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Estimating dynamic panel models in corporate finance

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ABSTRACT

Dynamic panel models play a natural role in several important areas of corporate finance, but the combination of fixed effects and lagged dependent variables introduces serious econometric bias. Several methods of counteracting these biases are available and these methodologies have been tested on small datasets with independent, normally-distributed explanatory variables. However, no one has evaluated the methods' performance with corporate finance data, in which the dependent variable may be clustered or censored and independent variables may be missing, correlated with one another, or endogenous. We find that the data's properties substantially affect the estimators' performances. We provide evidence about the impact of various data set characteristics on the estimators, so that researchers can determine the best approach for their datasets.

1. Introduction

Dynamic panel models play an increasingly prominent role in corporate finance research. Empirically understanding payout policy, capital structure, or investment decisions arguably requires the use of firm fixed effects to control for unobserved, time-invariant differences across firms.[1] Yet uncorrected coefficient estimates for a dynamic panel model can be severely biased. Following on the observations of Nerlove (1967), Nickell (1981) established that OLS estimates of the lagged dependent variable's coefficient in a dynamic panel model are biased due to the correlation between the fixed effects and the lagged dependent variable (see also Baltagi, 2008). The bias is inversely related to panel length ("T"), but potentially severe biases remain even with $T=30$ (Judson and Owen (1999)). Compustat firms have a mean (median) of 15 (11) years of annual data, well short of the number of observations required to make the bias negligible. Even when the researcher's primary concern lies elsewhere, a biased coefficient on the lagged dependent variable renders the other coefficient estimates suspect. As such, the short panel bias is a significant concern, and questions requiring dynamic panel models constitute some of the most contentious and unresolved areas of financial research.

The potential importance of choosing an appropriate estimation method for a dynamic panel model can be illustrated by recent efforts to estimate dynamic panel models of corporate leverage. Welch (2004) concludes that firms do not adjust toward target leverage; Fama and French (2002) estimate that firms adjust between 7 and 18% each year; Lemmon et al., (2008) estimate about 25% annually; Huang and Ritter (2009) estimate 17–23%; Flannery and Rangan (2006) estimate an adjustment speed above 30%. The econometric uncertainties associated with dynamic panel data have made it difficult to achieve consensus on the importance of adjustment behavior and of the factors affecting target leverage ratios. Similar problems exist in other areas of

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[1] For example, see Andres et al. (2009), Bond and Meghir (1994), Dittmar and Duchin (2010), Lemmon et al. (2008), Loudermilk (2007), Machin and Reenen (1993), and Ozkan (2000).

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corporate finance research such as corporate governance (Wintoki et al., (2012)), cash management (Dittmar and Duchin (2010)), and investment financing (Bond et al., 2003), as well as growth and banking research.

Of course, econometric techniques have evolved to correct these biases, including instrumental variables (IV), generalized method of moments (GMM) estimators, long differencing (LD), and bias correction formulae. These methods have been tested on small datasets, most of which have at most one, normally distributed independent variable. Yet corporate finance studies include multiple independent variables, of which many exhibit endogeneity and serial correlation. Therefore, an estimator's performance in simple Monte Carlo simulations may not apply to more complex empirical analysis. We examine the statistical properties of seven alternative methods for estimating dynamic panel models: OLS, standard fixed effects (FE) estimation, Arellano and Bond's (1991) difference GMM, Blundell and Bond (1998) system GMM, two variations of long differencing (Hahn et al., 2007, Huang and Ritter, 2009), and corrected least-squares (Kiviet, 1995, Bruno, 2005). By simulating data that resembles "real" corporate finance data, we evaluate the performance of these estimators under conditions that are likely to apply to corporate finance research topics. Our goal is to provide sufficient analysis that corporate empiricists can identify the estimation technique most appropriate to their data.

The paper is organized as follows. Section 2 illustrates the importance of dynamic panel estimation biases in the context of firms' capital structure choices. Section 3 explains the econometric issues and describes existing methods for addressing them. Like Petersen (2009), we utilize Monte Carlo simulations to assess the performance of various estimators in different situations. Section 4 describes how we simulate datasets. In addition to a straightforward set of independent and identically distributed (iid) simulated datasets, we also simulate datasets using a variance–covariance structure generated from actual Compustat variables. Section 5 presents some initial results. First, we confirm that most of the proposed estimation methods yield reasonably accurate coefficient estimates when data and regression residuals are generated from iid error distributions. When the simulated explanatory variables mimic Compustat data, the estimated coefficient on the lagged dependent variable remains reliable, but estimation errors for some of the other explanatory variables' coefficients increase dramatically. In Section 6, we evaluate each estimator in the presence of common corporate data features, such as missing observations, unbalanced panel lengths, and dependent variable censoring. One estimation method (Kiviet's (1995) corrected least squares dependent variable, or LSDVC) emerges as the most accurate methodology across all these dataset conditions and Blundell and Bond's (1998) system GMM estimator is often the second best choice.

Unfortunately, both have limitations. Not only does LSDVC's computer memory requirement make it difficult to apply in large datasets, it assumes exogenous regressors. Blundell Bond GMM (like Arellano Bond GMM) assumes an absence of second order serial correlation. In Section 7, we explore how violating these assumptions affects the performance of all seven estimators. Both endogenous regressors and second-order serial correlation seriously compromise many of the estimation methodologies, consistent with the theoretical literature. Perhaps surprisingly, these complications can be large enough that there are occasions when the much maligned fixed effects estimator performs best. Section 8 concludes by offering guidance about the best way to approach dynamic panel estimation in a corporate finance context.

2. An example of short panel bias

This section uses a partial adjustment model of capital structure to demonstrate the severity of the short panel bias and to illustrate the need for appropriate econometric procedures. Fischer et al. (1989) argue that adjustment costs prevent firms from adjusting completely to their optimal leverage each period. An appropriate regression specification therefore must include a lagged dependent variable to control for the prior period's capital structure. At the same time, the available data do not necessarily capture all relevant firm characteristics, perhaps including managerial risk aversion, the firm's governance structure, or cash-flow characteristics. MacKay and Phillips (2005) and Lemmon et al., (2008) conclude that fixed effects must be used to control for unobservable, time-invariant features of the firm. Yet the combination of a lagged dependent variable and firm fixed effects introduces a bias which can be substantial with short panels.

To illustrate this "short panel bias," assume that a firm's capital structure adjusts according to

$$MDR_{i,t+1} - MDR_{i,t} = \lambda\left(MDR_{i,t+1}{}^{*} - MDR_{i,t}\right) + \delta_{i,t+1} \tag{1}$$

where MDR is the ith firm's market debt ratio: the ratio of interest bearing debt to the sum of interest bearing debt plus the market value of equity,

MDR^*	is the firm's target debt ratio,
λ	is the adjustment speed toward the target, and
δ	is the error term.

If target leverage depends linearly on a set of observed and unobserved firm characteristics, we can write

$$MDR_i{}^{*} = \beta X_i + F_i$$

where X_i is a vector of observable firm-specific determinants of the target MDR, β is a vector of coefficients, and F_i is a firm fixed effect. Substituting this expression for MDR^* into Eq. (1) yields

$$MDR_{i,t+1} = (\lambda\beta)X_{i,t} + \lambda F_i + (1-\lambda)MDR_{i,t} + \delta_{i,t+1}. \tag{2}$$