Knowledge-Based Systems 000 (2017) 1–11

Contents lists available at ScienceDirect

Knowledge-Based Systems

journal homepage: www.elsevier.com/locate/knosys

International asset allocation optimization with fuzzy return

Yong-Jun Liu[a,*], Wei-Guo Zhang[a], Pankaj Gupta[b]

[a] School of Business Administration, South China University of Technology, Guangzhou 510641, PR China
[b] Department of Operational Research, University of Delhi, Delhi, India

ARTICLE INFO

Article history:
Received 5 December 2016
Revised 11 October 2017
Accepted 18 October 2017
Available online xxx

Keywords:
International asset allocation
Fuzzy set theory
HARA utility
Differential evolution algorithm

ABSTRACT

This paper investigates an international asset allocation problem in a fuzzy uncertain environment, where the risk attitudes of investors are taken into consideration. Since investors are usually risk aversion, we use the possibilistic risk premium index to measure their required compensation for implementing a venture investment in the paper. Then, we present a possibilistic international asset allocation optimization model with realistic constraints. The main features of the proposed model are that we represent investors' risk preferences by the commonly-used hyperbolic absolute risk aversion (HARA) utility function, and incorporate some realistic constraints into the proposed model to simulate the transaction in the real world financial markets. To solve the proposed model, we design a time variant differential evolution with harmony search (TVDEHS) algorithm in the paper. Finally, we provide a numerical example to demonstrate the application of the proposed model and highlight the performance of the designed algorithm.

1. Introduction

With the development of economic globalization, more and more investors have played attention to explore investment opportunities in foreign countries. Comparing with domestic investments, international asset allocation allows investors to achieve a better risk-return trade-off. The pioneer work of international asset allocation is the mean-variance model in Markowitz [34]. Research in this area began with Grubel [20], in which modern portfolio theory was applied to a global setting. After that, researches on international asset allocation have received increasing attention. Eun and Resnick [14] pointed out, even after controlling for exchange risk, an internationally diversified portfolio significantly outperforms a portfolio that was invested in only US securities. Grubel [20] mentioned that investors could achieve a lower variance in returns from the internationally diversified portfolio because of the less than perfect correlations amongst different stock markets around the world. Barras [4] examined the impact of specification uncertainty on the performance of international mean-variance conditional asset allocation. Topaloglou et al. [49] developed an integrated simulation and optimization framework for multicurrency asset allocation problems. Lioui and Poncet [31] discussed the issue of optimal international portfolio allocation in a general multi-period model with exchange rate and interest rate risks. Thapa and Poshakwale [47] discussed the influence of transaction costs on international equity portfolio allocation decisions. Fonseca and Rustem [16] discussed an alternative tractable approach to multiperiod international portfolio optimization based on an affine dependence between the decision variables and the past returns. As mentioned by Santis et al. [42], a stable broad money demand for the euro area over the period 1980–2011 can be obtained by modeling cross border international portfolio allocation.

1.1. Research issues and need for this paper

Notice that most of existing studies about international asset allocation are proposed on the basis of probability theory. Among these studies, they only considered the influence of random uncertainty on international asset allocation. Actually, there are many non-random factors such as vagueness and ambiguity affected international asset allocation. The aforementioned vagueness and ambiguity are mainly caused by human's subjective factors including political, legal, economic, cultural, social and people's psychological factors. Thus, it is necessary to investigate human's subjective factors on international portfolio decisions. Following the widely use of fuzzy set theory in Zadeh [54], more and more people have realized that they could use it to handle the vagueness or ambiguity associated with portfolio decision problems.

In this paper, we investigate an international asset allocation in a fuzzy environment. We present a possibilistic international

* Corresponding author.
E-mail addresses: bmyjliu@scut.edu.cn, yjlgx0202@126.com (Y.-J. Liu), wgzhang63@126.com, wgzhang@scut.edu.cn (W.-G. Zhang).

https://doi.org/10.1016/j.knosys.2017.10.019
0950-7051/

asset allocation optimization model with realistic constraints. In the proposed model, we use the commonly-used hyperbolic absolute risk aversion (HARA) utility function to express investors' different risk preferences. Considering the complex structure of the proposed model, we design a time variant differential evolution with harmony search (TVDEHS) algorithm to solve it.

1.2. Literature of relevant works

There is extensive literature on portfolio selection under the framework of probability theory. Though probability theory is used as a tool to handle the uncertainty of financial markets. However, it cannot completely describe the uncertainty of financial markets because the financial market behavior is often affected by many non-random factors such as vagueness and ambiguity (see[27]). As mentioned by Carlsson et al. [8], the use of probabilities is not a good choice in these cases that the assignment of probabilities is based on very rough, subjective estimates and then the subsequent calculations are carried out with a precision of two decimal points. The real meaning of the results of an analysis may be totally unclear or results with serious errors that may be accepted at face value. It is well known that the financial market is a complex and ever-changing system. Investors are often provided information with vague linguistic descriptions such as high risk, low profit, high interest rate, etc. (see [44]). In these cases, it is impossible for us to predict the precise values about the parameters what we need for making a portfolio decision. Fuzzy numbers and more generally linguistic values, given by experts and accepted by decision-makers, provide a powerful tool for describing the aforementioned fuzzy uncertainty (see [12]). In fact, researches on fuzzy portfolio selection were dated from 1990s. Numerous researchers have studied fuzzy portfolio selection problems. For example, Inuiguchi and Ramík [23] reviewed some fuzzy linear programming methods and techniques for portfolio selection problems from a practical point of view. Parra et al. [38] took return, risk and liquidity into consideration and proposed a fuzzy goal programming model for portfolio selection problem. Zhang et al. [57] discussed the portfolio selection problem for bounded assets based on the possibilistic mean-variance utility function and proposed a SMO algorithm special for the problem. Liu [32] presented a mean-absolute deviation risk function model for portfolio selection problem with fuzzy returns. Calvo et al. [6] presented a fuzzy multi-criteria portfolio selection model. García-Crespo et al. [17] provided a behavioral orientation to portfolio recommendations by means of fuzzy logic and semantic technologies. Gupta et al. [21] proposed a comprehensive three-stage multiple criteria decision making framework for portfolio selection based upon financial and ethical criteria simultaneously. Messaoudi et al. [36] proposed a fuzzy chance-constrained goal programming model for multi-attribute financial portfolio selection. Mashayekhi and Omrani [35] constructed an integrated multi-objective Markowitz-DEA cross-efficiency model with fuzzy returns for portfolio selection problem. Yue and Wang [53] proposed a fuzzy multi-objective higher order moment portfolio selection model.

Notice that the aforementioned fuzzy portfolio selection models were proposed on the basis of return and risk trade-off. However, in the real world, portfolio selection must consist of more criteria than only risk and return in order to provide investors with additional choices. Researches on the criteria of portfolio selection have become more popular in recent years [52]. Empirical studies show that it may result in an improved optimal portfolio by considering the skewness into an investor's portfolio for instant in Joro and Na [24], Li et al. [28] and Prakash et al. [39]. If the influence of the skewness on a portfolio is excluded, then it may lead to an inefficient portfolio (see [33]). In particular, when a portfolio with the same first and second moments, the influence of skewness on portfolio selection cannot be neglected. Vercher and Bermudez [50] introduced the skewness as the measure of the asymmetry of the fuzzy return on a given portfolio and studied its role in a fuzzy portfolio selection problem. So far, some researchers have investigated fuzzy portfolio selection problems with higher moments. Li et al. [28] employed the credibilitic skewness to describe asymmetry of the fuzzy return on a given portfolio and formulated a mean-variance-skewness model for fuzzy portfolio selection problem. Kamdem et al. [26] considered the credibilistic moments and semi-moments for portfolio selection with fuzzy risk factors. Georgescu [18] used a utility function to express an investor's different risk preferences. Zhang et al. [55] developed a mean-semivariance-entropy model with transaction costs for portfolio selection. In addition, incorporating more realistic constraints into portfolio selection models is also very important, which is related to their application. A few researchers formulated portfolio optimization models with cardinality constraints, see for example [3,5]. Fang et al. [15] investigated a portfolio rebalancing problem with transaction costs based on fuzzy decision theory. Zhang et al. [56] discussed a portfolio adjusting problem with added assets and transaction costs based on credibility measures. Zhang et al. [58] proposed a risk tolerance model for the portfolio adjusting problem based on possibilistic moments. Gupta et al. [22] constructed a multi-criteria credibilistic portfolio rebalancing model.

Though the above-mentioned fuzzy portfolio models provide guidance for portfolio management in the real world. They only focused on domestic investment decision problems, which may limit their application. In the real life, some investors especially institutional investors often emphasize on exploring investment opportunities in foreign countries. So, it is essential to investigate an international asset allocation problem in a fuzzy environment. For an international portfolio decision problem, some theoretical and empirical literature have shown that exchange rate is one of important factors that cannot be neglected (see e.g., [14,47]).

1.3. Focus of this paper

To our knowledge, there are few researches about fuzzy international asset allocation. The aim of this paper is to discuss a fuzzy international asset allocation problem based on possibility theory. The major contributions of this study are summarized the following three important aspects. (1) We use the HARA utility function to express investors' risk preferences for venture investment in international financial markets under fuzzy environment. (2) We propose a possibilistic international asset allocation optimization model by considering some real factors about portfolio selection including exchange rate, discounted buying and selling transaction costs, skewness, transaction lots constraint, cardinality constraint and class constraint. (3) We design a TVDEHS algorithm to solve the proposed model.

1.4. Organization of this paper

The remainder of this paper is organized as follows. In Section 2, we briefly introduce some basic conceptions about fuzzy numbers. In Section 3, we propose a possibilistic international asset allocation optimization model with realistic constraints. In Section 4, we design a time variant differential evolution with harmony search (TVDEHS) algorithm to solve the proposed model. In Section 5, we provide a numerical example to illustrate the effectiveness of the designed algorithm and discuss the implication of the obtained results. Finally, we present conclusions and future research directions in Section 6.

Please cite this article as: Y.-J. Liu et al., International asset allocation optimization with fuzzy return, Knowledge-Based Systems (2017), https://doi.org/10.1016/j.knosys.2017.10.019