Original Research Article

Study on the environmental impact of carbon sinks and carbon trading —A governance perspective on sustainable carbon management

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Abstract: Against the backdrop of global climate change, carbon trading markets and carbon sink mechanisms have become vital tools for controlling greenhouse gas emissions and achieving carbon neutrality. This paper takes the carbon markets in the European Union and China as examples and employs economic theories to construct a supply-demand model and a regression analysis model. The aim is to explore how increasing carbon sink supply contributes to carbon sequestration and ecological sustainability. To answer "What influences the market stability and carbon trading prices of the environment when implementing an environmental governance framework with an increase in carbon sink supply?". The study first reviews the current research on carbon trading and carbon sinks both domestically and internationally, then introduces the research methodology and data sources. Through the development of a mathematical model and empirical analysis, the mechanism of how increased carbon sink supply acts as a carbon sequestration mitigator and thus the policy recommendations are made. The results of the study show that an increase in carbon sink efficiency as a result of well-established governance, and more successful environmental regulations are needed to reach carbon neutrality in the long run by giving policy suggestions for better environmental sustainability.

Keywords: Carbon trading; Carbon sink; Supply–demand model; Regression analysis; Environmental economics

1. Introduction

In recent decades, global warming demonstrated outstanding obstacles to ecosystems, economic development, and social stability. According to the IPCC Sixth Assessment Report (IPCC, 2021), the global average temperature has risen significantly since the Industrial Revolution. To counter carbon neutrality, countries have designed legal frameworks while also market-based tools to control greenhouse gas emissions. Being a market-driven instrument to the low-carbon society, the carbon trading system captures the firms' cost of emissions by allowing them to buy or sell carbon allowances. At the same time, carbon sinks—the forests, ocean, and the rest of ecosystems—are used as a countermeasure to the extraction of CO_2 in the air. The fundamental object of this analysis is to get a grasp of the market supply-side of the carbon sink formation that can help to regulate carbon prices and contribute to a balanced carbon market, against the background of the conventional economic theories.

2. Literature review

The carbon trading sector in China has successfully progressed from pilot projects to the stage of the national ETS. However, this transition is impeded by regulatory obstacles and the requirement for more robust environmental governance frameworks. In opposition to the EU ETS, which is an environmentally structured and policy-driven system, China's system lacks thorough supervision of the environment and mechanisms for law enforcement. The stricter regulatory regime's introduction and the expansion of carbon sink mechanisms, apart from reducing price volatility and the level of carbon prices, can be more effective[4,5]. Research has shown that it is necessary to incorporate green governance strategies into the plans of carbon sequestration to achieve carbon trading plausibility and sustainability. Environmental regulations on the ecological aspect of life and the issue of emission accountability increase the effectiveness of carbon price mechanisms[3]. The research findings revealed that government policies and carbon sink expansion are essential for effective carbon sequestration and climate governance.[4]. The outcomes of these new researches show that better environment protection policies and more sustainable carbon sink management strategies are required.

3. Research methodology and theoretical framework

This research is carried out through the use of literary research as well as the creation of a mathematical model and thus finally through the regression analysis. A carbon trade model in the general economy is modeled as a supply and demand economic theory. Carbon production is settled as a key component of the supply side, thereby causing the price equilibrium in the market to shift. Let the demand function be expressed as $Q_d = a - bP$ and the supply function as $Q_s = c + dP + e(mtCO_2)$, where P represents the carbon price and a, b, c, d, and e are parameters to be estimated[1]. At market equilibrium, $Q_d = Q_s$, yielding a theoretical expression for the equilibrium price.

$$P^* = \frac{a - c - e(mtCO_2)}{b + d}$$

The model is further validated by an ARIMA-based forecasting method and is used to evaluate historical trends and predict future carbon prices. The ARIMA (1,1,1) model discerns time-dependent prices for ETS by employing autoregressive, differencing, and moving average components (Wen et al., 2023).

$$P = \alpha + \beta S + \gamma X + \varepsilon$$

Here, P denotes the carbon trading price, S the carbon sink supply, X represents other influencing factors, α, β, γ are the regression coefficients, and ε is the error term. The regression analysis has been utilized for policy discussion demonstrating evidence resulting from a data sample to evaluate the influence of changes in carbon sink supply on carbon pricing.

4. Data sources and description

The data used in this study are mainly derived from the following sources:

- Government reports: National Carbon Market Development Report (2024) issued by the Ministry of Ecology and Environment of the People's Republic of China;
- International databases: United Nations Framework Convention on Climate Change (UNFCCC);
- Academic databases: Core journal databases such as Web of Science and CNKI.

The data set includes the carbon trading prices, the total amount of carbon emissions, sink carbon supply, and industry-specific grouped data. The data is obtained from public sources and is standardized for its consistency.

5. Mathematical model construction and empirical analysis

This section explores the effect of changes in carbon sink supply on market prices by developing both a supply-demand model and a multiple regression model. First, consider the supply-demand model:

$$Q_d = a - bP$$

$$Q_s = c + dP$$

At equilibrium, where $Q_d = Q_s$, the equilibrium price P* can be derived theoretically. In theory, an increase in carbon sink supply (i.e., a rise in c or changes in d) shifts the supply curve rightward, leading to a reduction in the equilibrium price P*. To test this, the following multiple regression model is estimated:

$$P = \alpha + \beta_1 (Emission) + \beta_2 (Production) + \beta_3 (mtCO_2) + \beta_4 (mtCO_2) + \varepsilon$$

This equation incorporates the concepts of emission and production to explain environmental situation sustainability. Along with mtCO2 for carbon sink supply, the model predicts these parameters utilizing OLS regression with information from the National Carbon Market Development Report (2024). The figures from the model reveal a somehow surprising relation between $mtCO_2$ and carbon price, supporting the notion that increasing carbon sinks will bring more stability to the market.To expand the analysis, an Auto-Regressive Integrated Moving Average (ARIMA) model predicts future carbon trading prices (2025-2030). As carbon prices demonstrate time-dependent behavior, the ARIMA model addresses the issue by capturing both short-term and long-term variations.

The ARIMA model is specified as follows:

$$P_t = \phi P_{t-1} + \theta_1 \epsilon_{t-1} + \epsilon_t$$

Where, P_t represents the carbon price at time t, ϕ_1 accounts the effects of past prices on current prices, θ_1 represents past errors affecting the present and an error term. The ARIMA (1,1,1) model is used in this study, indicating: p=1: Time series of carbon prices are the ones that are correlated with their immediate past values. d=1: First-order differencing refers to the practice of creating a new variable that is the difference between the current and previous observations and is used to remove trends and ensure stationarity. q=1: The model has one term that contains moving average which is used to smooth the short-term price variation.

6. Empirical results and discussion

Based on the regression analysis, there is a substantial contrast between the carbon trading of the EU and that of China where the regulatory integration is less advanced. In the forecast, ARIMA predicts that the price of ETS will go down gradually from 2025 to 2030 in both the Chinese and the EU markets, which corresponds to a stabilization of the market. The situation corresponds to the supply-demand mechanism, and the carbon sinks serve as the stabilizing factor which is expected to reduce the impact of emissions. Additionally, the EU's emphasis on tight policies enhances carbon price stability, while in the China context, the price is simply driven by industrial production[11]. These findings underline that there is a need for more developed market mechanisms in China's carbon trading system.

The EU's mature Monitoring, Reporting, and Verification (MRV) system ensures transparency in emissions data, effectively linking carbon price signals to corporate decarbonization behaviors[11]. In contrast, China's market remains fragmented across regional pilots with inconsistent standards, leading to weak price discovery functions. This institutional disparity explains why China's carbon price predominantly reflects short-term industrial activity rather than long-term climate objectives. Furthermore, the EU's progressive tightening of annual emissions caps creates predictable scarcity, whereas China's allowance allocation still relies heavily on grandfathering methods, reducing market sensitivity. To enhance effectiveness, China could consider establishing a centralized national registry, introducing auction mechanisms for allowance allocation, and expanding sectoral coverage beyond the current power industry. International experiences also suggest that integrating financial instruments such as carbon futures could improve price stability through risk hedging. These institutional innovations would better align China's carbon pricing with its dual carbon goals while maintaining industrial competitiveness during the low-carbon transition.

7. Policy recommendations

Following the analysis made above, several policy recommendations are presented to strengthen both the efficiency of carbon markets and the sustainability of carbon sink management by increasing the effectiveness of environmental governance. The most fundamental point, to begin with, is to better identify emission reduction actions as carbon sinks that absorb greenhouse gases while passing through the atmosphere. A proper accreditation process is not possible without establishing a standardized scientific methodology that ensures credible data results[3]. Furthermore, transforming the construction of the market is required to obtain the needed secure and steady settings for the business. Environmental governance strategies must be implemented to maximize carbon absorption. This includes measures such as strict regulations on carbon emissions, promoting reforestation, and incorporating various carbon sequestration techniques into carbon credit transfer systems. A unified policy that combines both economic and environmental strategies will act as a catalyst for a more resilient and efficient carbon trading market. Fostering a heterogeneous participant base with the help of availability pathways and policy guidance of the carbon sink's supply side can lead to the development of a more resilient trade system. By broadening the range of participants and ensuring adequate liquidity, government officials can control unnecessary price changes and thus, promote market efficiency[9]. The other significant guideline to be followed is to pave the way for a stronger legal structure concerning carbon trading. Laws and their implementation take the management of carbon markets to a different level. The rule-based mode receives the liking that trade deals remain ethical, transparent, and within the national and global scope of climate requirements[10]. Lastly, technological resorts should be the long-term goal in maintaining the carbon footprint under the earth's surface. Capitalizing on the new and renewable technologies associated with carbon capture and liquidation will make a huge impact on emissions reduction. Policymakers can take care of the low-carbon transition and hence the durability in beating climate change through sustainable energy technology and carbon capture systems[7].

8. Conclusion

This research paper seeks to test the effect of the increased use of carbon sinks on environmental governance. The outcome indicates that as carbon sinks contribute more to the environment, carbon sequestration increases, and sustainable carbon neutrality is achieved. Moreover, carbon sink effectiveness is influenced by factors including policy, technology, and various other market dynamics. This research is innovative, given the role of environmental governance in the trade of carbon and the assistance data provides for decision-making in the industry. Future research in this area could be conducted using more reliable carbon sink measurement methods, gathering additional data, and examining how specific regulations or incentives influence the market to become both more efficient and sustainable in the long term.

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