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Estimation of a panel data model with parametric temporal variation in individual effects

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Abstract

This paper is an extension of Ahn et al. (J. Econom. 101 (2001) 219) to allow a *parametric* function for time-varying coefficients of the individual effects. It provides a fixed-effect treatment of models like those proposed by Kumbhakar (J. Econom. 46 (1990) 201) and Battese and Coelli (J. Prod. Anal. 3 (1992) 153). We present a number of GMM estimators based on different sets of assumptions. Least squares has unusual properties: its consistency requires white noise errors, and given white noise errors it is less efficient than a GMM estimator. We apply this model to the measurement of the cost efficiency of Spanish savings banks.

JEL classification: C13; C31

Keywords: GMM; Generalized method of moments; Time-varying individual effects; Fixed-effects; Cost efficiency

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1. Introduction

In this paper we consider the model

$$y_{it} = X'_{it}\beta + Z'_i\gamma + \lambda_t(\theta)\alpha_i + \varepsilon_{it}, \quad i = 1, \ldots, N, \;\; t = 1, \ldots, T. \tag{1}$$

We treat T as fixed, so that "asymptotic" means as $N \to \infty$. The distinctive feature of the model is the interaction between the time-varying parametric function $\lambda_t(\theta)$ and the individual effect α_i. We consider the case that the α_i are "fixed effects," as will be discussed in more detail below. In this case estimation may be non-trivial due to the "incidental parameters problem," i.e., the number of α's grows with sample size; see, for example, Chamberlain (1980).

Models of this form have been proposed and used in the literature on frontier productions functions (measurement of the efficiency of production). For example, Kumbhakar (1990) proposed the case that $\lambda_t(\theta) = [1 + \exp(\theta_1 t + \theta_2 t^2)]^{-1}$, and Battese and Coelli (1992) proposed the case that $\lambda_t(\theta) = \exp(-\theta(t - T))$. Both of these papers considered random effects models in which α_i is independent of X and Z. In fact, both of these papers proposed specific (truncated normal) distributions for the α_i, with estimation by maximum likelihood. The aim of the present paper is to provide a fixed-effects treatment of models of this type.

There is also a literature on the case that the λ_t themselves are treated as parameters. That is, the model becomes

$$y_{it} = X'_{it}\beta + Z'_i\gamma + \lambda_t\alpha_i + \varepsilon_{it}, \quad i = 1, \ldots, N, \;\; t = 1, \ldots, T. \tag{2}$$

This corresponds to using a set of dummy variables for time rather than a parametric function $\lambda_t(\theta)$, and now $\lambda_t\alpha_i$ is just the product of fixed time and individual effects. This model has been considered by Kiefer (1980), Holtz-Eakin et al. (1988), Lee (1991), Chamberlain (1992), Lee and Schmidt (1993), Ahn et al. (2001) and Bai (2003), among others. This model is sometimes called a one-factor model. Lee (1991) and Lee and Schmidt (1993) have applied this model to the frontier production function problem, in order to avoid having to assume a specific parametric function $\lambda_t(\theta)$. Another motivation for the model is that a fixed-effects version allows one to control for unobservables (e.g., macro-events) that are the same for each individual, but to which different individuals may react differently.

Ahn et al. (2001) establish some interesting results for the estimation of model (2). A generalized method of moments (GMM) estimator of the type considered by Holtz-Eakin et al. (1988) is consistent given exogeneity assumptions on the regressors X and Z. Least squares applied to (2), treating the α_i as fixed parameters, is consistent provided that the regressors are strictly exogenous and that the errors ε_{it} are white noise. The requirement of white noise errors for consistency of least squares is unusual, and is a reflection of the incidental parameters problem. Furthermore, if the errors are white noise, then a GMM estimator that incorporates the white noise assumption dominates least squares, in the sense of being asymptotically more efficient. This is also a somewhat unusual result, since in the usual linear model with normal errors, the moment conditions implied by the white noise assumption would not add to the efficiency of estimation.