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Two-faced property of a market factor in asset pricing and diversification effect

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HIGHLIGHTS

- This study focuses on the largest eigenvalue having the property of the market factor.
- The largest eigenvalue has the highest explanatory power on the stock return changes.
- The largest eigenvalue prevents the construction of a well-diversified portfolio.
- The market factor has the two-faced property in the pricing and the portfolio diversification.
- The devised method assists in constructing a more diversified portfolio with better performance.

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ABSTRACT

This study empirically investigates the test hypothesis that a market factor acting as a representative common factor in the pricing models has a negative influence on constructing a well-diversified portfolio from the Markowitz mean–variance optimization function (MVOF). We use the comparative correlation matrix (C-CM) method to control a single eigenvalue among all eigenvalues included in the sample correlation matrix (S-CM), through the random matrix theory (RMT). In particular, this study observes the effect of the largest eigenvalue that has the property of the market factor. According to the results, the largest eigenvalue has the highest explanatory power on the stock return changes. The C-CM without the largest eigenvalue in the S-CM constructs a more diversified portfolio capable of improving the practical applicability of the MVOF. Moreover, the more diversified portfolio constructed from this C-CM has better out-of-sample performance in the future period. These results support the test hypothesis for the two-faced property of the market factor, defined by the largest eigenvalue.

1. Introduction

In the field of finance, a market factor acts as a crucial common factor in the pricing models that significantly explain stock return changes, such as the capital asset pricing model by Sharpe–Lintner–Mossin, the three-factor model by Fama & French, and Carhart's four-factor model [1–5]. A factor with the property of a market factor exerts the significant influence in the pricing model that includes both well-known and unknown factors generated by statistical analysis [6,7]. This study aims to uncover empirical evidence to support the test hypothesis that the market factor plays a crucial role in explaining the stock return changes in the pricing model, while also negatively affecting the construction of a well-diversified portfolio from the Markowitz mean–variance optimization function (MVOF) [8]. The rationale for the research goals is as follows: Markowitz emphasizes that the effect of portfolio diversification is achieved by evenly distributing the investment weight

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over all stocks in a portfolio rather than by simply increasing the number of stocks. The modern portfolio theory proposes that as the correlation among stocks in a portfolio decreases, the portfolio efficiency increases through well-diversified investment weighting of stocks. The market factor must be a representative common factor capable of explaining the stock return changes in the pricing model because it is a common part of all stocks that are commonly affected by market changes. Therefore, the market factor increases the correlation among stocks and hence may negatively affect the construction of a more diversified portfolio. This study empirically proves the two-faced property of the market factor that plays a crucial role to increase the explanatory power for the stock return changes in the pricing model, and simultaneously, has a negative influence on constructing a well-diversified portfolio from the MVOF.

The Markowitz optimum theory has been highly acclaimed for its academic contribution in the field of finance, but unfortunately previous studies have reported problems in practical applications. Michaud [9] argues that the MVOF devised for effective asset allocation is actually an error maximizer that amplifies the error of input variables into the output. The difficulty in predicting inputs of the MVOF in the future investment period means that the input variables contain the prediction error. Portfolio diversification from the MVOF has been touted as a tool for limiting the risk of uncertainty arising from the prediction error of input variables. However, previous studies have indicated that the MVOF is very sensitive to the error of the input variables [10,11]. Furthermore, the MVOF tends to biasedly distribute most of investment weight into only certain stocks when using the sample covariance matrix among stocks, so that the constructed portfolio may be exposed to an idiosyncratic risk. Accordingly, Michaud stresses the difficulty in practically applying the MVOF without a careful adjustment of the input variables. On the other hand, other studies tried to overcome the practical problems of the MVOF [12–16]. One such method is using the covariance matrix estimated from the beta coefficient as a systematic risk, in order to sufficiently reflect the properties of common factors in the pricing models [12–14]. Another method adjusted the magnitude of the correlation matrix by using the average value of the correlation among stocks [15,16]. These previous studies suggest that methods focusing on the properties included in the covariance and correlation matrixes may substantially improve the practical applicability from the MVOF. Therefore, based on these previous studies, this study adjusts the magnitude of the correlation matrix by controlling the properties of various factors included in the sample correlation matrix (S-CM).

The random matrix theory (RMT) [17] effectively controls the properties of various factors included in the S-CM. Using RMT enables both known and unknown factors in the S-CM to be considered. Eigenvalues that deviate from the random correlation range in the RMT have the properties of market and industry factors [18]. In particular, the largest eigenvalue has the property of a market factor regardless of the sample data selected in the stock market [19]. Using the RMT, this study generates a comparative correlation matrix (C-CM) that controls the property of a single eigenvalue in the S-CM [20–22]. A two-type C-CM is devised: a correlation matrix having the property of only a single eigenvalue and a correlation matrix without the property of the single eigenvalue in the S-CM. This design may enhance the reliability of empirical evidence by verifying whether or not the results from the two-type C-CM are qualitatively the same. In particular, this study focuses on the largest eigenvalue having the property of the market factor among all eigenvalues included in the S-CM.

In addition, this study performs a joint test that combines results from the MVOF and the minimal spanning tree (MST) using the same correlation matrix as the key input data [23,24]. The rationale of the joint test is as follows: The stock network generated by the MST is directly affected by the correlation matrix among stocks [25]. The MST tends to preferentially connect stocks that are highly correlated to other stocks, and these stocks tend to have many links to other stocks in the center of the network. Meanwhile, stocks having low correlation to other stocks tend to have few links to other stocks in the outer of the network [23]. In addition, the number of links is positively related with the common factors [24]: stocks having higher correlation with common factors tend to have many links to other stocks. On the other hand, the MVOF tends to preferentially distribute investment weighting into stocks having low correlation to other stocks, i.e., the MVOF definitely prefers the lower correlation matrix as an input. Hence, both the MVOF and the MST are commonly affected by the changes of the correlation matrix. The joint test combining the two methods facilitates observation of the topological change according to the S-CM and the C-CM. The topological changes are observed in terms of the change of links and correlation to other stocks in the stock network.

The results are summarized briefly here. The largest eigenvalue has the highest explanatory power on the stock return changes. The structure of the stock network using the C-CM without the largest eigenvalue is clearly different from that using the S-CM. The largest eigenvalue significantly affects the structure of the network among stocks. The MVOF using the C-CM without the largest eigenvalue definitely generates many more stocks having non-zero investment weight, compared to the S-CM, i.e., the largest eigenvalue prevents the construction of a well-diversified portfolio from the MVOF. These results support the test hypothesis on the two-faced property of the market factor, defined by the largest eigenvalue, in the pricing and the portfolio diversification. Moreover, the more diversified portfolio from the C-CM without the largest eigenvalue may achieve better out-of-sample performance in the future period. Based on the main findings, this study differs from the previous studies in the following two perspectives. First, in an academic contribution, this study empirically proves that the market factor negatively affects the construction of a well-diversified portfolio from the MVOF. Second, in a practical contribution, this study proposes the C-CM without the market factor as alternative method to enhance the practical applicability of the MVOF.

The rest of this paper is organized as follows. Section 2 introduces the data and main methods. Section 3 presents the results for the effect of each eigenvalue on the pricing and the portfolio diversification, and results for the joint test combining