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Hypothesis Testing on Linear Structures of High Dimensional Covariance Matrix

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ABSTRACT

This paper is concerned with test of significance on high dimensional covariance structures, and aims to develop a unified framework for testing commonly-used linear covariance structures including independence structure, compound symmetric structure, banded structure and factor model structure. We first propose estimating the parameters involved in the linear covariance structure by the squared loss. This estimation procedure yields a consistent estimate of the covariance parameters. We develop two tests for these covariance structures based on the entropy loss and quadratic loss used for covariance matrix estimation in the classical multivariate analysis. Some existing tests for a specific covariance structure are special cases of these two tests. To study the asymptotic properties of the proposed tests, we study related high dimensional random matrix theory, and establish several highly useful asymptotic results for high-dimensional random matrix. Using these asymptotic results, we derive the limiting null distributions of these two tests, and their asymptotic distribution under the alternative hypothesis. The asymptotic distribution enables us to derive the power function of the proposed tests. We further show that the test is unbiased. We conduct Monte Carlo simulation study to examine the finite sample performance of the two tests. Our simulation results show that the limiting null distributions approximate their null distributions quite well, and the corresponding asymptotic critical values keep Type I error rate very well. Our numerical comparison implies that the proposed tests outperforms the likelihood ratio tests in terms of controlling Type I error rate and power.

Our simulation indicates that the test based on quadratic loss seems to have better power than the test based on entropy loss. We illustrate the proposed testing procedure by an empirical analysis of Chinese stock market data.
