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Is Per Capita Real GDP Stationary? An Empirical Note for 16 Transition Countries

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1. Introduction

Nelson and Plosser (1982) pointed out that whether real output levels are modeled as a trend stationary or as a difference stationary process has important implications vis-à-vis macroeconomic policymaking, modeling, testing, and forecasting. Studies of this issue are of considerable concern to researchers conducting empirical studies and to policymakers. Numerous studies have found support for a unit root in real output levels, but critics have staunchly contended that the drawing such a conclusion may be attributed to the low power of conventional unit root tests employed when compared with near-unit-root but stationary alternatives. Furthermore, conventional unit root tests have reportedly failed to consider information across regions, thereby reflecting less efficient estimations. It should therefore not be unexpected that these shortcomings have seriously called into question many of the earlier findings that are based on a unit root in real output levels.

One feasible way to increase power when testing for a unit root is, of course, to use panel data. Breuer et al. (2001) and Taylor and Taylor (2004) showed that the recent methodological refinements of the Levin-Lin-Chu (2002) test fail to fully address the "all-or-nothing" nature of the test. Because they are joint tests of the null hypothesis, they are not informative with regard to the number of series that are stationary processes when the null hypothesis is rejected. Breuer et al. (2001) further claimed that, by analogy to simple regression when an F-statistic rejects the null that a vector of coefficients is equal to zero, it does not follow that each coefficient is nonzero. Similarly, when the unit-root null hypothesis is rejected, it may be erroneous to conclude that all series in the panel are stationary.

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This empirical note contributes to this line of research by determining whether or not the unit root process is characteristic of the transition country real output levels. This study tests the non-stationarity of per capita real GDP of 16 transition countries using panel seemingly unrelated regressions augmented Dickey-Fuller (SURADF) unit root tests of Breuer et al. (2001). The present paper is the first to our knowledge to examine non-stationarity in real output levels for transition countries.

Transition countries represent an interesting arena to research for several reasons. First, transition countries underwent major changes in their economic and political systems during their transition to market economies in the 1990s. The economic transformations shared several common features, ranging from institutional changes promoting a market economy to practical issues like the accommodating changes in the exchange rate regime or the inflow of foreign direct investment to industries with comparative advantage. Second, during the transformation, transition countries launched various privatization programs and adopted an extensive range of measures to implement monetary and fiscal policies that would suit the needs of the overall transformation. Therefore, we do not know whether the extraordinarily high growth rates in some countries (e.g., Poland or Slovakia) reflected only a temporary growth spurt or whether rapid growth will persist, nor is it clear whether slow growth in other countries (e.g., Bulgaria or Romania) will accelerate when shortcomings in institution building and macroeconomic policies are overcome. Third, the variance in the growth rates of GDP and physical investment among the transition countries is extraordinarily large. Moreover, it remains unclear whether we can inform forecasts about real output prospects based on present trends in these countries. Thus, uncertainty about economic development in the accession candidates from transition countries is still high even a decade or more after the start of the economic transformation.

2. Data

This empirical study uses annual per capita real GDP (2005 = 100) for 16 transition countries over the 1969–2009 period: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Albania, Croatia, Serbia, Russia, and Ukraine. The source of the data is the World Economic Outlook Database. The per capita real GDP datasets indicate that Cyprus and Serbia have the highest and lowest average per capita incomes of USD 12,871 and 788, respectively. The Jarque–Bera test indicates that the per capita real GDP datasets for these 16 transition countries are non-normal, with the exception of Cyprus, Czech Republic, Hungry, Lithuania, Romania, Croatia, Serbia, Russia, and Ukraine.

3. Methodology and Empirical Results

3.1 The Breuer et al. (2001) SURADF Tests

Breuer et al. (2001) introduced the SURADF tests, which are augmented

Dickey-Fuller (ADF) tests based on panel estimation of seemingly unrelated regressions (SUR). The system of the ADF equations that we estimate here is:

$$\begin{aligned}
\Delta X_{1,t} &= \alpha_1 + \beta_1 X_{1,t-1} + \sum_{j=1}^{k1} \theta_{1,j} \Delta X_{1,t-j} + \varepsilon_{1,t}, \quad t = 1,\ldots,T \\
\Delta X_{2,t} &= \alpha_2 + \beta_2 X_{2,t-1} + \sum_{j=1}^{k2} \theta_{2,j} \Delta X_{2,t-j} + \varepsilon_{2,t}, \quad t = 1,\ldots,T \\
&\vdots \\
\Delta X_{N,t} &= \alpha_N + \beta_N X_{N,t-1} + \sum_{j=1}^{kN} \theta_{N,j} \Delta X_{N,t-j} + \varepsilon_{N,t}, \quad t = 1,\ldots,T .
\end{aligned} \tag{1}$$

We test the N null and alternative hypotheses individually:

$$\begin{aligned}
&H_0^1 : \beta_1 = 0 \quad \text{versus} \quad H_A^1 : \beta_1 < 0 \\
&H_0^2 : \beta_2 = 0 \quad \text{versus} \quad H_A^2 : \beta_2 < 0 \\
&\qquad \vdots \\
&H_0^N : \beta_N = 0 \quad \text{versus} \quad H_A^N : \beta_N < 0,
\end{aligned}$$

where we compute the test statistics from the SUR estimates of system (1). Breuer et al. (2001) demonstrated that the imposition of an identical lag structure across panel members could bias test statistics; thus, we select the lag structures for each equation based on the approach adopted by Perron (1989).

3.2 Empirical Results

For comparison, several univariate unit root and panel-based unit root tests are first employed to examine the null of a unit root in real GDP per capita for these 16 transition countries. The three univariate unit root tests—the ADF (1981), the Phillips and Perron (1988, PP) and the Kwiatkowski et al. (1992, KPSS) tests—all fail to reject the null of non-stationary real GDP per capita for these 16 transition countries. Unit root test results are suppressed here for space consideration but are available upon request. These results are consistent with those in the literature and imply that real GDP per capita for each country follows a random walk process during the sample period. But as we know, univariate unit root tests may have low power when the real GDP per capita series are highly persistent. In this situation, the panel-based unit tests are found to be of great help provided that they allow for an increase in the power of the order of the integration analysis by allowing the cross-section and temporal dimensions to be combined. Table 1 reports the results for the panel-based unit root tests. Three panel-based unit root tests (i.e., Im et al., 2003; Maddala and Wu, 1999; and Hadri, 2001) all yield the same results, indicating that real GDP per capita series are non-stationary in these 16 transition countries.

As noted above, panel-based unit root tests are joint tests of a unit root for all members of a panel and are incapable of determining the mix of I(0) and I(1) series in a panel setting. Panel SURADF tests investigate a separate unit root null

hypothesis for each individual panel member. In so doing, they clearly identify how many and which series in the panel are stationary processes. The panel SURADF test results indicate that there is a unit root in real GDP per capita for only Bulgaria, Poland, Slovenia, Albania, and Serbia. To avoid small-sample size bias, we estimate the 1%, 5%, and 10% critical values obtained from simulations based on observations for each series and 10,000 replications using the lag and covariance structure from the panel of real GDP per capita data series for each of the 16 panel members. These are presented in Table 2.

Table 1. Panel Unit Root and Stationary Tests

Panel A	**Per Capita Real Gross Domestic product**	***p*-value**
$t\Psi$	–1.275	0.101
$LM\Psi$	1.186	0.139
MW	38.127	0.211
Hardi (hom)	3.098	0.000
Hardi (het)	4.013	0.000

Panel B: Bootstrap distribution (%)

	1	**2.5**	**5**	**10**	**90**	**95**	**97.5**	**99**
$t\Psi$	–4.962	–3.640	–2.774	–2.014	2.418	3.202	3.990	5.084
$LM\Psi$	–3.312	–2.848	–2.435	–1.946	1.941	2.680	3.539	4.826
MW	13.833	16.634	19.291	22.758	62.272	74.008	92.366	133.463
Hardi (hom)	–2.992	–2.716	–2.415	–2.012	4.257	5.914	7.577	9.445
Hardi (het)	–2.657	–2.383	–2.084	–1.703	3.711	5.079	6.358	7.977

It is worth noting that our results are consistent with those of Fleissig and Strauss (1999) who found per capita real GDP for OECD countries to be trend stationary using three different panel-based unit root tests. Our results are also consistent with those of Cuestas and Garratt (2010) who found per capita real GDP for a panel of developed countries to be nonlinear stationary using both the Kapetanois et al. (2003) and Kruse (2011) nonlinear unit root tests.[1] The results, nevertheless, are inconsistent with those of Cheung and Chinn (1996), Cheung and Westermann (2002), and Rapach (2002) who support non-stationarity in real GDP for various panels of OECD countries A major policy implication of the present study is that a stabilization policy may not have persistent effects on the output level of most of the transition countries studied here.

4. Conclusions

This empirical note applies panel SURADF tests (Breuer et al., 2001) to investigate the time-series properties of per capita real GDP for 16 transition countries over the 1969–2009 period. The results from several conventional unit root tests indicate that the per capita real GDP for all countries are non-stationary; however, the Breuer et al. (2001) panel SURADF tests finds a unit root in per capita

real GDP in only 5 out of 16 countries. These results have important policy implications for the 16 transition countries under study.

Table 2. SURADF Tests and Critical Values

Country panel label	SURADF	Critical values		
		1%	5%	10%
Bulgaria	–0.494	–2.443	–1.713	–1.298
Cyprus	**–4.509*** **	–2.325	–1.651	–1.264
Czech Republic	**–2.249*** **	–2.111	–1.358	–0.963
Estonia	**–4.028*** **	–2.294	–1.511	–1.086
Hungary	**–3.815*** **	–2.173	–1.471	–1.0711
Latvia	**–4.015*** **	–2.263	–1.459	–1.058
Lithuania	**–6.881*** **	–2.074	–1.342	–0.9445
Poland	0.662	–2.851	–2.1234	–1.752
Romania	**–3.837*** **	–2.455	–1.715	–1.302
Slovakia	**–2.738*** **	–2.107	–1.386	–1.003
Slovenia	0.499	–2.928	–2.203	–1.854
Albania	–1.238	–2.315	–1.643	–1.248
Croatia	**–3.055*** **	–2.127	–1.421	–0.9959
Serbia	0.527	–2.798	–2.134	–1.781
Russia	**–5.121*** **	–2.181	–1.454	–1.058
Ukraine	**–4.203*** **	–2.506	–1.717	–1.323

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Critical values are calculated by Monte Carlo simulation with 10,000 draws tailored to the present sample size. (For simulation details see Breuer et al., 2001). Bold text indicates statistical significance.

Notes

1. Chang et al. (2006) also applied the same technique (panel SURADF test) to 47 African countries and found evidence of a unit root in per capita real GDP in only two-thirds of the countries studied.

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