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Metaheuristic multi-objective optimization of constrained futures portfolios for effective risk management

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ABSTRACT

In the Derivatives financial markets, Futures portfolios are perceived to be instruments of high risk, despite their flexibility of being used for portfolio protection (hedging) or for profitable trading (speculating). A multi-pronged approach for an effective management of the risks involved includes employing strategies such as, diversification between dissimilar markets, decision to go long or short on assets that make up the portfolio and risk tolerance or risk budgeting concerned with how risk is distributed across asset classes constituting the portfolio with all of these governed by investors' preferences and capital budgets. However, the inclusion of such objectives and constraints turns the problem model complex for direct solving using analytical methods, inducing the need to look for metaheuristic solutions.

In this paper, we present a metaheuristic solution to such a complex futures portfolio optimization problem, which strives to obtain an optimal well-diversified futures portfolio combining several asset classes such as equity indices, bonds and currencies, subject to the constraints of risk and capital budgets imposed on each of the asset classes, besides bounding constraints. The Herfindahl index function has been adopted to measure diversification of the long-short portfolio. In the absence of related work and considering the complexity of the problem that transforms it into a non linear multi-objective constrained optimization problem model, two metaheuristic strategies viz., multi-objective evolution strategy and multi-objective differential evolution, chosen from two different genres of evolutionary computation, have been employed to solve the complex problem and compare the results. Extensive simulations including performance analyses, convergence testing and back testing portfolio reliabilities have been undertaken to analyze the robustness of the optimization strategies.

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1. Introduction

Futures contracts are key players in the *Derivative financial markets*, which include a variety of other financial contracts such as Options, Forwards and Swaps, and variations of these [1]. A futures contract is an agreement to buy or sell a specified amount of commodity or a non-commodity such as index, currency, bond or other asset of value, for a certain price at a certain time in the future. The contract sets the value and is usually referred to by its delivery month which is set ahead of time. The price is known as the *futures price*. The futures contracts can be bought or sold only on the *futures exchange*. Anyone who *buys a futures contract* directly or through one of the pooled investment alternatives is said to take up a *long position* and anyone who *sells a futures*

contract by closing the position with a closing purchase transaction is said to take up a *short position*. Thus one of the crucial elements of the futures contracts is the decision on which positions need to be taken long or short which defines and distinguishes risk as well. Thus, futures markets deal with risk and risk transfer where investors (*hedgers*) hedge positions against risk by transferring the same to investors (*speculators*) who are willing to accept those risks in exchange for the profit potential. The profits and losses of a futures contract depend on the daily movements of the market for that contract and are calculated on a daily basis.

However, earning profits through futures trading is fraught with risks and therefore a perspective on futures requires a complete appreciation of the risks involved [2]. *Diversification* and the process of *allocation* which involves investments in different markets is a popular strategy to mitigate risk. With different securities performing differently at any point in time, the objective of diversification is to minimize financial losses by constructing a portfolio of mixed asset classes and types so that the decline of one or more assets in the portfolio does not severely

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