The Bidirectional Influence Between Energy and Carbon Emission Prices---- Primarily Studied from Perspective of New Energy and Traditional Energy Sources

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Abstract. In the context of the ongoing implementation of the Paris Agreement, global climate change issues continue to receive closer attention. As the carbon trading market established to achieve carbon emission targets, it is naturally one of the objects that should be paid most attention to. The Chinese carbon market is still at a very early stages, with its market mechanisms and pricing yet to be perfected. This paper focuses on the bidirectional impact between energy prices and carbon prices. This paper focus on the connection with energy structure, energy prices, and carbon market prices. Furthermore, price characteristics of the carbon emission market has been explored by studding perspectives of both traditional and new energy sources. Drawing insights from research in China and the European Union, it sheds light on the changes of carbon emission prices on energy prices, highlights the current shortcomings in related studies. The aim is to contribute China's carbon emission market mechanisms and to further advance solutions to greenhouse gas emissions reduction and related issues.

Keywords: Energy prices, carbon emission market, energy structure, bidirectional influence.

1. Introduction

In recent years, global warming has garnered continuous attention worldwide. China, as a major consumer and emitter of energy, has explicitly set energy-saving and emission reduction goals in its 11-5 and 12-5 plans. Simultaneously, China officially launched the carbon emissions trading market after having a pilot program at 7 cities and practical experimentation. In comparison to Western countries, China's carbon trading market is a youngt, still having many areas for improvement in terms of market mechanisms and other aspects [1]. Therefore, there is a need for more comprehensive research, especially in understanding the factors affecting trading pricing. Because energy price is an important factor, it’s a good choice to focus on it.

The formation and stability of carbon trading markets are closely linked to energy prices. Bredin and Muckley onducted research on the factors affecting European Union carbon trading prices, demonstrating an association between carbon trading prices, energy consumption prices, and economic levels [2]. Zengfu Li and Yixin Qiu indicated that China's dominance in coal might pose obstacles to carbon trading pricing [3]. Kui Zhou and Qingyan Du highlighted the pricing deficiencies in the requirement of study for the factors of carbon prices for resolution [4]. To improve China's market mechanisms, whether drawing from other countries' experiences or China's own energy structure, research on the influence of energy prices is crucial.

This paper summarizes the current research which dig into bidirectional impact of energy prices and carbon trading prices. It divides the study into two parts: traditional energy and new energy, including renewable energy. It categorizes existing research results and less-explored areas, focusing on systematically summarizing research that focus on energy prices in the European and Chinese carbon trading markets. In this process, it identifies the shortcomings in research on energy prices. Additionally, through surveys and literature searches, it explores the reasons, solutions, and future research directions regarding the new energy and carbon trading prices in the China.

This paper's primary contributions are as follows:

It starts by analyzing China's unique energy consumption structure, explaining the bidirectional influence of traditional energy's characteristics on the carbon trading market. It also suggests including international market price fluctuations and energy imports as factors to study.

It highlights the lack of clarity in research on the factors influencing new energy prices to change carbon market. Recognizing the interrelationship, substitution effects between new and traditional energy sources, it suggests that new energy prices is close to the carbon trading market. It provides research directions for future studies, contributing to a more comprehensive construction with carbon trading market, also enhancing China's carbon- mechanisms.

By combining research on the European Union market regarding the bidirectional influence between trade price of carbon and energy prices, the paper reveals the current scarcity of related research in China, which is primarily theoretical. It emphasizes the importance of integrating data to understand the impact mechanisms and improve the bidirectional impact system between energy prices and carbon trading prices.

2. A Brief Overview of China's Energy Structure

Energy is defined as natural resources and their derivatives that provide some form of energy for human use, or the sources of energy, such as solar energy, wind energy, fossil fuels, electricity, etc. [5]. Enterprises consume energy in their production processes, and their consumption of traditional energy mainly cause the carbon dioxide emissions. Fluctuations in traditional energy sources can affect the demand of enterprises, ultimately impacting the prices in the carbon market [6].

The bidirectional affect with carbon trading market and the energy structure is insist. Firstly, let's focus on how carbon market impact on the energy structure. According to Porter's hypothesis, environmental protection and economic development are not contradictory, and appropriate environmental regulations can stimulate innovation activities by enterprises. The construction can influence enterprises' carbon reduction choices, drive technological innovation [7]. Yang Z and others have found through regression analysis that controlling carbon emissions in pilot spots of China's carbon market is positive to reduce the use coal energy. Given China's dominant reliance on coal in its energy structure, the introduction of carbon market in China can initially affect demand of coal energy by enterprises, leading to changes in the energy structure [8].

Regarding the influence of the energy to carbon trading market, it is closely connected to the context of the energy structure and its construction. According to energy consumption structure data from 1999 to 2021, the scale of clean energy consumption in China is gradually increasing, while fossil energy consumption is gradually decreasing. However, China still relies excessively on traditional energy sources such as coal compared to developed countries like Japan [9]. China's enormous carbon emissions are directly connected with its status as the largest developing country and its energy structure [10]. The difference between China's carbon market and those in developed countries like Europe highly influenced by these factors.

Energy prices are a core issue affecting the energy structure. Changes in prices between different energy sources have a certain impact on the energy structure. As shown in Figure 1 and 2, the consumption of new energy sources other than coal, oil, and natural gas has increased from 1% in 2012 to 1.6% in 2020. Looking at the trend, although the proportion of traditional energy consumption structure is still at a relatively high level, the consumption of new energy sources will become increasingly important in the future, and its research value is continuously rising. Research needs to focus on both traditional and new energy sources and their impact on carbon trading prices.

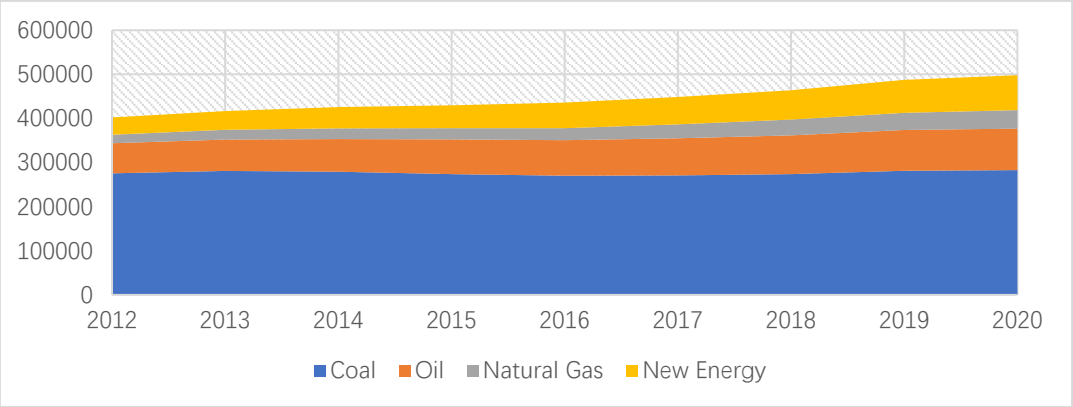


Figure 1. Energy Consumption of China (in billion tons of standard coal)
Data from National Bureau of Statistics

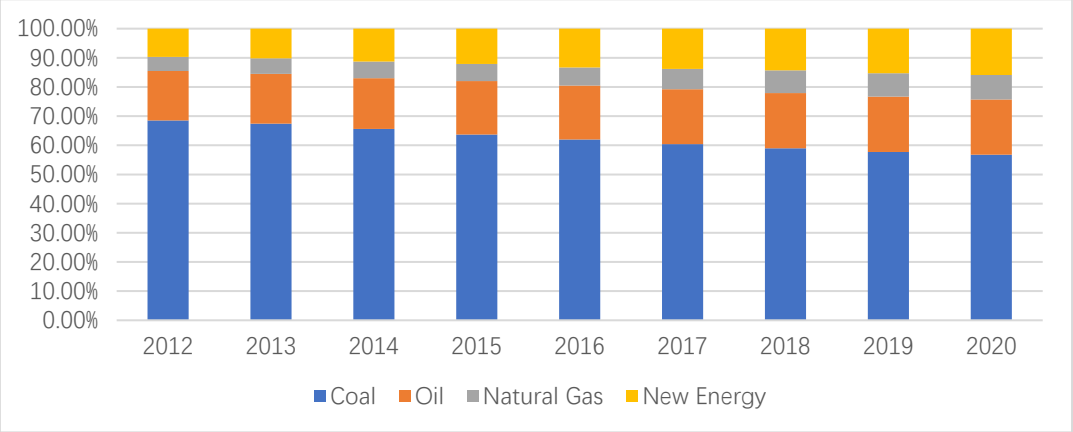


Figure 2. Energy Consumption Percentage (%)
Data from National Bureau of Statistics

3. The Function of Energy Prices on Carbon Trading Prices

3.1. About Traditional Energy

Traditional energy prices can affect carbon trading prices is a widely acknowledged viewpoint [11]. Traditional energy's influence on carbon prices is primarily evident in three resource categories: coal, oil, and natural gas. Peter Hoeller, Markku Wallin pointed out in their European market study that an increase in energy prices leads to higher costs for energy conservation, thereby reducing the demand for carbon emissions trading [12]. Additionally, research by Zhen-Hua Feng et al. indicates that carbon trading markets share many similarities with traditional markets. This suggests that the study of carbon trading markets can benefit from analogies to other mature market mechanisms. They also note that carbon trading markets do not adhere to the weak efficient market hypothesis; market prices cannot fully reflect all historical information. Various factors, including extreme weather, societal impacts, special events, and energy prices, can cause fluctuations in carbon trading prices within this market [13]. Understanding the carbon trading market should approach it from a dynamic, non-linear perspective.

Building on this research, due to China's inherent issues in its energy consumption structure, research primarily focuses on the three major traditional energy sources. Traditional energy can influence carbon trading prices through three pathways: substitution effects [14], total demand effects, and production inhibition effects. Given the strong interconnection between traditional energy sources, a comprehensive and holistic analysis is needed to understand their impact on carbon trading prices [15]. Among the three major traditional energy sources, coal and oil's price have received more

attention in their affection of the carbon trading market. Much research has utilized coal and oil prices as data to study how energy prices impact the carbon trading market. Wei Qi and Jin Zhuoran used data from the Beijing Carbon Exchange from 2013 to 2017 and analyzed both oil and coal prices. They found that coal prices have predictive power for carbon trading prices, while oil prices do not. Carbon trading prices are insensitive to oil prices, suggesting that mechanisms of China's carbon market need improvement, leading some impediments in price transmission in the Beijing Carbon Exchange's oil market [16]. China needs to enhance the mechanisms of its carbon trading market. Zhao Xuanmin and Wei Xue argued that China's high dependence on oil imports means that oil prices are highly influenced by international crude oil prices. Simultaneously, China's energy structure is predominantly coal-based, with rigid demand, making it challenging to reflect the impact on carbon market prices. Carbon trading prices are highly sensitive to natural gas due to government subsidies that stimulate natural gas demand, leading to changes in demand for the carbon trading market and ultimately impacting prices [6]. While the above research includes some exploration of natural gas, there is relatively less research that directly focuses on studying natural gas prices as a driving factor. Yin Lei pointed out that natural gas prices are significantly impact on the carbon trading market, influenced by international natural gas prices, including New York natural gas. To establish more reasonable pricing and regulations, the focus should be on the correlation between natural gas prices and carbon trading prices. Additionally, as natural gas is the cleanest energy source among traditional energy sources in terms of carbon emissions, research on its prices is crucial for reflecting the value of carbon trading [17].

In summary, China's current research is mostly connected with traditional energy's effect on carbon prices is diverse, drawing on experiences of European markets while taking into account China's own environmental context. Coal is dominating China's energy consumption structure is dominated in a long term, it is important to recognize that proportion of gas consumption is gradually increasing. Research should be based on coal prices while considering natural gas prices. As China's energy consumption structure continues to optimize, the factors affecting the carbon trading market will also change. Furthermore, China opened its own carbon emissions trading market on 2021. Future research data based on this development will be more comprehensive and convincing. Currently, domestic research of entirely new carbon market is limited, and the extent to which international energy prices affect carbon trading prices is not yet clear. Research should focus on post-pilot market dynamics and strengthen comparisons with international traditional energy prices.

3.2. About New Energy and Renewable Energy Prices

The world is undergoing its third energy revolution, which is the revolution of new and renewable energy sources [18]. Achieving carbon neutrality by the mid-century is not an unattainable dream; the energy revolution is vigorously underway [19]. Global attention to new and renewable energy is growing. The United States, in its pursuit of carbon neutrality goals, emphasizes the complementarity of various energy sources to achieve the most optimal efficiency and pathways, with a focus on non-traditional energy sources, specifically new energy sources [20]. Currently, natural gas in China has a important status, and the development of new energy sources is significant internationally. While new energy sources have weak peak load capabilities, natural gas has strong emergency capabilities, which can complement the deficiencies on the development of new energy sources. Combining natural gas and new energy development has unique advantages and is a scientific approach to solving energy issues and optimizing the energy structure, representing the future development trend [21]. The development and progress of new energy sources are a path that China will undoubtedly follow in the future. China's focus on new energy is increasing day by day, but there is limited research in that study's new energy. Xia Ruitong, in the context of external factors influencing carbon trading prices, suggests that clean and renewable energy will promote its substitution for traditional energy sources. Theoretically, as China's energy structure optimizes and develops, fossil energy prices will be negatively correlated with carbon trading prices [22]. However, since it uses coal and oil price data from the pilot trading period, and new energy prices themselves are not included as variables, it cannot

prove the impact of new or renewable energy sources on carbon trading prices. According to Figures 3 and 4, from 2018 to 2022, the proportion and total amount of photovoltaic, wind power generation have steadily increased year by year, demonstrating China's strong promotion-"carbon peak and carbon neutrality" goals. A future energy consumption structure dominated by new energy sources is China's development goal, and new energy, renewable energy sources will further displace traditional energy sources.

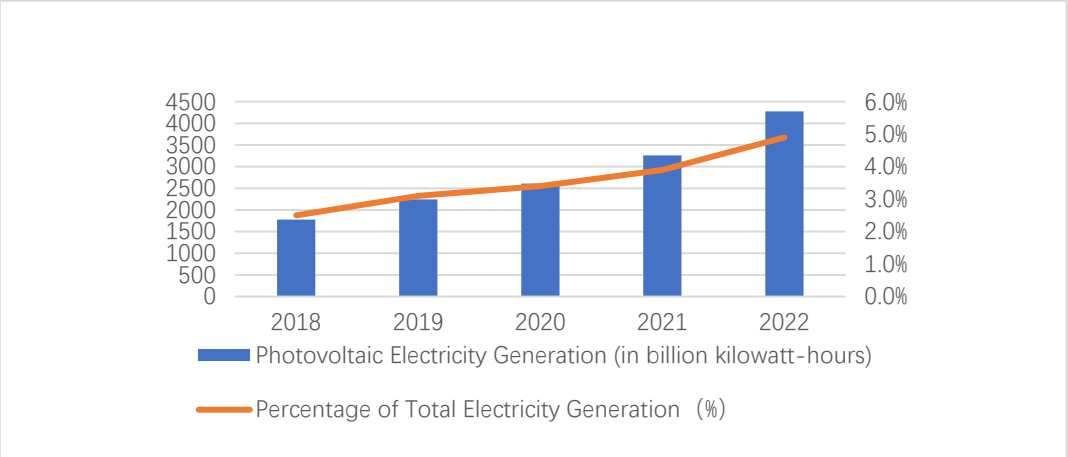


Figure 3. Over the past five years, China's photovoltaic power generation and its proportion

Data source: National Energy Administration

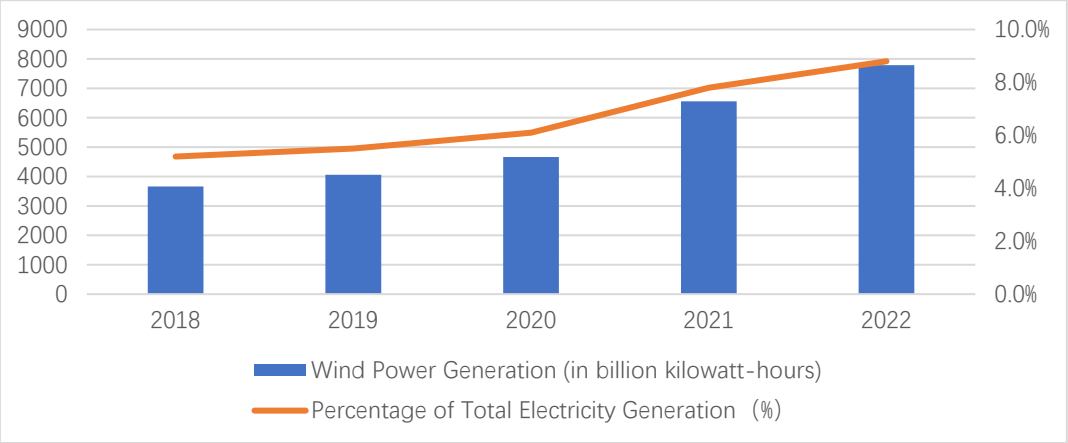


Figure 4. Over the past five years, China's wind power generation and its proportion

Data source: China Electricity Council

The goal of the carbon market is reducing greenhouse gas, and its connection with new and renewable energy sources is close. Continuing to deepen research with new and renewable energy sources, carbon trading prices is in line with China's national conditions and is an indispensable research direction. Currently, related research is not yet systematically complete, and further efforts are needed in this area to enhance the research of between energy prices and carbon trading prices' connection, thereby promoting reasonable pricing in Chinese carbon trading market and improving market mechanisms.

4. The Function of carbon trading Prices on Energy Prices

Multiple factors simultaneously influence carbon trading prices, and when it changes, they will inevitably affect energy prices. Xun Xirong confirmed a path analysis of the function of carbon trading prices on energy prices. Because the carbon trading market itself has financial attributes, when carbon trading prices rise, the demand for the carbon market by businesses decreases. In this case,

whether for reducing emission reduction costs or trading more carbon emissions rights, it will decrease company's carbon emissions, reduce demand for traditional energy sources and ultimately leading to a decrease in traditional energy prices. When the prices fall, the transmission pathways to energy prices are similar, ultimately resulting in an increase in traditional energy prices [23]. This process is illustrated in Figures 5 and 6.

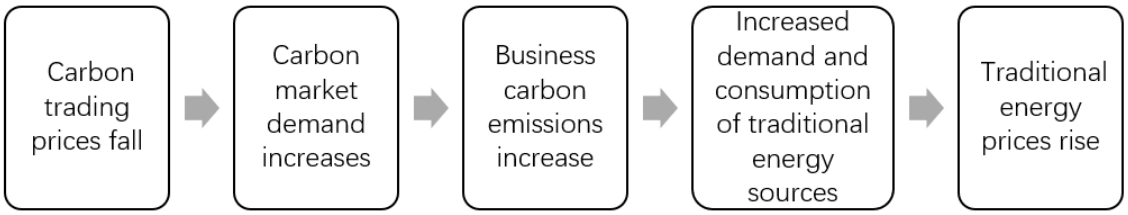


Figure 5. How Carbon Trading Price Increase Traditional Energy Prices

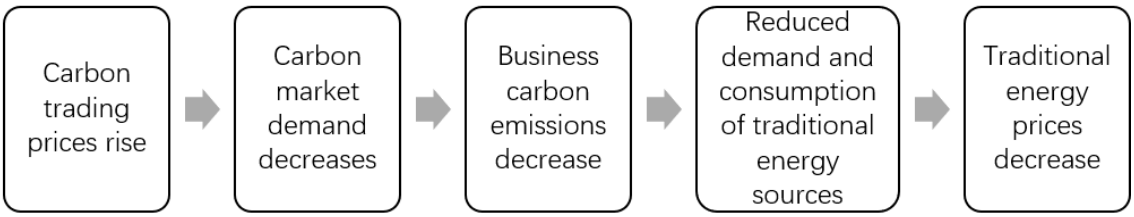


Figure 6. How Carbon Trading Price Decrease Traditional Energy Prices

Fezzi C, Bunn D W found that fluctuations in carbon trading prices have fluctuations in electricity prices [24]. Berrisch J, Pappert S, Ziel F proposed assumptions that energy prices depend on EUA prices, establishing a VECMCopula-GARCH model that jointly models with four variables, which are EUA prices, natural gas, oil, and coal, in order to understand the possible relationships between carbon and fuel prices [25].

From the above studies, the evident that carbon trading prices could significantly impact energy prices is significant and can be systematically studied. Whether theoretically or in terms of models, carbon trading prices and energy prices' relationship can be reflected. However, most of such research is based on the European market, with limited studies on the Chinese market. Additionally, the focus has been more on theoretical aspects such as transmission pathways of impacts rather than modeling and data. Furthermore, just a small part of research is for the impact of carbon trading prices to new energy prices. As it continues to rise, understanding the bidirectional relation from new energy and carbon trading prices is really important.

5. Conclusion

Energy and carbon prices are close intertwined. Research in this field is based on the more mature European market and is combined with domestic energy conditions and pilot area data in China. Regarding the affect traditional energy price prices to carbon trading prices, because of China's dominant position in coal consumption and its essential role in energy, carbon trading prices are influenced to a certain extent, but their sensitivity is not the highest. In contrast, in the case of natural gas, it is a focal point in China's efforts to optimize its energy consumption structure. Natural gas is relatively clean, has strong emergency capabilities, and is supported by government subsidies, making natural gas prices more intuitively and significantly impactful on carbon trading prices. Petroleum accounts for large part of energy consumption, and China relies on crude oil imports, oil prices on carbon trading prices has also been shown to be relevant. International situations and other factors may have a more substantial impact on petroleum prices, thereby affecting carbon trading prices. Including energy imports and exports in the scope of research would have a positive impact on further enhancing the understanding of the energy prices and carbon trading prices.

Research has mostly focused on traditional energy sources, with much of it based on EU data, lacking a Chinese perspective. This aspect of research is relatively lacking in the new energy sources filed and should be addressed to have a greater understanding of the connection of energy prices and carbon trading prices.

Regarding new energy sources, which the country is vigorously developing, still having a lack of relevant research. China only opened its national carbon trading market in 2021, so between new energy prices on carbon trading prices, it's may not have been effectively transmitted yet, making its analysis challenging. However, as a goal for improving the future energy structure, the prices of new energy sources, represented by wind and solar power, will undoubtedly influence carbon market. Because of the lack of research on this aspect, it's difficult to develop the nascent Chinese carbon trading market Specific analysis of new energy prices is an area that requires further development.

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