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Implementing a class of structural change tests: An econometric computing approach☆

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Abstract

The implementation of a recently suggested class of structural change tests, which test for parameter instability in general parametric models, in the R language for statistical computing is described: Focus is given to the question how the conceptual tools can be translated into computational tools that reflect the properties and flexibility of the underlying econometric methodology while being numerically reliable and easy to use. More precisely, the class of generalized M-fluctuation tests is implemented in the package **strucchange** providing easily extensible functions for computing empirical fluctuation processes and automatic tabulation of critical values for a functional capturing excessive fluctuations. Traditional significance tests are supplemented by graphical methods which do not only visualize the result of the testing procedure but also convey information about the nature and timing of the structural change and which component of the parametric model is affected by it.

Keywords: Econometric computing; R; Structural change; M-estimation; Fluctuation tests

1. Introduction

This paper is about combining two fields of econometric research—testing for structural change and econometric computing—with the following focus: How can a general

☆ The source code for reproducing all examples in this paper is available in the online supplements as files Zeileis.R and estfun.betareg.R

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class of tests be translated into a unified and sound implementation that reflects the conceptual properties of the theoretical tests and allows for as much flexibility as possible in applications?

Structural change has been receiving attention in many fields of research and data analysis, in particular in time series econometrics: to learn if, when and how the structure of the data generating mechanism underlying a set of observations changes. Starting from the Recursive CUSUM test of Brown et al. (1975) a large variety of fluctuation tests for structural change has been suggested and Kuan and Hornik (1995) introduced a generalized and unifying framework of fluctuation tests for linear regression models which has been extended to general parametric models estimated with M-type estimators by Zeileis and Hornik (2003). Among the special cases of this general class of tests are several well-known tests like the OLS-based CUSUM test (Ploberger and Krämer, 1992, 1996), the Nyblom-Hansen test (Nyblom, 1989; Hansen, 1992), the class of tests of Hjort and Koning (2002) and the sup*LM*, ave*LM* and exp*LM* tests of Andrews (1993) and Andrews and Ploberger (1994).

The generalized M-fluctuation test class provides a conceptual tool box for constructing structural change tests in the following steps: (1) estimate the model which should be tested for structural instabilities, (2) derive an empirical fluctuation process from the cumulative sums of the M-estimation scores that is governed by a functional central limit theorem and that captures fluctuations over time, (3) aggregate the empirical fluctuation process to a scalar test statistic, augmented by a suitable visualization technique. The idea for step 3 is that boundaries can be chosen that are crossed by the limiting process (or some functional of it) only with a known probability α. Hence, if the empirical fluctuation process crosses these theoretical boundaries the fluctuation is improbably large and the null hypothesis of parameter stability can be rejected.

Computing and computational methods play an important role in econometric practice and (applied) research. However, there is a broad spectrum of various possibilities of combining econometrics and computing: two terms which are sometimes used to denote different ends of this spectrum are (1) *computational econometrics* which is mainly about methods that require substantial computations (e.g., bootstrap or Monte Carlo methods), and (2) *econometric computing* which is about translating econometric ideas into software. Of course, both approaches are closely related and cannot be clearly separated, but this paper is mostly concerned with *econometric computing* in the above sense and it is of interest beyond the structural change scope as it illustrates how a flexible and general class of tests can be translated into a set of modern computational tools. We discuss strategies for such an implementation based on language features including object orientation, functions as first class objects, nested lexically scoped functions and incorporation of re-usable components. These strategies are applied subsequently to the class of generalized M-fluctuation tests which are implemented in the package **strucchange** written in the R language for statistical computing (R Development Core Team, 2005 see `http://www.R-project.org/`). R is an open-source system that offers all of the language features indicated above and is one of the most used environments for statistical computing—and although currently not the most popular language for econometric computing, R also finds increasing attention among econometricians (Cribari-Neto and Zarkos, 1999; Racine and Hyndman, 2002).