The University of Chicago
Department of Statistics

PhD Thesis Presentation

HAN XIAO

Department of Statistics
The University of Chicago

Simultaneous Inference on Sample Covariances

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ABSTRACT

We consider the maximum deviations of the sample covariances under the contexts of high dimensional data analysis and time series analysis.

In the large n (number of observations) and large m (data dimension) paradigm, we show that the maximum deviation of the sample covariances converges in distribution to the extreme value distribution of type I. The result has statistical applications in high dimensional covariance matrix estimation by thresholding, testing the covariance structure, and justifying the covariance matrix regularization procedures.

Suppose there is only one realization of a stationary process of length n. We prove that the maximum deviation of the sample autocovariances over the lags between 1 and $s_n = O(n^\eta)$ also converges to the Gumbel distribution, and obtain the stochastic order of the maximum deviation over the whole range of lags from 1 to $n-1$. These results are useful in testing for serial correlation, model diagnostics and constructing simultaneous confidence bands. We develop the asymptotic theory under the framework of causal representations and physical dependence measures.

Using the uniform convergence rate of the sample autocovariances obtained under the time series setting, we propose to estimate the autocovariance matrix by hard thresholding, and obtain the convergence rates. Furthermore, we develop a large deviation result for quadratic forms of stationary processes which implies a uniform convergence rate of the lag window spectral density estimate at all frequencies. Then we use the connection between the Toeplitz matrices and the corresponding spectral densities to derive sharp convergence rates for banded and tapered autocovariance matrix estimates.

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