International Journal of e-Collaboration
Volume 21 • Issue 1 • January-December 2025

Research on the Decision-Making Model of Carbon Quota Trading Based on Deep Reinforcement Learning

Jiawen Liu
Grid Planning and Research Center of Guangdong Power Grid Co., Ltd., China

Jiajia Huan
Grid Planning and Research Center of Guangdong Power Grid Co., Ltd., China

Xiaodong Lan
Grid Planning and Research Center of Guangdong Power Grid Co., Ltd., China

ABSTRACT

This study addresses the complexities of carbon quota trading markets amidst global warming concerns, proposing a deep reinforcement learning (DRL)-based decision-making model to enhance trading strategies. Acknowledging the limitations of conventional methods in navigating volatile carbon prices, policy shifts, and informational disparities, the research integrates DRL's advanced capabilities. It commences with an overview of DRL principles and its successful applications, followed by an analysis of market dynamics and trading nuances. A DRL model is then formulated, delineating state-action spaces and a tailored reward function for optimized learning within the carbon trading context. Model refinement involves hyperparameter tuning for superior performance. The summary concludes with an evaluation of the model's efficacy, highlighting its adaptability and computational demands, while outlining avenues for further enhancement and real-world implementation to combat climate change through improved carbon market operations.

KEYWORDS

Deep Reinforcement Learning, Carbon Quota, Trading, Decision Model

INTRODUCTION

With the increasingly serious problem of global warming, reducing greenhouse gas emissions has become a major task facing all countries (Sun, 2020). As an effective means of carbon emission control, carbon quota trading is gradually becoming a key policy tool to deal with climate change (Wu et al., 2022). However, the complexity and volatility of the carbon quota trading market make it difficult to accurately grasp the accuracy of trading decisions (X. Guo et al., 2024). Traditional trading decision-making methods often rely on a large number of historical data or simple mathematical statistical models, which have limitations in capturing market trends and predicting price trends, and are difficult to adapt to the rapidly changing characteristics of the carbon market (Zhang & Chen, 2024). Therefore, it is very important for the healthy development of this market to study a new method that can improve the accuracy and efficiency of carbon quota trading decisions (Zhou,Y. et al., 2024).

Drawing lessons from the deep reinforcement learning (DRL) technology formed by combining the powerful feature representation ability of deep learning with the decision-making optimization

DOI: 10.4018/IJeC.368042

ability of reinforcement learning, this paper constructs a carbon quota trading decision-making model, uses a large number of historical trading data to learn trading strategies, and continuously enriches and optimizes the strategies by simulating the real trading environment, which is helpful to effectively offset the problems caused by the complexity and uncertainty of the carbon quota trading market and improve the accuracy and efficiency of trading decisions.

This paper aims to study the decision-making model of carbon quota trading based on DRL and discuss its core principle, construction process, and other aspects, aiming at solving the complex and changeable decision-making problems in the carbon quota trading market and providing efficient and accurate decision-making support for trading subjects. In the process of model construction, the feature extraction ability of deep learning and the decision-making optimization ability of reinforcement learning are fully combined, and the model parameters are trained and adjusted through a large number of data, so that the model can accurately predict the trend of carbon price and make reasonable trading decisions. Although some achievements have been made in this study on the decision-making model of carbon quota trading based on DRL, there are still many problems worthy of in-depth exploration and potential improvement, including introducing more advanced deep learning algorithms and structures to improve the feature extraction ability and decision-making accuracy of the model, researching more effective reinforcement learning algorithms to speed up the training speed and convergence performance of the model, and considering integrating the model with other related technologies, such as natural language processing technology, to mine and analyze news policies related to the carbon market and provide additional input features for the model. In the future, we will continue to deepen the research on this model, promote its practical application and development in the field of carbon trading, and contribute more wisdom and strength to coping with global climate change.

LITERATURE REVIEW

The application of DRL in decision-making models has gained significant attention in various fields, including finance and trading. Chen and Su (2018) focused on modeling prosumers' energy trading behavior in a local energy market using DRL technology. Li et al. (2019) explored the investment strategy of the stock market based on a DRL model, highlighting the benefits of automated decision-making mechanisms in financial investments. Jeong et al. (2019) proposed methods to improve financial trading decisions using deep Q-learning, combining reinforcement learning with a deep neural network to predict the number of shares accurately. Similarly, Liu et al. (2021) discussed the application of DRL in stock trading strategies and stock forecasting, emphasizing the reliability and advantages of the model compared to traditional approaches. Zhu et al. (2023) introduced a decision-making model for autonomous navigation of maritime autonomous surface ships based on DRL, demonstrating the adaptability of DRL in uncertain environments. Leng et al. (2021) established an order acceptance decision model for printed circuit board manufacturing using a loosely-coupled DRL approach, showcasing the integration of deep learning and reinforcement learning techniques. Sun et al. (2020) presented a synchronous DRL model for automated multi-stock trading, leveraging multi-agent DRL to capture financial market dynamics effectively. Thilakarathna et al. (2020) developed an online optimal investment portfolio model based on DRL, combining deep learning's perception ability with reinforcement learning's online decision-making capabilities. Zhao et al. (2023) highlighted the importance of combining reinforcement learning with sentiment analysis for financial market sentiment prediction, addressing the challenges of poor application effects and low accuracy rates. Finally, Zhang et al. (2023) implemented a cryptocurrency trading bot using DRL, aiming to predict price fluctuations and determine optimal trading points to maximize investment returns.

Deep learning has been increasingly utilized in the financial trading domain to enhance decision-making processes. Chen et al. (2016) introduced a planar feature representation method and deep convolutional neural networks to improve algorithmic trading frameworks. Similarly, Thilakarathna et al. (2020) proposed a Markov decision process model for financial trading tasks