APPENDIX A

Box Cox Transformation

Since the seminal paper by Box and Cox, (1964), the Box-Cox type of power of transformation has become a widely tool in theoretical work and in practical applications. This approach is introduced to make the data behave according to the usual assumptions for Linear Regression Model (Marazzi and Yohai, 2004), that is $y \sim \mathrm{N}(\mathrm{X}\beta, \sigma^2 \mathrm{I}_n)$. Consider the data vectors of the response variable $\left(y_{i1}, y_{i2,} ..., y_{NT}\right)$, for $i = 1,2,..., N.$ $t = 1,2,...,T$ in which each $y_{it} > 0$, the Box-Cox transformation takes the following form (Box and Cox, 1964);

$$y_{it}(\lambda) = \begin{cases} \left(y_{it}{}^{\lambda} - 1\right)/\lambda & \text{if } \lambda = 0 \\ \ln(\lambda) & \text{if } \lambda \neq 0 \end{cases} \tag{a1}$$

where $y_{it}(\lambda)$ is the response variable, λ is transformation parameter (which are generally estimated by maximum likelihood (MLE). Note that, y_{it} in (a1) must always positive for each $i = 1,2,..., N$ and $t = 1,2,...,T$. Thus, the extended version for $y_{it} < 0$ is given as;

$$y_{it}(\lambda) = \begin{cases} \left((y_{it} + \lambda_2)^{\lambda_1} - 1\right)/\lambda_1 & \text{, if } \lambda_1 = 0 \\ \ln\left(y_{it} + \lambda_2\right) & \text{, if } \lambda_1 \neq 0 \end{cases} . \tag{a2}$$

Here, $\lambda = \left(\lambda_1, \lambda_2\right)^T$ where λ_2 is chosen such that $y_{it} + \lambda_2 > 0$ for any y_{it} .

The Box-Cox transformation is considered with the aim of transforming data in the presence of CD in panel data model. After the transformation, the cross correlated error should be independent across cross section and to verify this, the CD tests is applied to the transform data. To illustrate the phenomenon, consider the following pure static model:

$$y_{it} = \alpha_i + \beta_i^T x_{it} + e_{it} \quad i = 1,2,\ldots,N \text{ and } t = 1,2,\ldots,T \tag{a3}$$

where y_{it} is the response variable, x_{it} is the independent (predictor) variable, α_i, β_i are unknown parameters and varies across i and e_{it} are the random errors. The sample chosen is $(N,T) = (20,100)$ with three CD case (with the value of factor loadings, γ_i) ; (i) mild CD - $\gamma_i \sim iidU[0.1,0.3]$; (ii) strong CD - $\gamma_i \sim iidU[0.4,0.7]$; (iii) very strong CD - $\gamma_i \sim iidU[0.5,1.5]$. The estimate of λ is 0.436 so that the $\lambda = 0.5$ is chosen to perform the transformation and the result of CD tests on the transform data is given in Table A1.

Table A1: The results of CD tests on the transformed data

CD case	PCD Test	LM Test
$\gamma_i \sim iidU[0.1,0.3]$	-0.20	180.38
$\gamma_i \sim iidU[0.4,0.7]$	2.28*	194.37
$\gamma_i \sim iidU[0.5,1.5]$	10.89*	360.28*

* The test is significant when $\text{LM} > 223.16$ and $|\text{PCD}| > 1.96$.

Table A1 reports the CD test result for the transformed panel. Based on the result, the LM and PCD test give insignificant CD test for the case of mild CD, i.e. $\gamma_i \sim iidU[0.1,0.3]$. Both tests reject the presence of CD when mild CD effect is observed in panel. As the effect of CD increases, i.e. $\gamma_i \sim iidU[0.4,0.7]$, the CD result of LM test hold of no CD is observed. The CD tests of LM and PCD provide significant tests statistics value for the very strong CD effect, i.e. $\gamma_i \sim iidU[0.5,1.5]$. This clearly means that the Box-Cox transformation does not work for high cross correlated error. The transformation is only suggested when the mild CD is observed in panel.

APPENDIX B

Method of Estimation

Table B1: Method of estimation in panel model

No.	Method	Model	Parameter Estimates
1	Pooled	$Y_{it} = \alpha + \beta X_{it} + e_{it}$	$\hat{\beta} = (\sum_{i=1}^{N} X_i^T X_i)^{-1} \sum_{i=1}^{N} X_i^T Y_i$
2	Fixed Effects	$Y_{it} = \alpha_i + \beta X_{it} + e_{it}$	$\hat{\beta} = (\sum_{i=1}^{N} X^{\circ T}_i X^{\circ}_i)^{-1} \sum_{i=1}^{N} X^{\circ T}_i Y^{\circ}_i$ where $X^{\circ}_i = X_{it} - \overline{X}_i$, $\overline{X}_i = \left(\sum_{t=1}^{T} X_{it} \right) / T$ and $Y^{\circ}_i = Y_{it} - \overline{Y}_i$, $\overline{Y}_i = \left(\sum_{t=1}^{T} Y_{it} \right) / T$.
3	Two-way Fixed Effects	$Y_{it} = \alpha_i + \alpha_t + \beta X_{it} + e_{it}$	$\hat{\beta} = (\sum_{i=1}^{N} X^{*T}_i X^{*}_i)^{-1} \sum_{i=1}^{N} X^{*T}_i Y^{*}_i$ where $X^{*}_i = X_{it} - \overline{X}_i - \overline{X}_t + \overline{X}$ and $Y^{*}_i = Y_{it} - \overline{Y}_i - \overline{Y}_t + \overline{Y}$ $\overline{X}_{ti} = \left(\sum_{i=1}^{N} X_{it} \right) / N$ and $\overline{X} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} X_{it} \right) / NT$; $\overline{Y}_{ti} = \left(\sum_{i=1}^{N} Y_{it} \right) / N$ and $\overline{Y} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} Y_{it} \right) / NT$
4	Fixed Effects with Principal Components	$Y_{it} = \alpha_i + \beta X_{it} + c' Z_t + e_{it}$ where Z_t have J number of principal components of standardized residuals $(J < N)$.	$\hat{\beta} = (\sum_{i=1}^{N} R_i^T R_i)^{-1} \sum_{i=1}^{N} R_i^T Y_i$ where $R_i = (X_i, Z_t)$
5	Mean Group (MG)	$Y_{it} = \alpha_i + \beta_i X_{it} + e_{it}$	$\hat{\beta} = \frac{\sum_{i=1}^{N} \hat{\beta}_i}{N}$ where $\hat{\beta}_i = (X_i^T X_i)^{-1} X_i^T Y_i$

6	Seemingly unrelated (SUR) Mean Group	$Y_i = X_i \beta_i + e_i$, $i = 1,2,..., N$	$\hat{\beta}_i = (X^T \Sigma^{-1} X)^{-1} X^T \Sigma^{-1} Y$ where $\Sigma^{-1} = V^{-1}(e) = \begin{bmatrix} \sigma^{11}\mathrm{I} & \sigma^{12}\mathrm{I}\text{..........}\sigma^{1N}\mathrm{I} \\ \sigma^{21}\mathrm{I} & \sigma^{22}\mathrm{I}\text{...........}\sigma^{2N}\mathrm{I} \\ . & \text{....................} \\ . & \text{.....................} \\ \sigma^{N1}\mathrm{I} & \sigma^{N2}\mathrm{I}\text{...........}\sigma^{NN}\mathrm{I} \end{bmatrix}$ and I is a unit T by T matrix. $\hat{\beta} = \frac{\sum_{i=1}^{N} \hat{\beta}_i}{N}$
7	Demeaned mean group	$\ddot{Y}_{it} = \alpha_i + \beta_i \ddot{X}_{it} + e_{it}$	$\hat{\beta}_i = (\ddot{X}_i^T \ddot{X}_i)^{-1} \ddot{X}_i^T \ddot{Y}_i$ where $\ddot{X}_{ti} = X_{it} - \overline{X}_t$ and $\ddot{Y}_i = Y_{it} - \overline{Y}_t$
8	Mean Group with Principal Components	$Y_{it} = \alpha_i + \beta_i X_{it} + c' Z_t + e_{it}$ where Z_t have J number of principal components of standardized residuals $(J < N)$.	$\hat{\beta}_i = (R_i^T R_i)^{-1} R_i^T Y_i$ and $\hat{\beta} = \frac{\sum_{i=1}^{N} \hat{\beta}_i}{N}$
9	Between or Cross Section	$\overline{Y}_i = \alpha + \beta \overline{X}_t + e_i$	$\hat{\beta} = (\overline{X}_i^T \overline{X}_i)^{-1} \overline{X}_i^T \overline{Y}_i$ where $\overline{X}_i = \left(\sum_{t=1}^{T} X_{it} \right) / T$, $\overline{Y}_i = \left(\sum_{t=1}^{T} Y_{it} \right) / T$

APPENDIX C

Critical Values for CIPS

Table C1: Critical values of Average of Individual Cross Sectional Augmented Dickey-Fuller Distribution

T/*N*	20			30			50		
Quartile	1%	5%	10%	1%	5%	10%	1%	5%	10%
20	-2.40	-2.21	-2.10	-2.32	-2.15	-2.07	-2.25	-2.11	-2.03
30	-2.38	-2.20	-2.11	-2.30	-2.15	-2.07	-2.23	-2.11	-2.04
50	-2.36	-2.20	-2.11	-2.30	-2.16	-2.08	-2.23	-2.11	-2.05
100	-2.36	-2.20	-2.11	-2.30	-2.16	-2.08	-2.23	-2.12	-2.05
200	-2.36	-2.20	-2.11	-2.30	-2.16	-2.08	-2.23	-2.12	-2.05

The respective critical values are computed based on 50,000 number of simulation.

Table C2: Summary Statistic of Individual Cross Sectional Augmented Dickey-Fuller Distribution

Mean

T/*N*	20	30	50
20	-1.73	-1.74	-1.73
30	-1.75	-1.75	-1.76
50	-1.77	-1.77	-1.77
100	-1.78	-1.79	-1.79
200	-1.79	-1.79	-1.79

Standard Deviation

T/*N*	20	30	50
20	1.02	1.02	1.02
30	0.97	0.98	0.97
50	0.94	0.94	0.94
100	0.91	0.92	0.92
200	0.90	0.91	0.91

APPENDIX D

PPP data

Abbreviations:

1) ASIAN countries

CNY	China
HKG	Hong Kong
IND	India
INDO	Indonesia
KOR	Korea
MYS	Malaysia
MMR	Myanmar
PAK	Pakistan
PHL	Philippines
WSM	Samoa
SGP	Singapore
LKA	Sri Lanka
TWN	Taiwan
THA	Thailand

2) Central and Eastern Europe (CEEC) countries

AL	Algeria
CR	Croatia
CZ	Czech Republic
EE	Estonia
HU	Hungary
LV	Latvia
LT	Lithuania
MK	Macedonia
PL	Poland
RO	Romania
SK	Slovakia
SL	Slovenia