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An integrated approach to optimize moving average rules in the EUA futures market based on particle swarm optimization and genetic algorithms

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HIGHLIGHTS

- We proposed an integrated approach to optimize trading rules in EUA futures market.
- Adaptive moving average rules with different weights are used to make decision.
- The integrated rule is adjusted dynamically with PSO and genetic algorithms.
- Our results show generated trading rules can adapt price changes and make profits.
- This approach is helpful for traders in choosing trading rules and evading risks.

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ABSTRACT

Climate change is a big challenge facing global community in 21st century. The carbon emission futures markets has been treated as a key tool to combat climate change cost-effectively. Making profits from futures trading is the fundamental incentive mechanism to keep this market run sustainably and effectively, while few technique analysis research on this topic has been done in the energy finance field. This paper contributes to the literature by proposing an integrated moving average rule for the European Union Allowance (EUA) futures market and designing an approach to optimize the weights of rules based on Particle Swarm Optimization (PSO) and Genetic Algorithms (GAs). The similarity of trading rules designed here is used to select base rules. An integrated approach based on PSO and GAs is proposed to identify the optimal weights group for the selected base rules. A group of Adaptive Moving Average trading rules with different weights constitutes an integrated trading rule. Experiments using the EUA futures market price were conducted. The results show that: (1) our model is profitable in the EUA future market with the proper parameter except the case that prices fluctuate significantly; (2) the adjustment cycle of 5 days is more useful than 20 days or 50 days; (3) the algorithm achieves the best performance at the 0.78 similarity threshold; (4) the rule with the short period of 150 days and the long period of 200 days is a useful building block for a successive rule set. This approach is a useful reference to the practical investments in EUA futures market.

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1. Introduction

Carbon emission is a hot topic in the energy field. To reduce the industrial carbon dioxide emissions for fulfilling the goals of the Kyoto Protocol, the European Union (EU) launched the EU Emissions Trading Scheme (EU ETS) in 2005. Since then the research

on this system has become hotspot such as the mechanisms [1–3], performance [4–6], risk [7] and legal issues [8]. The impact of EU ETS on low-carbon innovation [9–11] and investment [5,12] has also been extensively debated and over reviewed [13]. Empirical studies about the economic effect on the EU ETS on energy sector have been carried by [14–17] and that on non-energy industries by [18–20]. Related research has been discussed and reviewed by [4,21]. However, most of the existing research focused on the macro level of EU ETS and few studies pay enough attention to the micro aspect of this system, such as the trading

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strategies, which is also important. Since the traders, of this system, the indispensable component of the EU ETS, care more about how to earn more profits in the carbon emission trading markets.

Futures is widely to reduce the investment risk. Carbon emission futures market can help companies store CO₂ allowances or reduce the risk of carbon emissions trading in spot market. Analyzing the price change and price trend features of the carbon emission futures markets and thus deciding an appropriate investment strategy is very important for investors to make profits or reduce the risk substantially. Different studies have been conducted on the CO₂ futures market. Tang et al. [22] analyzed the time range of market efficiency and concluded that the EUA futures market is efficient within 1 month, while Crossland et al. [23] provided evidence that the EU ETS is not market efficient and concluded that investors can do predictions to some degree. Narayan and Sharma [24] found further evidence on the predictability of carbon emission trading prices. Therefore, in this paper we designed an algorithm and did related technical analysis for that kind predictability to help traders make investment decisions in carbon futures market. We proposed a new approach to determine profitable integrated moving average trading rules in the carbon emission futures markets based on the combination of Particle Swarm Optimization (PSO) and Genetic Algorithms (GAs). This algorithm is the core academic contribution of this paper to the literature and owns the value of realistic application.

Whether technical analysis can help traders earn profits is always a controversial topic in the finance field. Neither is there significant evidence that technical methods are completely helpless in all financial markets nor sufficient evidence proving its usefulness in all market circumstances [25,26]. Testing the performance of specific technical trading rules in a target market thus is adopted as appropriate research approach for scholars. Any small profitable opportunities or price change found by technical analysis can provide great market value in the case of huge trading volume. Therefore, there are studies applying various technical analysis of various financial markets pertaining to stock markets [27–29], futures markets [30,31], and exchange markets [32,33]. In this paper, we focus on the design of optimal integrated moving average trading rules to be used in the EUA futures market.

Moving average trading rules are widely used in stock markets [34,35], exchange markets [36] and futures markets [37] because of their effectiveness in describing price trends and ease for conducting. Moving average trading rules inform investors of the transaction timing by comparing the short-period average price with the long-period average price. The short-period average price will exceed the long-period average price when the price is going up. Hence, a long position is taken in this case. Inversely, a short position is taken when the short-period moving average price is lower than that of the long period. Moving average trading rules can be categorized into different types on the basis of the calculation methods of the average prices, and there are several types of moving averages that can be used. Adaptive Moving Averages (AMA) is used in this study because of its performance in describing the price features [38,39]. However, it is worthy of attention that one single AMA with a specific period is incomplete since different short-period lengths and long-period lengths produce various AMA rules and each of them is able to depict partially the price series information. Furthermore, it is extremely difficult, even not possible to find a universal moving average trading rule that fits into with all market circumstances. Thus, a combination of moving average trading rules based on varied period lengths is more suitable for describing different market circumstances.

On the basis of the mentioned above reasons, we decided to integrate different AMA rules based on various period lengths into one comprehensive moving average rule, and the AMA rules selection thus plays a critical role in obtaining an optimal integrated

moving average rule. We designed an algorithm firstly to calculate the similarity degree among short or long position decisions to select the base AMA rules for the integrated moving average rule. With these base AMA rules in hand, we allocated weights to them, which follows the second critical point of our algorithm, that is, the optimal weight allocation for the optimal integrated moving average rule. And the weight allocation of each rule need to be adaptively adjusted based on their performance in the past.

Existing research always used optimization algorithms to determine the final solutions, such as Artificial Neural Networks (ANN) [37,40], adaptive network-based fuzzy inference systems [41], GAs [28,42–46], and PSO algorithms [47–50]. These algorithms are all used to find the most suitable solutions through a training and selection process. A neural network is a black-box approach that is “data-driven and model-free” [51], which is not appropriate for this study since the identification of the optimal weight allocation for basic AMA rules in the EUA futures market is not a black-box problem. For our purpose, we designed our algorithm combining GAs and PSO for two reasons. Firstly, the evolutionary mechanisms of GAs and PSO are very similar. GAs can identify the optimal solutions among a large set of feasible solutions [52]. And all individuals in the group will move to the best individual in every evolutionary generation in PSO process. Secondly, the combination can overcome the corresponding drawbacks of each other. The GAs has slower convergence speed than PSO process while PSO easily converges to the local optimum values. Based on the reason noted above, we proposed a new approach combining GAs and PSO to allocate weight to each base AMA rules for the optimal moving average trading rules in the EUA futures market. And this combination can meet the requirement of dynamic adjustments.

The remainder of this paper is organized as follows: Section 2 describes the data and methods that we use here to find the integrated moving average trading rules in the EUA futures market; it describes the parameter settings as well. The experimental results are presented to analyze the performance and the adaptability of the integrated trading rules in Section 3. We discuss the integrated approach and the experimental results in Section 4. Section 5 concludes the paper with suggestions for traders in the EUA futures market.

2. Data and methods

2.1. Data

We used the EUA Futures prices of European Climate Exchange (ECX) from 2008 to 2015 as sample data to design the optimal integrated moving average trading rules. Each contract represents 1000 CO₂ EU Allowances. With all the sample data we conducted nine experiments to analyze the performances of the adaptive trading rules in the EUA Futures market. Each independent experiment contains 1000 trading days' data. For each independent experiment, the 1000 data points are divided into three sub-samples for specific purposes. The first period of 250 trading days (auxiliary data) are used to select the base moving average rules to be used in the following training and test process. The second period of 250 trading days (training data) are used to identify the optimal weights to all selected base rules. In the final period, a time period of 500 trading days (test data) are used to test the adaptive trading rules to see whether traders can earn profits in the CO₂ emission futures markets. For more detailed results, we divided the last period into several sub-periods and calculated an average return rate of fixed days to check the return rate of the generated adaptive trading rules in different investment cycles.

The following eight experiment is lag behind the former one with 100 trading days. For instance, the sub-sample data for the

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