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A novel portfolio selection model based on fuzzy goal programming with different importance and priorities

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ABSTRACT

Despite the risk–return tradeoff is main concern of financial theory; the rational investment decisions requires considering many criteria simultaneously. In addition to determining a certain importance and priority among these criteria, modeling the investor behaviors in accordance with market trends provides much more realistic approach. However, the researchers mostly overlook to evaluate these concepts simultaneously. This article introduces a novel fuzzy portfolio selection model that takes into accounts the risk preferences in accordance with the market moving trends as well as the risk–return tradeoff, and allows the decision makers to define a certain importance and priority among their objectives. To construct this model, firstly the portfolio return, risk and beta coefficient are assumed as main objectives including the possibilistic uncertainties. To define possibilistic uncertainty, the specific fuzzy membership functions are constituted for these objectives with respect to the risk preferences of investors and market moving trends. By means of the fuzzy goal programming techniques, a novel portfolio selection model is developed using these specific fuzzy membership functions. In the application section, three investment terms are examined in the Istanbul Stock Exchange National 30 Index. While ISE30 index has the upward (bullish) and the downward (bearish) moving trends in the first two implementations, the third implementation includes a scenario in which the investors desire to chase the ISE30 index. In the analyses, the proposed model is compared with the classical Mean–Variance, Mean-Absolute-Deviation and Maxmin models in terms of their portfolio returns based on the selling prices in the test periods. As a result, the proposed model gives superior performance than the classical models because it takes into account the investor preferences in accordance with market moving trend.

1. Introduction

The evaluation of risky assets is one of the major research tasks in finance for years. Markowitz (1952) defined the risk as the variance that is basically measured as the expected value of the squared deviation from the expected return of an asset. Essentially, the total risk can be divided into two general types of risk: systematic risk and unsystematic risk (Kocadagli, 2013). Sharpe (1964) defined systematic risk as a portion of an asset's variability that is caused by inherent uncertainty of benchmark market. Whereas unsystematic risk is described as a reducible factor that comes with an asset and it can be diversified away (Fabozzi, 1999). Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and Lintner (1965), and then extended by Black, Jensen, and Myron (1972), is mostly used to measure the systematic risk in the portfolio selection evaluations. In this model, known as Sharpe-Lintner-Black mean–variance CAPM, the typical measure of asset riskiness is beta coefficient. This coefficient, referred as a systematic risk, simply deals with the variability of an asset's historical returns to a benchmark market. In other words, beta coefficient corresponds to the expected change of an asset for every percentage change in the benchmark index (Clarfeld & Bernstein, 1997). Besides, CAPM allows the investors to make powerful and intuitively pleasing predictions about how to measure risk and the relation between expected return and risk (Fama & French, 2004). While making investment decisions, the investors are concerned only with the systematic risk, because the unsystematic risk is diversified away by a well-balanced portfolio. For this reason, beta coefficient plays important role to make the realistic investment decisions (Kocadağlı & Keskin, 2013; Maximiliano, 2001).

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For well-known classic portfolio selection models such as mean–variance (L^2 risk) of Markowitz (1952), mean-absolute deviation (L^1 risk) of Konno and Yamazaki (1991), Minimax portfolio selection model of Young (1998) (based on Maxmin selection criterion in Game Theory), etc.; the main concern is to minimize the risk at any given expected return level. However, there are various factors that the decision makers should take into accounts making true investment decisions such as the liquidity, the currency exchange risk, the transaction costs, the different types of investor behaviors and the financial market trends rather than the risk-return tradeoff. If the liquidity, the currency exchange risk and transaction cost are overlooked in the decision process, the movements of financial market and the different types of investor strategies plays important roles in the decision making process in the financial markets (Keskin, Kocadağlı, & Cinemre, 2015). In order to model the market movements, beta coefficient should be used as a fuzzy goal or a restriction in any portfolio selection model together with different types of investor strategies (Gunasekaran & Ramaswami, 2014; Kocadağlı & Keskin, 2013).

While the decision makers are developing the portfolio selection models, they encounter probabilistic and possibilistic uncertainties simultaneously related to the concepts of investment process. Although the researches have mostly endeavored to define all the uncertainties by means of the probability theory, some uncertainties cannot be explained accurately in the probabilistic nature. In order to model this kind of uncertainty, the fuzzy theory provides a useful framework. Essentially, such a framework provides a natural way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables (Zadeh, 1965).

In course of constructing the portfolio selection models, another issue deals with considering different kinds of objectives simultaneously. In the investment process, the investors generally assign different sizes of goals to these objectives having different importance and priority in accordance with their investment strategies. To make reasonable investment decisions, all these concepts must be evaluated accurately. In context of the expert and intelligent systems, constructing the portfolio selection models can be handled by the multi-objective programming (MOP) which provides flexible and natural way to model different types of objectives, and then these models can be solved by artificial intelligence techniques. If these objectives are considered in the fuzzy nature, MOP is transformed into by the fuzz multi-objective programming (FMOP). In FMOP, the fuzzy goal programming is a special case in which the fuzzy goals are assigned to the related objectives in the certain importance and priority with respect to different types of decision maker behaviors (Chen & Tsai, 2001; Keskin et al., 2015; Kocadağlı & Keskin, 2013; Messaoudi & Rebai, 2013; Wang & Fu, 1997).

Generally, goal programming, developed by Charnes and Cooper (1961), is a mathematical programming technique that allows handling multiple objectives simultaneously. Bellman and Zadeh (1970) introduced a basic framework for multiple decision making in the fuzzy environment. Afterwards, Zimmermann (1976) extended the fuzzy linear programming approach to the conventional FMOP. Narasimhan (1980) and Hannan (1981) worked on the goal programming based on the fuzzy set theory. In the context of the fuzzy goal programming and fuzzy multi criteria, the other remarkable contributions can be found in Rubin and Narasimhan (1984), Tiwari, Dharmar, and Rao (1987), Wang and Fu (1997), Chen and Tsai (2001), Yaghoobi and Tamiz (2007), Hu, Teng, and Li (2007), Walter, Stefan, Peter, Christian, and Michaela (2010), Sener and Karsak (2011), Cheng (2013), Liu, Xia, and Chi (2014), Liao and Xu (2015)

In the financial implementation of FMOP; Parra, Terol, and Urıa (2001), Watada (2001), Fang, Lai, and Wang (2006), Kocadağlı (2006), Hu, Wang, Fetch, and Bidanda (2008), Zarandi and Yazdi (2008), Gupta, Mehlawat, and Saxena (2008), Kocadağlı and Cinemre (2010) proposed the multi-objective models with different perspectives in the fuzzy nature. Recently, Messaoudi and Rebai (2013) solved the portfolio selection problem by means of a fuzzy stochastic goal programming approach. Kocadağlı and Keskin (2013) developed a fuzzy portfolio selection model with preemptive structure that considers CAPM beta, risk and return tradeoff in accordance with different decision maker behaviors. Gunasekaran and Ramaswami (2014) developed a portfolio selection procedure based on the hybrid intelligent system of ANFIS and CAPM beta. Zhang and Zhang (2014) proposed a new multi-period mean absolute deviation fuzzy portfolio selection model with transaction cost, borrowing constraints, threshold constraints and cardinality constraints based on the theory of possibility measure. Li, Zhang, and Xu (2015) and Li, Guo, and Yu (2015) constructed a fuzzy portfolio selection model with background risk based on the definitions of the possibilistic return and possibilistic risk where the returns of assets are defined by LR-type possibility distribution. Li et al. (2015) and Li, Guo, et al. (2015) propose a fuzzy mean–variance–skewness portfolio selection model in which variance, mean and skewness concepts are redefined by fuzzy theory. Xu, Deng, and Li (2015) handled the vagueness of the investor's preferences in the fuzzy portfolio selection model based on the elastic increment of decision-making risk, background risk, and other financial risks. Keskin et al. (2015) developed the fuzzy portfolio selection model which allows the decision makers to determine preemptive structure among the fuzzy goals.

The purpose of this study is to develop a novel portfolio selection model based on the fuzzy goal programming which allows the decision makers to evaluate their objectives considering different importance and priority according to market moving trends. As mentioned above, many portfolio selection models have been proposed in the different perspective to make a reasonable decision in the multi-objective cases. However, there are very few studies where the market moving trends and decision maker behaviors are considered simultaneously in the fuzzy nature. In this study, to construct the reasonable portfolio selection models in accordance with market moving trends and investor behaviors, all the objectives encountered in the investment process are handled in the fuzzy nature. To do so, firstly it is assumed that risk, return and CAPM beta coefficient of portfolio have the possibilistic uncertainties, and then their fuzzy membership functions are constituted with respect to different investor behaviors: risk aversion, risk neutral and risk seeking. Differently from available portfolio selection models in the literature; the fuzzy goals are assigned to risk, return and beta coefficient of portfolio in the certain importance and priority. Lastly, a novel portfolio selection model is constructed by means of the fuzzy goal programming approaches based on certain importance and priority over fuzzy goals.

To summarize, the proposed approach allows the researchers to construct the flexible portfolio selection models accordance with market moving trend and investor behaviors and it provides reasonable solutions in the context of expert and intelligent systems. In order to introduce this novel approach, this paper is organized as following. Section 2 includes the general fuzzy goal programming background of the proposed approach. Section 3 is left to constitute the fuzzy membership functions of risk, return and CAPM beta coefficient, respectively. Section 4 covers how to construct the proposed portfolio selection model. Lastly, Section 5 demonstrates the real life implementations of proposed models. In this section, to evaluate the return performances of portfolio selection models constructed according to investor behaviors in the different moving trend cases, three investment terms are determined separately