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A new method for better portfolio investment: A case of the Korean stock market

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ABSTRACT

In this study, a method is devised to estimate a correlation matrix capable of constructing a well-diversified portfolio by the Markowitz mean-variance (MV) optimization function (MVOF), after which evidence is presented to empirically prove that the proposed method effectively reduces the sensitivity of portfolio output caused by the error of input variables, such as the mean and standard deviation of stocks in a portfolio. The proposed method removes the property of a market factor included in the sample correlation matrix through random matrix theory. The results demonstrate the comparative advantage of the proposed method in effectively reducing the sensitivity on both the estimation error and the prediction error from the mean and standard deviation. In particular, this comparative advantage is dependent on the striking reduction of portfolio risk gained by constructing the well-diversified portfolio. The proposed method also achieves high investment performance in the risk-return domain, and is particularly stronger in the unstable situation of either a market crash or a higher-risk portfolio. Consequently, this study offers new insight into how to enhance the practical applicability of the MVOF by controlling the property of the market factor in the sample correlation matrix.

1. Introduction

The Markowitz (1952) mean-variance optimization function (MVOF) provides a method that can quantitatively determine the investment weight of stocks constructing a portfolio in the domain of risk-return relation. The MVOF can be used to construct an efficient portfolio satisfying both the risk-return investment rule and well-diversified investment weights. The risk-return investment rule provides an investment opportunity set composed of various combinations between risk and return of portfolio for investors. The portfolio generated by the MVOF is an efficient portfolio having the minimum risk for given return or the maximum return for given risk. Markowitz (1952) emphasizes that an efficient portfolio is strongly dependent on evenly distributing investment weights for stocks in a portfolio, rather than the increasing number of stocks in a portfolio. However, many practical investors have hesitated to utilize the MVOF as a tool for determining the allocation of investment weight for stocks in a portfolio, in spite of the theoretical and the scientific robustness. This is because of the practical problem of the MVOF that biasedly distributes most investment weight into some stocks in a portfolio. Therefore, the recent studies related to the Markowitz optimum theory have focused on uncovering an alternative method capable of overcoming the practical problem of the MVOF. On the one hand, volatility of stock return has time-varying property over time. Campbell et al. (2001) report that market volatility has decreased but idiosyncratic volatility has recently shown a tendency to increase. Ang et al. (2006, 2009) show evidence supporting the significant effect of idiosyncratic volatility on

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the expected return. Brandt et al. (2010) and Bekaert et al. (2012) suggest that idiosyncratic volatility has increased compared to the past and that it changes according to the market situation and business cycle. These results imply that even a well-diversified portfolio may be exposed to high risk and that, moreover, a poorly diversified portfolio can be exposed to more serious risk. The decrease of market volatility and the increase of idiosyncratic volatility have a meaningful influence on the correlation among stocks. These previous studies emphasize the need for research on the effect of the correlation matrix among stocks on portfolio diversification, both in practice and in academia; our study is founded on this motivation.

Michaud (1989), Best and Grauer (1991) and Jorion (1992) argue that the MVOF tends to ignore the error of input variables, and further amplifies the influence of the error into the investment weight of stocks in a portfolio as the output. The MVOF determines the amount to be invested in each stock during the future period using estimates of input variables in the past period, such as the mean and standard deviation of stocks and the correlation matrix between stocks. The input variables that are estimated in the past period cannot avoid the possibility of the error because it is not a true value. Michaud (1989) mentions that the MVOF may produce a harmful allocation decision rather than a good allocation decision if the error of input variables is not adjusted. The MVOF has a tendency to excessively distribute investment weight into stocks having higher mean, lower standard deviation, and lower correlation matrix with other stocks, due to the objectives function for minimizing portfolio risk or maximizing portfolio return. Hence, the investment weight that is biasedly distributed by the preference of the MVOF may amplify the impact of the error of input variables on the portfolio output in the future period. Michaud (1989) describes the MVOF as an error maximizer, based on the financial instabilities and defects that cause excessively large changes of output on the even small error of input variables. Best and Grauer (1991) and Jorion (1992) empirically examine the sensitivity of the MVOF on the error of stock mean. In here, the sensitivity represents the magnitude of changes in portfolio output generated from the MVOF, such as portfolio return and risk, as well as investment weight for each stock. The stock mean indicates the estimate in the past period as a role of the expected return of stock in the future period. They show that the portfolio output from the MVOF is very sensitive to the error of the stock mean estimated in the past period, in particular, when allowing the condition of short-sale, which is evidence to support the error maximizer asserted by Michaud (1989). On the other hand, the practical problem mentioned in the previous studies might be explained based on the characteristic of the sample covariance matrix, as one of the input variables in the MVOF. The sample covariance matrix having a component of the correlation matrix among stocks is the measurement to quantify the relationship on the return changes of stocks.

Chan et al. (1999) and Ledoit and Wolf (2003, 2004) focus on the covariance matrix in order to improve the practical problem of the MVOF. In particular, the portfolio output from the perspective of out-of-sample in the future is empirically investigated. The method of these studies determines the investment weight for stocks by focusing on the role of the covariance matrix having sufficient properties of common factors in the MVOF. Chan et al. (1999) utilize the covariance matrix estimated from the factor models using the statistical factors and the fundamental factors. They report that the portfolio output of the MVOF using the covariance matrix that strongly reflects the properties of common factors has a lower sensitivity on the prediction error of the input variables in the future period, compared to using the sample covariance matrix. Ledoit and Wolf (2003, 2004) propose the shrinkage method that generates the weight-averaged covariance matrix between the sample covariance matrix and the estimated covariance matrix based on the research goal. The shrinkage constant as a weighting ratio is determined by minimizing the difference between the estimated value and the true value of the covariance matrix. By the shrinkage method in Ledoit and Wolf (2003), a weighting of 70–80% is given to the covariance matrix that reflects the property of the common factor, on average. Therefore, the shrinkage method adjusts the weight in order to limit the impact of firm-specific properties of stocks in the covariance matrix and to simultaneously increase the influence of the property of the common factor in the covariance matrix. Ledoit and Wolf (2003, 2004) present empirical evidence revealing that the sensitivity of the MVOF from the prediction error is reduced when using the shrinkage method based on the covariance matrixes estimated by the single-factor model of Sharpe (1963) and the constant correlation method of Elton and Gruber (1973). More recent studies under the shrinkage framework suggest methods for constructing the portfolio that are better diversified and less sensitive to the estimation error of input variables. Kourtis et al. (2012) propose the estimation method of the covariance matrix that provides a higher risk-adjusted return and a lower risk in the global minimum variance portfolio using out-of-sample. The method based on the shrinkage framework is a linear combination between the maximum likelihood estimator of the covariance matrix and the structure matrices (target matrix), which are less sensitive to estimator error. The weighted average coefficient of the linear combination is determined using two non-parametric methods: a cross-validation methodology that achieves lower out-of-sample portfolio risk, and the serial dependence of portfolio returns that performs higher out-of-sample risk-adjusted return. They show evidence supporting the higher risk-adjusted return and lower risk of the proposed portfolio strategy, compared to methods of previous studies. Behr et al. (2013) introduce a new strategy of the global minimum variance portfolio with upper and lower portfolio weight constraints. Based on the trade-off between the reduction of sampling error and the loss of sample information, the method under the shrinkage framework utilizes the set of lower and upper portfolio weight constraints that minimizes the sum of the mean squared error of elements in the covariance matrix in order to achieve a lower out-of-sample variance and a higher Sharpe ratio. They show that the new portfolio strategy has lower out-of-sample variance and higher Sharpe ratio compared to the equal-weighted portfolio, that is, the 1/N strategy suggested by DeMiguel et al. (2009).

This study aims to devise a method to estimate a correlation matrix capable of effectively reducing the influence of the error from the mean and standard deviation of stocks on the MVOF by constructing a well-diversified portfolio, and then to empirically investigate whether the proposed method substantially overcomes the practical problem of the MVOF. Generally, the practical applicability of the MVOF is expected in terms of the stability of portfolio performance from the passive investment strategy by asset allocation, rather than the profitability from the active investment strategy by prediction and selection. Hence, investors expect to be able to construct a well-diversified portfolio by using the investment weight for stocks generated by the MVOF. However, as mentioned in Michaud (1989), the MVOF using the sample correlation matrix induces a practical problem that biasedly distributes