dmat universidade de aveiro departamento de matemática

fct Fundação para a Ciência e a Tecnologia

Seminário

Grupo de Probabilidades e Estatística

21 de fevereiro de 2024 14:15 Sala 11.2.21

Parameter estimation in state-space models – strategies for handling outliers

F. Catarina Pereira

PhD Student of Applied Mathematics at University of Minho, Portugal

Abstract

Time series analysis and modeling play a crucial role in predicting future observations. Most time series data exhibit certain components, such as trend or seasonality and the presence of outliers, which make analysis challenging, as well as the selection of the most suitable model. On the one hand, state-space models (SSM) are very flexible, since it is possible to incorporate these components in several ways. On the other hand, the presence of outliers can impact parameter estimation, forecasts and inferential results, and can lead to erroneous conclusions [1,2]. Therefore, detection and treatment of outliers are important steps in time series analysis [3].

In general, the SSM is not specified and the parameters need to be estimated. The maximum likelihood (ML) method is the most widely used due to its asymptotic properties, versatility and good properties for constructing confidence intervals and hypothesis tests. Since the ML function is not easy to maximize, optimization algorithms are typically employed. The Newton-Raphson method is a widely used iterative algorithm for parameter estimation. This method applied in the context of the SSM considers the score vector and the information matrix. However, in the presence of outliers, this method may not be robust for two main reasons; firstly, it can generate

This seminar is supported by CIDMA – Center for Research and Development in Mathematics and Applications through FCT – Fundação para a Ciência e a Tecnologia, within projects UIDB/04106/2020 and UIDP/04106/2020, with links https://doi.org/10.54499/UIDB/04106/2020 and https://doi.org/10.54499/UIDP/04106/2020.

CIDMA CENTRO DE I&D EM MATEMÁTICA E APLICAÇÕES CENTER FOR R&D IN MATHEMATICS AND APPLICATIONS

REPÚBLICA PORTUGUESA

high gradients and lead to local convergence; secondly, the information matrix is obtained approximately from the first-order partial derivatives and expressed as the sum of two parcels, one of which is simplified by dropping the expected value operator. [4]. This simplification can affect convergence in the numerical method and also lead to confidence intervals that may not accurately reflect reality.

In this seminar, we will present and discuss some alternatives to address this situation. One of these alternatives involves bootstrapping the standardized innovations to obtain an asymptotic information matrix that considers the mean value and/or robust measures when dealing with data containing outliers.

References:

[1] F. Z. Che, Rose , M. T., Ismail , N. A. K., Rosili (2019). Outlier Detection in Local Level Model: Impulse Indicator Saturation Approach. *Mathematics and Statistics,* 7(4A), 41 - 48. DOI: 10.13189/ms.2019.070706.

[2] You, D., Hunter, M., Chen, M., Chow, S. M. (2020). A Diagnostic Procedure for Detecting Outliers in Linear State-Space Models. *Multivariate behavioral research*, 55(2), 231–255. DOI: 10.1080/00273171.2019.1627659.

[3] Pereira, F.C., Gonçalves, A.M., Costa, M. (2023). Improving Predictive Accuracy in the Context of Dynamic Modelling of Non-Stationary Time Series with Outliers. *Engineering Proceedings*. 2023; 39(1):36. DOI: 10.3390/engproc2023039036.

[4] Harvey, A. (2009). Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge: Cambridge University Press. DOI: 10.1017/CBO9781107049994.

This seminar is supported by CIDMA – Center for Research and Development in Mathematics and Applications through FCT – Fundação para a Ciência e a Tecnologia, within projects UIDB/04106/2020 and UIDP/04106/2020, with links https://doi.org/10.54499/UIDB/04106/2020 and https://doi.org/10.54499/UIDP/04106/2020.

CIDMA CENTRO DE I&D EM MATEMÁTICA E APLICAÇÕES CENTER FOR R&D IN MATHEMATICS AND APPLICATIONS

REPÚBLICA PORTUGUESA