Using optimal transport to assess the impact of prior choice on Bayesian parameter inference in dynamical systems

Damian M. Ndiwago[1], Christophe Ley[2], Jack S. Hale[1].

[1] Institute of Computational Engineering, Faculty of Science, Technology and Medicine, University of Luxembourg, Esch–sur–Alzette, Luxembourg.
[2] Department of Mathematics, Faculty of Science, Technology and Medicine, University of Luxembourg, Esch–sur–Alzette, Luxembourg.

16/12/2023, 16th International Conference of the ERCIM WG on Computational and Methodological Statistics and 17th International Conference on Computational and Financial Econometrics Session EO156 CMStatistics: ADVANCES IN DYNAMIC MODELS

Abstract There exist many studies in the literature on the impact of prior choice in Bayesian inference. Some of these studies have proposed the use of probability distances that satisfy the properties of a divergence, as opposed to a metric. Regardless of the distance used, intepretation of the computed distance in terms of assessing prior impact is typically complicated by a lack of relative scaling, i.e. is this distance large or small? In this study we extend the use of the Wasserstein Impact Measure (WIM) proposed by Ghaderinezhad and co-workers to the problem of assessing prior impact in Bayesian models governed by systems of ordinary differential equations (ODEs). These ODE problems have moderate parametric dimension (~ 10) and the results using the original WIM are consequently difficult to interpret due to this moderate dimensionality and a lack of relative scaling. Our study consists of two main contributions; firstly, we utilise algorithms from computational optimal transport to extent the application of the WIM to problems of moderate parametric dimension. Secondly, we propose a new standardized Wasserstein Impact Measure (sWIM) which gives a relative sense of

distance, easing with intepretation of the sWIM for the purposes of understanding the role of the prior. To illustrate the effectiveness of our approach, we calibrate a Lotka–Voltera model predator-prey model under a baseline and two alternative priors and assess the impact of the prior using the proposed sWIM approach.

Keywords: Optimal transport, prior distribution, Wasserstein Impact Measure, time-series models, ODEs.