HYSTERESIS IN UNEMPLOYMENT FOR TAIWAN'S REGIONAL DATA: PANEL KSS UNIT ROOT TEST WITH A FOURIER FUNCTION THROUGH THE SEQUENTIAL PANEL SELECTION METHOD

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ABSTRACT

This study applies the Sequential Panel Selection Method (SPSM) proposed by Chortareas and Kapetanios (2009) to test the validity of hysteresis of unemployment for a sample of Taiwan's 20 regions semiannual from 1993 to 2012. SPSM classifies the whole panel into a group of stationary countries and a group of non-stationary countries. In so doing, we can clearly identify how many and which series in the panel are stationary processes. We propose a Panel KSS test with a Fourier function for the SPSM in our empirical study, the results of which indicate that natural rate of unemployment holds true for most of the 20 regions studied. Our results have important policy implications for Taiwan's 20 regions in this study.

Keywords: Hysteresis of unemployment; Taiwan's 20 regions; Sequential Panel Selection Method; Panel KSS Test with a Fourier Function

1. Introduction

Investigating whether the hypothesis of hysteresis in unemployment holds true is critical not only for empirical researchers but also for policymakers. On the basis of the assumptions inherent in the hysteresis hypothesis in unemployment, if unemployment is an I(1) process, then the shocks affecting the series will have permanent effects, thus shifting the unemployment equilibrium from one level to another. Should this be the case, from the policy point of view, policy action necessary so as to return unemployment to its equilibrium level. On the other hand, if unemployment is an I(0) process, the effect of the shock is merely transitory, and as a result, the need for policy action is less mandatory since unemployment will eventually return to its equilibrium level.

Previous literature refers to the second case as the natural-rate of unemployment hypothesis (NAIRU) for it characterizes unemployment dynamics as a mean reversion process. Because hysteresis is associated with non-stationary unemployment rates, unit root tests have been widely used in literature to empirically investigate its validity. Blanchard and Summers (1986), for example, using data for France, Germany, the United Kingdom, and the United States from the period 1953 to 1984, were pioneers in presenting the first empirical study that employed conventional unit root tests to investigate the effect of hysteresis on unemployment. In so doing, they were unable to reject the non-stationarity of unemployment rates for the countries they studied, except for the United States, where they did find evidence of stationarity. A little later, Brunello (1990), using Japanese unemployment data from the period 1955 to 1987, was unable to reject the null hypothesis of a unit root. Mitchell (1993) later used Perron's (1989) unit root test, which assumes one exogenously given structural break, and similarly confirmed support for hysteresis in several Organization for Economic Co-operation & Development (OECD) countries. Likewise, Jaeger and Parkinson (1994) reported results again indicating that unemployment hysteresis exists in Germany, the United Kingdom, and Canada, but not in the United States. In contrast, Arestis and Mariscal (2000) applied the structural break univariate unit root test of Perron (1997) to unemployment rates from 22 OECD countries. Although their results were mixed, they mostly rejected the unit root and hysteresis. Using data from 1970 to 1994, Roed (1996) empirically investigated the presence of unemployment hysteresis in 16 OECD countries and strongly suggested that hysteresis prevails in Australia, Canada, and Japan, as well as in several European countries; however, once again, hysteresis was rejected in the case of the United States (Roed, 1999).

Although the above studies tended to support a unit root in unemployment, and therefore, hysteresis, critics of the hysteresis theory counterclaim that earlier empirical support may have been a result of the lower power of the conventional unit root tests employed. In line with this, more recent studies have, in fact, found that conventional unit root tests not only have failed to consider information across regions, thereby leading to a loss in efficiency in the estimations, but also have low power against near unit root but stationary alternatives. These factors obviously cast considerable doubt on the many findings from earlier studies of a unit root in unemployment rates.

A recently proposed approach to increase power in testing for a unit root involves the use of panel data. Levin et al. (2002) and Im et al. (2003) developed the asymptotic theory and finite-sample properties of the Augmented Dickey–Fuller (ADF) tests of panel data. The authors have both demonstrated that even relatively small panels offer large improvements with respect to power. By now, these panel-based unit root tests have been widely used in empirical testing, particularly as found in the literature pertaining to purchasing power parity; for example, see the work of MacDonald (1996), Oh (1996), Wu (1996), Papell (1997), Papell and Theodoridis (2001), and Wu and Wu (2001). In addition, Fleissig and Strauss (1997), Wu (2000), Holmes (2002), and Rapach (2002), have just recently tested for a unit root in real wages, current accounts, inflation rates, and international real gross domestic product (GDP) and GDP per capita data, respectively, using selected panels of OECD countries. Their results indicate that while conventional single-equation ADF tests for real wages, current accounts, inflation rates, and international real GDP and GDP per capita data cannot, in general, reject the unit root null hypothesis, the panel based unit root tests do nevertheless overwhelmingly reject the unit root hypothesis. In the case of unemployment, Song and Wu, tested the hysteresis hypothesis in unemployment for 48 contiguous US states, 1997 and 16 OECD countries, 1998 by simultaneously using the univariate, as well as the panel-based, unit root tests of Levin et al. (2002). They observed that when the standard ADF and Philips–Perron (P–P) tests are applied to individual unemployment series, the unit root null is never rejected. In sharp contrast, when the data are pooled and the panel-based unit root test is conducted, the unit root null can, for the most part, be rejected; hence, the hysteresis hypothesis is not supported in their empirical studies. More recently, Leon-Ledesma (2002) and Osterholm (2004) applied the panel-based unit root test of Im et al. (2003) to test for unemployment hysteresis in the European Union (EU) and United States and reported that hysteresis for the EU and the natural-rate for the United States are the most plausible hypotheses.

This study contributes to this line of research by determining whether hysteresis in unemployment is a characteristic of Taiwan's labor market. We test the hypothesis of hysteresis in unemployment from Taiwan's 20 regional data sets using the Sequential Panel Selection Method (SPSM) proposed by Chortareas and Kapetanios (2009), combining the Panel KSS unit root tests with a Fourier function, to investigate the time-series properties of unemployment 20 Taiwan's regional areas. In contrast to those panel-based unit root tests that are joint tests of a unit root for all members of a panel and that are incapable of determining the mix of I(0) and I(1) series in a panel setting, the SPSM proposed by Chortareas and Kapetanios (2009), classifies a 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.

Taiwan provides an interesting research arena for several reasons. For one, the year 2000 began a new era for Taiwan in that it marked a change in political party control, with the 50-year reign of the National Party (KMT) ending in a loss to the Democratic Progress Party (DPP), but after eight years the KMT retake Political power. This has led to a certain degree of political instability as well as high volatility and fluctuations in the stock market. Secondly, and most importantly, sharply increasing labor costs have been the motivating force for some enterprises to leave Taiwan for Mainland China, and, this relocation has brought about a worsening of the overall economic situation. Unemployment has risen from well under 2% in the 1980s and 1990s to over 5.7% in early 2001. As the issue of unemployment is undoubtedly

Taiwan's most pressing problem, testing whether unemployment hysteresis prevails in Taiwan has not only become an important focus for empirical work, but also has drastically important policy implications.

The remainder of this paper is organized as follows. Section 2 presents the data used in our study. Section 3 briefly describes the SPSM test proposed by Chortareas and Kapetanios (2009), and Section 4 presents the empirical results. Section 5 concludes the paper and presents it policy implications.

2. Data

Our empirical analysis covers a sample of Taiwan's 20 regions: New Taipei city, Taipei city, Keelung county, Hsinchu county, Ilan county, Taoyuan county, Hsinchu county, Taichung City, Miaoli county, Changhua county, Nantou county, Yunlin county, Tainan City, Kaohsiung city, Chiayi city, Chiayi county, Pingtung county, Penghu county, Taitung county, and Hualian county. Semiannual data are employed in this study, the time span of which is from 1993 to the first semiannual period of 2012. The data begin in 1993 since the series in semiannual frequency for the 20 regions is only available from that time. All data are from the AREMOS database of the Ministry of Education of Taiwan. Each data rate series was transformed into natural logarithms before the econometric analysis.

3. Methodology

3.1. Sequential Panel Selection Method and the Panel KSS Unit Root Test with a Fourier Function

Recently, there is a growing consensus that the unemployment rate exhibits nonlinearities, and consequently, conventional unit root tests, such as the Augmented Dickey Fuller (ADF) test, have low power in detecting the mean reversion of the unemployment rate. A number of studies have provided empirical evidence on the nonlinear adjustment of unemployment rate. However, the finding of nonlinear adjustment does not necessarily imply nonlinear mean reversion (stationarity). As such, stationarity tests based on a nonlinear framework must be applied. Ucar and Omay (2009) propose a nonlinear panel unit root test by combining the nonlinear framework by Kapetanios et al. (2003, KSS) with the panel unit root testing procedure of Im *et al*. (2003), which has proved to be useful in testing the mean reversion of real unemployment rate. Perron (1989) 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 that are present in the data generating process, but have been neglected, sway the analysis toward accepting the null hypothesis of a unit root. Therefore, the Sequential Panel Selection Method (SPSM) proposed by Chortareas and Kapetanios (2009), mixed with the Panel KSS tests with a

Fourier function, were used to test the unemployment rate for a sample of Taiwan's 20 regions in our study.
In line with the research of Kapetanios et al. (2003), the KSS test is based on detecting the presence of non-stationarity against a nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) process. The model is given by

$$\Delta UE_t = \gamma UE_{t-1}\{1-\exp(-\theta UE_{t-1}^2)\} + v_t, \qquad (1)$$

where UE_t is unemployment rate, v_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, UE_t follows a linear unit root process, while it follows a nonlinear stationary ESTAR process under the alternative. One shortcoming of this framework is that the parameter γ is not identified under the null hypothesis. Kapetanios et al. (2003) have used a first-order Taylor series approximation for $\{1-\exp(-\theta UE_{t-1}^2)\}$ under the null hypothesis $\theta = 0$ and have then approximated equation (1) by using the following auxiliary regression:

$$\Delta UE_t = \xi + \delta UE_{t-1}^3 + \sum_{i=1}^{k} \theta_i \Delta UE_{t-i} + v_t \quad t = 1,2,....,T \qquad (2)$$

In this framework the null hypothesis and alternative hypotheses are expressed as $\delta = 0$ (non-stationarity) against $\delta < 0$ (non-linear ESTAR stationarity). The system of the KSS equations with a Fourier function that we estimate here is:

$$\Delta UE_{i,t} = \xi_i + \delta_{1,i} UE^3{}_{i,t-1} + \sum_{j=1}^{k1} \theta_{1,j} \Delta UE_{i,t-j} + a_1 \sin(\frac{2\pi kt}{T}) + b_1 \cos(\frac{2\pi kt}{T}) + \varepsilon_{1,t} \qquad (3)$$

where $t = 1,2,....,T$. The rational for selecting $[\sin(2\pi kt/T), \cos(2\pi kt/T)]$ is based on the fact that a Fourier expression is capable of approximating absolutely integrable functions to any desired degree of accuracy, where k represents the frequency selected for the approximation, and $[a_i, b_j]'$ measures the amplitude and displacement of the frequency component. It also follows that at least one frequency component must be present if there is a structural break.[1] Gallant (1981), Becker et al. (2004), 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 a priori knowledge concerning the shape of the breaks in the data, a grid-search is first performed to find the best frequency.

[1] Enders and Lee (2012) suggest that the frequencies in (3) should be obtained via the minimization of the sum of squared residuals. However, their Monte Carlo experiments suggest that no more than one or two frequencies should be used due to the loss of power associated with a larger number of frequencies.

The SPSM proposed by Chortareas and Kapetanios (2009) is based on the following steps:

(1) The Panel KSS test with a Fourier function is first conducted to all unemployment rates in the panel. If we reject the unit-root null hypothesis, then the procedure is stopped and we conclude that all the series in the panel are non-stationary. If the null is rejected then we can continue on to step2.

(2) The series with the minimum KSS statistic is removed since it is identified as being stationary.

(3) We return to Step 1 for the remaining series, or stop the procedure if all the series are removed from the panel.

The final result is a separation of the whole panel into a set of mean-reverting series and a set of non-stationary series.

4. Empirical Results, Economic and Policy Implications

A. Empirical Results

We first apply several conventional unit root tests to examine the null of a unit root in the unemployment rate of each region. We select the lag order of the test on the basis of the recursive t-statistic, as suggested by Perron (1989). The results in Table 2 clearly indicate that both the ADF and the PP tests fail to reject the null of non-stationary unemployment for all of Taiwan's 20 regions. However, the results for the first difference indicate a strong rejection of the null hypothesis for all 20 regions. These results exhibit that the unemployment rates for Taiwan's 20 regions are non-stationary.

Moreover, in the KPSS test, we found that Taiwan's 20 regions fail to reject the null of stationary unemployment when the KPSS without a trend term is used in the testing model. In other words, hysteresis in unemployment is confirmed for most of Taiwan's 20 regions. As stated earlier, there is a growing consensus that conventional unit root tests, such as the ADF and PP tests, fail to incorporate structural breaks in the model and have a limited ability to detect the mean reversion of unemployment rates.

For comparison purposes, Tables 3 and 4 report the results for the first-generation and second-generation panel-based unit root tests. In Table 3, three first-generation panel-based unit root tests yield different results, indicating that unemployment rates are either stationary or nonstationary (when the test of Maddla and Wu (1999) was conducted) in Taiwan's 20 regions. Conversely, Table 4 shows that based on the second-generation panel-based unit root tests, the stationarity does hold among these 20 regions.

To identify how many and which series in the panel are stationary processes, we proceed with the SPSM mixed with the Panel KSS test. As a benchmark, we first provide the results of the Panel KSS test without a Fourier function. Table 5 shows that the null hypothesis of the unit root is rejected when the Panel KSS test is first applied to the whole panel, producing a value of –2.154 with a p-value of 0.045. After implementing the SPSM, we find New Taipei city is stationary, having the smallest KSS value of –2.914 in the panel. Next, we remove New Taipei city from the panel and implement the Panel KSS test again on the remaining set of series. The results show that the Panel KSS test still rejects the unit root null with a value of –2.114 and a p-value of 0.028, and Kaohsiung city is found to be stationary, having the lowest KSS value of –2.723 this time. Kaohsiung city is then removed from the panel and the Panel KSS test is conducted again on the remaining set of series. This procedure is continued until the Panel KSS test fails to reject the unit root null hypothesis at the 10% significance level. To check the robustness of our test, we continue the procedure until the last sequence. The SPSM using the Panel KSS test without a Fourier function provides evidence of stationary in the unemployment rates for five out of the 20 regions in Taiwan.

We next implement the Panel KSS test with a Fourier function. First, a grid search is performed to find the best frequency, as there is no a priori knowledge concerning the shape of the breaks in the data. Table 6 reports the results of the Panel KSS test with a Fourier function. Particularly, we estimate Equation 3 for each Fourier frequency integer k = 1–5, following the assumption of Enders and Lee (2012) that a small frequency k can capture a wide variety of breaks. In the fourth column of Table 6, the Residual Sum of Squares (RSSs) indicates the optimal frequency integer k. Similarly, the procedure is again continued until the Panel KSS test fails to reject the unit root null hypothesis at the 10% significance level, and finally the unit root hypothesis is rejected for twelve out of Taiwan's 20 regions, the remaining regions being Hualian county, Miaoli county, Taichung City, Taipei City, Changhua county, Nantou county, Taoyuan county, and Penghu county. Our empirical findings suggest that allowing for nonlinearities and structural breaks results in more rejection of the unit root null hypothesis.

B. Economic and Policy Implications

Apparently, the SPSM procedure using the Panel KSS unit root test with a Fourier function provided weak evidence favouring the hysteresis in unemployment for Taiwan's 20 regional unemployment being studied, with the exception of Pingtung county, Tainan city, Ilan county, Hsinhchu ciy, Yunlin county, Hsinchu county, Keelung county, Kaohsiung city, Chiayi city, Chiayi county, New Taipei city, Taitung county. A rejection of the hysteresis hypothesis implies evidence in favor of the natural-rate of unemployment hypothesis, our finding suggests that unemployment in these 12 regions are flexible enough to easily revert to its long-run equilibrium determined by the labor market. A major policy implication of our study is that a stabilization policy may have some permanent effects on the unemployment rates for

Hualian county, Miaoli county, Taichung City, Taipei City, Changhua county, Nantou county, Taoyuan county, and Penghu county these 8 regions in Taiwan

Worth noting is that the results here are not consistent with those of Song and Wu (1997, 1998) which, based on the unemployment rate data for 48 U.S. states and 16 OECD countries, support the weak version of the natural-rate hypothesis. Our results, nevertheless, are consistent with those of Roed (1996), Leon-Ledesam (2002), Camarero and Tamarit (2004), Chang et al. (2005), and Chang (2011), which support the notion of hysteresis in unemployment for most of the European countries.
An additional implication for our study is that the unemployment rates are regime-wise stationary along with the structural change presented by the Fourier function for all of Taiwan's 20 regions. Furthermore, the mean reversion property can be used with confidence for the stochastic modeling of unemployment rates. However, economists should be mindful of the presence of structural breaks or changes caused by fiscal stabilization policies in the behaviour of unemployment rates over time.

5. Conclusions

While previous panel-based unit root tests are joint tests of a unit root for all members of a panel and that are incapable of determining the mix of I(0) and I(1) series in a panel setting, the Sequential Panel Selection Method (SPSM), proposed by Chortareas and Kapetanios (2009), classifies a whole panel into a group of stationary members and a group of non-stationary members. In doing so, we can clearly identify how many and which series in the panel are stationary processes. This paper contributes to literature by adopting the SPSM, to test the hysteresis of unemployment in a sample from Taiwan's 20 regions over the period from 1993 to the first semiannual period of 2012. The combined use of the Panel KSS test with a Fourier function and the SPSM allows us to obtain clear conclusions on the stationarity of individual unemployment rates in our study. We find that the SPSM provides weak evidence for the hysteresis of unemployment in 8 out of the 20 regions. Our study implies a fiscal or monetary stabilization policy would possibly have permanent effects on the unemployment rates for these eight out of the 20 regions in Taiwan.

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Table 1. Summary Statistics for the employment rates of Taiwan's 20 regional (1993-S1-2012-S1)(original data)

Region	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque -Bera
New Taipei city	3.721	3.800	6.000	1.300	1.337	-0.140	2.043	1.615
Taipei city	3.577	3.700	5.900	1.500	1.127	0.045	2.282	0.850
Keelung county	4.323	4.300	5.900	2.400	0.795	-0.143	2.822	0.185
Hsinchu city	3.590	3.800	5.900	1.400	1.380	-0.051	1.667	2.904
Ilan county	3.931	4.100	5.900	1.400	1.184	-0.543	2.559	2.230
Taoyuan county	3.413	3.900	6.100	1.100	1.490	-0.055	1.708	2.730
Hsinchu county	3.097	3.700	6.000	0.800	1.498	-0.010	1.773	2.447
Taichung city	3.792	4.000	5.900	1.400	1.290	-0.256	2.081	1.799
Miaoli county	3.521	3.900	6.000	1.200	1.370	-0.118	1.811	2.389
Changhua county	3.282	3.900	5.900	0.800	1.544	-0.108	1.603	3.246
Nantou county	3.815	4.200	6.100	1.100	1.426	-0.517	2.120	2.995
Yunlin county	3.377	3.800	5.900	0.900	1.509	-0.266	1.759	2.962
Tainan city	3.772	3.900	5.900	1.200	1.203	-0.515	2.577	2.017
Kaohsiung city	3.956	4.200	6.000	1.400	1.242	-0.540	2.563	2.205
Chiayi city	3.649	3.900	5.900	1.400	1.274	-0.112	1.882	2.112
Chiayi county	3.526	3.900	6.000	0.700	1.455	-0.280	2.012	2.097
Pingtung county	3.479	3.800	5.900	1.000	1.436	-0.352	2.004	2.417
Penghu county	3.113	3.800	5.800	0.500	1.568	-0.180	1.701	2.954
Taitung county	3.785	3.900	5.900	1.400	1.188	-0.409	2.474	1.539
Hualian county	3.995	4.200	6.000	1.200	1.265	-0.615	2.663	2.642

Table 2. Unit Root Tests (ADF, PP and KPSS) for the employment rates of Taiwan's 20 regional (Take natural log)

Region	Levels			First Difference		
	ADF	PP	KPSS	ADF	PP	KPSS
New Taipei city	-2.173(1)	-1.935(2)	0.561[5]**	-3.764(0)***	-3.330(11)**	0.139[2]
Taipei city	-1.916(0)	-1.978(2)	0.640[5]**	-5.607(0)***	-5.611(4)***	0.108[3]
Keelung county	-2.035(1)	-1.859(0)	0.482[4]**	-5.854(0)***	-5.856(2)***	0.098[1]
Hsinchu city	-1.700(0)	-1.740(1)	0.592[5]**	-5.138(0)***	-5.138(0) ***	0.148[0]
Ilan county	-2.280(1)	-1.775(2)	0.535[5]**	-4.744(0)***	-4.703(4)***	0.149[1]
Taoyuan county	-1.634(0)	-1.694(3)	0.632[5]**	-5.047(0)***	-4.959(6)***	0.101[4]
Hsinchu county	-1.659(0)	-1.636(4)	0.663[5]**	-5.596(0)***	-5.683(6)***	0.144[6]
Taichung city	-2.233(1)	-1.825(0)	0.565[5]**	-4.150(0)***	-4.062(5)***	0.265[0]
Miaoli county	-1.650(1)	-1.763(0)	0.618[5]**	-5.606(0)***	-5.606(0)***	0.135[0]
Changhua county	-1.681(1)	-1.607(0)	0.626[5]**	-4.163(0)***	-4.036(5)***	0.159[0]
Nantou county	-1.921(0)	-1.921(0)	0.590[5]**	-6.706(0)***	-6.695(1)***	0.158[0]
Yunlin county	-1.558(0)	-1.590(2)	0.627[5]**	-5.953(0)***	-5.985(2)***	0.136[2]
Tainan city	-1.909(1)	-2.231(6)	0.556[5]**	-4.774(0)***	-4.678(9)***	0.245[5]
Kaohsiung city	-3.104(4)	-2.182(7)	0.545[5]**	-5.777(0)***	-5.774(7)***	0.275[7]
Chiayi city	-1.658(0)	-1.646(1)	0.562[5]**	-6.380(0)***	-6.375(1)***	0.117[2]
Chiayi county	-1.983(0)	-1.983(1)	0.611[5]**	-5.788(0)***	-5.786(1)***	0.218[1]
Pingtung county	-2.067(1)	-1.881(3)	0.601[5]**	-5.036(0)***	-4.943(6)***	0.106[4]
Penghu county	-1.536(0)	-1.536(0)	0.666[5]**	-6.956(0)***	-6.956(0)***	0.099[1]
Taitung county	-2.180(0)	-2.127(2)	0.612[5]**	-6.621(0)***	-6.625(1)***	0.114[2]
Hualian county	-2.201(1)	-2.333(5)	0.538[5]**	-4.065(0)***	-3.788(9)***	0.218[3]

Notes: The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by Newey and West (1994).
*, **, and *** denote the significance levels at 10%, 5%, and 1%, respectively.

Table 3. Panel unit root tests for the employment rates of Taiwan's 20 regional

First generation panel unit root test

Levin, Lin, and Chu (2002)	t_ρ^*	$\hat{\rho}$	t_ρ^{*B}	t_ρ^{*C}	
	-1.585 (0.057)	-0.111***(0.000)	-3.701 (0.000)	-3.656 (0.000)	
Im, Pesaran, and Shin (2003)	t_bar_{NT}	$W_{t,bar}$	$Z_{t,bar}$	$t\_bar_{NT}^{DF}$	$Z_{t,bar}^{DF}$
	-1.866	-1.763** (0.039)	-1.749** (0.040)	-1.843	-1.631* (0.051)
Maddala and Wu (1999)	P_{MW}	Z_{MW}			
	43.847 (0.321)	0.430 (0.334)			

Notes:

Levin, Lin, and Chu (2002): t_p^* denotes the adjusted t-statistic computed with a Bartlett kernel function and a common lag truncation parameter given by $\bar{K} = 3.21T^{1/3}$ (Levin and Lin, 2002). The corresponding p-value is in parentheses. $\hat{\rho}$ is the pooled least squares estimator. The corresponding standard error is in parentheses. t_p^{*B} denotes the adjusted t-statistic computed with a Bartlett kernel function and individual bandwidth parameters (Newey and West, 1994). t_p^{*C} denotes the adjusted t-statistic computed with a Quadratic Spectral kernel function and individual bandwidth parameters. *** indicates significance at the 1% level.

Im, Pesaran, and Shin (2003): $t\_bar_{NT}^{DF}$ (respectively t_bar_{NT}) denotes the mean of Dickey Fuller (respectively Augmented Dickey Fuller) individual statistics. $Z_{t,bar}^{DF}$ is the standardized $t\_bar_{NT}^{DF}$ statistic and the associated p-values are in parentheses. $Z_{t,bar}$ is the standardized t_bar_{NT} statistic based on the moments of the Dickey Fuller distribution. $W_{t,bar}$ denotes the standardized t_bar_{NT} statistic based on simulated approximated moments (Im, Pesaran, and Shin, 2003; Table 3). The corresponding p-values are in parentheses. * *indicates significance at the 5% level.

Maddala and Wu (1999): P_{MW} denotes the Fisher's test statistic defined as $P_{MW} = -2\sum \log(p_i)$, where p_i are the p-values from ADF unit root tests for each cross-section. Under H_0, P_{MW} has a χ^2 distribution with 2N of freedom when T tends to infinity and N is fixed. Z_{MW} is the standardized statistic used for large N samples. Under H0, Z_{MW} has a N (0, 1) distribution when T and N tend to infinity.

Table 4. Panel unit root tests for the employment rates of Taiwan's 20 regional

First generation panel unit root test					
Bai and Ng (2004)	$\hat{r}$	$Z_{\hat{e}}^{c}$	$P_{\hat{e}}^{c}$	MQ_c	MQ_f
	2	4.685*** (0.000)	81.903*** (0.000)	1	2
Moon and Perron (2004)	t_a^*	t_b^*	$\hat{\rho}_{pool}^*$	t_a^{*B}	t_b^{*B}
	-18.589*** (0.000)	-8.669*** (0.000)	0.829	-18.876***(0.000)	-8.784***(0.000)
Choi (2002)	P_m	Z	L^*		
	4.207***(0.000)	-4.676*** (0.000)	-4.359***(0.000)		
Pesaran (2003)	P^*	$CIPS$	$CIPS^*$		
	1	-2.692** (0.010)	-2.692**(0.010)		

Notes:

Bai and Ng (2004): $\hat{r}$ is the estimated number of common factors based on IC criteria functions. $P_{\hat{e}}^{c}$ is a Fisher's type statistic based on p-values of the individual ADF tests. $Z_{\hat{e}}^{c}$ is a standardized Choi's type statistic for large N samples. P-values are in parentheses. The first estimated value $\hat{r}_1$ is derived from the filtered test MQ_f and the second one is derived from the corrected test, MQ_c, ** and *** indicate significance at the 5% and 1% levels, respectively.

Moon and Perron (2004): t_a^* and t_b^* are the unit root test statistics based on de-factored panel data (Moon and Perron, 2004). The corresponding p-values are in parentheses. $\hat{\rho}_{pool}^*$ is the corrected pooled estimates of the auto-regressive parameter. t_a^{*B} and t_b^{*B} are computed with a Bartlett kernel function in spite of a Quadratic Spectral kernel function.

Choi (2002): The P_m test is a modified Fisher's inverse chi-square test (Choi, 2001). The Z test is an inverse normal test. The L^* test is a modified logit test. P-values are in parentheses.

Pesaran (2003): $CIPS$ is the mean of individual Cross sectionally augmented ADF statistics (CADF). $CIPS^*$ denotes the mean of truncated individual CADF statistics. The corresponding p-values are in parentheses. P^* denotes the nearest integer of the mean of the individual lag lengths in the ADF tests.

Table 5.Panel KSS Unit Root Test without a Fourier Function

Sequence	OU statistic	Min. KSS statistic	Series
1	-2.154(0.045)**	-2.914	New Taipei city
2	-2.114(0.028)**	-2.723	Kaohsiung city
3	-2.081(0.052)*	-2.682	Changhua county
4	-2.045(0.079)*	-2.650	Taichung city
5	-2.007(0.099)*	-2.557	Hualian county
6	-1.971(0.119)	-2.494	Ilan county
7	-1.933(0.175)	-2.434	Tainan city
8	-1.895(0.137)	-2.255	Chiayi county
9	-1.865(0.220)	-2.014	Hsinchu city
10	-1.851(0.237)	-2.002	Taitung county
11	-1.836(0.189)	-1.996	Pingtung county
12	-1.819(0.171)	-1.994	Yunlin county
13	-1.797(0.270)	-1.954	Taipei city
14	-1.774(0.209)	-1.897	Hsinchu county
15	-1.754(0.193)	-1.875	Taoyuan county
16	-1.729(0.423)	-1.868	Nantou county
17	-1.695(0.212)	-1.863	Miaoli county
18	-1.639(0.470)	-1.759	Keelung county
19	-1.579(0.460)	-1.681	Chiayi city
20	-1.477(0.554)	-1.477	Penghu county

Notes: The Entries in parentheses stand for the bootstrap P-values. The significance level is 10%. The maximum lag is set to be 8. The bootstrap replications are 5,000. * and ** indicate significance at the 10% and 5% levels, respectively

Table 6. Panel KSS Unit Root Test with Fourier function

Sequence	OU statistic	Min. KSS	Fourier(K)	Series
1	-2.9019(0.001)***	-5.348	3	Pingtung county
2	-2.7731(0.001)***	-4.395	3	Tainan city
3	-2.6831(0.002)***	-4.239	3	Ilan county
4	-2.5915(0.001)***	-4.078	3	Hsinchu city
5	-2.4987(0.003)***	-3.925	3	Yunlin county
6	-2.4036(0.004)***	-3.580	5	Hsinchu county
7	-2.3196(0.010)**	-3.307	3	Keelung county
8	-2.2436(0.012)**	-3.092	3	Kaohsiung city
9	-2.1732(0.016)**	-2.924	4	Chiayi city
10	-2.1047(0.025)**	-2.874	3	Chiayi county
11	-2.0278(0.042)**	-2.798	2	New Taipei city
12	-1.9423(0.069)*	-2.769	3	Taitung county
13	-1.8389(0.114)	-2.746	3	Hualian county
14	-1.7094(0.161)	-2.351	3	Miaoli county
15	-1.6024(0.259)	-2.261	3	Taichung city
16	-1.4706(0.311)	-1.962	3	Taipei city
17	-1.3478(0.350)	-1.523	3	Changhua county
18	-1.2894(0.470)	-1.514	3	Nantou county
19	-1.1768(0.687)	-1.433	3	Taoyuan county
20	-0.9204(0.673)	-0.920	3	Penghu county

Notes: The Entries in parentheses stand for the asymptotic P-values. The significance level is 10%. The maximum lag is set to be 8. The asymptotic p-values are computed by means of Bootstrap simulations using 5,000 replications. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.