**Revisiting the Stability of Real GDP in Tiger Cub Economies – New Evidence from Quantile Unit Root test with Smooth Breaks**

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***Abstract***

This paper investigates whether the real GDP is stationary in Tiger Cub Economies (Indonesia, Malaysia, Philippines and Thailand). The conventional unit root tests together hold nonstationary conclusions for these four countries, but the Quantile Unit Root test agrees with stationary process for Indonesia, Malaysia and Philippines. However, the move trend of the real GDP among these four nations indicates these two strands of conclusion are unconvincing. By employing a more powerful Quantile Unit Root test with Smooth Breaks, we find the real GDP of Malaysia and Thailand is stationary. Besides, we also calculate the half-lives and mean reversion properties of the four countries. All of the empirical results have important macroeconomic implications for policy makers, modeling and forecasting institutions.

***Keywords***: The Real GDP, Quantile Unit Root Test with Smooth Breaks, Tiger Cub Economies

***JEL Classfication***: C53, E17, E23

1. **Introduction**

Testing whether the real output levels is stationary or not has meaningful economic implications for macroeconomic policy makers, modeling and forecasting institutions Nelson and Plosser (1982). Most of economic researchers are always interested in the time series properties of the real GDP. Regarding the theoretical economic policy implications, Keynesian business cycle theory indicates that governments should implement macroeconomic policies, especially fiscal policies, to smooth the business cycle fluctuations. However, the conventional business cycle theory argues that GDP fluctuations are temporary deviating from the main moving trend. In line with the Neo-classical macroeconomic points, it is unnecessary to apply monetary and fiscal policies to deal with GDP shock because of its transitory impacts on the economic system. In other words, if the real GDP is a stationary process, economic policies including monetary and fiscal policies could only make transitory impacts on the long-run path of the real GDP. But if the real GDP is a nonstationary process, the shocks such as technology shocks as well as monetary and fiscal shocks may permanently affect the moving trend of the real GDP.

Due to the fast development of the econometric models, many tests, such as ADF test, PP test and KPSS test, could be conducted to achieve this goal. However, in the presence of warfare, economic recession, financial crisis and oil shock, the macroeconomic series always contain structural breaks. Perron (1989) indicated that structural breaks would decrease the testing power to reject the null hypothesis, which suggests the lower power of conventional method when testing the structural series. Given that, loads of papers contribute to solve the problems of structural breaks, such as dummy variables. However, Leybourne et al. (1998) pointed out that breaks of macroeconomic variables should be approximated as smooth and gradual processes. Henceforth, Becker, Enders, and Lee (2004, 2006) and Enders and Lee (2012) develop tests which model any structural breaks by flexible Fourier function which could approximate the smooth and gradual process. Nevertheless, unit root test with Fourier function cannot provide more insightful information about the duration of shock. Besides, the conventional methods is not able to reveal the mean reversion properties of the series. Koenker and Xiao (2004) created Quantile Unit Root test (QUR) which could investigate the mean reversion process of macroeconomic variables at different quantiles.

To sum up, two aspects could be summarized to indicate the drawbacks of the ongoing conventional stationary test, such as the smooth breaks and mean reversion properties of the investigated series. Luckily, a novel econometric model proposed by Bahmani-Oskoee et al. (2016), namely Quantile Unit Root test with Fourier Function (QUR with Smooth Breaks), is able to solve smooth breaks and to provide more empirical results of mean reversion traits of macroeconomic variables at the same time. Last but not the least, to our best knowledge, this method has not been employed to test the real GDP among Tiger Cub Economies (including Indonesia, Malaysia, Philippines and Thailand) which achieve remarkable success in economic development since the 1990s. Given that, this paper could provide more insightful economic implications for these countries and also fill in the gap of econometric models.

The rest of the paper is organized as follows. Section 2 presents data selection and statistical descriptions. Section 3 introduce econometric model considering smooth breaks by means of Fourier function. Section 4 shows empirical results and makes some analysis. Section 5 concludes the paper.

1. **Data selection and statistical description**

The Tiger Cub Economies refer to Indonesia, Malaysia, Philippines and Thailand. Due to the accessibility of the real GDP from International Financial Statistic (IFS) in IMF dataset, the time span is various. Specifically, the time span is from 1997:Q1 to 2014:Q4 for Indonesia and from 1998:Q1 to 2016: Q3 for Malaysia and from 1981:Q1 to 2016:Q4 for Philippnies and from 1993:Q1 to 2014:Q4 for Thailand. Besides, in order to avoid the seasonal factors’ impacts on the efficiency of the test, we make use of the X-12 seasonal adjustment method which is conducted by EViews 8.0. Next, we take logarithm form of the real GDP in order to eliminate the effects of heteroscedasticity. Figure 1 plots all of the data used in this paper.

**<Insert Figure 1 around here>**

We could easily find some common traits from the dataset, such as the breaks from 1999 to 2000 and 2009 to 2010 of Indonesia. In terms of the Malaysia, there are more structural breaks. However, the most significant break for Philippines is from 1998 to 1999. Besides, in the periods from 1998 to 1999, from 2008 to 2009 and from 2011 to 2012, there are also structural break points in these periods in Thailand. Next, we sum up the statistical descriptions of these variables.

**<Insert Table 1 around here>**

The smallest log real GDP is from Philippines with 4.9426, but the highest log real GDP is from Indonesia with a striking 14.6924. However, all of the mean and median of log real GDP are over 5. The most drastic fluctuation could be seen from Indonesia whose Std. Dev. is 1.0441. Besides, all of the skewness is negative except Thailand. The Kurtosis of for all of the nations is well below 3. Lastly, the log real GDP is subjected to Gaussian distribution with considering the Jarque-Bera statistics regarding 5% significant level.

1. **Econometric Model**

To begin with, we consider a real GDP series  which follows a data generation process (DGP) as follows,



where  is subjected to a stationary process with variance ,  is a deterministic term with time-varying characteristics. Due to the merits of accurate approximation of Fourier function to integrable functions, we follow Gallant (1981) to employ Fourier terms  and  to globally approximate smooth structural breaks. Thus,  could be expressed as follows,



To be noted, *k*, *t* and *T* represent the frequency of the Fourier function, trend term and sample size, respectively. As usual, we set *π*=3.1416.  is an optional exogenous regressor which consists of a constant term *c* in our case. Lastly, n denotes the number of frequency in the approximation, which satisfies the requirement.

We can rewrite the equation (1) as follows,



We need to set the parameters *n* and *k* beforehand so as to estimate the equation (3). Becker et al. (2004) and Enders and Lee (2012) restrict *n*=1 because the joint null hypothesis  could be rejected at one frequency level and also saving the degrees of freedom, which, if not, may result in over-fitting problem. Thus, the equation (2) could be rewritten as follows,



Then, the equation (3) can be simplified as,



where,  is assumed to be an *I*(0) process with zero mean.  and measure the amplitude and displacement of the frequency component. In particular,  is a special case of standard linear specification. There must be at least one of the both frequency components existed if a structural break is appeared. Becker et al. (2004) create a more powerful test to detect structural breaks under an unknown form than Bai and Perron (2003) test. Next, we set the maximum of k=5 when we determine an optimal k. For any K=k, we estimate equation (5) employing ordinary least squares (OLS) method and save the sum of squared residuals (SSR). Frequency k\* is setting as optimum frequency at the minimum of SSR. With above assumption and respect to the deterministic components, we test the following null hypothesis:



Under the null hypothesis of a unit root, the alternative hypothesis is. To test the null hypothesis, we follow Christopoulos and Leon-Ledesma (2010) to calculate the statistic via the following steps:

Firstly, we set a maximum k equals to 5, and then find out the optimal frequency of  by employing the methodology described above. We compute the OLS residuals as that:



Secondly, a unit root on the OLS residuals given from equation (7) is tested by using quantile regression frameworks which was proposed by Koenker and Xiao (2004). The test is an extension of Augmented Dickey-Fuller (ADF) type unit root test and has much more power than standard ADF test when a given shock exhibits heavy-tailed behavior. Another advantage of the test is that it allows for different adjustment mechanism towards the long-run equilibrium at different quantiles. To illustrate the test, we start with standard ADF test:



where, *c* is still a constant, *et* is the estimated residuals from equation (7). To be noted, *α* represents the autoregression coefficient and describes the persistence of *et*. When , the growth rate of real GDP employed in this paper has mean reverting properties. Following Koenker and Xiao (2004), the ADF form could be rewritten at quantile *τth* as,



Here,  can be obtained at *τ*-*th* quantile given the information set ,  could measure the series shock of *et* at different quantiles. Besides, captures the reversion speed of *et* given each quantile. In addition, following Bahmani-Oskooee *et al.* (2016), we could suggest the half-lives of a shock as . Here, AIC information criteria works to select the optimum lags. To obtain the coefficient and, we could minimize the following equation,

here,  if , otherwise . Koenker and Xiao (2004) further propose *t*–ratio statistic the null hypothesis , which could be expressed as,



where  is probability functions of *et*, and  is cumulative density function of series *et*.  is the vector of lagged dependent variables () and  is the projection matrix onto the space orthogonal to .  is a consistent estimator of  indicated by Koenker and Xiao (2004), which can be expressed as,



hereand . We set  and . Obviously, we are able to test the unit root hypothesis at different quantiles in comparison with traditional ADF test only emphasizing on the conditional central tendency.

In order to assess the performance ofQuantile Unit Root test, Koenker and Xiao (2004) suggested a Kolmogorov-Smirnov (QKS) test which could be presented as,



In this paper, we select the maximum of  to build the *QKS-Fourier* statistics over the quantiles . Although the limiting distributions of both  and *QKS* tests are nonstandard, Koenker and Xiao (2004) propose re-sampling procedures to derive critical values. In this paper, we make the bootstrap iterations to 5000 times to accurate the empirical results. The detailed re-sampling procedures are shown as follows:

Firstly, we run the following k-order autoregression by ordinary least square:



Then, we save the fitted values  and error term , and then create the bootstrap residuals  with replacement from the centered residuals .

Secondly, we then calculate the bootstrap sample of observations  as follows:



We construct the  and  based on equation (9), statistics based on equation (11), and QKS statistics based on equations (13). We repeat steps 2 for 5000 times and the collection of realizedand QKS statistics provides us an approximation to the cumulative distribution functions of them. Also, to construct the 95% confidence intervals for the  and , we use their empirical distribution functions.

Besides, the finite-sample size and power properties of QKS test has been revealed in the Table 1, 2 and 3 of the study Bahmani-Oskooee *et al.* (2016). Readers who are interested in this section could directly review this paper.

1. **Empirical Results**

In order to make comparisons, we test the stability of real GDP not only by Quantile Unit Root test with Fourier Function, but also take conventional unit root test and Quantile Unit Root test without Fourier Function into consideration.

**4.1 Results from Conventional Unit Root Tests**

We incorporate three conventional unit root tests, including ADF test, PP test and KPSS test. Besides, we take different forms of these tests with and without trend into account. The empirical results are shown in Table 2 and 3.

**<Insert Table 2 around here>**

Obviously, when only considering constant term, ADF test, PP test and KPSS test all indicate nonstationary conclusion at level value. However, at 1st difference level, The ADF test, PP test and KPSS test together present the real GDP in these four countries is stationary.

**<Insert Table 3 around here>**

Table 3 considers both intercept and trend when testing the unit root of the time series. Clearly, in line with the above test without considering trend, the ADF test and PP test are all indicating the real GDP is instable in level value. However, the KPSS test presents nonstationary results except Indonesia. However, all of the test indicate stationary conclusions after taking 1st difference form.

After combing the empirical results, we could conclude that the real GDP is always nonstationary at level value by employing conventional method without considering mean-reverting properties and smooth breaks.

**4.2 Results from Quantile Unit Root Test (Koenker and Xiao, 2004)**

Here, we employ Quantile Unit Root test proposed by Koenker and Xiao (2004), without taking structural breaks into account, to again test the real GDP among Tiger Cub Economies. All of the results are shown in Table 4.

**<Insert Table 4 around here>**

Based on Table 4, we can conclude that the real GDP is stationary among Indonesia, Malaysia and Philippines, which is indicated by the QKS statistics 2.600, 4.929 and 4.281, respectively. But the QKS statistics of Thailand is 1.267 which is in line with nonstationary conclusion.

**4.3 Results from Quantile Unit Root Test with Fourier Function (Bahmani-Oskoee et al., 2016)**

Due to without considering structural breaks of the method Koenker and Xiao (2004) proposed, we cannot get satisfied empirical results. Hence, we employ Quantile Unit Root test with Fourier Function to reexamine the stability of real GDP among Tiger Cub Economies. The results are shown in Table 5.

**<Insert Table 5 around here>**

To sum up, the real GDP of Malaysia and Thailand is stationary when considering smooth breaks when considering 5% significant level. However, the real GDP of Indonesia and Philippines is instable which could be revealed by QKS statistics with 1.215 and 2.300, respectively. For the group of Malaysia and Thailand, the test result confirms that all types of shocks to real GDP lead to temporary effects. This means the economic policy such as monetary and fiscal policies could only make transitory impacts on the real GDP. The empirical results are more reliable combining with the move trend of the real GDP plotted in Figure 1.

Table 5 also shows the persistent estimates of *α*(*τ*) for  in Tiger Cub countries. The persistent point estimate is slightly above one at the upper quantile for Philippines and slightly above one at the lower tail quantile for Indonesia and Malaysia. Besides, the persistent point estimates of Thailand are well below 1 for all quantiles. When we check the coefficients of each quantile for those countries that support the real GDP is stationary, we find that shocks to real exchange rate adjust at different speed which is in line with asymmetric shock effects to real GDP in Malaysia and Thailand.

Then, we also calculate the half-lives of a shock for all of nations. We can easily find that the countries with half-lives less than 5 years, such as Malaysia and Thailand, which again indicates the transitory impacts of shocks on real GDP due to the less persistent years. However, for Indonesia and Philippines, the half-lives are over 10 years at specific quantiles. For instance, at quantiles  and , the half-lives are 57.676 and 24.669 years in Indonesia. These results indicate the shocks including monetary and fiscal policies may make permanently impacts on real GDP in Indonesia and Philippines.

In order to describe the mean reversion process of real GDP in Tiger Cub Economies, we plot the variation trend of both *c*(*τ*) and *α*(*τ*) which are shown in Figure 2.

**<Insert Figure 2 around here>**

For Indonesia and Malaysia, the move trend of *α*(*τ*) is downward. After combing the values of *c*(*τ*) and *α*(*τ*) for this group reveals that negative shocks may make permanent impacts on the real GDP path, but positive shocks only make transitory impacts. However, for Philippines, the overall moving trend is upward, so we could sum up that the positive shocks may have permanent effects on the path of the real GDP. Lastly, for Thailand, the shock both positive and negative may only violate the real GDP in the short term due to the waving trend of *α*(*τ*). The empirical results have meaningful economic implications for the stationary group (including Malaysia and Thailand), the negative shocks of Malaysia would make more sense than positive shock in the short run. But for Thailand, both positive and negative shock makes equal impacts on the move trend of real GDP. However, in term of the nonstationary group, the negative shock of Indonesia contributes more to the path of real GDP, but positive shock permanently influence the real GDP of Philippines.

1. **Conclusion Remarks**

In this paper, we apply three kind of stationary tests, including conventional univariate unit root test (ADF test, PP test and KPSS test), Quantile Unit Root test introduced by Koenker and Xiao (2004) and Quantile Unit Root test with Fourier function proposed by Bahmani-Oskoee et al.(2016), to investigate the stability of the real GDP in Tiger Cub Economies (Indonesia, Malaysia, Philippines and Thailand). Due to the structural breaks contained in the data series, conventional method cannot give strong evidence of the stability. The ADF test, PP test and KPSS test together agree with nonstationary conclusion. However, the quantile unit root test are more likely to hold stationary conclusion in Indonesia, Malaysia and Philippines. However, the empirical results of Quantile Unit Root test with Smooth Breaks indicate the inaccurate results from the above two methods. For Malaysia and Thailand, the real GDP is stable, but instable for the rest of the two countries. Then, the half-lives calculated indicate the shocks could only make less 5-years impacts on the real GDP for Malaysia and Thailand, but more likely to affect more than 10 years at some specific quantiles in Indonesia and Philippines. Lastly, the mean reversion results hold the asymmetric effects of the positive and negative shock to the path of real GDP.

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**Figure 1. Real GDP of Tiger Cub Economies (Indonesia, Malaysia, Philippines and Thailand)**









**Table 1. Summary Statistics of Real GDP among Tiger Cub Economies (Indonesia, Malaysia, Philippines and Thailand)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Indonesia** | **Malaysia** | **Philippines** | **Thailand** |
| **Mean** | 13.2929 | 11.3113 | 6.1975 | 6.8054 |
| **Median** | 13.0720 | 11.4361 | 6.7337 | 6.8005 |
| **Maximum** | 14.6924 | 12.5365 | 7.6372 | 7.1653 |
| **Minimum** | 11.4055 | 9.6767 | 4.9426 | 6.3844 |
| **Std. Dev.** | 1.0441 | 0.8702 | 1.0109 | 0.2225 |
| **Skewness** | -0.2081 | -0.2589 | -0.0162 | 0.0421 |
| **Kurtosis** | 2.0748 | 1.8032 | 1.1768 | 1.6932 |
| **Jarque-Bera** | 3.4309 | 8.1473 | 19.9510 | 6.2873 |
| **Probability** | 0.1799 | 0.0170 | 0.0000 | 0.0431 |
| **Observations** | 80 | 115 | 144 | 88 |

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| **Table 2. Univariate unit root tests (without trend)** |
|  | **Level** | **1st difference** |
|  | **ADF** | **PP** | **KPSS** | **ADF** | **PP** | **KPSS** |
| **Indonesia** | 0.6975(0) | 0.6975 (0)  | **1.1462(6)\*\*\*** | **-9.0012 (0)\*\*\*** | **-9.0012(2)\*\*\*** | 0.0571(0) |
| **Malaysia** | -1.3940(0) | -1.4071(4) | **1.2437 (9)\*\*\*** | **-10.9171 (0)\*\*\*** | **-10.9135 (3)\*\*\*** | 0.1268(3) |
| **Philippines** | -0.3163(0) | -0.3313(2) | **1.3223(10)\*\*\*** | **-12.2229(0)\*\*\*** | **-12.2200(1)\*\*\*** | 0.1079(2) |
| **Thailand** | -1.0025(0) | -1.0008(4) | **1.1802(7)\*\*\*** | **-9.5081(0)\*\*\*** | **-9.5081(0)\*\*\*** | 0.0725(1) |
| Note: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. 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 the Newey-West test (1987). |

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| **Table 3. Univariate unit root tests (with intercept and trend)** |
|  | **Level** | **1st difference** |
|  | **ADF** | **PP** | **KPSS** | **ADF** | **PP** | **KPSS** |
| **Indonesia** | -2.4196 (0) | -2.5597(2)  | 0.0707(6) | **-8.9616(0)\*\*\*** | **-8.9616(0)\*\*\*** | 0.0430 (0) |
| **Malaysia** | -2.4263(0) | -2.4263(0) | **0.1994(8)\*\*** | **-10.9770(0)\*\*\*** | **-10.9739(4)\*\*\*** | 0.0279(5) |
| **Philippines** | -2.1253 (0) | -2.1179(1) | **0.1512(9)\*\*** | **-12.1912(0)\*\*\*** | **-12.1899(2)\*\*\*** | 0.0946(2) |
| **Thailand** | -2.3661(0) | -2.4765(2) | **0.1180(6)\*** | **-9.4742(0)\*\*\*** | **-9.4742(0)\*\*\*** | 0.0662(1) |
| Note: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. 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 the Newey-West test (1987). |

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| **Table 4. Empirical results of quantile estimation and unit-root tests for each quantile (without taking into smooth breaks) – Koenker and Xiao (2004)** |
|  | **τ** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
| **Indonesia** | **c(𝛕)** | -0.011 | -0.006 | 0.000 | 0.007 | 0.014 | 0.016 | 0.022 | **0.038\*\*** | 0.057 |
|  | **𝜶(𝛕)** | 1.013 | 1.011 | 1.008 | 1.004 | 1.000 | 0.998 | 0.994 | 0.983 | 0.980 |
|  | **tn(𝛕 i)** | 1.031 | 1.913 | 2.600 | 1.353 | -0.114 | -0.440 | **-1.059\*** | **-2.368\*\*** | -0.189 |
| **QKS-Stat. 2.600\*\*** |
| **Malaysia** | **c(𝛕)** | -0.006 | 0.005 | 0.008 | 0.013 | 0.015 | **0.019\*\*** | **0.023\*\*\*** | **0.029\*\*\*** | 0.033 |
|  | **𝜶(𝛕)** | 0.997 | 1.003 | 1.000 | 0.997 | 0.996 | 0.995 | 0.993 | 0.990 | 0.989 |
|  | **tn(𝛕 i)** | -0.414 | 1.027 | 0.159 | -1.365 | **-1.920\*\*** | **-2.676\*\*\*** | **-2.924\*\*\*** | **-4.929\*\*\*** | -0.263 |
| **QKS-Stat. 4.929\*\*\*** |
| **Philippines** | **c(𝛕)** | -0.007 | -0.003 | 0.003 | 0.007 | 0.010 | **0.013\*** | **0.016\*\*** | **0.021\*\*\*** | **0.029\*** |
|  | **𝜶(𝛕)** | 1.010 | 1.009 | 1.006 | 1.005 | 1.003 | 1.002 | 1.002 | 0.999 | 0.995 |
|  | **tn(𝛕 i)** | 1.968 | 4.281 | 3.297 | 3.251 | 2.259 | 1.475 | 1.458 | -0.312 | -0.696 |
| **QKS-Stat. 4.281\*\*\*** |
| Notes: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. Numbers in parenthesis denote bootstrap p-values with the bootstrap replications set to be 5000. For α (τ), the unit-root null is examined with the tn(τ) statistic. The lag length q is selected based on robust Schwarz information criterion as suggested by Galvao (2009) with a maximum lag set to be 12. |
| **Table 4. Empirical results of quantile estimation and unit-root tests for each quantile (without taking into smooth breaks) – Koenker and Xiao (2004) (to be continued)**  |
|  | **τ** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
| **Thailand** | **c(𝛕)** | -0.019 | -0.009 | -0.001 | 0.009 | **0.011\*** | **0.013\*\*** | **0.018\*\*** | **0.022\*\*** | **0.029\*\*** |
|  | **𝜶(𝛕)** | 0.991 | 1.008 | 1.012 | 1.001 | 0.994 | 0.994 | 0.989 | 0.991 | 0.992 |
|  | **tn(𝛕 i)** | -0.15 | 0.431 | 0.755 | 0.057 | -0.532 | -0.698 | -1.267 | -0.453 | -0.285 |
| **QKS-Stat. 1.267** |
| Notes: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. Numbers in parenthesis denote bootstrap p-values with the bootstrap replications set to be 5000. For α (τ), the unit-root null is examined with the tn(τ) statistic. The lag length q is selected based on robust Schwarz information criterion as suggested by Galvao (2009) with a maximum lag set to be 12. |

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| **Table 5. Empirical results of quantile estimation and unit-root tests for each quantile (taking into smooth breaks – Fourier Function) – Bahmani-Oskoee et al. (2016)** |
|  | ***τ*** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
| **Indonesia** | **c(𝛕)** | -0.062 | -0.047 | -0.037 | -0.03 | -0.028 | -0.024 | -0.021 | -0.008 | 0.008 |
|  | **𝜶(𝛕)** | 1.006 | 1.008 | 1.002 | 0.998 | 1.001 | 0.997 | 0.993 | 0.963 | 0.968 |
|  | **tn(𝛕 i)** | 0.133 | 0.429 | 0.163 | -0.217 | 0.126 | -0.272 | -0.461 | -1.215 | -0.078 |
|  | **Half-lives** |  |  |  |  |  | 57.676 | 24.669 | 4.596 | 5.328 |
|  | **Optimum Frequency0.100** | **Optimum F statistics 356.622** | **QKS-Stat. 1.215** |
| **Malaysia** | **c(𝛕)** | **-0.030\*\*\*** | **-0.021\*\*\*** | **-0.015\*\*\*** | **-0.01\*\*\*** | **-0.007\*\*\*** | **-0.004\*\*\*** | -0.001 | 0.002 | 0.008 |
|  | **𝜶(𝛕)** | 1.020 | 0.966 | 0.959 | **0.963\*\*** | **0.963\*\*** | **0.959\*\*** | **0.959\*\*** | **0.957\*** | 0.925 |
|  | **tn(𝛕 i)** | 0.354 | -1.175 | -1.724 | -1.940 | -2.326 | -2.925 | -2.641 | -0.808 | -0.243 |
|  | **Half-lives** |  | 5.010 | 4.139 | 4.596 | 4.596 | 4.139 | 4.139 | 3.943 | 2.223 |
|  | **Optimum Frequency0.200** | **Optimum F statistics 3893.091** | **QKS-Stat. 2.925\*\*** |
| **Philippines** | **c(𝛕)** | **-0.038\*\*\*** | **-0.026\*\*\*** | **-0.020\*\*\*** | **-0.015\*\*\*** | **-0.006\*** | 0.002 | **0.012\*\*** | **0.023\*\*\*** | **0.031\*\*\*** |
|  | **𝜶(𝛕)** | 0.987 | 0.976 | 0.986 | 0.988 | 0.968 | 0.988 | 0.991 | 1.020 | 1.006 |
|  | **tn(𝛕 i)** | **-0.609** | **-1.736\*\*** | **-1.184\*\*** | **-1.027** | **-2.300\*\*** | -0.7400 | -0.572 | 1.433 | 0.418 |
|  | **Half-lives** | 13.243 | 7.133 | 12.291 | 14.354 | 5.328 | 14.354 | 19.167 |  |  |
|  | **Optimum Frequency0.700** | **Optimum F statistics 1206.541**  | **QKS-Stat. 2.300** |
| Notes: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. Numbers in parenthesis denote bootstrap p-values with the bootstrap replications set to be 5000. For α (τ), the unit-root null is examined with the tn(τ) statistic. The lag length q is selected based on robust Schwarz information criterion as suggested by Galvao (2009) with a maximum lag set to be 12. |
| **Table 5. Empirical results of quantile estimation and unit-root tests for each quantile (taking into smooth breaks – Fourier Function) – Bahmani-Oskoee et al. (2016) (to be continued)**  |
|  | **τ** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
| **Thailand** | **c(𝛕)** | **-0.018\*\*\*** | **-0.010\*\*\*** | **-0.004\*** | 0.000 | **0.003\*\*** | **0.006\*\*\*** | **0.010\*\*\*** | **0.015\*\*\*** | **0.022\*\*\*** |
|  | **𝜶(𝛕)** | 0.852 | **0.870\*\*** | **0.905\*\*** | **0.887\*\*\*** | **0.911\*\*** | **0.923\***\* | 0.935 | **0.893\*\*** | **0.847\*** |
|  | **tn(𝛕 i)** | -0.804 | -0.971 | **-1.834\*** | **-2.747\*\*\*** | **-2.200\*\*** | **-2.239\*\*** | -1.441 | -1.401 | -0.930 |
|  | **Half-lives** | 1.082 | 1.244 | 1.736 | 1.445 | 1.859 | 2.163 | 2.578 | 1.531 | 1.044 |
|  | **Optimum Frequency0.400** | **Optimum F statistics 785.848** | **QKS-Stat. 2.747\*\*** |
| Notes: \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels, respectively. Numbers in parenthesis denote bootstrap p-values with the bootstrap replications set to be 5000. For α(τ), the unit-root null is examined with the tn(τ) statistic. The lag length q is selected based on robust Schwarz information criterion as suggested by Galvao (2009) with a maximum lag set to be 12. |

C(τ) α(τ)

Indonesia

C(τ) α(τ)

Malaysia

Figure2 The Move Trend of C(τ) and α(τ) for Tiger Cub Economies

C(τ) α(τ)

Philippines

C(τ) α(τ)

Thailand

Figure2 The Move Trend of C(τ) and α(τ) for Tiger Cub Economies (To be continued)

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