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The wild bootstrap and heteroskedasticity-robust tests for serial correlation in dynamic regression models

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Abstract

Conditional heteroskedasticity is a common feature of financial and macroeconomic time series data. When such heteroskedasticity is present, standard checks for serial correlation in dynamic regression models are inappropriate. In such circumstances, it is obviously important to have asymptotically valid tests that are reliable in finite samples. Monte Carlo evidence reported in this paper indicates that asymptotic critical values fail to give good control of finite sample significance levels of heteroskedasticity-robust versions of the standard Lagrange multiplier test, a Hausman-type check, and a new procedure. The application of computer-intensive methods to removing size distortion is, therefore, examined. It is found that a particularly simple form of the wild bootstrap leads to well-behaved tests. Some simulation evidence on power is also given.

Keywords: Heteroskedasticity; Serial correlation; Wild bootstrap

1. Introduction

The importance of testing for serial correlation after the least-squares estimation of a dynamic regression model has been understood for many years. Lagrange multiplier (LM) tests allow for flexibility in the choice of alternative hypothesis, are easily implemented, and are now used as a matter of routine in estimation programmes. A standard means

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of implementing such tests is to carry out an artificial regression and base the test on the significance of coefficient(s) in that regression. It is shown in Belsley (1997, 2000) that misleading inferences can result from using such an approach in static regression with small and moderate samples. In the earlier of these two papers, an adjustment to the *t*-statistic for testing the null of no serial correlation against the alternative of a simple scheme of specified order is proposed. The companion paper extends the approach to an *F*-test for joint autoregressive schemes and the efficacy of both suggestions is demonstrated by reporting Monte Carlo results based upon independent and identically distributed (iid) regression errors. The present paper is concerned with the application of such tests when the regressors include lagged dependent variables, as well as exogenous variables. In the presence of both types of regressors, tests based on the popular portmanteau-type approach are, of course, invalid and so LM tests may be particularly attractive to empirical workers.

However, standard LM-type tests (and the modifications suggested by Belsley), along with many others, are predicated on an assumption of homoskedasticity. It is now recognized that conditional heteroskedasticity may be common, especially (but certainly not exclusively) when the data relate to financial variables. In the presence of conditional heteroskedasticity, standard checks for serial correlation cannot be assumed to be asymptotically valid and may lead to misleading inferences. There is therefore a need to examine heteroskedasticity-robust (HR) procedures.

An obvious way to derive LM-type checks that are asymptotically HR is to employ heteroskedasticity-consistent covariance matrix estimates (HCCME) as discussed in White (1980). The basic idea of using HCCME to obtain diagnostic tests is long established; see, for example, Pagan and Hall (1983). Details of a specific application of HCCME to testing for serial correlation are given in Godfrey (1994). However, there is a considerable body of evidence indicating that tests derived from the HCCME can have finite sample distributions that are quite unlike those predicted by asymptotic theory. In particular, finite sample significance levels can be far from what is desired.

The main purpose of this paper is to report Monte Carlo results on the wild bootstrap approach when it is used to obtain critical values or *p*-values for serial correlation tests based upon HCCME. Given the significant increases in the availability of cheap and powerful computers in the last few years, this approach is attractive. Once implemented in standard programmes, it could be used not only for serial correlation tests, but also for other variable-addition diagnostic checks, e.g. the RESET test. Thus the wild bootstrap described below provides a way for applied workers to obtain misspecification tests that are asymptotically robust to heteroskedasticity (and nonnormality) with the bootstrap being used to improve upon the approximation provided by asymptotic theory. This combination of features matches recommendations in Hansen (1999) for good econometric practice.

In order to assess the added value of the results given below, reference should be made to the existing body of published work pertaining to serial correlation tests and conditional heteroskedasticity. There are relatively few contributions. Robinson (1991) considers a static linear regression model and derives an LM test for serial correlation that is asymptotically valid under dynamic conditional heteroskedasticity and nonnormality. No evidence on finite sample performance is provided and, as noted by Robinson, the test is inappropriate in the presence of lagged dependent variables. Whang (1998) derives tests for serial correlation in dynamic models that are asymptotically valid in the presence of heteroskedasticity of