Monte Carlo Studies on Finite Sample Performance of the CCEP-HT Estimator in Panels with Heterogeneous Unobserved Common Factors

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1 Introduction

Serlenga and Shin (2006) consider a panel data model augmented with observed and unobserved time-specific factors with heterogeneous factor loadings, and propose to combine the Hausman-Taylor (HT) instrumental variable estimator with the correlated common effect pooled (CCEP) estimator recently advanced by Pesaran (2006). This procedure allows us to avoid the potential biased estimation stemming from an inappropriate treatment of unobserved heterogeneous common factors.

In an application to an analysis of the gravity equation of bilateral trade flows amongst fifteen European countries over 1960-2001, Serlenga and Shin find that the empirical results obtained using the CCEP-HT estimation procedure are much more sensible than those obtained using the conventional approach based on the two-way fixed effects (FE) estimation. *First*, when using the two-way FE-HT estimation, the estimated impact of the GDP on the bilateral trade flows is too large, whereas the impacts of distance and common border dummy are no longer significant. *Secondly*, the CCEP-HT estimation results produce more sensible predictions on the impacts of differences in factor endowments and of the common currency dummy on EU trade flows, which is more plausible in current EU contexts. *Finally*, once the correlation between the common language dummy and individual effect is accommodated by the CCEP-HT estimation, there is evidence that the effects of the variables that may proxy for geographical distance, *i.e.* distance and common border dummy, might be compensating each other, whereas the role of cultural affinities proxied by common language dummy becomes more significant.

This note further conducts a simple Monte Carlo study, and demonstrates that the small sample performance of the CCEP-HT estimator is indeed much superior to that of the two-

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way FE-HT estimator in the presence of unobserved heterogeneous common factor in panels. These findings may indicate that an inappropriate treatment of heterogeneous common unobserved factors will result in severely biased estimates and thus misleading inference.

2 The Monte Carlo Design

We consider the following data generating process (DGP):

$$y_{it} = \beta_1 x_{1,it} + \beta_2 x_{2,it} + \gamma_1 z_{1,i} + \gamma_2 z_{2,i} + \alpha_i + \varphi_i \theta_t + u_{it}, \tag{2.1}$$

where $\alpha_i \sim iidN\left(0, \sigma_\alpha^2\right)$ and $u_{it} \sim iidN\left(0, \sigma_u^2\right)$ with $\sigma_\alpha^2 = \sigma_u^2 = 1$, and the common time-specific factor, θ_t, is generated by

$$\theta_t = \rho_\theta \theta_{t-1} + v_{\theta,t}, \tag{2.2}$$

where $v_{\theta,t} \sim iidN\left(0, \sigma_\theta^2\right)$ with $\sigma_\theta^2 = (1 - \rho_\theta^2)$. Both time-varying and time-invariant regressors, x_{1it}, x_{2it}, z_{1i}, z_{2i}, are generated respectively by

$$x_{1,it} = \rho_1 x_{1,it-1} + \delta_i + \varphi_{1i} \theta_t + v_{1,it}, \tag{2.3}$$

$$x_{2,it} = \rho_2 x_{1,it-1} + \alpha_i + \varphi_{2i} \theta_t + v_{2,it}, \tag{2.4}$$

$$z_{1,i} = 1, \tag{2.5}$$

$$z_{2,i} = \alpha_i + \delta_i + \eta_i, \tag{2.6}$$

where $\delta_i \sim U\left[-2, 2\right]$, $v_{1,it} \sim iidN\left(0, \sigma_{v_1}^2\right)$, $v_{2,it} \sim iidN\left(0, \sigma_{v2}^2\right)$ and $\eta_i \sim iidN\left(0, \sigma_\eta^2\right)$ with $\sigma_{v_1}^2 = (1 - \rho_1^2)$, $\sigma_{v_2}^2 = (1 - \rho_2^2)$ and $\sigma_\eta^2 = 1$. For simplicity, we consider the homogeneous parameter values: $\beta_1 = \beta_2 = \gamma_1 = \gamma_2 = 1$ and $\rho_1 = \rho_2 = 0.7$. But, we allow for heterogeneous factor loadings in (2.1), (2.3) and (2.4); namely, $\varphi_i \sim U\left[0, 4\right]$, $\varphi_{1i} \sim U\left[0, 4\right]$, and $\varphi_{2i} \sim U\left[0, 4\right]$. This experimental design is based on combining the one-way panel data specification of the HT model considered by Baltagi *et al.* (2003) and the panel data model with heterogeneous unobserved common factors considered by Pesaran (2006).

The main object of this study is to compare the performance of the HT instrumental variable estimator combined with the two-way Fixed Effects and the CCEP estimators. These estimators are called the FE-HT and CCEP-HT and denoted by $\left(\hat{\beta}_{1,F}, \hat{\beta}_{2,F}, \hat{\gamma}_{1,F}, \hat{\gamma}_{2,F}\right)'$ and $\left(\hat{\beta}_{1,C}, \hat{\beta}_{2,C}, \hat{\gamma}_{1,C}, \hat{\gamma}_{2,C}\right)'$, respectively. For details on the estimation procedure see Serlenga and Shin (2006).

We report the following summary statistics:

Bias: $\hat{\beta}_R - \beta_0$, where β_0 is true parameter value and $\hat{\beta}_R = R^{-1} \sum_{r=1}^R \hat{\beta}_r$ is the mean of estimates of β across R replications.

RMSE: the root mean square error estimated by $\sqrt{R^{-1} \sum_{r=1}^R \left(\hat{\beta}_r - \beta_0\right)^2}$.

Size: the empirical rejection probability of the t-test of the null hypothesis $\beta = \beta_0$ against $\beta \neq \beta_0$ at the 5% nominal significance.

We consider the panel sample sizes of $(N, T) = (25, 50, 75, 100, 200)$ and set the number of replications at $R = 5000$.

3 Simulation Results

We are interested mainly in the relative performance of both estimators of γ_2, the coefficient on the time-invariant regressors correlated with individual effects, though we also report the results for β_1 and β_2 for completeness. Notice that $x_{2,it}$ and $z_{2,i}$ are correlated with individual effects and γ_1 is simply an intercept by simulation design.

The results for β_1 and β_2 are summarized in Tables 1 and 2. First, the biases of the CCEP estimators of β_1 and β_2 are fairly small in all cases considered, and mostly negligible even when both N and T are as small as 25. On the other hand, biases of the two-way FE estimator are substantial for most cases considered. As N increases, the biases of the FE estimator become smaller, but they are still non-negligible. The general reading of the RMSE results is qualitatively similar to the bias results, though the difference between the CCEP and the FE estimators is somewhat muted here. The RMSEs of the CCEP estimator decrease as either N or T increases as expected, whereas those of the FE estimator decrease only with N, which is also a consistent finding with the bias result. The empirical sizes of the t-test for $\beta_1 = 1$ or $\beta_2 = 1$ based on the CCEP estimators, $\hat{\beta}_{1,C}$ and $\hat{\beta}_{2,C}$, are reasonably close to the nominal 5% level in almost all cases considered, whilst the t-test based on the FE estimators, $\hat{\beta}_{1,F}$ and $\hat{\beta}_{2,F}$ are not reliable at all as the size is well above the nominal 5% level in most cases (there are also under-rejection problem in a few cases). Overall these results clearly indicate that the CCEP estimation performs very well in small samples, which also supports the simulation findings obtained by Kapetanios and Pesaran (2005) and Pesaran (2006).

Tables 1 and 2 about here

Next, we turn to the main focus of the paper and summarize the results for γ_2 in Table 3. First, the biases of the CCEP-HT estimator of γ_2 are non-negligible especially when N is small, though they are substantially smaller than the biases of the FE-HT estimator of γ_2 in all cases considered. Importantly, the bias of $\hat{\gamma}_{2,C}$ tends to decrease quickly with N but somewhat slowly with T, whereas there is no such tendency for $\hat{\gamma}_{2,F}$. On the other hand, the RMSE results do not provide a clear picture as before since the RMSEs for $\hat{\gamma}_{2,F}$ is smaller than those of $\hat{\gamma}_{2,C}$.[1] The RMSEs of the both estimators decrease as either N or T increases, but more rapidly with N. Finally, the empirical sizes of the t-test for $\gamma_2 = 1$ based on the CCEP-HT estimator are reasonably close to the nominal 5% level in almost all cases considered with a slight over-rejection only for $N = 25$. On the other hand, the t-test based on the FE-HT estimator tends to over-reject in most cases, though its performance is not as bad as in the case of $\boldsymbol{\beta}$ estimation.

Table 3 about here

Based on these simulation findings we may conclude that the CCEP-HT estimation performs well in small sample and is much superior to the two-way FE-HT estimation.

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[1] See also the results for RMSE ratio, which is constructed as a ratio of RMSE of $\hat{\gamma}_{2,C}$ or $\hat{\gamma}_{2,F}$ to RMSE of the infeasible cross-section instrumental variable estimator. The latter is obtained by using the true parameter values, $\beta_1 = 1$ and $\beta_2 = 1$, and constructing the within residuals from the first-stage regression. The biases of the CCEP-HT estimator of γ_2 are comparably close to those of the infeasible estimator, though interestingly the RMSE ratios for $\hat{\gamma}_{2,C}$ are larger than those of $\hat{\gamma}_{2,F}$.

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Table 1. Summary Simulation Results for β_1

	Two-way FE Estimator					CCEP Estimator				
	Bias									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	-.045	-.051	-.052	-.053	-.053	.0011	-.0007	.0004	-.0002	.0003
50	.028	.028	.028	.028	.028	.0000	.0002	.0005	.0002	0003
75	.025	.020	.025	.025	.024	-.0001	-.0001	-.0002	-.0002	-.0001
100	-.025	-.026	-.026	-.026	-.026	.0000	.0003	.0001	0000	0000
200	-.013	-.014	-.014	-.014	-.014	-.0004	-.0002	.0002	0000	.0000
	RMSE									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	.055	.054	.054	.054	.054	.047	.030	.024	.020	.015
50	.033	.030	.029	.029	.029	.033	.022	.017	.014	.010
75	.014	.009	.007	.006	.005	.027	.017	.014	.012	.008
100	.027	.027	.027	.027	.027	.023	.015	.012	.010	007
200	.015	.015	.014	.014	.014	.016	.011	.008	.007	005
	Size									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	.401	.785	.938	.983	1.0	.053	.056	.058	.053	.055
50	.299	.668	.864	.950	1.0	.049	.055	.049	.052	.056
75	.033	.027	.027	.033	.048	.054	.047	.052	.049	.058
100	.539	.897	.982	.999	1.0	.053	.052	.049	.050	.053
200	.278	.622	.833	.933	.999	.056	.050	.044	.050	051

Table 2. Summary Simulation Results for β_2

	Two-way FE Estimator					CCEP Estimator				
	Bias									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	-.059	-.059	-.059	-.059	-.059	.0003	.0005	.0002	0000	-.0001
50	.072	.073	.074	.074	.074	.0010	.0006	.0001	.0000	0003
75	-.018	-.018	-.018	-.018	-.018	-.0002	-.0004	.0003	0002	-.0002
100	-.007	-.007	-.007	-.007	-.007	-.0003	.0000	-.0003	0001	-.0002
200	.010	.010	.010	.010	.010	-.0002	.0000	.0002	.0002	0000
	RMSE									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	.063	.061	.060	.060	.059	.049	.032	.025	.021	.015
50	.075	.074	.074	.074	.074	.034	.022	.017	.015	.010
75	.022	.020	.019	.018	.018	.028	.018	.014	.012	.008
100	.013	.010	.009	.008	.008	.023	.015	.012	.010	007
200	.013	.011	.011	.010	.010	.016	.011	.009	.007	005
	Size									
(N,T)	25	50	75	100	200	25	50	75	100	200
25	.764	.982	.999	1.0	1.0	.056	.059	.054	.059	.054
50	.912	.999	1.0	1.0	1.0	.050	.051	.049	.049	.053
75	.227	.538	.752	.886	.997	.056	.049	.056	.052	.051
100	.054	.100	.173	.230	.522	.048	.054	.047	.048	051
200	.158	.386	.578	.745	.976	.047	.049	.050	.047	052

Table 3. Summary Simulation Results for γ_2

	Two-way FE-HT Estimator					CCEP-HT Estimator				
	Bias									
(N, T)	25	50	75	100	200	25	50	75	100	200
25	.090	.124	.137	.136	.142	-.059	-.066	-.068	-.068	-.063
50	-.106	-.109	-.113	-.110	-.111	-.030	-.025	-.024	-.032	-.019
75	-.021	-.017	-.022	-.020	-.021	-.015	-.015	-.019	-.018	-.012
100	.068	.077	.079	.081	.077	-.013	-.016	-.010	-.011	-.011
200	.034	.040	.041	.042	.041	-.002	-.005	-.007	-.004	0003
	RMSE									
(N, T)	25	50	75	100	200	25	50	75	100	200
25	.351	.313	.313	.302	.321	.503	.456	.411	.425	.413
50	.241	.184	.179	.173	.174	.255	.226	.216	.214	.199
75	.149	.133	.129	.123	.122	.192	.167	.168	.157	.145
100	.138	.126	.124	.123	.119	.165	.143	.138	.135	126
200	.089	.081	.078	.076	.074	.112	.098	.094	.090	088
	Size									
(N, T)	25	50	75	100	200	25	50	75	100	200
25	.184	.212	.222	.234	.241	.073	.070	.076	.076	.079
50	.046	.035	.036	.034	.038	.053	.054	.061	.059	.054
75	.050	.050	.045	.047	.044	.059	.058	.056	.059	.056
100	.177	.199	.209	.231	.219	.061	.050	.059	.057	055
200	.129	.147	.150	.150	.159	.065	.061	.055	.053	058
	RMSE ratio									
(N, T)	25	50	75	100	200	25	50	75	100	200
25	1.018	1.039	1.041	1.092	1.063	1.128	1.192	1.108	1.106	1.067
50	1.285	1.171	1.168	1.169	1.150	1.258	1.255	1.220	1.223	1.116
75	1.127	1.084	1.085	1.086	1.082	1.278	1.194	1.185	1.192	1.143
100	1.104	1.191	1.219	1.249	1.219	1.204	1.201	1.186	1.210	1.171
200	1.086	1.106	1.106	1.121	1.107	1.241	1.203	1.203	1.205	1.181