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Simultaneous multiple change-point and factor analysis for high-dimensional time series

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Abstract

We propose the first comprehensive treatment of high-dimensional time series factor models with multiple change-points in their second-order structure. We operate under the most flexible definition of piecewise stationarity, and estimate the number and locations of change-points consistently as well as identifying whether they originate in the common or idiosyncratic components. Through the use of wavelets, we transform the problem of change-point detection in the second-order structure of a high-dimensional time series, into the (relatively easier) problem of change-point detection in the means of high-dimensional panel data. Also, our methodology circumvents the difficult issue of the accurate estimation of the true number of factors in the presence of multiple change-points by adopting a screening procedure. We further show that consistent factor analysis is achieved over each segment defined by the change-points estimated by the proposed methodology. In extensive simulation studies, we observe that factor analysis prior to change-point detection improves the detectability of change-points, and identify and describe an interesting 'spillover' effect in which substantial breaks in the idiosyncratic components get, naturally enough, identified as change-points in the common components, which prompts us to regard the corresponding change-points as also acting as a form of 'factors'. Our methodology is implemented in the R package `factorcpt`, available from CRAN.

Key words: piecewise stationary factor model, change-point detection, principal component analysis, wavelet transformation, Double CUSUM Binary Segmentation.

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