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Exact permutation tests for non-nested non-linear regression models

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Abstract

This paper proposes exact distribution-free permutation tests for the specification of a non-linear regression model against one or more possibly non-nested alternatives. The new tests may be validly applied to a wide class of models, including models with endogenous regressors and lag structures. These tests build on the well-known J test developed by Davidson and MacKinnon [1981. Several tests for model specification in the presence of alternative hypotheses. Econometrica 49, 781–793] and their exactness holds under broader assumptions than those underlying the conventional J test. The J-type test statistics are used with a randomization or Monte Carlo resampling technique which yields an exact and computationally inexpensive inference procedure. A simulation experiment confirms the theoretical results and also shows the performance of the new procedure under violations of the maintained assumptions. The test procedure developed is illustrated by an application to inflation dynamics.

JEL classification: C12; C15; C52

Keywords: Non-nested hypotheses; J test; Finite-sample distribution-free test; Monte Carlo test; New Keynesian Phillips curve

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1. Introduction

The J test proposed by Davidson and MacKinnon (1981) is a well-known procedure for testing non-nested regression models. This procedure does not yield an exact test so that inference based on it can be misleading in finite samples. For example, Godfrey and Pesaran (1983) report simulation evidence showing that the J test suffers severe size distortions in small samples, rejecting too often, especially when the number of regressors in the alternative model exceeds that in the null model. This overrejection problem is further exacerbated as the correlations between the non-nested regressors tend to zero. Michelis (1999) derives the asymptotic distribution of the J test statistic when the non-nested regressors are nearly orthogonal. In this case, the J test is no longer asymptotically standard normal as in the case of non-orthogonal models.

Attempts have been made to improve the finite-sample properties of the J test. Fisher and McAleer (1981) proposed a variant of the J test, called the JA test, which is exact in the case of linear regression models with exogenous regressors and normal errors (Godfrey, 1983). More recently, simulation methods have been proposed to obtain finite-sample improvements. Fan and Li (1995) and Godfrey (1998), for example, demonstrate that the bootstrap can be used to control the empirical significance level of the J and JA tests. However, neither Fan and Li nor Godfrey provide a theoretical explanation of why the bootstrap apparently works so well when testing non-nested linear regression models.

Davidson and MacKinnon (2002) develop an approach that gives a precise characterization of the finite-sample distribution of the J test. Based on this characterization, they propose a simulation method to obtain an exact version of the J test. Their approach assumes that the error terms are normally distributed and only applies in the case of linear models with exogenous regressors. However, they present simulation evidence which shows that their bootstrap J test perform extremely well even when those assumptions are not satisfied.

This paper extends the permutation principles described in Dufour and Roy (1985, 1989), McCabe (1989), and Kennedy (1995) to tests of non-nested non-linear regression models. Although Davidson and MacKinnon's (1981) J test statistic forms the basic building block of the proposed tests, their validity holds under broader assumptions than those underlying the conventional J test. Here it is assumed that: (i) the variables of the null model and the regressors exclusive to the alternative model are independent, and (ii) that either of these two sets forms a collection of exchangeable random vectors. These assumptions are extended to cover situations where a null model is tested against several alternatives at once. The proposed tests are exact under those assumptions. This framework is more general than that in Davidson and MacKinnon (2002) since: (i) the error terms need not be normally distributed, (ii) the models may contain endogenous regressors and lag structures, and (iii) they may be non-linear.

The exchangeability assumption means that serial dependence is not allowed in both the variables of the null model and the regressors exclusive to the alternative model, simultaneously. In this respect, the exchangeability assumption is more likely