Statistical Inference for Large-dimensional Tucker-decomposition Tensor Factor Model

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Tensor Factor Models (TFM) are appealing dimension reduction tools for high-order large-dimensional time series, and have wide applications in economics, finance and medical imaging. Two types of TFM have been proposed in the literature, essentially based on the Tucker or CP decomposition of tensors. In this paper, we propose a projection estimator for the Tucker-decomposition based TFM, and provide its least-square interpretation which parallels to the least-square interpretation of the Principal Component Analysis (PCA) for the vector factor model. The projection technique simultaneously reduce the dimensionality and the magnitudes of the idiosyncratic error matrix, thus leading to an increase of signal-to-noise ratio. We derive a faster convergence rate of the projection estimator than that of the naive PCA-based estimator, under mild conditions which allow the idiosyncratic noise to have weak cross-correlations and weak autocorrelations. Further motivated by the least-squares interpretation, we propose a robust version by utilizing a Huber-loss function, which leads to a weighted iterative projection technique. Extensive numerical studies are conducted to investigate the empirical performance of the proposed (weighted) projection estimator relative to the sate-of-the-art ones. The simulation results shows that the projection estimator performs better than the non-projection estimators, and the weighted projection estimator performs much better than the existing ones in the heavy-tailed case.

Keyword: Huber Loss; Least squares; Tensor factor model; Projection Estimation.