Are real GDP levels nonstationary across Central and Eastern European countries?

Pei-Long Shen¹, Chih-Wei Su² and Hsu-Ling Chang³

Abstract

This study applies the Sequential Panel Selection Method (SPSM) proposed by Chortareas and Kapetanios (2009) to investigate and assess the non-stationary properties of whether real GDP follows a trend stationary or a difference stationary process for Central Eastern European (CEE) countries. SPSM can classify the whole panel into a group of stationary series and a group of non-stationary series. We clearly identify how many and which series in the panel are stationary processes and provide robust evidence clearly indicating that per capita real GDP for CEE countries holds stationary for three countries. Our findings point out their per capita real GDP convergence is a mean reversion towards equilibrium values in a non-linear way. Our results have important policy implications for macroeconomic policy, modeling, testing and forecasting for these CEE countries under study.

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1. Introduction

The modeling of per capita real GDP as either a trend stationary or a difference stationary process has received much attention since Nelson and Plosser (1982). Researchers have been especially interested in the time-series properties of real output levels. In this regard, 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 policy-making, modeling and testing, not to mention forecasting. Studies on this issue are of considerable concern to researchers conducting empirical studies and policy-makers alike. Nelson and Plosser note that a unit root in real output is inconsistent with the notion that business cycles are stationary fluctuations around a deterministic trend; instead, it suggests that shocks to real output have permanent effects on the system. While empirical evidence on the stationarity of real GDP is abundant in developing countries (Cheung and Chinn, 1996; Rapach, 2002; Cheung and Westermann, 2002), the literature dealing specifically with the Central Eastern European (CEE) countries and other European transition countries is rather

¹ Professor, Faculty of Finance and Banking, Shanxi University of Finance and Economics, 696, Wucheng Rd., Taiyuan, Shanxi, China. Phone: +86-13513513839. E-Mail: plongshen@163.com
² Corresponding author, Professor, Faculty of Finance and Banking, Shanxi University of Finance and Economics, 696, Wucheng Rd., Taiyuan, Shanxi, China. Phone: +86-13225926332. E-Mail: davidsuuu@gmail.com
³ Associate Professor, Department of Accounting and Information, Ling Tung University, 1, Lingtung Rd., Taichung, Taiwan. Phone: +886-939147336. E-Mail: hsulingchang@yahoo.com.tw
The empirical literature cited above reached the conclusion that real GDP levels are nonstationary by using rather univariate unit root statistics (Cheung and Chinn, 1996) or panel unit root tests (Rapach, 2002) along the lines of Augmented Dickey-Fuller (ADF) statistics. The linear unit root test methodology assumes that in spite of the deviation situation, the process of real GDP levels moving to the equilibrium is linear and the velocity of adjustment is a constant. One feasible way to increase power when testing for a unit root is, of course, to use panel data. Taylor (2003) and Taylor and Taylor (2004) showed that the recent methodological refinements of the Levin et al. (2002) test fail to fully address the ‘all-or-nothing’ nature of the test. If the unit-root null hypothesis is rejected, it may be erroneous to conclude that all series in the panel are stationary. Furthermore, in the data generating process (DGP), if nonlinear factors were neglected, we cannot receive the expected results via real GDP stationary. Meanwhile, the omission of some structural breaks is a possible cause of traditional unit root tests failing to reject the null hypothesis for stationarity. Perron (1997) argued that if there is a structural break, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. Structural changes present in the DGP, but which have been neglected, sway the analysis toward accepting the null hypothesis of a unit root. As we know, real GDP might be affected by internal and external shocks generated by structural changes, which may be subject to considerable short-run variation. It is important to investigate whether per capita real GDP has any tendency to settle down to a long-run equilibrium level. If per capita real GDP convergence is found stationary by using the unit root test with structural break(s), the effects of shocks that cause deviations around a mean value or deterministic trend are only temporary.

As discussed, traditional unit root tests lose power if structural breaks are ignored in unit root testing. The general method to account for breaks is to approximate those using dummy variables. However, this approach has several undesirable consequences. First, one has to know the exact number and location of the breaks. Second, current available tests account only for one to two breaks. Third, the use of dummies suggests sharp and sudden changes in the trend or level. However, for low frequency data it is more likely that structural changes take the form of large swings which cannot be captured well using only dummies. Breaks should therefore be approximated as smooth and gradual processes (see Leybourne et al., 1998). Becker et al. (2006), Enders and Lee (2012), and Christopoulos and León-Ledesma (2010) develop tests which model any structural break of an unknown form as a smooth process via means of Flexible Fourier transforms (i.e., an expansion of a periodic function in terms of an infinite sum of sines and cosines). Several authors, including Becker et al. (2006), Enders and
Lee (2012), and Christopoulos and León-Ledesma (2010), show that a Fourier approximation can often capture the behavior of an unknown function even if the function itself is not periodic. The authors argue that their testing framework requires only specification of the proper frequency in the estimating equations. By reducing the number of estimated parameters, they ensure the tests have good size and power irrespective of the time or shape of the break. Recently, there is a growing consensus that macroeconomic variables exhibit nonlinearities and, consequently, conventional unit root tests, such as the ADF test, have low power in detecting mean reversion. To solve this problem, non-stationary tests based on a nonlinear framework must be applied. Ucar and Omay (2009) proposed a nonlinear panel unit root test by combining the nonlinear framework in Kapetanios et al. (2003, KSS) with the panel unit root testing procedure of Im et al. (2003), which has been proved to be useful in testing the mean reversion of time-series data. Hence, this empirical study applies the Panel KSS test with a Fourier function, using the Sequential Panel Selection Method (SPSM) procedure, to investigate the time-series properties of per capita real GDP of 9 CEE countries.

The central aim of this study contributes significantly to this field of research because, first, to the best of our knowledge, this study is the first of its kind to utilize the Panel KSS unit root test with a Fourier function through the SPSM procedure to examine evidence for per capita real GDP for CEE countries. Secondly, it is well-known that independence is not a realistic assumption in that the per capita real GDP of different countries may be contemporaneously correlated. To control for any cross-section dependence found among the data sets, we approximate the bootstrap distribution of the tests, which is not done in previous studies (Chang et al., 2005; Vougas, 2007; Cuestas and Garratt, 2011) which assumes the individuals are cross-section independent. With these, the current research hopes to fill an existing gap in the literature. The empirical results indicate that per capita real GDP hold stationary for six of the CEE countries studied and our results have important policy implications for macroeconomic policy, modeling, testing and forecasting with temporal effect of shocks for these transition countries under study. Furthermore, our empirical findings also suggest that allowing for nonlinearities and structural breaks results in rejection of the unit root null hypothesis. Our results point out the importance of proper modeling of both structural breaks and nonlinearities in per capita real GDP of CEE countries.

The remainder of this study is organized as follows. Section 2 describes the methodology of the SPSM test proposed by Chortareas and Kapetanios (2009). Section 3 presents the data used in our study and discusses the empirical findings. Finally, Section 4 reviews the conclusions we have drawn.

2. Sequential Panel Selection Method (SPSM) and Panel KSS Unit Root Test with a Fourier Function

Existing studies have found that many macroeconomic and financial time series not only contain unit roots but also exhibit nonlinearities; thus stationary tests in a nonlinear framework must be applied. Ucar and Omay (2009) proposed a nonlinear panel unit root test by combining the nonlinear framework in Kapetanios et al. (2003, KSS) with the panel unit root testing procedure of Im et al. (2003). If structural breaks are neglected in the unit root rest, the result would be spurious. Therefore, the Sequential Panel Selection Method (SPSM)
proposed by Chortareas and Kapetanios (2009), mixed with Panel KSS unit root tests with a Fourier function, were used to test for the stationarity of per capita real GDP for a sample of 9 CEE countries in our study.

In line with Kapetanios et al. (2003), the KSS unit root test is based on detecting the presence of non-stationarity against a nonlinear but globally stationary exponential smooth transition autoregressive (hereafter, ESTAR) process. The model is given by

\[ \Delta X_t = \gamma X_{t-1} \{1 - \exp(-\theta X_{t-1}^2)\} + \nu_t, \]  

(1)

where \( X_t \) is the data series of per capita real GDP, \( \nu_t \) is an i.i.d. error with zero mean and constant variance, and \( \theta \geq 0 \) is the transition parameter of the ESTAR model and governs the speed of transition. Under the null hypothesis \( X_t \) follows a linear unit root process, but \( X_t \) follows a nonlinear stationary ESTAR process under the alternative. One shortcoming of this framework is that the parameter \( \theta \) is not identified under the null hypothesis. Kapetanios et al. (2003) have used a first-order Taylor series approximation for \{1 - \exp(-\theta X_{t-1}^2)\} under the null hypothesis \( \theta = 0 \) and have then approximated Equation (1) by using the following auxiliary regression:

\[ \Delta X_t = \xi + \delta X_{t-1}^3 + \sum_{j=2}^{k} \theta_{j} \Delta X_{t-j} + \nu_t \quad t = 1,2,\ldots,T \]  

(2)

In this framework the null hypothesis and alternative hypotheses are expressed as \( \delta = 0 \) (non-stationarity) against \( \delta < 0 \) (non-linear ESTAR stationarity). Then, Ucar and Omay (2009) have expanded a nonlinear panel data unit root test based on Equation (1). The regression is:

\[ \Delta X_{i,t} = \gamma_{i} X_{i,t-1} \{1 - \exp(-\theta_{i} X_{i,t-1}^2)\} + \nu_{i,t} \]  

(3)

Ucar and Omay (2009) have also applied first-order Taylor series approximation to the Panel ESTAR model around \( \theta_{i}=0 \) for all \( i \), and have obtained the auxiliary regression:

\[ \Delta X_{i,t} = \xi_{i} + \delta_{i} X_{i,t-1}^3 + \sum_{j=2}^{k} \theta_{i,j} \Delta X_{i,t-j} + \nu_{i,t} \]  

(4)

where \( \delta_{i} = \theta_{i} \gamma_{i} \), and the hypotheses established by them for unit root testing based on Equation (4) are as follows:

\[ H_0: \delta_i = 0, \text{ for all } i, \text{ (linear nonstationarity)} \]

\[ H_0: \delta_i < 0, \text{ for some } i, \text{ (nonlinear stationarity)} \]  

(5)

Furthermore, the system of the KSS equations with a Fourier function that we estimate here is:

\[ \Delta X_{i,t} = \xi_{i} + \delta_{i} X_{i,t-1}^3 + \sum_{j=2}^{k} \theta_{i,j} \Delta X_{i,t-j} + a_{i,t} \sin\left(\frac{2\pi k t}{T}\right) + b_{i,t} \cos\left(\frac{2\pi k t}{T}\right) + \epsilon_{i,t} \]  

(6)

where \( t = 1,2,\ldots,T \), \( k \) represents the frequency selected for the approximation, \([a_{i,t}, b_{i,t}]'\) measures the amplitude and displacement of the frequency component, and the rational for se-
lecting \([\sin(2\pi k / T), \cos(2\pi k / T)]\) is based on the fact that a Fourier expression is capable of approximating absolutely integrable functions to any desired degree of accuracy. It also follows that at least one frequency component must be present if there is a structural break\(^4\). Enders and Lee (2012) and Pascalau (2010), show that a Fourier approximation can often capture the behavior of an unknown function even if the function itself is not periodic. As there is no \textit{a priori} knowledge concerning the shape of the breaks in the data, a grid-search is first performed to find the best frequency.

The SPSM procedure proposed by Chortareas and Kapetanios (2009) is applied to Equation (6) in three steps: (i) we apply the panel KSS test with a Fourier function to all series in the panel. If the null hypothesis of unit root cannot be rejected, the procedure is stopped, and all the series in the panel are non-stationary. If the null is rejected, we proceed to Step 2; (ii) we remove the series with the minimum KSS statistic since it is identified as being stationary; (iii) we turn back to Step 1 for the remaining series, or stop the procedure if all the series are removed from the panel. The final result from the above three steps is the separation of the whole panel into a set of stationary series and a set of non-stationary series.

3. Data and empirical results

This empirical study is based on yearly per capita real GDP data for nine CEE countries, namely Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia for the period 1991 to 2012. All the data were converted into natural logarithmic form before the empirical analysis. The source of the data is from EUROSTAT, as well as estimated and projected values developed by the Economic Research Service all converted to a 2005 base year.

As stated earlier, there is a growing consensus that conventional unit root tests such as ADF and PP tests - fail to incorporate structural breaks in the model and have low power in detecting the mean reversion of per capita real GDP. Otherwise, panel based unit root tests are joint tests of a unit root for all members of a panel, which are incapable of determining the mix of I(0) and I(1) series in panel setting. If we fail to incorporate the structural breaks in the model, the power will be low in detecting the mean reversion of per capita real GDP. Therefore, we proceed to utilize the SPSM mixed with the Panel KSS unit root test with a Fourier function to investigate the time-series properties of per capita real GDP for the 9 CEE countries. The SPSM classifies the whole panel into a group of stationary series and a group of non-stationary series. In doing so, we can clearly identify how many and which series in the panel are stationary processes. Perron (1997) argued that if there is a structural break, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. Meanwhile, structural changes present in the data generating process, but which have been neglected, sway the analysis toward accepting the null hypothesis of a unit root. Therefore, we go for the Panel KSS unit root test with a Fourier function. First, a grid-search is performed to find the best frequency, as there is no \textit{a priori} knowledge concerning the shape of the breaks in the data. We estimate Equation (6) for each integer \(k = 1, \ldots, 5\), following the recommendations of Enders and Lee (2012) and the asymp-

\(^4\) Enders and Lee (2012) suggest that the frequencies in Equation (6) should be obtained via minimization of the sum of squared residuals. However, their Monte Carlo experiments suggest that no more than one or two frequencies should be used because of the loss of power associated with a larger number of frequencies.
Asymptotic p-values are computed by means of Bootstrap simulations using 10,000 replications. The residual sum of squares (RSSs) indicates that a single frequency (k=1) works best for five of the series, with the exception of sequences 1, 3, 7 and 8. For sequence 8, we found the best frequency is (k=2); sequence 1 is for (k=3); sequences 3 and 7 are for (k=4), respectively (see the fifth column at the Table 1). Table 1 reports the results of the Panel KSS unit root test with a Fourier function on per capita real GDP where we also give a sequence of the Panel KSS statistics with their bootstrap p-values on a reducing panel, the individual minimum KSS statistic, and the stationary series identified by this procedure each time.

Table 1. Results of Panel KSS with Fourier test on Per Capita Real GDP

<table>
<thead>
<tr>
<th>Sequence</th>
<th>OU Statistic</th>
<th>p-Value</th>
<th>Min KSS</th>
<th>k</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.707***</td>
<td>0.000</td>
<td>-7.812</td>
<td>3</td>
<td>Slovakia</td>
</tr>
<tr>
<td>2</td>
<td>-3.194***</td>
<td>0.000</td>
<td>-5.489</td>
<td>1</td>
<td>Estonia</td>
</tr>
<tr>
<td>3</td>
<td>-2.866***</td>
<td>0.001</td>
<td>-4.567</td>
<td>4</td>
<td>Lithuania</td>
</tr>
<tr>
<td>4</td>
<td>-2.582***</td>
<td>0.007</td>
<td>-4.106</td>
<td>1</td>
<td>Romania</td>
</tr>
<tr>
<td>5</td>
<td>-2.277**</td>
<td>0.027</td>
<td>-3.666</td>
<td>1</td>
<td>Latvia</td>
</tr>
<tr>
<td>6</td>
<td>-1.930*</td>
<td>0.063</td>
<td>-3.398</td>
<td>1</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>7</td>
<td>-1.441</td>
<td>0.185</td>
<td>-1.931</td>
<td>4</td>
<td>Poland</td>
</tr>
<tr>
<td>8</td>
<td>-1.196</td>
<td>0.278</td>
<td>-1.655</td>
<td>2</td>
<td>Hungary</td>
</tr>
<tr>
<td>9</td>
<td>-0.737</td>
<td>0.370</td>
<td>-0.737</td>
<td>1</td>
<td>Bulgaria</td>
</tr>
</tbody>
</table>

Notes: ***, ** and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively. The asymptotic p-values are computed by means of Bootstrap simulations using 10,000 replications.

As we can see from Table 1, the null hypothesis of unit root in per capita real GDP was rejected when the Panel KSS unit root test was first applied to the whole panel, producing a value of -3.707 significantly in 1% levels. After implementing the SPSM procedure, we found Slovakia is stationary with the minimum KSS value of -7.812 among the panel. Then, Slovakia was removed from the panel and the Panel KSS unit root test was implemented again to the remaining set of series. After that, we found that the Panel KSS unit root test still rejected the unit root null hypothesis with a value of -3.914, and Estonia was found to be stationary with the minimum KSS value of -5.489 among the panel this time. Then, Estonia was removed from the panel and the Panel KSS unit root test was implemented again to the remaining set of series. The procedure was continued until the Panel KSS unit root test failed to reject the unit root null hypothesis at the 10% significance level, and finally we found that this procedure stopped at sequence 6, when the per capita real GDP for six countries (i.e., Slovakia, Estonia, Lithuania, Romania, Latvia and the Czech Republic) were removed from the panel. To check the robustness of our test, we continued the procedure until the last sequence.
Figure 1. Plots of Per Capita Real GDP Convergence for CEE Countries and Fitted Nonlinearities

Are real GDP levels nonstationary across Central and Eastern European countries?
We found that the Panel KSS statistic all failed to reject the unit root null hypothesis for the rest of the sequences. Apparently, the SPSM procedure using the Panel KSS unit root test with a Fourier function provided some evidence for the stationary in per capita real GDP for these six CEE countries. Our empirical findings suggest that allowing for nonlinearities and structural breaks results in rejection of the unit root null hypothesis. The results point to the importance of proper modeling of structural breaks and nonlinearities in per capita real GDP series of CEE countries. Taken together our results provide strong support stationary for per capita real GDP for these six CEE countries and point out that these countries are non-linear stationary, implying that per capita real GDP follows a non-linear trend process, and policy innovations then have temporary effects. However, we find that the economic evolution across the CEE region was uneven, with some countries being more successful than others in transforming their economy without a persistent decline in output. As far as major policies are concerned, this study implies that a real shock would possibly permanently affect the real output levels of three CEE countries (i.e. Poland, Hungary and Bulgaria) under study. During the ongoing transformation, the CEE countries launched various privatization programs and adopted an extensive range of measures to implement monetary and fiscal policies that would suit the needs of overall transformation. Therefore, we find the extraordinarily high growth rates in some countries (e.g. Poland, Hungary) reflect only a temporary recovery and persist for longer time periods. Furthermore, it is clear that slow growth of output in Bulgaria will accelerate when shortcomings in institution building and macroeconomic policies are overcome. The variance in the growth rates of GDP and physical investment among these three CEE countries is extraordinarily high. The empirical evidence regarding the state of GDP convergence will be helpful for political decision makers.

We can clearly observe structural shifts in the trend of the data. Accordingly, it appears sensible to allow for structural breaks in testing for a unit root (and/or stationarity). The estimated time paths of the time-varying intercepts are also shown in Figure 1. For most countries in the sample observed in Figure 1, with the exception of Poland, Hungary and Bulgaria output started to grow sustainably in 1994 or 1995. Inflation rates also soared up, with some countries experiencing hyper-inflation and by the end of the 1990s inflation had been brought down to one-digit or low two-digit numbers. Thus, among these countries, government stabilization policy may be useful and growth is widely experienced. A further examination of the figures indicates that all Fourier approximations seem reasonable and support the notion of long swings in per capita real GDP.

4. Conclusion

This study contributes to the literature by adopting the SPSM approach, proposed by Chortareas and Kapetanios (2009), to investigate the time-series properties of per capita real GDP for CEE countries. We can clearly identify how many and which series in the panel are stationary processes. The combined use of the Panel KSS test with a Fourier function and the SPSM procedure allows us to convey clear conclusions on the stationarity of individual per capita real GDP in our study. We found that the SPSM provided robust empirical evidence supporting the real shocks which have temporary effects on the long-run per capita real GDP, suggesting in these six countries that their per capita real GDP adjustment is a mean reversion towards equilibrium values which exhibits periods of exploding behavior. It shows whether real GDP follows a stochastic or deterministic path and has far-reaching implications for
modeling, forecasting and for judging the importance and role of macroeconomic stabilization programs. Thus, per capita real GDP follows a steady rate of growth, and policy innovations then have temporary effects for Slovakia, Estonia, Lithuania, Romania, Latvia and the Czech Republic. This might offer an alternative explanation for the difficulty researchers have encountered in rejecting the unit root hypothesis for per capita real GDP.

References


