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Are unemployment rates stationary in Asia-Pacific countries? New findings from Fourier ADF test

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This article examines whether the unemployment rates in five Asia-Pacific countries can be described as a stationary process. It employs a newly developed nonlinear Fourier ADF test for this purpose. The findings indicated that South Korea's unemployment rate could be described as a stationary process; the unemployment rates in Australia and Hong Kong could be considered as a stationary process around the structural breaks; in China and Japan the unemployment rates exhibited a weak tendency to return to equilibrium level.

Keywords: unemployment; hysteresis; Asia-Pacific

JEL classification: E24; E62; J08

1. Introduction

Since the publication of Blanchard and Summers' (1986a) seminal work, the applicability of the hysteresis hypothesis to explain unemployment has become one of the most debated and researched topics in macroeconomics. Standard macroeconomic theory assumes that the equilibrium unemployment rate will not be influenced by the actual level of unemployment. Any discrepancies between the two will be adjusted by changes in the inflation rates; eventually, the actual unemployment rate will return to the equilibrium level. However, the need to explain persistently high unemployment rates in European countries in the 1980s led to the development of the hysteresis hypothesis. The hypothesis defines the behaviour of the unemployment rate as path-dependent. This means that the equilibrium level of unemployment depends on the previous behaviour of the actual unemployment rate (Blanchard & Summers, 1986a).

The abundant research literature on the hysteresis hypothesis reports mixed results (Gustavsson & Osterholm, 2011). Due to the inconsistencies in the findings there exist three contradicting hypotheses that explain the behaviour of the unemployment rates (Gomes and da Silva, 2008). Firstly, the natural rate hypothesis or the non-accelerating inflation rate of unemployment (NAIRU) (Phelps, 1967; Friedman, 1968) assumes that the unemployment rates fluctuate around the equilibrium level. Under this assumption, the unemployment rate is characterised as a stationary process. Secondly, the structural slump hypothesis assumes that the unemployment rate fluctuates around the equilibrium level that shifts occasionally due to some structural changes, such as technological progress (Phelps, 1994). In this case, the unemployment rate can be described as a stationary process around the structural breaks. Finally, the hysteresis hypothesis assumes that

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the equilibrium level of unemployment is path-dependent and the unemployment rate exhibits a weak tendency to return to the equilibrium level (Blanchard & Summers, 1986b). Under this hypothesis, the unemployment rate could be characterised as a non-stationary process.

Trade unions and the provision of unemployment benefits are important institutional factors that help to explain the differences in the unemployment behaviour (Furuoka, 2012).[1] First and foremost, countries with strong trade unions tend to have less dynamic labour markets and their unemployment rates tend not to revert to normal level. By contrast, if a country's trade unions are weak its labour market is more dynamic and the unemployment rate exhibits a mean-reverting tendency. Secondly, the provision of unemployment benefits has a strong influence on unemployment dynamics. This is because unemployed workers tend to remain jobless for longer periods of time if they have sufficient unemployment benefits; this can lead to hysteresis in unemployment. By contrast, a lack of unemployment benefits prompts people to find a new employment as soon as possible. As a result, a higher-than-normal unemployment would revert to the equilibrium level.

To test these competing hypotheses, the present study employs a nonlinear Fourier Augmented Dickey-Fuller (ADF) test (Enders & Lee, 2004; 2012).[2] It examines whether the unemployment rates in five Asia-Pacific countries (i.e. Australia, China, Hong Kong, Japan and South Korea) over the period from 1980 to 2009 can be described as a stationary process. The focus on the Asia-Pacific region and the newly developed method distinguish this study from other studies. The article has the following structure: subsequent to this Introduction, Section 2 offers a review of the relevant literature. Section 3 explains the data collection procedure and the research method. Section 4 describes basic characteristics of the unemployment rates in the selected Asia-Pacific countries. The findings of the study are reported in Section 5 while Section 6 discusses the results. Section 7 offers concluding remarks.

2. Literature review

The proposition of unemployment hysteresis was first put forward by Edmund S. Phelps (1972) in his seminal book *Inflation and Unemployment Theory*. He defined unemployment hysteresis as a situation in which equilibrium unemployment is determined by the path of the actual unemployment rate. Due to the importance of this topic for macroeconomic theories numerous research studies have followed. Blanchard and Summers (1986b) have greatly contributed to the development of the theoretical framework of hysteresis in unemployment. The researchers defined unemployment hysteresis as a situation in which current unemployment rate is determined mainly by past unemployment. As they argued, 'Unemployment exhibits hysteresis when current unemployment depends on past values. … We shall instead use hysteresis more loosely to refer to the case where the degree of the past is very high' (Blanchard & Summers, 1986b, p. 17).

Many researchers have linked non-stationarity of unemployment time series to the unemployment hysteresis hypothesis and they examined the hypothesis using univariate unit root tests, such as the ADF test and the Phillips-Perron (PP) test (Brunello, 1990; Røed, 1996; Neudorfer, Pichelmann, & Wagner, 1990; Mitchell, 1993). These studies tended to fail to reject the null hypothesis of hysteresis; in other words, they detected the existence of unemployment hysteresis. By contrast, more recent studies have employed panel-based unit root tests or unit root tests with structural breaks in order to increase the power of test (Song & Wu, 1998; Camarero & Tamarit, 2004; Chang et al., 2005; Christopoulos & Leon-Ledesma, 2007; Romero-Ávila & Usabiaga, 2007; Lee et al., 2010;

Ener & Arica, 2011). These studies tended to reject the null hypothesis of hysteresis due to a better power of the panel-based analyses. This means that they detected mean-reversion properties in the unemployment rate time series.

Studies on the hysteresis hypothesis can be separated into three clusters according to the regions that they had focused on, namely: (1) Asia-Pacific region; (2) Europe and North America; and (3) Other regions. With regard to the Asia-Pacific region, only a handful of empirical inquiries are available. Several such studies have focused on Japan and they detected the existence of unemployment hysteresis (Brunello, 1990; Røed, 1996; Song & Wu, 1998; Camarero & Tamarit, 2004).

Lee et al. (2009) have included South Korea and Japan in their analysis of unemployment hysteresis between 1960 and 2004. They rejected the null hypothesis of hysteresis in both these countries. Furthermore, Lee et al. (2010) have examined unemployment hysteresis in nine East Asian countries over the period 1976–2004, employing a sophisticated econometric analysis. Their findings failed to reject the null hypothesis, even after taking account of structural breaks. Furuoka (2012) has analysed unemployment hysteresis in 12 countries in East Asia and Pacific region between 1980 and 2009. He employed the panel-based SURADF test for this purpose; the study failed to reject the null hypothesis of hysteresis in Asia-Pacific region, except for New Zealand and South Korea.

Europe and North America have been the focal points for numerous research studies on the hysteresis hypothesis. The results of these studies are contradictory. Some researchers found that unemployment in these regions was a stationary process (Røed, 1996; Song & Wu, 1998; Camarero & Tamarit, 2004; Christopoulos & Leon-Ledesma, 2007; Romero-Ávila & Usabiaga, 2007; Sephton, 2009; Lee et al., 2009; Ener & Arica, 2011) while others reached an opposite conclusion (Neudorfer, Pichelmann, & Wagner, 1990; Mitchell, 1993; Chang et al., 2005). It should be noted that the majority of the studies that concluded that unemployment was a stationary process used advanced analysis to investigate the hypothesis.

Regarding other regions, a systematic in-depth research on unemployment hysteresis has been lacking. One notable exception is a study by Gomes and da Silva (2008) that investigated unemployment hysteresis in Latin America. The researchers used the unit root test with structural breaks for their analysis and they failed to reject the null hypothesis of hysteresis in unemployment.

3. Data and research method

The World Development Indicators databank (World Bank, 2012) was the source of data on the unemployment rates in five Asia-Pacific countries – Australia, China, Hong Kong, Japan and South Korea – over the period 1980–2009. These countries were selected for the analysis due to the availability of reliable and consistent data sets. In the case of other countries in the region, there existed large discrepancies between the unemployment time-series data as reported in the World Development Indicators by the World Bank (2012) and the ASEAN regional database compiled by the Philippines' National Economic and Development Authority (NEDA, 2013).[3] Due to this problem the other Asia-Pacific countries were excluded from the analysis.

Regarding the research method, Enders and Lee (2012) have developed an ADF-type unit root test that uses a selected frequency component of a Fourier function to approximate the deterministic component of the model. The standard linear ADF specification for the unit root test can be expressed as:

$$\Delta y_t = \rho y_{t-1} + c_0 + \sum_{i=1}^{l} c_i \Delta y_{t-i} + e_t \tag{1}$$

where y_t is the time-series of interest, ρ and c are the parameters to be estimated, l is the lag length for the lagged values of Δy_t, and e_t are the error terms. Under the null hypothesis $\rho = 0$, y_t is characterised as a stationary process. Enders and Lee (2012) suggested using a Fourier approximation to capture unknown structural breaks or unattended nonlinearity in the deterministic component of the model. The nonlinear Fourier ADF statistic (τ_{DF}) is based on the following equation:

$$y_t = \rho y_t + c_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l} c_i \Delta y_{t-i} + e_t \tag{2}$$

where k is the selected frequency for the Fourier approximation, γ are the parameters for the Fourier approximation, t is the trend term, T is the number of observations, π = 3.1416. The Fourier ADF statistic (τ_{DF}) is the t-statistic for the null hypothesis ρ = 0 in Equation 2.

To compare the two tests, clearly the standard ADF test is a special case of the Fourier ADF test in which the trigonometric terms are set as zero (i.e. $\gamma_1 = \gamma_2 = 0$). According to Enders and Lee (2012), the usual F-statistic can be used to test whether the trigonometric terms should be included into the model. Under the null hypothesis of linearity, the F-statistic can be calculated as follows:

$$F(k) = \frac{(SSR_0 - SSR_1)/q}{SSR_1(k)/(T-k)} \tag{3}$$

where SSR_1 is the sum of squared residuals (SSR) from regression (2), SSR_0 is the SSR from y_t the regression without the trigonometric terms, $q$is the number of restrictions, and k is the number of regressors in the regression.

As Equation 3 shows, the Fourier augmented Dickey–Fuller test (FADF) statistic depends on the frequency (k) and the lag length (l). Following Enders and Lee's (2012) suggestion that a Fourier function with k = 1 or k = 2 can serve as a reasonable approximation to capture many types of unknown structural breaks, the maximum frequency ($k_{\max}$) was set in the present study as 2. The optimal frequency ($\tilde{k}$) was selected by the data-driven method; it is a selected frequency that produces the smallest sum of the squared residuals (SSR) among the different specifications in Equation 2.

The optimal lag length ($\tilde{l}$) was selected by using the Akaike Information Criterion (AIC). The optimal lag length is a selected lag length that produces the smallest AIC value among the different choices of lag length. The AIC can be calculated as:

$$AIC = -2(L/T) + 2(k/T) \tag{4}$$

where L is the log likelihood value which can be estimated as:

$$L = -\frac{T}{2}\left(1 + \ln(2\pi) + \ln\left(\frac{\hat{\varepsilon}'\hat{\varepsilon}}{T}\right)\right) \tag{5}$$

where $\hat{\varepsilon}$ are the residuals estimated from Equation 2. To select the lag length, there is a need to specify the upper bound or the maximum lag length ($l_{\max}$). Hayashi (2000) has suggested using the following equation for this purpose:

$$l_{\max} = \text{int}(T/3)^*(T/100)^{1/4} \tag{6}$$

where *int* is the integer function that rounds a real number down to the nearest integer. Due to some missing data in the unemployment rate data sets, the maximum lag length was set as 6.[4]

Three steps must be implemented to test the three competing hypotheses on unemployment (i.e. the natural rate hypothesis, the structural slump hypothesis and the hysteresis hypotheses). In the first step of the analysis linear unit root tests can be used to examine a stationary process in the unemployment rates, such as: the ADF test (Dickey & Fuller, 1979); the DF-GLS detrending test (Elliott et al., 1996); the PP Z_t test (Phillips & Perron, 1988); and the KPSS test (Kwiatkowski et al., 1992).[5]

The second step of the analysis determines the optimal frequency ($\tilde{k}$) and the optimal lag length ($\tilde{l}$). The optimal frequency is selected by using the SSR from Equation 2. The optimal lag length is chosen by using the AIC. After the frequency and the lag length are selected, the *F*-test can be applied to analyse whether the trigonometric terms should be incorporated into the model. If the *F*-test rejects the null hypothesis of linearity, a nonlinear FADF test would be an appropriate method for the analysis. Otherwise, a standard linear ADF test should be used.

The findings from step 1 and step 2 of the analysis can be interpreted as follows. If the unit root tests in step 1 fail to reject the null and, likewise, the *F*-test in step 2 also fails to reject the null, the unemployment rate could be considered as a non-stationary process in line with the hysteresis hypothesis. By contrast, if the unit root tests in step 1 *do* reject the null but the *F*-test fails to reject it, the unemployment rate would be best described as a stationary process in accordance with the natural rate hypothesis.

In the third step of the analysis the FADF test is applied to determine whether unemployment can be described as a stationary process through using an appropriate modelling that captures unattended structural breaks. The findings can be interpreted as follows. If the FADF test in step 3 rejects the null and, likewise, the *F*-test in step 2 rejects the null, then the unemployment rate could be described as a stationary process around the structural breaks in accordance with the structural slump hypothesis. By contrast, if the FADF test fails to reject the null but the *F*-test rejects the null a country's unemployment rate could be characterised as a non-stationary process. However, the decision on the outcome of the hypotheses tests should be made with a considerable caution.[6]

4. Basic characteristics of the unemployment rates

This section describes basic characteristics and patterns of unemployment in the five selected Asia-Pacific countries. A summary of statistics on their unemployment rates is reported in Table 1. As the table shows, unemployment in these countries was relatively

Table 1. Summary of statistics on unemployment (1980–2009).

	Mean	Minimum	Maximum	Standard deviation
Australia	7.29	4.20	10.90	1.84
China	3.10	1.80	4.90	0.78
Hong Kong	3.74	1.10	7.90	1.82
Japan	3.40	2.00	5.40	1.09
South Korea	3.56	2.00	7.00	1.15

Source: World Bank, 2012.

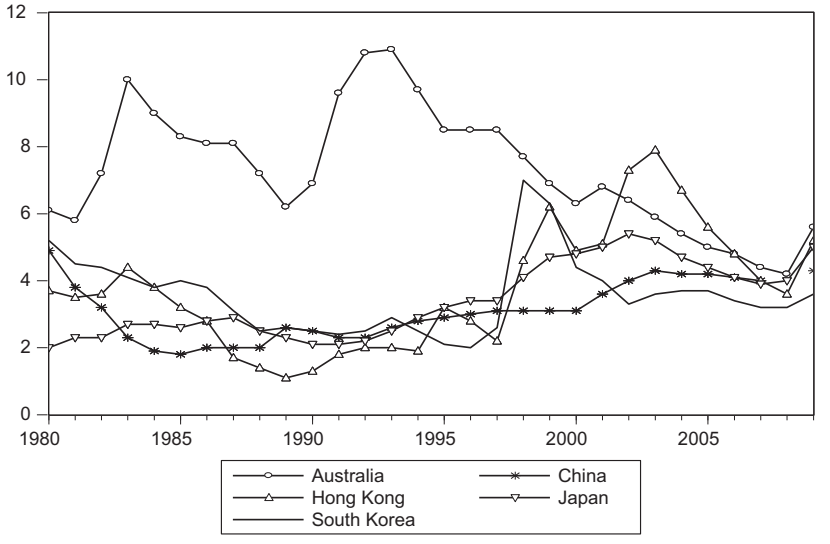

Figure 1. Time-path of unemployment (1980–2009).
Source: World Bank, 2012.

low; in four countries –China, Hong Kong, Japan and South Korea – the average unemployment rates did not exceed 4%.

Australia had the highest average unemployment (7.29%) and the widest fluctuations (Standard Deviation = 1.84) in the unemployment rate. The lowest average unemployment rate (3.10%) was in China; also, this country had the least volatile unemployment situation (Standard Deviation = 0.87). However, Hong Kong, which is now a special administrative region of China, had a relatively high average unemployment rate (3.74%). Japan's average unemployment rate was the second lowest among the five selected countries (3.05%) while South Korea's average unemployment rate (3.56%) can be considered as moderate.

Time-path of the unemployment rates in the five Asia-Pacific countries is depicted in Figure 1. As the figure demonstrates, during the observation period Australia suffered from a high unemployment problem twice: in the beginning of the 1980s and 1990s. China experienced a relatively high unemployment in the beginning of the 1980s. Hong Kong underwent two phases of high unemployment: during the end of the 1990s and during the beginning of the 2000s. Japan's unemployment rate was relatively low (below 3%) until the middle of the 1990s, after which there had been a moderate increase. South Korea suffered from a problem of high unemployment in the end of the 1990s. As a consequence of the regional economic crisis the unemployment in the country rocketed from 2.6% in 1997 to 7% in 1998.

5. Empirical results

In the first step of the analysis, linear unit root tests were used to examine whether the unemployment rates in the five Asia-Pacific countries had a unit root. The empirical findings from the ADF test, the DF-GLS test, the PP test, and the KPSS test are reported in Table 2. The results of the *KPSS* test indicated that the unemployment rates in Hong Kong and South Korea were a stationary process. The findings from the PP test

Table 2. Results of linear unit root tests.

	ADF	DF-GLS	PP	KPSS
Australia	−1.328(2)	−1.369(2)	−1.654[3]	0.353[4]*
China	−2.010(0)	−1.263(0)	−2.277[0]	0.378[4]*
Hong Kong	−1.591(3)	−1.635(3)	−1.470[1]	0.340[4]
Japan	0.466(5)	0.842(5)	−0.915[2]	0.563[4]**
South Korea	−3.087(1)**	−2.320(0)**	−2.589[5]	0.113[2]

Notes: The numbers in the parentheses indicate the optimal lag length suggested by the Akaike Information Criterion (AIC). The numbers in the brackets indicate the optimal bandwidth suggested by Newey-West bandwidth selection method (Newey and West, 1994).
Source: Author's own calculation.
**indicates significance at the 5% level; *indicates significance at the 10% level.

implied that the unemployment rate in South Korea had a unit root. Overall, the linear unit root tests could not reject the null hypothesis of a unit root for all countries, except for South Korea.

In the next step of the analysis, the optimal frequency ($\tilde{k}$) was determined by using the SSR from Equation 2, while the optimal lag length ($\tilde{l}$) was chosen by the AIC. As Table 3 shows, the optimal frequencies for Australia, China and Hong Kong were set as 1. For Japan and South Korea, the optimal frequencies were set as 2. The optimal lag lengths suggested by the AIC varied from 1 to 6. To compare, the Schwarz Information Criterion (SIC) suggested exactly the same lag lengths.

The F-test was used to test the null hypothesis $\gamma_1 = \gamma_2 = 0$ in Equation 2. The null hypothesis of linearity was rejected for two countries, namely, Australia and Hong Kong. This means that the linear unit root tests should be used to analyse the unemployment rates in China, Japan and South Korea. The findings from step 1 and step 2 indicated that the unit root tests did not reject the null hypothesis for China and Japan; the F-test also failed to reject the null. Therefore, the unemployment rates in China and Japan could be characterised as a non-stationary process in line with the hysteresis hypothesis.

In the case of South Korea, the unit root tests *did* reject the null hypothesis while the F-test did not reject the null. These results indicate that South Korea's unemployment rate could be best described as a stationary process in accordance with the natural rate hypothesis. More interestingly, the nonlinear version of the ADF test produced significantly different empirical results from those reported by the linear test. The FADF

Table 3. Nonlinear FADF test results.

	$\tilde{k}$	SSR	$\tilde{l}$	AIC	$F(\hat{k})$	τ_{DF}
Australia	1	2.901	6	1.637	13.180***	−4.172***
China	1	0.514	4	−0.266	4.528	−3.019
Hong Kong	1	8.206	3	2.223	9.885**	−3.672*
Japan	2	0.832	5	0.226	4.800	0.966
South Korea	2	15.566	1	2.607	2.552	−3.701**

Notes: The optimal lag ($\tilde{l}$) is the lag length that minimises the Akaike Information Criterion (AIC). The optimal frequency ($\tilde{k}$) was selected by using the data-driven grid-search method in which the frequency minimised the SSR from Equation 2.
Source: Author's own calculation.
***indicates significance at the 1% level; **indicates significance at the 5% level; *indicates significance at the 10% level.

test rejected the null hypothesis of a unit root for three countries, namely, Australia, Hong Kong, and South Korea.[7]

As the empirical findings reveal, the unemployment rates in Australia and Hong Kong could be described as a stationary process only when an appropriate modelling to capture unknown structural breaks was used. In other words, the unemployment rates in Australia and Hong Kong could be described as a stationary process around structural breaks in accordance with the structural slump hypothesis. In short, the results of the linear unit root tests indicated that the unemployment rates in the five Asia-Pacific countries had a unit root, except for South Korea. However, the empirical findings from the newly developed nonlinear Fourier ADF test indicated that the unemployment rates in Australia and Hong Kong could be described as a stationary process around structural breaks.

6. Discussion

This section compares the findings obtained from the presents study with the results reported in the previous academic inquiries. Table 4 provides a summary of the findings. Despite some minor discrepancies, the current study's results are comparable with the findings reported by Lee et al. (2009, 2010) and Furuoka (2012).

Regarding the existence of hysteresis in Australia's unemployment rate, Furuoka's (2012) study, which did not take account of structural breaks, found that it was non-stationary. However, Lee et al. (2009) as well as the present study, which took account of structural breaks, found no unit root in Australia's unemployment. This means that the unemployment rate in Australia could be considered as a stationary process around structural breaks. Only one previous study (i.e. Furuoka, 2012) has analysed the behaviour of unemployment in China; it adopted a method that incorporated a possibility of structural breaks. The results indicated that China's unemployment rate was non-stationary. The findings of the current study yielded similar results. The two previous studies

Table 4. Summary of findings.

Data/methods	Lee et al. (2009)	Lee et al. (2010)	Furuoka (2012)	Current study
Research methods and data				
Statistical test	Unit root test with structural breaks	Unit root test with structural breaks	Panel-based SURADF test	Nonlinear FADF test
Countries	Nine countries in East Asia	Nineteen OECD countries	Twelve countries in East Asia and Pacific	Five countries in Asia-Pacific region
Period	1960–2004	1976–2004	1980–2009	1980–2009
Empirical findings				
Country				
Australia	Stationary with structural breaks	Not included	Non-stationary	Stationary with structural breaks
China	Not included	Not included	Non-stationary	Non-stationary
Hong Kong	Not included	Non-stationary	Non-stationary	Stationary with structural breaks
Japan	Stationary with structural breaks	Non-stationary	Non-stationary	Non-stationary
South Korea	Stationary with structural breaks	Non-stationary	Stationary	Stationary

Source: Compiled by the author.

that investigated unemployment dynamics in Hong Kong without incorporating structural breaks produced the empirical findings that supported non-stationarity of the unemployment rate. These results contradict the findings of the current study. Overall, unemployment in Hong Kong could be considered as non-stationary.

Japan's unemployment rate was found to be non-stationary in three studies, including the current one. This means that unemployment in Japan can be considered as a non-stationary process. By contrast, in the case of South Korea, two of the previous studies as well as the current study found that the unemployment rate could be described as stationary process. Overall, South Korea's unemployment rate could be considered as a stationary process.

7. Conclusion

This article examined whether the unemployment rates in five Asia-Pacific countries – Australia, China, Hong Kong, Japan and South Korea – can be described as a stationary process. A newly developed nonlinear Fourier ADF test was used for this purpose. The findings indicated that only South Korea's unemployment rate could be considered as a stationary process in accordance with the natural rate hypothesis. The FADF test indicated that the unemployment rates in Australia and Hong Kong could be described as a stationary process around structural breaks in accordance with the structural slump hypothesis. In the remaining two countries – China and Japan – the unemployment rates exhibited a weak tendency to return to equilibrium level, which is in line with the hysteresis hypothesis.

Labour markets in Asia-Pacific region could be considered as reasonably flexible and efficient (Lee et al., 2010). To reflect this reality, the unemployment rates in three Asia-Pacific countries – Australia, Hong Kong and South Korea – can be described as a stationary process. Hysteresis was found to exist only in two Asia-Pacific countries, namely, Japan and China. Two reasons could be offered to explain the existence of unemployment hysteresis in these relatively efficient labours markets. First of all, as the previous research indicated (Furuoka, 2011), output time series in the region can be described as a non-stationary process. According to the Okun's law, there is a close linkage between the output and the unemployment rate; this means that the unemployment rates are strongly influenced by the non-stationary process of outcome. Secondly, Japanese and Chinese economies are deeply integrated into the global economy; besides, there is a strong economic interdependency between the countries. As a result, China's and Japan's economic conditions and labour market situations could be strongly influenced by fluctuations in the international trade earnings. Lee et al. (2010) have found that the terms of trade (TOT) time series in the region can be considered as a non-stationary process. Therefore, there is possibility that the behaviour of unemployment in China and Japan was influenced by this non-stationary process.

Several important policy implications could be drawn from the findings of this study. First and foremost, the results suggested that high unemployment rates in Japan and China might persist unless the governments in these countries take appropriate measures to address the issue. In other words, China's and Japan's high unemployment rates would not automatically revert back to normal level without some appropriate policies aimed at creating new job opportunities. On the other hand, higher-than-normal unemployment rates in Australia, Hong Kong and South Korea are likely to revert back to natural level without interventions from the governments.

This study has some limitations. Thus, due to the lack of reliable and consistent data sets it focused on five Asia-Pacific countries over the period of 1980–2009. Future studies may want to investigate the existence of unemployment hysteresis in the developing countries in Asia-Pacific region. The findings of such studies would deepen our understanding of the unemployment hysteresis hypothesis and expand our perspective on unemployment dynamics. This would lead to generating more informed policies to deal with the issue of unemployment.

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Notes

1. The behaviour of the unemployment rate under the structural slump hypothesis and the natural rate hypothesis can be similar because these hypotheses support a mean reversion property of unemployment. The only difference between these two hypotheses concerns equilibrium level of unemployment. The natural rate hypothesis assumes that equilibrium unemployment rate will be constant in the long-term. The structural slump hypothesis assumes that the equilibrium unemployment rate will vary when a structural break occurs, for example, a technological breakthrough.
2. Recently, methods that incorporate a Fourier function into unit root tests have generated interest among researchers. For example, Becker, Enders, and Lee (2006) used a nonlinear Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test; Rodrigues and Taylor (2012) used the Dickey-Fuller with the Generalised Least Square (DF-GLS) de-trending method, and Enders and Lee (2011) employed the Lagrange Multiplier (LM) de-trending method. For application of the Fourier unit root test see Chang et al. (2012).
3. The World Bank (2012) classifies 36 countries as the Asia-Pacific countries. Due to a lack of reliable and sufficient data this study excluded 31 countries from the analysis, namely: American Samoa, Brunei Darussalam, Cambodia, Guam, Fiji, French Polynesia, Indonesia, Kiribati, Laos, Macao, Malaysia, Marshall Islands, Micronesia, Mongolia, Myanmar, New Caledonia, New Zealand, North Korea, Northern Mariana Islands, Palau, Papua New Guinea, the Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu and Vietnam.
4. Due to a lack of information on China's unemployment rate in the year 2008, the number of observations for this country was 29. For the other four countries, the number of observations was 30.
5. In the KPSS test, the null hypothesis was that the unemployment rate is stationary. If the null hypothesis is not rejected, the time-series on unemployment could be characterised as a stationary process.
6. This is because it would be difficult to judge whether the trigonometric terms should be incorporated in the unit root tests. According to Becker et al. (2006), the *F*-test has a lower power when the data are non-stationary.
7. In the case of South Korea, the empirical findings from the FADF test confirmed the result of the unit root tests that the country's unemployment could be described as a stationary process. Furthermore, the F-test in step 2 failed to reject the null, which means that linear unit root tests could be more appropriate for the analysis.

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