The Double-edged Impact and Solution of Emission Trading Scheme:
Perspective from China

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Abstract. Emission Trading Scheme (ETS) is widely used for carbon emission globally, but there are few comprehensive studies about the debate of the impact of ETS. This paper presents new evidence of the double-edged impact and solution of Emission Trading Scheme by conducting qualitative methods like literature review to overcome the debate. Using evidence from China, it is found that the positive impact of ETS includes emission reduction, technological innovation and cheaper cost for emission reduction; the negative impact includes loss of GDP, carbon leakage and price bubble. In light of the findings, the negative impact of ETS could be overwhelmed by related policies like extending the coverage of areas and industries, combing ETS with a package of other related intervention and the supply of carbon tax.

Keywords: Double-edged impact; Emission Trading Scheme; carbon reduction; carbon leakage; price bubble.

1. Introduction

Carbon dioxide (CO2) is an important heat-trapping gas which keeps earth warm. However, according to the data collected by NASA, human activities have raised the atmosphere's CO2 content by 50% in less than 200 years. Excessively increasing CO2 has led to a gradual increase in the average annual temperature of the planet which caused more frequent extreme weather in recent years (Mikhaylov et al., 2020). With the environment deteriorated rapidly, countries all across the world have prioritized the decrease of atmospheric CO2.

Emission Trading Scheme (ETS), which was formally announced by European Union (EU) first in 2005, was established to reduce CO2 with a cost-effective means (Egenhofer, 2007). It puts a limit on overall emission from high-emitting industry sectors. Then governments split quotas into different enterprises and forced the emission reduction according to their emission reduction targets. Within overall limit, companies can buy and sell emission allowances to achieve their reduction task and make a profit (Wang et al., 2015). This scheme showed a great success that it would achieve a 21% reduction in emissions by 2020 from 2005 levels in industries covered by the EU ETS (Thema et al., 2013) and a 10% reduction in other sectors. Subsequently, this scheme was copied by many countries, including China.

Under the background of "double carbon", China has initially established a carbon emissions trading market based on a quota-based carbon emissions trading system, but there are still certain deficiencies in practice, which need to be synergized with other means of carbon emission reduction. Carbon emissions trading and carbon tax have the same function in the system, which can better make up for the weaknesses of carbon emissions trading. better make up for the deficiencies of carbon emissions trading. In order to promote the synergistic management of carbon emissions trading and carbon tax, it is necessary to improve the relevant system, formulate a perfect synergistic management mechanism, and establish a carbon emission reduction synergistic supervision and enforcement mechanism. In order to promote the synergistic governance of carbon emission trading and carbon tax, it is necessary to improve the relevant system, formulate a perfect synergistic governance mechanism, establish a synergistic carbon emission reduction supervision and law enforcement system, and deepen the synergistic reform of environmental justice to ensure the effectiveness of synergistic governance.

Since the establishment of seven pilots in 2011, China has implemented ETS for decade. It is concerned that whether ETS has achieved its primary peak of emission reduction and addition to this, whether it produce other positive impact. What's more, whether that ETS is detrimental to China from some aspects is also a question worth thinking. Finally, according to the double-edged impact of ETS, is it worth long-term insist or how to weakening its negative impact in order to make it more efficient? The purpose of this paper is trying to solves the problems above.

Analyzing the opposite impact of ETS and consider its efficiency to the whole country is of great significant. China has pursued sustainable development for a long time which emphasized both environmental protection and economic development. As a whole, ETS performs well in environmental protection but shows issues in economic aspect. Analyzing the double-edged impact of ETS aims at presenting an integrated understanding of ETS. Furthermore, it suggests direction on how to adhere the strengths of ETS continuously while weakening its negative impacts in order to establish a more efficient scheme for sustainable development.

Meanwhile, the negative impact shouldn't be ignored, too. Its negative impact is mainly concentrated in three aspects, the loss of GDP, risk of carbon leakage and price bubble. In fact, with different method for research, different literatures would draw different conclusion on the same question. In order to obtain as objective a conclusion as possible, this paper collects and analyzes current literatures and attempts to qualitatively analyze the impact of various aspects of ETS and degree of impact which has been done by few literatures.

The remainder of the paper is divided into four sections. Section 2 review research on the positive impacts of ETS which includes emission reduction, enterprise's technological innovation and cheaper cost for emission reduction.

Section 3 focuses on negative impacts on ETS which is divided into three parts, including the loss of GDP, possibility of carbon leakage and price bubble. Section 4 would conclude a concise comparison qualitatively between the positive and negative impact and in the last section, some suggestions on how to perfect ETS will be offered.

2. Positive Impact

Since 2011, seven pilots in China under ETS have been established for more than ten years. A large amount of literature focus on ETS and found that ETS have positively impacted China in different aspects. As a market-based tool that allows companies to buy and sell permits to emit a limited amount of greenhouse gases, it seems that ETS has showed great influence in emission reduction, incentivizing enterprises' innovation and saving cost for emission reduction target. In this section, literatures focus on different positive impact will be analyzed and that how ETS can positively impact China from these aspects will also be discussed.

2.1 Emission reduction

Carbon finance helps reduce emissions by internalizing external costs, and is an important tool for using market-based mechanisms to help reach the dual-carbon goal. China's Carbon Market Mechanism Design

China's carbon market is the world's first major carbon market based on carbon intensity, but there are problems such as large fluctuations in carbon prices, significant tidal phenomena and insufficient market effectiveness in the national carbon market. However, the national carbon market also suffers from high carbon price volatility, significant tidal phenomena, and insufficient market effectiveness. The promotion of carbon neutrality, the enrichment of carbon market trading tools, the expansion of carbon market participants, and the improvement of the regulatory and legal framework of the carbon financial market are the key factors to promote the development of China's carbon market and carbon emission reduction. The promotion of carbon neutrality, enrichment of carbon market trading tools, expansion of carbon market participants, and improvement of the regulatory and legal framework of the carbon financial market are effective means to promote the orderly development of China's carbon market.

As an important institutional arrangement to promote China's ecological civilization, the carbon trading policy has received widespread attention. Under the background of "double carbon" target, accelerating the construction and improvement of the national carbon market is an inherent requirement and reasonable choice to promote the high-quality development of the economy and realize the low-carbon transformation of the economy. In this paper, the DSGE theoretical model of carbon emission reduction policy is constructed to evaluate the systematic effect of carbon trading policy on economic and environmental performance within the framework of dynamic economic mechanism. The simulation analysis finds that the construction of the carbon market system has a positive adjustment effect on the long-term steady state level of the main variables of China's economic fundamentals, which is conducive to pulling the low-carbon transformation of the economy. Based on the analysis of the theoretical model, the carbon trading policy has a significant promotion effect on carbon emission reduction in the pilot regions, and there is a certain policy expectation effect; PSM-DID, triple difference method and falsification test are used to conduct a more comprehensive evaluation of the impacts of the carbon trading policy on carbon emission reduction in the pilot regions.

The PSM-DID, triple difference method and falsification test are used to conduct a more detailed robustness test, and the conclusion is still valid. Further from the three perspectives of transmission mechanism, spatial correlation and policy synergy, we examine the path and mechanism of carbon pilot policy emission reduction effect, and find that the policy mainly realizes carbon emission reduction through two paths, namely, improving energy efficiency and improving production input technology.

It is found that the policy mainly realizes carbon emission reduction through improving energy efficiency and production input technology, but its policy spatial spillover effect and the role of energy consumption structure adjustment have not yet been effectively released; and the coordination of carbon emission reduction economic policies has a crucial impact on the realization of the synergistic effect of pollution reduction and carbon reduction.

Therefore, in order to better play the national carbon market in the realization of dual-carbon goals in the basic leading role, should also do the following four aspects of work: First, give full play to the carbon trading mechanism in the transformation of the energy economy and structural optimization of the economic incentives. At present, energy structure adjustment on the supply side and energy efficiency improvement on the consumption side are still the main directions for effectively curbing greenhouse gas emissions, and the energy structure adjustment effect of the carbon trading policy should be fully released; secondly, fully grasp the reasonableness of the total amount of carbon emissions trading, responsibility sharing and quota allocation, and beware of the "carbon transfer" and "carbon transfer" between regions and industries.

Secondly, it should fully grasp the rationality of the total amount of carbon emissions trading, responsibility sharing and quota allocation, and beware of "carbon transfer" and "carbon leakage" among regions and industries. This requires the establishment of a sound carbon emission information disclosure mechanism, the promotion of the practical experience of the first covered industries, and the steady expansion of the carbon market's coverage of industries and scale, while at the same time giving full play to the policy spillover and demonstration effects of the carbon pilot regions; thirdly, the full promotion of the coordination and interaction between carbon trading and other emission reduction policies and mechanisms.

In order to gradually realize the target pattern of pollution reduction and carbon synergy, it is urgent to superimpose the carbon pricing mechanism with green finance and other carbon emission reduction economic policies, and preset the policy space for synergistic governance of the climate and environment; fourth, maintain and carry forward the fine tradition of attaching great importance to the construction of ecological civilization in China's modernized governance system, and actively participate in the process of global climate governance. China should plan ahead to dock with the international carbon market, and fully consider the compatibility of the program design, technical elements and operational mechanisms of China's carbon market with other international markets.

To sum up, despite some scholars question the emission reduction effect of ETS, more scholars confirmed ETS’s positive impact in carbon emission with specific date and rigorous models. ETS is achieving it primary target indeed.

2.2 Enterprise’s technological innovation

Whether ETS will promote enterprise’s technological innovation is somewhat controversial. Some scholars confirmed the positive impact of ETS in technological innovation whereas some scholars hold the opposite opinion. Adhering to the market-oriented green technological innovation system, it is necessary to enhance the main role of enterprises in green technological innovation, and continuously improve the level of green technological innovation of enterprises.

However, the high investment, high risk and double externality characteristics of green technological innovation will reduce the enterprise's willingness to innovate, at this time it is necessary for the government to carry out constraints and guidance through administrative and market means, the carbon emissions trading system is an effective means for the government to effectively solve the problem of double externality, which will take the carbon emission index as property rights, carbon price as a market signal, not only through the carbon price signal to force the enterprise to carry out green technological innovation, but also through the market trading mechanism to realize the balance of total carbon emissions, so as to achieve the green technological innovation level.

Carbon emissions trading system is an effective means for the government to effectively solve the problem of double externality. Carbon emissions trading belongs to one of the market incentive-type environmental regulation, which is more operable than traditional enforcement measures, and has a pivotal impact in promoting carbon emission reduction, and can also enhance the management level of green innovation of enterprises, thus promoting the establishment of a long-term mechanism for the green development of the whole society and carbon saving and reduction in China.

Existing literature has confirmed that carbon emissions trading promotes corporate green technological innovation and has been studied based on different perspectives. Liu et al. (2017) found that the trading mechanism of carbon emissions can form a direct impact and an indirect effect on the innovative activities of enterprises by improving the level of corporate cash flow and net return on assets. Song et al. (2021) found that carbon emissions trading has an incentive effect on corporate green technology innovation, and that the effect of this incentive effect is affected by the method of quota allocation. Wei et al. (2021), on the other hand, based on the perspective of carbon price, found the mediating role played by carbon price signals, and further discussed the effects of heterogeneity of property rights and industry.

Collectively, these studies provide important insights into that ETS has positive impact on technology innovation in the long term. Furthermore, with the extension of the covered areas and industries, this effect will gradually promote.

2.3 Cheaper cost for emission reduction

In terms of increasing cost pressure on enterprises, on the one hand, the carbon emissions trading system assigns a fixed amount of carbon emissions to each enterprise, thus restricting its carbon emissions. On the one hand, the carbon emissions trading system allocates a fixed amount of carbon emission target to each enterprise, thus restricting the carbon emission of the enterprise. If an enterprise does not make timely green technological innovations, but uses its original production technology and mode of production, it may exceed this allotted quota, and then it can only buy the quota in the market. If the price of carbon is higher than the marginal abatement cost of the enterprise, it will lead to an increase in production cost; on the other hand, if the enterprise avoids the cost of over-allocation by reducing its production, it will have to pay a higher price. On the other hand, if the enterprise avoids the cost of over-allocation by reducing production, it will bring the enterprise unfavorable impacts such as reduction of operating income, product market share and competitiveness. On the other hand, if an enterprise avoids over-incurred costs by reducing its production, it will have adverse effects on its operating income, product market share and competitiveness.

In terms of providing innovation compensation, on the one hand, through green technological innovation, enterprises can greatly reduce their carbon emissions when their carbon emissions are lower than the amount of allocated credits. When their own carbon emissions are lower than the allotted quota, they can choose to sell the excess targets, which brings additional revenue to the enterprises. On the other hand, green innovation can also promote the improvement and optimization of production processes, improve production efficiency, realize clean production, and enhance the green competitiveness of enterprises. On the other hand, green innovation can also promote the improvement and optimization of production processes, improve production efficiency, achieve cleaner production, and enhance the green competitiveness of enterprises, thus bringing innovation compensation.

3. Negative Impact

With the implementation of the world's largest carbon market, China's ETS is expected to help the country achieve its ambitious climate goals. However, concerns are raised that the ETS could bring some negative impacts. A number of studies indicate different impact of ETS which can be summarized as the loss of GDP, possibility of carbon leakage and occurrence of price bubble.

3.1 The loss of GDP

Previous research has established that ETS will cause loss of GDP. Zhang et al. (2015) argued that the implementation of the ETS would increase carbon costs and raise the costs of production. As a result, the output and revenue of enterprises would decrease, leading to GDP declines in the short term. Besides, the ETS would lead to structural adjustments in the industry, and some small and medium-sized enterprises unable to meet the stringent emission standards may collapse with the potential risks of a domino effect that may ripple through the supply chains. Moreover, Xie et al. (2018) noted that the price increase of carbon permits would further impact domestic companies' investment. The report further posited that the increase in investment costs would lead to a decline in corporate production efficiency and increased corporate debt, eventually jeopardizing economic development. Dai et al. (2018) make an estimation based on the historical data and indicated that in 2030, if the covered areas and industries don't extend, the GDP loss would be the worst, as high as 6.47%.

The loss of GDP under ETS is inevitable. However, there are some ways to recover this loss. Dai et al. (2018) suggested three ways to recover the loss. First, the governments must consider the specific circumstances of each industry and enterprise to determine the emission limit. Second, the research and development of renewable energy can reduce the loss of GDP respectively. Finally, more industries participating in the carbon emissions trading system will further reduce GDP losses. Wang et al. (2016) give their advice as well.

3.2 Possibility of Carbon Leakage

First, a carbon trading mechanism does not stimulate firms to compete with each other to maximize environmental performance. The performance standards of command-and-control environmental regulation are more stringent than those of carbon trading. emissions, command-and-control environmental regulation provides more incentives to maximize environmental performance than carbon trading. The U.S. Bubble Program demonstrates that market-based The U.S. Bubble Program has demonstrated the poor environmental performance of market-based mitigation measures.

A number of studies of bubble programs have shown that Some studies of bubble programs have shown that polluters are often unable to prove that they have reduced emissions in accordance with the regulatory requirements of the bubble program (Driesen, 1998). (Driesen, 1998). Polluters almost never implement new pollution control programs to meet these requirements. On the contrary. they believe that they might have reduced emissions without the bubble program. The EPA's introduction of the bubble program deregulated the program and neither stimulated innovation nor provided a better price for the program. It does not stimulate innovation, nor does it stimulate adequate environmental performance at a lower price. Instead, companies were allowed to substitute paper credits in lieu of actual emissions reductions.

Second, fraud and manipulation are important issues that plague carbon trading schemes, where companies can make profits by fudging data. companies can make a profit by fictionalizing data. Accurate calculation of carbon emissions from different sources is plagued by technical uncertainty. A regulatory approach based on This is a problem for both BAT-based regulatory approaches and carbon trading methods.

However, for carbon trading, the accuracy of carbon emissions is more important than BAT-based regulation because pollution accounting constitutes the number of emission reduction credits required for each facility. Because pollution accounting forms the basis for the number of emission reduction credits required for each facility. The incidence of fraud is likely to be higher when carbon trading methods are used, as firms may be able to reduce emissions by fictionalizing data. The incidence of fraud is likely to be higher when carbon trading methods are used, as companies can profit from fraudulent schemes such as fictitious data. Los Angeles automobile end-of-life pollution trading relies heavily on industry self-reporting of emission reductions or reductions in emissions. operates on industry self-reported emission reductions or increases, but has been plagued by under-reporting of actual industry emissions (Drury et al., 2011).

The Los Angeles automobile emissions trading program relies heavily on industry self-reporting of emission reductions and increases, but has been plagued by underreporting of actual industry emissions (Drury et al. 1999). Based on these reports, regulators must assign air pollution credits, which are commonly underreported, underreported, and underreported. Pervasive under-reporting, under-reporting, and manipulation plague the carbon emissions trading mechanism. Complex carbon trading mechanisms can create the illusion of reduced carbon emissions and good environmental performance in the data. This creates economic incentives for fraudulent behavior. This creates economic incentives for fraudulent behavior (Hahn and Axtell, 1995). If a company is able to under-report its carbon emissions, it can avoid

If a firm can under-report its carbon emissions, it can avoid purchasing expensive carbon credits. If another firm is able to falsely report pollution reductions, then that firm can avoid purchasing expensive carbon credits. If another firm is able to falsely report pollution reductions, then that firm can sell false carbon credits to other firms. In Los Angeles, where environmental regulations are more stringent, the practice of selling carbon credits to other firms has been recognized. Los Angeles, where environmental regulation is more stringent, fraud and manipulation are almost unavoidable in countries and regions with smaller, less sophisticated regulators. Fraud and manipulation are almost inevitable in countries and regions with smaller, less sophisticated regulatory agencies.

Third, there is a trade-off between the flexible nature of a carbon trading scheme and the environmental performance it creates. A program's ability to generate good environmental performance is at least as important as its ability to The ability of a program to generate good environmental performance depends on at least three factors: the stringency of the emission limitations on the source; the amount of the expected penalty; and the amount of the environmental impact (Hahn and Axtell, 1995). Given the flexibility of the carbon trading mechanism, environmental performance is affected by the "potential for regulatory avoidance" (Hahn and Axtell, 1995). Given the flexibility of the carbon trading mechanism, environmental performance is most affected by the "likelihood of regulatory avoidance".

When the complexity of environmental enforcement increases, polluters are more likely to evade regulation, thus increasing the likelihood of evasion. When the complexity of environmental enforcement increases, polluters are more likely to evade regulation, thus reducing the likelihood that enforcers will find that they have failed to reduce emissions as expected. Enforcers need to Enforcers need to conduct extensive checks to ensure that there is no double counting or other omissions. Regulation under a carbon emissions trading scheme is more likely than under a traditional command-and-control approach. Regulation under a carbon trading scheme requires more resources and more complexity than traditional command-and-control environmental regulation to verify compliance.

3.3 Price Bubble

A price bubble is usually defined as a period in which prices diverge unsustainably from fundamental value, that is, when the price of an asset deviates from its basic value (Diba and Grossman, 1988). If the price of an asset suddenly rises in a certain period and then rapidly falls, then the price bubble can be observed (Lind, 2009). If problems on price bubbles exist in the carbon market, then the distorted carbon price will not help the carbon quota enterprises achieve the emission reduction goal at the lowest cost. Carbon price bubbles will also have adverse impact on the portfolio strategy and risk management of investors. The uncertainty and fluctuation of carbon price is a problem that many countries are concerned in designing the carbon market mechanism. The affecting factors of carbon price in different regions significantly differ. The inconsistency of corporate governance structure at the micro level and the distortion of capital allocation caused by the incentives of the ETS at the macro level will lead to the emergence of ETS price bubbles (Riedl, 2022).

Although the biggest price bubble appeared in the EU ETS, and the issue of price bubble is not particularly serious in Chinese carbon trading market, the risk of price bubble should be paid great attention (Wei et al., 2022). Xu and Salem (2021) studied the existence of price bubbles in eight ETS pilot regions in China. Their research found that only the two carbon pilot areas of Chongqing and Tianjin had price bubbles, whereas the other five carbon pilot areas of Beijing, Fujian, Guangdong, Hubei, Shanghai and Shenzhen had no price bubbles. However, Wei et al. (2022) found that there was price bubble in Shenzhen which is different from Xu and Salem's research.

The reasons for the occurrence of price bubble have also been discussed by previous investigation (Li et al., 2020). First, new energy- and renewable energy-related policies improve the market development expectation of emission control enterprises and lead the carbon price to gradually reflect the emission reduction cost (Li et al., 2020). Thus, it drives to the fluctuation in carbon price. Second, the energy prices will affect carbon price significantly. The rapid development of clean energy leads to the low price of clean energy. It decreases the demand of enterprises for carbon emission but improves the expectation of market speculators to the development of carbon market to a great extent (Li et al., 2020). This situation results in the rise of market prices and the emergence of price bubbles. Finally, the carbon market-related policies are of immense influence on China's ETS. Policies are able to interfered with the price bubble and play roles in the intervention of the carbon emission trading market (Li et al., 2020).

4. Conclusion and Solution

This paper reviews previous literatures that focus on different impact of China's ETS and analyzes both positive impact and negative impact. Other studies which start from different aspects and use different methods have drawn similar or opposite opinions, while this paper provides comprehensive evaluation of ETS according to previous studies, as follows.

The carbon emission reduction effect in pilots is proved to be efficient. However, this paper takes distance from Li and Wang (2022) who affirmed that ETS established in pilots would positively affect non-pilots for sure as the risk of carbon leakage should be taken into account as well.

Whether ETS put positive influence on enterprises' technology innovation is controversial. There is no doubt that the establishment of ETS may increase the carbon cost and put immense stress on enterprise which may incentives companies to reduce output instead of achieving innovation when the system is not particularly perfect. This paper takes the same position with Lanoie et al. (2008) that ETS may inhibit the green technology innovation in short term due to “innovation offsets” lagging “compliance cost” effects. But in long period, ETS will instead promote green innovation. This conclusion can be an encouragement for insisting and perfecting ETS continuously.

Although the GDP loss under carbon emission reduction policy is inevitable, this paper finds that ETS can recover a great proportion of GDP loss, which is approved by Wu and Gong (2021), by evaluating ETS’s negative impact of GDP loss and positive impact of saving reduction cost comprehensively. Furthermore, if government consider the emission limit carefully according to industries and enterprises’ specific situation and cover more industries in ETS, the loss of GDP can be mitigated further. In addition, research and development of renewable energy is also a good way to recover the GDP loss.

In contrast to GDP loss which is hard to prevent, carbon leakage and price bubble are issues more easily to avoid but need to be attached with greater importance. Both of the issues are not particularly severe at present, but government should be aware of the potential risk and take action to weaken their influence. For carbon leakage, the reason of it is the asymmetric advantages of unregulated emission sources over regulated emission sources (Zhang et al., 2020). As a result, governments are supposed to allow ETS to cover more industries and regions, provide equal emission restrictions to competing enterprises, and reduce carbon leakage caused by enterprises to saving production costs. While for price bubble, the priority is to stabilize the carbon price. The methods can be researching and development of renewable energy and the introduction of reasonable environmental policies.

Overall, ETS is a policy that has significant benefits for China and its drawbacks can be mitigated or avoided through reasonable means as well. Except for the temporal and spatial extension of ETS, it is suggested to combine different environmental policies such as Chinese Certified Emission Reduction (CCER) or carbon tax. The complementarity between policies can greatly weaken the negative impact, and better achieve the goals of energy conservation, emission reduction, and sustainable development.

Although both negative and positive impact have been analyzed in this research comprehensively, further research with more accurate quantitative calculations should be done. What’s more, studies on how government should extend the ETS coverage of the industries and what specific policy should be combined with ETS in order to obtain the best result should be established as well.

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