Chapter 11
Random Matrix Approach for Analysis of the Johannesburg Stock Exchange

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ABSTRACT

Random Matrix Theory gives us the theatrical framework to analyze computational and statistical properties of cross-correlation matrix. Usually, the cross-correlation matrix is noisy because of the estimation's error for the length and the finite nature of the underlying time series. The present work studies the Johannesburg Stock Market and the effects of eigenvalues filtering techniques on portfolio optimization

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in the mean-variance framework. The data stock prices are scraped on the Yahoo Financial website from 1st January 2020 to 1st January 2024. Further, we applied the LCPB, PG+, and KR cleaning techniques and observed that the predicted risk was closer to the realized risk in the prediction period. We conclude that the KR method is the best technique. In addition, the Johannesburg Stock Exchange reacts more to bad events than to good ones. This result considerably improves the constructive approach often used by practitioners in this market.

INTRODUCTION

Random Matrix Theory (RMT) is a potent tool for analyzing multivariate financial data by examining the statistical properties of matrices derived from univariate financial time series. The method involves comparing the correlation matrix C with a random matrix W (Often referred to as "Wishart matrix") at various levels, such as eigenvalues and eigenvectors. If the C's properties are consistent with those of W, it suggests that the eigenstate of C is random. Conversely, any deviations between the correlation matrix's properties and the random matrix's properties provide insights into genuine correlations. As noted by Urama (2018) and Pafka and Kondor (2003), the correlation matrix's analysis can be susceptible to noise:

- The length of the period considered relative to the number of assets.

Indeed, for a certain number of assets, the correlation matrix must provide enough information to be sufficiently informative. For this to be achieved, the length of the study period should be sufficiently large relative to the number of assets considered in the portfolio. However, this length should be within a certain range so that the effects of changes in economic policies do not bias the analysis.

- The finite or bounded nature of the time series inadvertently introduces errors in the correlation matrix estimation.

Indeed, the availability of historical information frequently limits the scope of time series analysis. This can result in erroneous correlation coefficient estimates.

As a result, the empirical correlation matrix is noisy, and cleaning techniques are the appropriate tools for reducing or eliminating the noise. Indeed, non-deviating eigenvectors (whose associated eigenvalues lie within the noise band) are considered uninformative and insignificant for risk management and asset allocation (Urama, 2018), unlike deviating eigenvectors. Given the importance of the empirical correlation matrix in the mean-variance optimization problem, it is of great interest to