

Unit root test for stationery economics essay

[Economics](#)



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1. Introduction

The strong link between the rate of changes in wages and the unemployment level was first discovered by Phillips (1958) for United Kingdom data from 1861 to 1957. He found out the presence of a trade-off relationship between inflation rate and unemployment rate, following by various researches on this topic. Hence, the contrary relationship between inflation rate and unemployment rate is generally known as the "Phillips curve".^[1] The rationale behind the Phillips curve can be seen by the disequilibrium in the labor market. If the labor demand exceeds the labor supply, the consequences would be higher wage rates and leads to high inflation rate in the nation. Under this circumstance, it is relatively easier for workers to enter the labor market. The unemployment rate should be low. However, if it is the labor supply that exceeds labor demand, lower wages rates and inflation rate would be the final outcome. Thus, workers will find difficulty in finding jobs. The unemployment rate should be high. Normally, economic boom is accompanied with high inflation rate and vice versa. If there is an economic boom in the nation, firms would expand their production capacity and employ more workers, encouraged by the favorable profit level. During good times, high inflation rate would co-exist with low unemployment rate. Otherwise, when there is an economic recession, firms would reduce their production cost by dismissing workers. In such situation, low inflation rate co-exist high unemployment rate. The purpose of this paper is to determine whether, empirically, there is inverse relationship between inflation rate and unemployment rate among the New Industrialized Economies (NIEs).^[2] Phillips curve has its own political implications.

Generally, central banks aim to keep inflation rate as low as possible. But, the low inflation rate is at the expense of high unemployment rate if Phillips curve hold. Thus, central bankers would face a dilemma to choose either combination of low-inflation rate and high-unemployment rate or combination of low-unemployment rate and high-inflation rate. So, the Phillips curve has been a vital tool for decision makers to determine best combinations of inflation and unemployment level. Moreover, a better understanding of Phillips curve is fine for policy makers to design the better fiscal and monetary policies. Overall, Phillips curve has become one of the most crucial foundations for macroeconomics. Graph 1: Unemployment and Inflation in NIEs (1980-2011) Basically, there is inverse relationship between unemployment rate and inflation rate in NIEs. But, inflation rate has greater fluctuations if comparing to unemployment rate between 1980 and 2011. For the past ten years, NIEs (Hong Kong, South Korea, Singapore, and Taiwan) has high unemployment rate. To promote economic growth, policy makers would like to reduce unemployment rate, however, central bankers aim to stabilize the price level all the time. Thus, there will be conflict of interest. The Phillips curve relation is being discussed by various studies, namely Phelps (1967), Leijonhufvud (1968) and Brinner (1977). The results showed that the trade-off Phillips curve is disappeared in the industrialized countries. Friedman (1968) further discovered that the temporary and accidental Phillips curve would not present in the long run. However, Fuhrer (1995) found the Phillips curve to be hold in the United Kingdom. The argument is supported by Malinov and Sommers (1997), who found that the relation is stable across many OECD countries. The objective of this paper is to develop the econometric models of Philips curve in NIEs separately. Time series

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analysis is used to analyze the Phillips curve relation in these nations.

Despite of the numerous studies on Phillips curve hypothesis, but as to our knowledge, there is lack of time series analysis to examine the hypothesis in different nations. Especially, there is no such empirical study on the Phillips curve among NIEs.

2. Literature Review

The publish of William Phillips' paper entitled " The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom 1861-1957" in year 1958 is crucial to the history of economic thought. It is the first time ever that an economist pointed out the inflation-unemployment relationship. The New Zealand-born economist found that strong inverse relationship between inflation rate and unemployment rate is existed in the nation during the time. After it, numerous researches had been done for the purpose of affirm or deny the Phillips curve hypothesis. The hypothesis was publicly supported by Samuelson and Solow (1960) by examined the inflation-unemployment relationship in United States. The findings show that there is a negative relationships associated between inflation rate and unemployment rate in the nation. Further verification of the present of trade-off Phillips curve is made by Solow (1970) and Gordon (1971). They found that the Phillips curve is consistently held in U. S. during pre-1970s and post-1970s. The latter researches are commonly known as the " Solow-Gordon affirmation" of the " Phillips curve" hypothesis. Despite of the strong theoretical foundation and some empirical support, however, some of the economists have strongly questioned the existence of Phillips curve hypothesis since 1960s. For instance, Milton Friedman (1968) and

Edmund Phelps (1967) has openly criticized the hypothesis and argued that there could be an inverse relationship between inflation rate and unemployment rate with only available in the short run, but not in long run. They found that the original version of Phillips curve is not taking the role of inflation expectations into account. As these expectations were taken place in the long run, the trade-off between inflation rate and unemployment rate is no longer exist, with co-existence of a " natural" rate of unemployment and any inflation rate. The trade-off however retain in the short run because of lags in the adjustment of expectations. The findings were supported by Cashell (2004), whose argues that unemployment rate tend to move towards equilibrium level in the long run. The equilibrium of unemployment rate are commonly called as natural rate of unemployment or " non-accelerating inflation rate of unemployment" (NAIRU). If the " original" Phillips curve is said to be heavily critiqued by Friedman (1968) and Phelps (1967), then Lucas critique probably is the most affluence to the " modified" Phillips curve. Lucas (1976) claimed that as policy makers rely on estimators from macroeconometric models, which are not structural to design the economic policy, hence the policy conclusion based on those models would be not efficient. In fact, all information including policy regime should be incorporated into the model rational expectation. The increasing inflation rate in Western economies during 1970s raises the reliability of Lucas critique. Despite of the numerous criticisms on the stability or existence of Phillips curve, however, Fuhrer (1995) successes to show that Phillips curve was still alive, well and widely used in macroeconometric models. He argued that the model critique by others in the 1960s and 1970s were not really structural. Although variables such as inflation rate and unemployment rate

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are included, however the interactions between consumers and firms in the economy are not taken into consideration. Moreover, Malinov and Sommers (1997) found that out of 19 OECD countries, only Switzerland and United States do not significant with stable Phillips curve. Hence, empirically Phillips curve still works in many OECD countries. Otherwise, Niskanen (2002) critique that the Phillips curve was misspecified. He discovered that inflation rate and unemployment rate tend to have positive relationship in the long run. The underlying reasons are, (1) inflation will increase tax rate, to cut cost firm will lay off some workers; (2) given firm's monetary restraint in short run, wage inflation might leads to temporary increase in unemployment. Overall, positive relationship Phillips curve is more efficient for policy makers to use as guidepost. The findings are ascertained by Reichel (2004). He employed the cointegration technique to reproduce Niskanen's results and broaden the analysis to other industrialized economies. The result is that trade-off Phillips curve only exists in the United States. So, he concludes that the doctrine of Phillips curve should be buried and it is useless to be a policy guideline. The existing empirical studies shows that conflicting results on the presence of Phillips curve are often due to model-specification problem. Although previous research used time series analysis to determine the presence of the Phillips curve in a particular country, however, this paper aims to devote to the existing literature by using time series analysis to examine the existence of the Phillips curve among NIEs. Or, the objective of this paper is to contribute methodologically to the literature.

3. Methodology

Given the theories and empirical evidences from previous studies, the Phillips curve function can be expressed as follows: $\pi_t = f(u_t)$ An econometric model can be further developed to examine the inverse relationship between inflation rate and unemployment rate: $\pi_t = \alpha + \beta_1 u_t + \mu_t$ where π_t is the inflation rate in the year t , u_t is the unemployment rate in the year t , α is the constant, β_1 is the slope coefficient and μ_t is the disturbance term. The stochastic error term captures all the factors that may affect the inflation rate but are not taken into account explicitly. In the meanwhile, data of Hong Kong, South Korea, Singapore and Taiwan is used to obtain the estimates separately. At here, a statistical technique of regression analysis is used to examine the dependence of inflation rate on unemployment rate. The estimators are obtained through Ordinary Least Square (OLS) method.

4. Data and Variables

As the short of comprehensive time series econometric analysis in explaining the inflation-unemployment relationship of the Asian circumstance, therefore time series analysis is use to examine the Phillips curve among Hong Kong, South Korea, Singapore and Taiwan during 1980-2011. The annual secondary time series data for inflation rate and unemployment rate in these nations are extracted from the International Monetary Fund (IMF). In this paper, the inflation rate is benchmarked to the annual percent change in the consumer prices index (CPI). Consequently, the variables are defined as follows:

π Inflation rate, average CPI (percent change)
 u Unemployment rate (percent of total labor force)

Table 1: Descriptive Statistics

mean median st. dev. min max Inflation Rate (in %) Hong Kong 4.74. 94. 7-3.
 911. 3 South Korea 5.64. 05. 60. 828. 7 Singapore 2.21. 72. 3-1. 48. 5 Taiwan 2.
 71. 54. 2-0. 919. 0

Average

3.8

2.8

4.5

-3.9

28.7

Unemployment Rate (in %) Hong Kong 3.83. 61. 81. 17. 9 South Korea 3.73.
 51. 22. 27. 4 Singapore 3.02. 61. 51. 46. 3 Taiwan 3.02. 71. 41. 25. 9

Average

3.4

3.2

1.5

1.1

7.9

Table 1 shows the descriptive statistics of each variable. The first row shows that on average the inflation rate in NIEs are 3.8%, range from 2.2% (Singapore) to 5.6% (South Korea). The peak of 28.7% is recorded by South Korea in 1980 whereas the bottom of -3.9% is achieved by Hong Kong in 1999. It is obvious that the unemployment rate across NIEs is almost the same. The second row indicates that on average the unemployment rate in

NIEs are 3.4%, range from 3.0% (Singapore & Taiwan) to 3.8% (Hong Kong). The peak of 7.9% is recorded by Hong Kong in 2003 while the bottom of 1.1% is achieved by Hong Kong too in 1989.

5. Empirical Results

First of all, it is necessary to investigate time series properties of the variables, given time series data. The testing of stationarity/nonstationarity is crucial before doing any empirical research which is closely link to unit root test. Augmented Dickey-Fuller (ADF) test is employ to the test for unit root.

Unit Root Test for Stationery

Before the test for unit root, inclusion or ignorance of intercept and trend under ADF test need to be decided. First of all, it is obvious that the intercept should be including in all series.[3]Next, we regress the series on time to examine whether there is a trend for that particular series. The null hypothesis would be in the series is time-invariant. The rejection of the null hypothesis implies that there is a trend for the series. Lastly, the results are summarized as below (Table 2):

Country	π	Inclusion of π	Inclusion of Trend	Intercept	Trend
Hong Kong	-4.244***	Trend	3.000***	Trend(0.0002)	Intercept(0.0054)
South Korea	-3.149***	Trend	-0.485	Intercept(0.0037)	Intercept(0.6314)
Singapore	-1.183	Intercept	-3.307***	Trend(0.2461)	(0.0025)
Taiwan	-2.833***	Trend	7.608***	Trend(0.0082)	Intercept(0.0000)

Significance level: *** = 1%
Note: The figures in first row are t test statistic and the figures in parentheses are p-values of time variable. π = inflation rate, u = unemployment rate.

Significance level: *** = 1%; ** = 5%; * = 10% Note: The figures in first row are t^* (ADF test-statistic) and the figures in parentheses are MacKinnon (1996) one-sided p-values. S = stationary and NS = nonstationary, π = inflation rate, u = unemployment rate. The results of the unit root test are presents in Table 3. The null hypothesis would be the series contain unit root or are non-stationary. In the meanwhile, it is rejected when the ADF test statistic is less than the MacKinnon critical values. The inflation rate of South Korea, Singapore and Taiwan as well as unemployment rate of South Korea is significant at levels. As a conclusion, these series are stationary at level. In other words, these series is said to be integrated of order zero which is $I(0)$. On the other hand, the inflation rate of Hong Kong and the unemployment rate of Hong Kong, Singapore, and Taiwan are insignificant at levels. However, they are significant at first difference and this implies that these series are stationary at first difference. Furthermore, these series are said to be integrated of order one which is $I(1)$. They tend to behave in "stationary" form with constant means and variances after the first integration.

Model Estimation

To study the Phillips curve relation in Hong Kong, South Korea, Singapore, and Taiwan, the relationship between inflation rate and unemployment rate is estimated and presented in Table 4 below: Table 4: Estimation Results Using OLS - Dependent Variable: π_t Model (1) Model (2) Model (3) Model (4)

Coefficients**Hong Kong****South Korea****Singapore****Taiwan** **α**

0.0112.8682.222***2.904***(0.028)(0.856)(5.662)(3.907)

 β_1

-1.222***0.7420.783*-1.947(-3.075)(0.856)(1.800)(-1.473)

Total R²

0.24590.02390.09750.0675

F Testa

9.455***0.7333.240*2.171(0.0046)(0.3987)(0.0819)(0.

1511)Significance level: *** = 1%;* = 10% (t-stats in parentheses)a The

figures in first row are F-stats and the figures in parentheses are p-values.

First of all, F-test approach is used in testing the overall significance of the regression model. The null hypothesis would be R² equal to 0. From the table

4, it said that only model (1) and (3) are statistically significant at 1 percent and 10 percent level corresponding. The model (2) and (4) are insignificant.

Next, t test approach can be used to test the individually significance of the regressor. Under the individual null hypothesis is each true population

coefficient (β_1) is zero. In conclusion, the coefficient of Hong Kong's

unemployment rate is individually statistically significant at level of 1

percent. The coefficient of Singapore's unemployment rate is individually statistically significant at level of 10 percent. While the coefficient of South Korea and Taiwan's unemployment rates are insignificant. If Phillips curve exists, inflation rate should be negatively correlated with unemployment rate. The results show that Phillips curve only presence in Hong Kong. Then, the CLRM assumptions such as zero mean value of residuals as well as normality, homoscedasticity, no autocorrelation of residual are diagnostically checked using the various tests below.

Residual Test for Zero Mean

Table 5: Residual Test ResultsModel

Mean of Residual

(1)

Hong Kong

-1.43e-16(2)

South Korea

8.05e-16(3)

Singapore

6.11e-16(4)

Taiwan

-2.78e-17The mean of residuals is summarized in Table 5. It is clear that the mean value of residuals for model (1), (2), (3) and (4) was approximately equal to 0. Thus, the assumption of zero mean value of residuals is met in each model.

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Jarque-Bera (JB) Test for Normality

Table 6: Jarque-Bera (JB) Test ResultsModel

Test Statistic

JB-stat

p-value

(1)

Hong Kong

3. 6340. 1626(2)

South Korea

115. 315***0. 0000(3)

Singapore

3. 9470. 1389(4)

Taiwan

95. 522***0. 0000Significance level: *** = 1%

White Test for Heteroscedasticity

Table 7: White Heteroscedasticity Test ResultsModel

Test Statistic

Obs*R-squared

p-value

(1)

Hong Kong

1. 2790. 5276(2)

South Korea

4. 777*0. 0917(3)

Singapore

8. 261**0. 0161(4)

Taiwan

3. 8750. 1440Significance level: ** = 5%; * = 10%Regarding to the model estimated in fulfilling the assumption of homoscedasticity, the White Heteroscedasticity Test was carried out to detect the existence of heteroscedasticity. Under the null hypothesis would be there is no heteroscedasticity. When comparing p-value with α , it is referred to the p-value of the chi square test statistic which has the distribution with 2 degree of freedom. For residuals of model (1) and (4), the H0 of no heteroscedasticity problem is not rejected as $p\text{-value} > \alpha$. On the other hand, the null hypothesis is rejected for residuals of model (2) and (3) hence there is heteroscedasticity problem.

Breusch-Godfrey (BG) Test for Autocorrelation

Table 8: Breusch-Godfrey (BG) Serial Correlation LM test (Lags= 2)Model

Test Statistic**Obs*R-squared****p-value**

(1)

Hong Kong

1. 7010. 4272(2)

South Korea

10. 976***0. 0041(3)

Singapore

5. 368*0. 0683(4)

Taiwan

13. 229***0. 0013Significance level: *** = 1%; * = 10%The BG test for autocorrelation allows for nonstochastic regressors such as the lagged values of regressand, higher-order autoregressive schemes such as AR(2) as well as AR(3) and higher-order moving average of white noise error terms (Gujarati & Porter, 2009). The null hypothesis of BG test is no serial correlation up to the specific number of lags (2). It is clear that only residuals of model (1) has no serial correlation problem ($p\text{-value} > \alpha$). Table 9: Summary of Heteroscedasticity and Autocorrelation

	Model (1)	Model (2)	Model (3)	Model (4)
Heteroscedasticity	No	Yes	Yes	No
Autocorrelation	No	Yes	Yes	No

Hong Kong**South Korea****Singapore****Taiwan****Heteroscedasticity**

NoYesYesNo

Autocorrelation

At here, Newey-West method is used to solve the problem of heteroscedasticity and (or) autocorrelation that exists in model (2), (3) and (4). These models are re-estimated with corrected standard error: Table 10: Estimations Results with Corrected Standard Error - Dependent Variable: $\ln t$

Model (1)	Model (2)*	Model (3)*	Model (4)*
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Coefficients

Hong Kong

South Korea

Singapore

Taiwan

α

0.0112. 8682. 222*** 2.904** (0.028)(0.755)(4.133)(2.570)

β_1

-1.222*** 0.7420. 783-1.947(-3.075)(0.574)(1.354)(-1.386)

Total R2

0.24590. 02390. 09750. 0675

F Testa

9.455*** 0.7333. 240* 2.171(0.0046)(0.3987)(0.0819)(0.

1511) Significance level: *** = 1%; ** = 5%; * = 10% (t-stats in

parentheses) a The figures in first row are F-stats and the figures in

parentheses are p-values. Comparing model (2)*, (3)* and (4)* with model

(2), (3) and (4) respectively, it is obvious that the coefficients and R2 as well

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as F-stats remain unchanged, however, t-stats is lower now due to the higher standard error. Moreover, the coefficient of Singapore's unemployment rate is insignificant now. At this point, it is concluded that model (1), (2)*, (3)* and (4)* has passed all the CLRM assumptions, hence the OLS estimators are unbiased, consistent, and efficient (BLUE). In conclusion, Phillips curve (inverse inflation-unemployment relations) only holds in Hong Kong (model 1). The coefficient of -1.222 implies that if the unemployment rate goes up by 1 percentage point, on average inflation rate goes down by 1.222 percentage point. The R² of 0.2459 mean that 24.59% of the variation in inflation rate is explained by the variation in unemployment rate. The inflation rate is uncorrelated with unemployment rate in South Korea, Singapore, and Taiwan.

6. Conclusion

This paper employed time series analysis (OLS method) to study the inverse relationship between the inflation rate and unemployment rate or to examine the existence of the "Phillips curve" in NIEs (i. e. Hong Kong, South Korea, Singapore and the Taiwan) individually. As the results show, trade-off relationship between the inflation rate and unemployment rate only occurs in Hong Kong. In contrast, there is no significant relationship between the inflation rate and unemployment in South Korea, Singapore, and Taiwan. In short, empirical findings refute the existence of a Phillips curve in the NIEs on the whole. The breakdown of the Phillips curve is mainly due to the oil crisis (increase in the price of oil). The increases in non-labor costs force firms to increase the prices of goods[4], which in turn lead an increase in inflation, even at a given rate of unemployment. Others, it might also because wage

setters changed the way they formed their expectations of inflation.[5]The non-existence of the Phillips curve in South Korea, Singapore, and Taiwan might indicate that policy makers in these nations can carry out expansionary policies (either fiscal or monetary) to stimulate employment level as well as economic growth without pay the price of high inflation rate. At the same time, policy makers of Hong Kong need to be cautious of the policies implement in order to achieve both price stability and low unemployment rate in the economy. As the sample size is only 31 observations, hence the result might be inconsistence or inaccurate. Moreover, the t and F test may appear to be less accurate when the sample size is small (not normally distributed). Hence, it is hard to conclude that whether there is an inverse relationship between the inflation rate and unemployment rate in NIEs based on this small sample size data. So, more observations are required to get a better or more accurate result in examining the existence of Phillips curve in NIEs. Others, future research may incorporate other variables, such as rational expectations to examine the presence of Phillips curve in NIEs.