Beyond Moran's I: Testing for spatial dependence based on the SAR model

Hongfei Li
Catherine A. Calder
Noel Cressie
The Ohio State University

Abstract

The statistic known as Moran's I is widely used to test for the presence of spatial dependence in observations taken on a lattice. Under the null hypothesis that the data are independent and identically distributed normal random variates, the distribution of Moran's I is known, and hypothesis tests based on this statistic have been shown in the literature to have various optimal properties. Given its simplicity, Moran's I is also frequently used outside of the formal hypothesis testing setting in exploratory analyses of spatially referenced data. In this paper, we argue against this informal use of Moran's I. We show that for data generated according to the spatial autoregressive (SAR) model, Moran's I is only a good estimator of the strength of the spatial dependence parameter when there is little spatial dependence in the data. Based on this observation, we develop an alternative to Moran's I, which we call APLE since it is an approximate profile likelihood estimator (APLE) of the SAR spatial dependence parameter. We show that APLE can be used both as a test statistic and an estimator of the strength of spatial dependence. We include both theoretical and simulation-based motivation for using APLE as an estimator, and we propose the APLE scatterplot, an exploratory graphical tool that is analogous to the Moran scatterplot. We demonstrate that the APLE scatterplot is a better visual tool for assessing the strength of spatial dependence in the data than the Moran scatterplot. In addition, Monte Carlo tests based on both APLE and Moran's I are introduced and compared. Finally, we include an analysis of the well known Mercer and Hall wheat-yield data to illustrate the difference between APLE and Moran's I when they are used in exploratory analyses of spatial data.