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A note on variable addition tests for linear and log-linear models ☆

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Abstract

Results on variable addition tests for linear and log-linear models are unified using an instrumental variables framework, which allows the identification of the specific alternatives for which well-known tests are optimal.

Keywords: Box–Cox transformation; Instrumental variables; Internal instruments

JEL classification: C52

1. Introduction

We give a general instrumental variable (IV) approach to testing linear and log-linear regression models which unifies existing results on variable addition tests of the type described in Pagan (1984) and also guides the interpretation of previous Monte Carlo results that were presented without a theoretical framework. Variable addition tests used in this context are tests derived in Godfrey and Wickens (1981) from results in Andrews (1971), the P_E test of MacKinnon et al. (1983), the RESET test recommended in Godfrey et al. (1988) and the test for non-nested hypotheses suggested in Bera and McAleer (1989).

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Tests that involve the specification of the likelihood function provide alternatives to variable addition checks. Examples of papers using likelihood-based methods include Godfrey and Wickens (1981), Davidson and MacKinnon (1985), Kobayashi and McAleer (1999) and Yang and Abeysinghe (2003). However, misspecification of the error distribution can lead to misleading inferences when likelihood-based tests are used; see Godfrey and Santos Silva (2004). Which of the two types of test is more appropriate depends on the nature of the problem in hand. In many regression applications, the emphasis is on inference about the parameters of the conditional mean and in this case variable addition tests are certainly of interest.

2. The IV approach

Consider the case in which the researcher wants to test the models

$$M_0 : \ln(\mathrm{y}_i) = \beta_0^0 + \sum_{j=1}^{k} \beta_j^0 \ln(x_{ji}) + \epsilon_{0i}, \tag{1}$$

$$M_1 : y_i = \beta_0^1 + \sum_{j=1}^{k} \beta_j^1 x_{ji} + \epsilon_{1i}. \tag{2}$$

It is assumed that $E(\epsilon_{li}|x_{1i},\ldots, x_{ki})=0$, $E(\epsilon_{li}\epsilon_{lj}|x_{1i},\ldots, x_{ki}, x_{1j},\ldots, x_{kj})=0$, and $E(\epsilon_{li}^2|x_{1i},\ldots, x_{ki})=\sigma_l^2$, $i, j=1,\ldots, n$, $i\neq j$, under M_l, $l=0, 1$. The form of the conditional distribution of the error terms is not specified. The OLS estimates of the parameters in Eqs. (1) and (2) are denoted by $\hat{\beta}_j^0$ and $\tilde{\beta}_j^1$, $j=0, 1,\ldots, k$, respectively. The fitted values for Eqs. (1) and (2) are $\widehat{\ln(y_i)} = \hat{\beta}_0^0 + \sum_{j=1}^k \hat{\beta}_j^0 \ln(x_{ji})$ and $\tilde{y}_i = \tilde{\beta}_0^1 + \sum_{j=1}^k \tilde{\beta}_j^1 x_{ji}$, respectively.

Models (1) and (2) can both be tested against

$$y_i[\delta] = \beta_0^\delta + \sum_{j=1}^{k} \beta_j^\delta x_{ji}[\delta] + \epsilon_{\delta i}, \tag{3}$$

where δ is a parameter and $z_i[\delta]$ denotes a family of transformations, differentiable with respect to δ, such that

$$z[\delta] = \begin{cases} \ln(z) & \text{for} \quad \delta = 0 \\ z & \text{for} \quad \delta = 1 \end{cases}.$$

Whatever the form of $z[\delta]$ that is chosen, the adequacy of both Eqs. (1) and (2) can be assessed by testing a null hypothesis of the form H_0: $\delta=\delta_0$ against H_1: $\delta\neq\delta_0$. In order to avoid dependence on an assumed distribution of the errors, tests should be constructed using a method that does not require the specification of the likelihood function.

In a set of independent papers, Godfrey (1991), Santos Silva (1991) and Robinson (1993) proposed using LM-type tests based on the Non-Linear Two Stages Least Squares (NL2SLS) estimator of Amemiya