, and capacity building, accumulating practical experience for the price mechanism of the national market [8].

2.2.3 Recent trading performance

On October 28, 2024, China's National Carbon Emission Rights Trading System officially launched the trading of the 2023 carbon emission quotas. According to data released by the Shanghai Environment and Energy Exchange (see Figure 1), the annual trading volume for each quota variant illustrates a clear concentration of liquidity in more recent vintages. Specifically, the turnover for the 2019-2020 quota amounted to 9.687 million tons, accounting for 5.13% of the annual total, with a transaction value of RMB 925 million. The 2021 quota reached a volume of 6.9944 million tons, representing 3.71% of annual trades and a value of RMB 658 million. In contrast, the 2022 quota recorded significantly higher activity, reaching 69.378 million tons—36.78% of the yearly total—and a turnover value of RMB 6.519 billion. The most actively traded was the 2023 quota, with a volume of 103 million tons, constituting 54.38% of all transactions and a market value of RMB 10.011 billion.

This distribution highlights that market participation is heavily concentrated in the most recent allowances, with the 2022 and 2023 quotas collectively representing over 90% of both trading volume and value. Such a pattern reflects improved market liquidity and participant confidence in the pricing of current-year instruments. Furthermore, it signifies a maturation process in China's national carbon market, illustrating its evolution from fragmented local pilot explorations toward an integrated, expanded, and increasingly liquid national trading system. The dominance of near-term quotas also underscores the market's growing alignment with contemporary compliance demand and policy expectations.

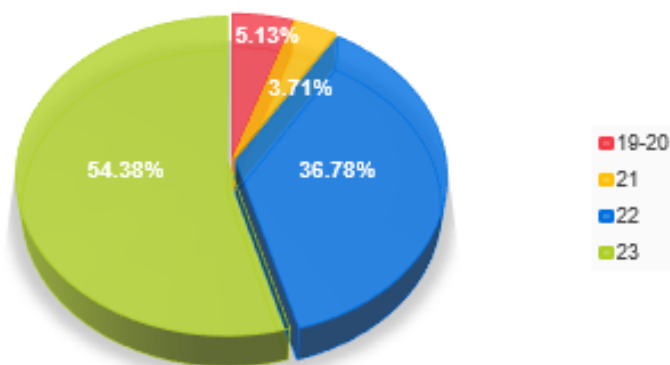


Fig. 1 Trading volume of Carbon Emission Quotas

2.3. Carbon Emission Rights Pricing Factors

2.3.1 Economic factors

Economic factors exert a cyclical influence on the carbon trading market, closely linked to macroeconomic fluctuations. During periods of medium to high-speed economic growth, industrial output expands, leading to increased production and consumption. This rise in economic activity typically elevates energy consumption, particularly from fossil fuels, which in turn generates higher greenhouse gas emissions [9]. As a consequence, regulated enterprises face greater demand for carbon quotas to cover their increased emissions. Simultaneously, mounting pressure from energy conservation and emission reduction targets constrains the overall supply of allowances. This combination of heightened demand and limited or tightening supply creates upward pressure on carbon prices within emission trading systems [9].

Furthermore, the intrinsic pro-cyclicality of carbon markets means that price volatility often mirrors broader economic conditions. In expansionary phases, compliance needs drive active trading and higher allowance prices, reflecting both regulatory constraints and actual carbon intensity. This dual role underscores that carbon markets operate as both environmental policy tools and economically sensitive mechanisms that evolve with cyclical fluctuations. Understanding this relationship is essential for policymakers and market participants to anticipate price movements and design stable, effective carbon market regulations.

2.3.2 Energy factors

Energy factors significantly affect carbon trading prices, and the adjustment of China's energy structure is crucial in this regard. China is transitioning its energy mix from heavy reliance on fossil fuels toward a more diversified and cleaner energy portfolio. Coal, long a major part of China's energy, is declining as "dual carbon" goals advance. In 2022, coal's share of total energy consumption fell to 56.2%, while renewable energy use is rising—its power generation is expected to reach 93%-94% by 2060. This shift directly changes carbon emission levels and intensity, thus impacting carbon prices.

Looking at supply and demand, on the supply side, less coal use means fewer high-carbon emissions. With fixed carbon quotas, this loosens the supply of emission rights, pressuring prices downward. Also, widespread renewable energy lets companies cut emissions and turn excess reductions into tradable assets, boosting supply and curbing price hikes. On the demand side, if industries stay reliant on coal, carbon emission demand remains high. Companies will need more quotas, pushing prices up. However, as energy structures adjust, high-energy industries are switching to clean energy, reducing emission needs and quota demand—putting prices at risk of falling.

Technology plays a key role. China continues to push forward in energy technology research, development and application. For example, clean coal utilization technologies are constantly improving, which can enhance coal use efficiency and reduce carbon emissions per unit of energy consumption. This reduces enterprises' demand for carbon quotas to some extent, thereby curbing carbon trading prices.

In addition, the development of energy storage technology is crucial for the absorption of renewable energy. Advances in energy storage technology can enhance the stability and reliability of renewable energy, promote its large-scale application, indirectly reduce the demand for high-carbon energy, and thus affect carbon trading prices.

2.3.3 Other factors

Carbon trading prices are subject to a range of external influences, including international carbon market dynamics, fluctuations in currency exchange rates, and unforeseen force majeure events [9]. In particular, the European Union's Emissions Trading System (EU ETS), as one of the world's most mature and stable carbon markets, is closely monitored by Chinese scholars and policymakers. By analyzing trends and policy adjustments within the EU ETS, experts can better anticipate and implement interventions aimed at stabilizing China's domestic carbon market and mitigating associated risks [9].

Furthermore, international climate governance frameworks play a critical role in shaping national carbon pricing mechanisms. Emission reduction targets are often established through collaborative efforts between the United Nations Climate Committee and individual national governments. To meet these commitments, participating countries frequently introduce stricter emission regulations, which directly affect domestic carbon allowance supply and demand, thereby driving price changes [9]. This regulatory alignment suggests a tangible linkage between international carbon pricing trends and China's carbon market outcomes [10].

Exchange rate volatility also contributes to carbon price instability by altering the cost structures of emission-intensive industries, influencing levels of foreign investment, and ultimately affecting the supply-demand balance of carbon assets. Additionally, force majeure events—such as natural disasters, geopolitical conflicts, or major economic disruptions—can induce sudden fluctuations in production outputs and energy consumption, further impacting carbon trading prices [9]. These multifaceted external factors underscore the complexity of carbon market behavior and highlight the need for robust risk management frameworks.

3. The Future Changes in Carbon Trading Price

3.1. Enhanced Flexibility in Mechanism Design

China's rate-based ETS sets different emission benchmarks depending on technology levels, fuel types, and regional development. This helps reduce compliance costs for less advanced companies and prevents sudden carbon price increases, supporting short-term market stability. The system also uses gradually tightening benchmarks that decline as technology improves. This encourages rising carbon prices over time, motivating companies to invest in low-carbon upgrades.

The flexible benchmarks also prevent market distortion by reflecting regional and structural differences. This maintains market liquidity and helps keep carbon prices aligned with actual reduction costs. Companies can earn tradable allowances by emitting less than their benchmark, promoting innovation. As low-carbon technology becomes more widespread, overall costs may fall, slowing price growth while still meeting emission targets.

In summary, China's carbon market balances short-term practicality with long-term goals, leading to carbon prices that rise steadily without major fluctuations. This supports decarbonization while minimizing economic disruption.

3.2. Changing Influence of Economic and Energy Factors

With China's ongoing economic and energy structure transformation, advances in new energy technology are set to significantly reshape the factors influencing carbon pricing.

Economically, China recorded a GDP of 134.91 trillion yuan in 2024, growing by 5%, reflecting stable expansion. Industrial electricity consumption increased by 5.1%, while energy intensity fell by 3.8%, and clean energy accounted for 28.6% of total consumption. These trends signal improved energy efficiency and a gradual shift toward cleaner energy. Over time, as clean energy becomes more prevalent, economic growth will become less tied to carbon emissions. This will weaken the direct impact of economic activity on carbon pricing. For example, companies using more clean energy will emit less and require fewer carbon allowances, loosening the relationship between economic scale and carbon costs.

In the energy sector, technological innovation is a major driving force. Breakthroughs in wind and solar power have lowered costs and accelerated the adoption of renewables. Companies now have more access to low- or zero-carbon energy, reducing both their emissions and their need for carbon quotas. As a result, energy-related factors are gaining influence in carbon pricing. A company switching from coal to solar power, for instance, can drastically cut emissions, reduce its quota purchases, and even sell surplus allowances—demonstrating the growing role of energy technology in carbon market dynamics.

In summary, economic factors will have a diminishing effect on carbon pricing in China's carbon market, while energy technology advancements will play an increasingly central role. This shift will help establish a more efficient and environmentally driven carbon trading system.

3.3. U.S. Retreat Disrupts Markets

Furthermore, the U.S. withdrawal from the Paris Agreement has had some impact on carbon prices. From the perspective of global carbon market stability, this withdrawal has hindered the stability of the global carbon market and the development of low-carbon technologies. This event could easily lead to an imbalance between supply and demand in regional carbon markets worldwide. The U.S. originally held a certain share in the global carbon market. Its withdrawal has disrupted market supply and demand, increasing fluctuations in carbon prices across regions. At the same time, in the short term, enterprises' enthusiasm to participate in the carbon market has decreased, weakening the market's role in promoting emission reductions. Moreover, the U.S. leads in green technologies such as hydrogen energy. Its withdrawal may hinder R&D breakthroughs and international cooperation in these technologies, slowing down the progress of global low-carbon technologies. In the long run, this is not conducive to reducing carbon emissions and stabilizing carbon prices through technological means.

4. Suggestions

4.1. Government

For the government, it is advisable to establish a scientifically grounded and dynamically adjustable mechanism for setting emission benchmarks, taking into full account factors such as technological progress, regional developmental disparities, and the increasing penetration of clean energy. Policy design should emphasize systematic coordination to ensure that carbon prices reflect the true social cost of emissions and rise in a stable and predictable manner, thereby preventing market distortions and enhancing long-term investment certainty. Additionally, greater emphasis should be placed on promoting regional equity, for instance by implementing differentiated allocation rules and providing financial support for enterprises in less developed regions. This would improve compliance affordability, stimulate market participation, and ultimately enhance overall market liquidity and operational efficiency. Such measures will contribute to a more equitable, efficient, and sustainable national carbon market.

4.2. Businesses

For businesses, it is imperative to proactively invest in the research, development, and adoption of low-carbon technologies, with particular emphasis on renewable energy integration and energy efficiency improvements. Such initiatives are crucial for reducing long-term compliance costs, especially as carbon prices exhibit a rising trend under tightening emission constraints. Enterprises should also strengthen specialized carbon asset management capabilities, establishing robust monitoring, trading, and risk hedging strategies to navigate market volatility effectively. Furthermore, a strategic shift in energy consumption structure toward clean and low-carbon sources is strongly advised. This transition will help reduce direct emissions and associated costs and enable firms to capitalize on potential revenue streams through the trading of surplus carbon allowances, thereby turning regulatory compliance into a strategic advantage.

4.3. Institutions

For academic and financial institutions, it is crucial to conduct in-depth research on the mechanisms through which advancements in energy technology—such as breakthroughs in renewable energy, carbon capture, and energy storage—influence carbon market pricing dynamics. A nuanced understanding of these relationships can provide valuable insights for the formulation of

evidence-based policies and the development of forward-looking corporate strategies. Furthermore, financial institutions should promote innovation in carbon finance, designing and implementing diversified financial instruments such as carbon futures, options, and green bonds to improve risk management and channel capital toward emission reduction projects. Additionally, efforts should be intensified to enhance information transparency, disseminate market knowledge, and strengthen capacity-building programs for market participants. These measures will help elevate overall market literacy, participation efficiency, and the allocative effectiveness of the carbon market.

5. Conclusion

This paper provides a systematic review of foundational carbon trading theories and examines the practical evolution of China's carbon market, with a particular focus on its transition from decentralized regional pilots to an integrated national emissions trading system. A pie chart is utilized to visually illustrate the progressive expansion of trading volumes across different allowance vintages, reinforcing the empirical observation of market maturation and liquidity concentration in recent years. Drawing on existing literature, this study identifies and categorizes key factors influencing carbon pricing—including policy mechanisms, energy structure transitions, macroeconomic conditions, and international events—while introducing an original perspective regarding the impact of the U.S. withdrawal from the Paris Agreement on global carbon market sentiment and price volatility. The paper concludes with a forward-looking analysis of potential carbon price trends, establishing a conceptual foundation for subsequent scholarly inquiry.

A notable limitation of this research is the absence of quantitative modeling capable of precisely estimating the relative contributions and weightings of specific influencing variables, such as renewable energy penetration rates, fluctuations in economic indicators, or specific policy interventions. The reliance on qualitative and descriptive methods restricts the ability to perform causal inference or reliable medium- to long-term price projections, thereby limiting the operational utility of the findings for risk management and policy design.

Future studies should prioritize the development of empirical frameworks to quantify the effects of energy-related factors, especially the accelerating integration of renewable energy technologies and shifts in national electricity generation mix, on carbon allowance supply-demand dynamics. Furthermore, as carbon markets are highly policy-sensitive, it is essential to continuously integrate the latest regulatory developments and climate targets into analytical models to maintain relevance. The application of rigorous empirical approaches—such as time-series econometrics, panel regression models, machine learning-based forecasting, or structural factor analysis—will be critical in isolating the marginal impacts of individual variables, ultimately enhancing the predictive accuracy and practical value of carbon market research.

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