How Credible is Inflation Targeting in Asia? A Quantile Unit Root Perspective

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Abstract

This article examines the dynamic behavior of the inflation rate for eight Asian countries using a quantile unit root test. We advocate a three-way definition of inflation targeting based on perfect, imperfect and zero credibility. In doing so, we offer new insights by showing that the credibility of inflation targeting and the alternative monetary policy frameworks in Asia are imperfect, except for Malaysia. In contrast to past studies that focus on the mean-reversion in inflation rates, we also consider trend-reversion and find that Asian IT countries have been building up their monetary policy credibility more than the non-IT countries in terms of a faster rate of decline in inflation rate changes. Our results generally indicate the presence of mean reversion at the lower quantiles only. Where stationarity is present, we find evidence of a varied speed of adjustment process across the quantiles. Finally, we determine the threshold levels whereby inflation becomes stationary and demonstrate that Asian inflation rates generally display stationary behavior during periods of inflation declining or slowing down.

Keywords: Quantile ADF regression model, inflation targeting, inflation persistence
JEL Classification: C32, E31, E58

1. Introduction

To assess inflation targeting (IT hereafter) particularly in emerging Asian countries, the different behavior of the inflation rate has been a keen area of research in recent years. One important direction of this research has been the examination of the stationarity properties of the inflation rate. A clear understanding of this research is important especially in light of the 2008-2009 financial crisis that brought attention again the concerns about lack of credibility of IT central banks. According to some researchers, the financial crisis has bared the flaws of IT more widely along with the re-emergence of a wider debate on rethinking the suitability of IT as a monetary policy strategy (Drakos and Kouretas, 2015; Volz, 2015; Céspedes *et al*., 2014). But as Gillitzer and Simon (2015) argued, the conflicting outcomes of the large shocks from the financial crisis in terms of inflation remaining close to target and calling the need to re-engineer IT could be a reflection of the success of IT.

Unfortunately, the few empirical studies that address the stationarity or persistence of inflation for Asian countries demonstrate contrasting findings. While studies such as Gerlach and Tillmann (2012) find a significant drop in inflation persistence in four Asian IT countries, Siklos (2008) and Filardo and Genberg (2010) report opposite findings for Indonesia, Thailand and the Philippines. Furthermore, Teles and Zaidan (2010), for example, find that the deviation of the expected inflation from its target is stationary in Thailand but not in the Philippines.

There are also studies that examine inflation at various quantiles. The motivation is largely driven by the need to improve the performance of monetary policy by accounting for possible asymmetries in the speed of adjustment at different quantiles, and the desire to study local persistence in the inflation series. Yet even studies of the dynamic behavior of inflation across quantiles do not reach a consensus for developed countries. For example, Tsong and Lee (2011) find stationarity for inflation in the lower quantiles, but the presence of a unit root in the higher quantiles in 12 OECD countries. In contrast, Wolters and Tillmann (2015) find mean reversion in the US inflation across all quantiles after allowing for structural breaks at an unknown date. Meanwhile, Çiçek and Akar (2013) also apply the quantile unit root approach for the inflation rate in Turkey. They find that the inflation rate does not follow a constant unit root process and the corresponding speed of adjustment across different quantiles is asymmetric before and after the start of an IT regime.

This paper examines the different behavior of the inflation rate data for 8 Asian countries. We address one major question: how credible is IT in Asia in terms of stabilizing inflation? In other words, we assess the credibility of IT in terms of whether or not the inflation rate is mean reverting. Specifically, we study the unit-root hypothesis not only at the conditional mean of inflation, but also in the tails of the distribution. We employ Koenker and Xiao's (2004) quantile unit root test, which is an extension of the standard Augmented Dickey-Fuller (ADF) test. The test allows for the possibility that shocks of various sign and size have different impact on inflation, and asymmetric adjustment in different quantiles. Moreover, it allows generally for differences in the transmission of all kinds of different shocks and avoids the estimation of additional regime parameters. In other words, this technique offers a more flexible framework for the purpose of unit-root testing that considers structural changes and reduces estimation uncertainty.

We contribute to the literature in four ways. First, we examine the unit root hypothesis for inflation in relation to the credibility of monetary policy in Asian countries. Benati (2008) points out that a key driver for the drop in inflation persistence is the conduct of a credible monetary regime such as IT (Baxa *et al*., 2015). Similarly, Srinivasan and Kumar (2013) emphasized that credibility is an important determinant of lag dynamics in inflation. In line with this context, we offer new insights in terms of advocating a three-way definition of IT based on *perfect credibility*, *imperfect* or *weak credibility* and *zero credibility* based on the quantile regression estimation results.

Second, we search for an inflation threshold whereby it becomes non-stationary. This is important for policymakers insofar as highly persistent inflation can mean that inflationary expectations become difficult to anchor. Thus far the relevant literature relies on a threshold unit root testing method in explaining the stationary properties of inflation in different regimes. For example, Henry and Shields (2004), who employed the threshold unit root method of Caner and Hansen (2001), find that for Japan and the UK, shocks to inflation are highly persistent in one regime, but have finite lives in another regime. In contrast, this study employs a method similar with Lee *et al*. (2013) for separating periods of inflation non-stationarity from stationary ones. That is, the study aims to search for time varying threshold for inflation based on the largest quantile in which the inflation rate exhibits stationary behaviour.

Third, in contrast to past studies that focus on mean reversion for inflation across quantiles, we capture the trend-reversion to offer new insight on the effects of IT on inflation behaviour. That is, we aim to verify if an IT country having inflation under control might be characterized by a negative trend coefficient at different quantiles. In doing so, one can see whether inflation is guided by an inertia that follows a deterministic trend process (Gottschalk, 2003). If inflation is trend stationary, then it follows that the level will return to its trend path over time and so it is possible to forecast future movements in inflation based on past behaviour (Lee and Chang, 2008).

And finally, we analyze the inflation dynamics for Asian economies that have hitherto received little attention. Asian countries experienced structural shifts after the 1997 financial crisis. Some Asian countries have shifted to IT and floating exchange regimes while others have also been exposed to periods of pronounced turbulence due to financial crisis, political and economic unrest and reform. Therefore, this implies a potential for complex dynamics of adjustment in the inflation rate.

Given the results of our quantile unit root regression model, this paper sheds new light on the dynamics of inflation and the imperfect nature of the credibility of IT and alternative monetary policy framework in a sample of Asian countries. The rest of the paper is organized as follows: Section 2 discusses the quantile unit root test that we employ and the data; Section 3 discusses the empirical results and Section 4 gives the conclusions.

2. Methodology and data

2.1 Quantile unit root test

To study the stationarity of Asian inflation rates, we employ Koenker and Xiao's (2004) quantile unit root test, which is an extension of ADF type unit root test. Let π_t denote the inflation rate, ρ_0 an intercept term and ε_t a white noise residual. The standard ADF regression with deterministic trend *t* can be written as:

$$\Delta\pi_t = \rho_0 + \rho_1\pi_{t-1} + \beta t + \sum_{i=1}^{q} \gamma_i \Delta\pi_{t-i} + \varepsilon_t \qquad (1)$$

where the autoregression (AR) coefficient ρ_1 measures the persistence of inflation. The inflation process contains a unit root if $\rho_1 = 0$. The condition for stationary properties of inflation and for ruling out explosive behavior is where $-2 < \rho_1 < 0$. Following Koenker and Xiao (2004), we define the τth conditional quantile of $\Delta\pi_t$ as:

$$Q_{\Delta\pi_t}(\tau|\Gamma_{t-1}) = \rho_0(\tau) + \rho_1(\tau)\pi_{t-1} + \beta(\tau)t + \sum_{i=1}^{q} \gamma_i(\tau)\Delta\pi_{t-i} + \varepsilon_t \qquad (2)$$

where $Q_{\Delta\pi_t}(\tau|\Gamma_{t-1})$ is τth quantile of $\Delta\pi_t$ conditional on the past information set, Γ_{t-1}. In (2), the τth conditional quantile of $\Delta\pi_t$ is denoted by $\rho_0(\tau)$, which measures the average size of inflation shock in each quantile (Tsong and Lee, 2011). $\rho_1(\tau)$ measures the speed of mean reversion of $\Delta\pi_t$ within each quantile. The estimates for $\rho_1(\tau)$ can be used in approximating the half-lives (HL) for any monotonic stationary inflation process in each quantile through the formula $\text{HL} = \ln(0.5)/\ln(\hat{\rho}_1(\tau) + 1)$. The HL can be approximated when the null hypothesis of $\rho_1(\tau) = 0$ is rejected; otherwise, half-lives are set to be infinite. The optimal lag length is chosen according to the Akaike Information Criteria (AIC).

The coefficients $\rho_0(\tau)$, $\rho_1(\tau)$, $\beta(\tau)$ and $\gamma_i(\tau)$ are estimated by minimizing the sum of asymmetrically weighted absolute deviations:

$$min \sum_{t=1}^{n} \left(\tau - I \left(\pi_t < \rho_0(\tau) + \rho_1(\tau)\pi_{t-1} + \beta(\tau)t + \sum_{i=1}^{q} \gamma_i(\tau)\Delta\pi_{t-i} \right) \right) \left| \pi_t - \rho_0(\tau) + \rho_1(\tau)\pi_{t-1} + \beta(\tau)t + \sum_{i=1}^{q} \gamma_i(\tau)\Delta\pi_{t-i} \right| \tag{3}$$

where $I = 1$ if $\pi_t < \left(\rho_0(\tau) + \rho_1(\tau)\pi_{t-1} + \beta(\tau)t + \sum_{i=1}^{q} \gamma_i(\tau)\Delta\pi_{t-i} \right)$ and $I = 0$, otherwise. Given the solution for $\hat{\rho}(\tau)$ from (3), the stochastic properties of $\Delta\pi_t$ within the τth quantile can be tested using the *t*-ratio statistic proposed by Koenker and Xiao (2004) as follows:

$$t_n(\tau) = \frac{f\left(\widehat{F^{-1}(\tau)}\right)}{\sqrt{\tau(1-\tau)}} (\pi'_{-1} M_Z \pi_{-1})^{1/2} (\hat{\rho}(\tau) - 1) \tag{4}$$

where π_{-1} is the vector of lagged inflation data and M_Z is the projection matrix onto the space orthogonal to $Z = (1, \Delta\pi_{t-1}, \dots, \Delta\pi_{t-q})$. The consistent estimator of $f(F^{-}(\tau))$ is $f\left(\widehat{F^{-1}(\tau)}\right)$, with f and F denoting the probability and cumulative density functions of ε_t in (2). To estimate $f\left(F^{-1}(\tau)\right)$, Koenker and Xiao (2004) proposed the following rule:

$$f\left(\widehat{F^{-1}(\tau)}\right) = \frac{(\tau_i - \tau_{i-1})}{x'(\hat{\rho}(\tau_i) - \hat{\rho}(\tau_{i-1}))} \tag{5}$$

with $\tau_i \in \Gamma$. As shown in the empirical analysis below, we select $\Gamma = \{0.1, 0.2, \dots, 0.9\}$. The use of $t_n(\tau)$ statistic allows us to test the unit root hypothesis in each quantile. To be specific, this allows us to examine both the dynamics of inflation and the possibility of different mean reverting behavior when the series is hit by various sizes and signs of shock at a range of quantiles. The ADF and other unit root tests that only concentrate on the conditional central tendency of the series behavior do not permit an elaboration of such behavior.

To obtain a more complete inference of the unit root behavior across quantiles, Koenker and Xiao (2004) proposed the quantile Kolmogorov-Smirnov (QKS) test as follows:

$$\text{QKS} = sup|t_n(\tau)|. \tag{6}$$

We construct the QKS statistics by taking the maximum $|t_n(\tau)|$ statistics at $\tau_i \epsilon \Gamma$. Note that the limiting distributions of $t_n(\tau)$ and QKS test statistics are non-standard. To this end, we employ the resampling procedures of Koenker and Xiao (2004) to derive critical values for the aforementioned test.[1] The QKS test provides a general perspective of the behavior of inflation rates and insights into global persistence. For example, if the shocks to inflation are short and long-lived in small and large quantiles, respectively, the QKS test means that the stationary behavior of inflation rates in the low quantiles facilitates the whole process to revert to inflation's steady-state level (Çiçek and Akar, 2013).

In this study, we advocate a three-way definition of IT in terms of perfect, imperfect (weak) and zero credibility based on the coefficient estimates for $\rho_0(\tau)$, $\rho_1(\tau)$ and $\beta(\tau)$. Table 1 summarizes this categorization. A *perfectly* credible IT country is defined where the non-stationarity of inflation is rejected across all quantiles, the $\rho_0(\tau)$ reflects the inflation target when $\beta(\tau) = 0$, as well as the values of $\rho_1(\tau)$ is close to -1 and therefore a fast speed of adjustment or short half-life. A *perfectly* credible IT country would be expected to have estimates for $\rho_0(\tau)$ that are closer to zero as compared to an non-IT country. For perfect credibility, one might also expect the QKS test to support stationarity.

The *imperfect* or *weak* credibility is defined where some of these characteristics are less distinct, for example, non-rejection of non-stationarity in some quantiles. However, in the weaker credibility case, one might expect a negative and significant $\beta(\tau)$ that suggests efforts to stabilize inflation are moving in the right direction. Moreover, one might expect the QKS test to reject non-stationarity for *imperfect* (*weak*) credibility case. The *zero* credibility

[1] We follow the testing procedure in Koenker and Xiao (2004) for calculating the *p*-values. See Koenker and Machado (1999), and Koenker and Xiao (2006) for details.

is defined where most the aforementioned features are absent, for example, non-rejection of non-stationarity across all quantiles and the QKS test will not reject non-stationarity.

INSERT TABLE 1 HERE

Finally, this section also outlines the approximation of the threshold level whereby inflation becomes stationary using the method by Lee *et al*. (2013). This approach separates periods of non-stationarity from stationary on the basis of the quantile regression estimation. In other words, we attempt to identify those periods whereby the stationarity of inflation prevails. First, the largest quantile τ_b at which the inflation displays stationary behaviour is identified based on the $t_n(\tau)$ test from the quantile unit root regression. Second, the inflation rate observation at *t*, $\Delta\pi_t$, is identified as generated by a unit-root process if $\Delta\pi_t > \widehat{Q}_{\Delta\pi_t}(\tau_b|\Gamma_{t-1})$. In contrast, the inflation rate is generated by a stationary process if $\Delta\pi_t \leq \widehat{Q}_{\Delta\pi_t}(\tau_b|\Gamma_{t-1})$. The threshold level $\widehat{Q}_{\Delta\pi_t}(\tau_b|\Gamma_{t-1})$ is then regarded as the maximum value of inflation rate with stationary behaviour. This threshold level can be calculated by substituting the quantiles estimates from (2) into (3), conditional on its past history and the chosen covariate, namely $\widehat{Q}_{\Delta\pi_t}(\tau_b|\Gamma_{t-1}) = x'_t\hat{\rho}(\tau_b)$ where $x_t = (1, \pi_{t-1}, t, \Delta\pi_{t-1}, \dots, \Delta\pi_{t-q})'$ and $\rho(\tau) = (\rho_0(\tau), \rho_1(\tau), \dots, \rho_{q+1}(\tau))'$.

2.2 The data

We apply the above quantile unit root test to 8 Asian countries consisting of the IT economies of South Korea, Thailand, the Philippines, Indonesia and non-IT countries that include China, Hong Kong, Malaysia and Singapore. Monthly consumer price index (CPI) data over the period 1987:M1–2013:M11 are used for each country. We calculate the inflation rate as the annual change in the log of monthly CPI data, which are obtained from IMF's *International Financial Statistics*.

Our dataset comprises the original members of the ASEAN-5 economies, namely: Indonesia, Malaysia, the Philippines, Thailand and Singapore. According to Dufrenot and

Keddad (2014), the initiative for multilateral negotiating forum for strengthening monetary integration is more likely in these five countries. We also consider South Korea because it was the first country to adopt IT in Asia. Along with Malaysia and Singapore, we further consider China and Hong Kong in order to compare the alternative monetary policy framework in these countries over an IT regime. Moreover, our sample countries belong to East Asian economic region, where cooperation and integration in trade, investment, finance and money areas are actually perceived as the best strategies for enhancing macroeconomic stability and promoting growth within the region (Dufrenot and Keddad, 2014).

Table 2 displays the first four sample moments of the inflation rates and the Jarque-Bera (JB) normality test statistic. Indonesia and Singapore respectively has the largest and smallest mean annual inflation rates of 9.383% and 1.953%. Indonesia has the largest standard deviation (8.996), while Malaysia has the smallest (1.482). The skewness and kurtosis statistics suggest that the inflation rates were not likely to be drawn from normal distributions in most cases. In general, the kurtosis statistic is much higher than the value of 3 associated with a normal distribution, meaning the inflation rates exhibit fat tails. Moreover, the JB test shows strong evidence of non-normality in the distribution of inflation rates since the associated *p*-values are statistically significant at the 1% level. Hence, the summary statistics in Table 2 lend credence to the application of the quantile unit test for capturing inflation dynamics in Asian countries.

INSERT TABLE 2 HERE

3. Empirical results

3.1 Univariate unit root tests

Before embarking on the analysis, we consider the results obtained from the standard univariate unit root or stationary tests such as ADF, Elliot *et al.*(1996, DF-GLS), Phillips and Perron (1988, PP), Ng and Perron (2001, NP), and Kwiatkowski (1992, KPSS) tests. The

ADF, DF-GLS, PP and NP tests are of a unit root null, while the KPSS test is of a stationary null. None of these tests allow for structural break, so we also consider the minimum LM unit root tests by Lee and Strazicich (LS, 2003) that incorporates structural breaks under the non-stationary null hypothesis. The results with and without a deterministic trend are reported in Table 3 for unit root tests that do not allow for structural breaks. For the ADF, DF-GLS and LS, we determine the optimal lag using the AIC. For the KPSS, NP and PP, we choose bandwidth by the Bartlett Kernel, as suggested by the Newey and West (1987) test.

INSERT TABLE 3 HERE

Table 3 shows that the ADF and DF-GLS reject the null of a unit root for all countries except Hong Kong. The PP rejects the null for six countries, namely Indonesia, Malaysia, the Philippines, Singapore, South Korea and Thailand. The NP tests reject the unit root for China and Indonesia at 1% significance level, while Malaysia rejected the unit root at 10% significance level with a time trend specification. For the KPSS tests, the null hypothesis of stationarity is not rejected for Indonesia, Malaysia, Singapore and Thailand for the case of trend specification. After allowing for two endogenously-determined breaks in both the level and trend, Table 4 shows that the LS test rejects the unit root null in all cases, suggesting that the inflation rates are trend stationary. Hence, we also include a deterministic trend variable in the quantile unit root regression model.

In terms of the data-driven breaks identified by the Lee-Strazicich unit root test, the first break occurs in 1991:M11 for the Philippines and 1991:M12 for South Korea. For Indonesia and Thailand, the first break happens respectively in 1997:M11 and 1999:M1. In the case of non-IT countries, the first breaks are identified in 1990:M8 (China), 1993:M12 (Hong Kong), 1992:M8 (Malaysia) and 1992:M6 (Singapore). On the other hand, the second breaks for IT countries are identified as follows: 2000:M6 (Indonesia), 2004:M8 (Philippines and Thailand) and 2000:M9 (South Korea). The second breaks occur in 1996:M4 for China, 1999:M4 for Hong Kong, 2005:M7 for Malaysia and 2007:03 for Singapore. Overall, the above mentioned break dates have coincided with major economic events that might be relevant for the inflation dynamics. For example, the first break for the Philippines occurs during a recession and fiscal constraint between 1990 and 1992, while that of South Korea coincides with monetary targeting regime. The first break for Indonesia coincides with the abandonment of crawling band in 1997, while it reflects a crucial transition year for Thailand before the adoption of IT in 2000. Meanwhile, the second break for the Philippines marked the period when the inflation target has been set to 4.0-6.0% in 2005. As for Thailand, the second break happened when the Bank of Thailand had raised policy rate three times in 2004. The second break for Malaysia concurs with the period when the country opted for bilateral exchange rate stability against the U.S. dollar, while it reflects the onset of the credit turmoil in mid-2007 for Singapore.

INSERT TABLE 4 HERE

4.2 Quantile unit root test results

The results from the quantile unit root tests are reported in Table 5. We conduct the tests for the case of a trend and no trend. However, we present only the results for trend specification case as the estimates for time trend variable *T* are significant in most of the cases. We select the optimal lag using AIC.

We analyze first the QKS test to provide an overall view of inflation rate behaviour over the range of quantiles. The QKS test rejects the unit root null hypothesis at the 5% significance level or better in all cases except for Hong Kong. In a global way, these results support inflation stationarity and therefore provide an indication that both an IT regime as well as alternative monetary policy frameworks on the part of non-IT countries has some degree of credibility. The global mean reversion results also imply that even if the shocks to inflation are respectively short and long-lived in small and large quantiles, the resulting increase in inflation is not anchored in inflationary expectations by workers and firms. This finding is highly relevant for central banks in judging whether the inflationary expectations have been anchored to inflation target, and help them to assess the proper actions for achieving the target.

INSERT TABLE 5 HERE

It can be seen from Table 5 that for all countries, the estimates for the intercept $\rho_0(\tau)$ increase as the quantiles become larger. The results also show varying sizes of shocks across countries. In particular, looking across the $\rho_0(\tau)$ estimates for each country, China exhibits the most dispersive shocks or monthly change in the inflation rate that range from -0.499 to 1.627, while Singapore displays the least dispersion of shocks ranging from -0.341 to 0.473. Overall, the dispersion of average shocks for IT countries (-0.249 to 1.602) is smaller than for non-IT countries (-0.499 to 1.627). This observation is important because it is consistent with Asian IT central banks' greater focus and efforts on inflation control under this regime.

Focusing on the prime coefficient of interest in Table 5, the estimates for the autoregressive coefficient $\rho_1(\tau)$ at the 10% to 50% quantiles are negative and significant in most cases thereby rejecting the unit-root null for most countries. Hong Kong is the only exception where the estimates for $\rho_1(\tau)$ are not significantly different from zero across all quantiles. Since Hong Kong has operated under a fixed exchange rate, the results suggest that both negative and positive shocks have permanent effects on the country's inflation rate. Based on the insignificance of $\rho_1(\tau)$, non-stationarity tends to prevail at the upper quantiles (60% and above) in the case of the IT countries. Similar findings emerge for China and Singapore where a unit root in the inflation process is dominant at the higher quantiles. This implies that the credibility of an IT regime in Asia and the monetary policy in China and Singapore can be described as being *imperfect*.

In contrast, the estimates for $\rho_1(\tau)$ for Malaysia are significantly below zero over the whole conditional distribution which leads us to reject the unit root hypothesis throughout. In other words, the behaviour of inflation in Malaysia exhibits mean reversion across all quantiles. This means that for non-IT economy Malaysia, the country would fit into the description of central bank having *perfect* monetary control and credibility. As noted by Capistrán and Ramos-Francia (2009), in countries characterized by monetary policies that are conducive to low and stable inflation but where the target is not public, the heterogeneity of inflation expectations will not be large because the expectations will be close to the target. This finding lends support to the view that Malaysia's monetary policy has considerable weight attached to inflation stability without relying on IT (Gerlach and Tillmann, 2012). For non-IT country with sensible monetary policy, Capistrán and Ramos-Francia (2009) explain that economic agents know that their best long-run inflation forecast is the target, but they do not know the actual number. Since in this case the optimal forecast is the simple average of past inflation, expectations may be close to the target even if the target is not public.

Figure 1 illustrates the above estimated results for $\rho_0(\tau)$ and $\rho_1(\tau)$ along with their 95% confidence intervals obtained from the bootstrapping procedure. In general, the estimated values of $\rho_0(\tau)$ for all countries tend to increase passing through the zero point at least at the 60% quantile or higher. Also, it can be seen that the estimates for $\rho_0(\tau)$ are generally higher for IT countries, which is not in support of the perfect IT credibility hypothesis. This can be attributed to the fact that an IT country could still experience large unforeseen exogenous inflation shocks that are beyond the (credible) central bank's control. These shocks might push up or down $\rho_0(\tau)$. In terms of the estimates for $\rho_1(\tau)$, we find that $\rho_1(\tau)$ increases with τ in the cases of China, Indonesia and the Philippines. Indeed, the values of $\rho_1(\tau)$ in these countries are more negative in the low quantiles. By contrast, Malaysia, Hong Kong, Singapore, South Korea and Thailand are characterized by $\rho_1(\tau)$ appearing to have no significant variation across the quantiles. Indeed, Hong Kong always exhibits a zero slope inside the confidence interval thereby lending visual support for Hong Kong inflation being non-stationary across all the quantiles.

INSERT FIGURE 1 HERE

Overall, our results indicate that the presence of negative shocks creates weaker inertia, making inflation revert to its long-run equilibrium level. It confirms the view that under an IT regime, central banks respond strongly to smaller inflation deviations from the target to ensure that inflation shocks are only temporary and by doing so the observed inflation would tend to follow a mean-reverting behavior around the target (Chiquiar *et al*., 2010). However, extreme positive shocks are not associated with mean-reversion in the cases of China, Hong Kong, Indonesia, the Philippines and Singapore. Such results are similar with the findings in Tsong and Lee (2011) who applied quantile unit root regression to OECD countries, and Henry and Shields (2004) who employed Caner and Hansen's (2001) threshold unit root method to Japan and UK inflation data. Time-series studies such as these address a vital issue about whether the inflation rates contain a unit root in one quantile or regime, while exhibit stationary behaviour in the other quantile or regime. As mentioned earlier, this issue is further enriched in this study by taking into account potential trend-reversion in inflation rate behaviour.

Table 5 also reports the HLs associated with the quantiles where inflation is stationary. The HLs in the lowest quantile (10%) are relatively small, ranging from 4.12 months in Indonesia to 9.39 months in China. In the highest quantile (90%), the stationary cases of Malaysia, South Korea and Thailand where HLs are characterised by values in the range of 6-7 months. It is noticeable that there is an asymmetry in the speed of inflation adjustment across different quantiles of its distribution for the sample countries except for Malaysia. The results of asymmetry suggest that the inflation rates respond differently to various signs and sizes of shocks. For example, at lower quantiles, the speed of inflation adjustment is faster when large negative shocks hit the inflation rates. In contrast, at higher quantiles, the inflation rates contain a unit root and are therefore highly persistent. This implies lack of IT credibility regarding large inflation shocks.

Table 5 also reports that the estimates for the time trend coefficients are negative and statistically significant for the Philippines across all quantiles. Likewise, the estimates for time trend coefficients are negative and statistically significant in varying degrees across the other IT countries across the quantiles. The estimates for the time trend in the case of Asian non-IT countries enter mostly with a negative sign except for Singapore, but these are statistically significant only at the smaller quantiles. Overall, the estimates of the coefficient range from -0.321 to -0.016 for Asian IT countries and from -0.295 to -0.001 for non-IT countries. This evidence is consistent with the Asian IT countries building up their monetary policy credibility more than the non-IT countries in terms of a faster rate of decline in inflation rate changes.

Figure 2 plots the trend coefficient across the quantiles. Considering the lower and upper boundaries, the evidence is mixed on whether the trend coefficient is significantly different across the quantiles. For IT countries, the figure shows that the trend coefficient is often below a zero slope that remains outside the 95% confidence intervals for the Philippines and South Korea. In contrast, the 95% confidence intervals often encompass a zero slope, except for some quantiles. In addition to this, the declining trend over the whole conditional distribution is more pronounced for the Philippines and South Korea particularly between the middle and higher quantiles. In the case of non-IT countries, there is evidence that the 95% confidence intervals often contain a zero slope notably from the middle to higher quantiles.

For Singapore and Hong Kong, the estimates for time trend exhibit an upward trend and enter with some positive signs.

INSERT FIGURE 2 HERE

Finally, this section offers an interpretation of the quantile regression results in terms of whether there is a threshold level whereby inflation becomes stationary. It has been shown in Table 5 that the inflation rates exhibit asymmetric adjustment in most of the countries. Based on these asymmetric results, it is shown that Indonesia displays strong stationary behaviour at the quantiles $\tau = 0.1, 0.2, 0.3, 0.4$. This suggests that the threshold level for the case of Indonesia is $\widehat{Q}_{\Delta\pi_t}(0.4|\Gamma_{t-1}) = x'_t\hat{\rho}(0.4)$. Using the method by Lee *et al*. (2013), the stationary observations of inflation rates in Indonesia are identified. Based also on the asymmetric results from Table 5, the threshold level is different for each country. Specifically, the chosen quantile for the Philippines is $\tau = 0.6$, $\tau = 0.5$ for China and Thailand, $\tau = 0.4$ for South Korea and $\tau = 0.7$ for Singapore. Note that the inflation rates in Malaysia are stationary across all quantiles based on the results displayed in Table 5, and therefore there is no need to determine the threshold level

Figure 3 plots the actual data on the changes in inflation rate and the corresponding stationary observations. The figure demonstrates that the stationary observations of inflation (the unshaded areas) seem to frequently occur when inflation is falling from above or slowing down, while those non-stationary observations (shaded areas) often occur during the periods when inflation is rising from below or increasing. Figure 3 also vividly illustrates that that the large positive spikes appear to generally occur in the non-shaded areas, mostly in1997-1998 and 2008. For example, inflation in Indonesia increased sharply in February 1998 on account of a sharp currency depreciation that started from late 1997 (Ito and Hayashi, 2004). Likewise, there was an abrupt increase in inflation in June 2008 in the cases of Indonesia, Malaysia, Philippines, and Thailand and this can be attributed to a food price crisis in 2008

(Dawe and Slayton, 2010). This is consistent with the above quantile results insofar as $\rho_1(\tau)$ is negative and significant at lower quantiles. Since the QKS test is supportive of global stationarity, the overall result in Figure 3 indicates that the mean-reverting properties in the low quantiles enable the whole process to return back to a shaded or stationary area. From a policy perspective, this result might imply that central banks in most countries avoid a high level of inflation and may conduct tightened monetary policy to curb inflation when the level is relatively high.

INSERT FIGURE 3 HERE

The above results are in line with Tsong and Lee (2011), Çiçek and Akar (2013) and Wolters and Tillmann (2015). However, these studies only focus on the mean-reversion in inflation rates mostly for OECD countries while the present study further enrich this issue by capturing trend-reversion in the series for a sample of Asian countries. This then enables us to confirm that IT countries are building up their monetary policy credibility more than non-IT countries based on a faster rate of decline in inflation rate changes. In addition, the specific sample of Asian countries lends itself more readily to an examination of pronounced turbulence due to financial crisis and shifts in monetary policy.

4.3 Quantile regression results without global financial crisis shock

Finally, given the evidence of globally stationary inflation, monotonic increases in the size of inflation shocks, asymmetric inflation adjustment, and trend-reversion in inflation rates, we now consider whether these results have differed before the 2008-2009 global financial crisis. Since economies around the world have become more wary of deflation and a number of central banks have hit the zero lower bound, this may have impacted on the analysis. That is, if deflation has a greater concern, then this has an impact on what happens at the lowest quantile. Consequently, it is difficult to analyse a post-global financial crisis period on account of a limited sub-sample size. For this reason, this study used instead subsample periods of monthly inflation rate data from 1987:M1–2007:M12.

Table 6 presents new estimation results of the quantile unit root test. In comparison with the results in Table 5, the counterparts in Table 6 show the following observations. First, the QKS still indicates that the inflation rates are globally mean-reverting for majority of the countries. The only exceptions are Thailand and Hong Kong. For Thailand, the QKS test fails to reject the unit root null. This result contradicts the earlier finding of globally stationary inflation for Thailand, which can be attributed to the change in monetary policy behavior of the Bank of Thailand during the global financial crisis of 2008-2009. In the case of Hong Kong, the QKS test rejects the unit root null at the 10% significance level. As shown in Table 6, the estimated value of $\rho_1(\tau)$ at 90% quantile is far below zero for Hong Kong. Hence, the stationary behaviour of inflation rate in this extreme quantile enables the whole process to revert back to its long-run equilibrium level even though it contains a unit root in the remaining quantiles.

INSERT TABLE 6 HERE

Second, Table 6 shows that the values of $\rho_0(\tau)$ for Indonesia and Thailand were slightly less than the preceding results displayed in Table 5. The estimates for $\rho_0(\tau)$ in the case of the Philippines and South Korea were marginally higher than the earlier results. Similar findings can also be observed for Singapore. For other Asian non-IT countries, the estimates for $\rho_0(\tau)$ do not vary substantially from the previous results. Overall, the results indicate that the values of $\rho_0(\tau)$ remain to increase as the quantiles get large.

Third, except for Singapore, the persistence of inflation is still asymmetric depending on the sizes and signs of the shocks. The estimated values of $\rho_1(\tau)$ for Singapore are not significantly different from zero across all quantiles, suggesting that inflation rates follow a unit root process in the subsample period. It is also noticeable that the values of $\rho_1(\tau)$ for Malaysia are far below zero and statistically significant mostly at the 5% level or better but at the 10% up to the 60% quantiles only. Furthermore, the inflation rates in South Korea contain a unit root in the extreme low quantiles (10% and 20% quantiles) but stationary all throughout from the 30% up to the 90% quantiles. This implies that a greater concern on inflation following the global financial crisis has impacted on the inflation adjustment in the lowest quantile. Overall, the results based on sub-period indicate that the rejection of non-stationarity across quantiles depends on whether or not the deterministic trend is included.

4. Conclusions

We examine the dynamic behavior of the inflation rates in eight Asian countries using the quantile unit root test from 1987-2013. This method allows for the possibility that shocks of different signs and sizes have a different impact on inflation, and accounts for possible asymmetric adjustment of the inflation towards to its long-run equilibrium. We provide new evidence of globally stationary inflation rates for IT and non-IT countries in Asia.

We also find that there is an asymmetric speed of adjustment in the inflation adjustment process, in which large negative shocks tend to induce strong mean reversion in the lower quantiles, while inflation follows unit root behaviour in the higher quantiles. These findings corroborate with what has been found in previous studies. However, we depart substantially by capturing both the mean and trend reversion in the inflation rates. This has enabled us to offer new insight on the effect of IT effect on the behaviour of inflation by verifying if an IT country having inflation under control might be characterized by a negative trend coefficient at different quantiles of inflation. Our findings also shed new light on whether stationarity is linked to smaller or larger changes in inflation by working with first differenced inflation data, which have clear implications for understanding the behavior of the level of inflation (i.e. stationary or non-stationary).

Our results indicate that the negative estimates for the deterministic time trend are mostly significant for Asian IT countries and noticeably lower than non-IT countries. This indicates that IT central banks have been building up their monetary policy credibility more than the non-IT countries from a faster rate of decline in inflation rate changes. This new insight is of significant value to academic and policymaker circles alike. With inflation being trend stationary, researchers would then have a more conclusive analysis of monetary theory's assumption of mean-reverting inflation after controlling for structural breaks. In addition, policymakers have the opportunity to forecast future movements in inflation based on past behaviour and demonstrate the credibility of IT policy in controlling inflation in the presence of large positive shocks.

Finally, the results for determining the threshold levels where inflation becomes stationary suggest that stationarity seems to frequently occur when inflation is falling from above or slowing down, while the non-stationary observations often occur during the periods when inflation is rising from below or increasing. Such results are similar with Henry and Shields (2004) who employed Caner and Hansen's (2001) threshold unit root method to Japan and UK inflation data. Time-series study such as this addresses an important vital issue about whether the inflation rates contain a unit root in one regime, while exhibit stationary behaviour in another regime. This issue is further enriched in this study by taking into account the trend-reversion in inflation rates.

Overall, our results suggest that the credibility of Asian IT regime and even the alternative monetary policy frameworks in some non-IT countries can be better described as being *imperfect* or *weak* because the changes in inflation rate are only stable when the level of inflation is low. These results may have important monetary policy implications. Large negative shocks to inflation in the lower quantiles may have less effect than large positive shocks in the upper quantiles. The evidence in this study suggests lack of IT credibility regarding large inflation shocks. Hence, it seems preferable for central banks to respond strongly when the inflation is hit by large positive shocks in order to prevent inflation expectations by the public to become higher, and therefore the inflation exhibits mean-reverting behaviour. However, central banks should be careful on the possibility of deflation to occur in the short run when negative shocks hit the inflation. Japan, for example, has established long track records of tight inflation control (Gerlach and Tillmann, 2012), but faced risk from deflation. With the dangers from deflationary pressures such as depressed revenues and higher real debt burden (Gregouriou and Kontonikas, 2009), central banks should also treat seriously the negative inflation shocks albeit their effects are only transitory.

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Table 1. Three-way definition of IT credibility

IT credibility	Definition
Perfect	$\rho_1(\tau) = 0$ rejected across all τ $\rho_0(\tau)$ reflects inflation target when $\beta(\tau) = 0$ $\rho_1(\tau)$ close to -1 QKS test rejects non-stationarity
Imperfect (weak)	$\rho_1(\tau) = 0$ rejected in some τ $\beta(\tau) < 0$ and significant QKS test rejects non-stationarity
Zero	$\rho_1(\tau) = 0$ rejected in some τ QKS test does not reject non-stationarity

Table 2. Summary statistics for inflation rates

Country	Mean	S.D.	Skewness	Kurtosis	JB stat. (*p*-value)
Indonesia	9.383	8.996	3.940	19.746	4609.760*** (000)
Philippines	6.209	3.676	0.860	4.302	62.652*** (000)
South Korea	4.172	2.138	0.676	3.036	24.600*** (000)
Thailand	3.555	2.223	-0.089	3.818	9.424*** (000)
China	5.752	7.246	1.608	4.862	185.823*** (000)
Hong Kong	3.788	4.520	-0.256	1.997	17.058*** (000)
Malaysia	2.653	1.482	0.348	5.047	62.928*** (000)
Singapore	1.953	1.736	0.655	3.360	24.862*** (000)

Notes: JB stat. denotes the Jarque–Bera normality test, which is χ^2 (2) distributed asymptotically. *** denotes significance at the 1% level.

Table 3. Results for univariate unit root tests on inflation rates

	ADF		DF-GLS		PP		NP		KPSS	
Country	No trend	With trend	No trend	With trend	No trend	With trend	No trend	With trend	No trend	With trend
Indonesia	-5.903***	-5.938***	-5.834***	-3.787***	-3.625***	-3.652**	-3.581***	-10.217***	0.158	0.223***
Philippines	-3.600***	-4.998***	-1.733*	-1.190***	-3.101**	-4.187***	-1.533	-1.056	0.988***	1.594
South Korea	-2.673*	-2.673***	-1.668*	-1.528***	-2.801*	-4.333***	-1.712*	-1.083	1.240	2.008
Thailand	-4.463***	-4.912***	-3.717***	-1.844*	-3.626***	-3.936**	-3.109***	-1.822	0.483*	0.698**
China	-3.443**	-4.051***	-3.445***	-3.002***	-2.482	-2.933	-2.477**	-3.677***	0.704**	1.252
Hong Kong	-1.570	-1.669	-1.509	-1.185	-1.471	-1.637	-1.430	-1.235	0.930***	1.794
Malaysia	-5.228***	-5.438***	-3.054***	-1.600***	-3.155**	-3.264*	-1.964*	-1.627*	0.261	0.361*
Singapore	-4.216***	-4.337***	-2.278**	-0.794***	-3.56***	-3.564**	-1.876*	-0.875	0.316	0.487**

Notes: Optimal lag for ADF, DF-GLS and LS is determined using the AIC criteria. We choose the bandwidth using the Bartlett Kernel, as suggested by Newey and West (1987) for KPSS, NP and PP. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 4. Lee-Strazicich unit root test results

Country	TB1	TB2	*t*-min	k
Indonesia	1997:11	2000:06	-6.879***	12
Philippines	1991:11	2004:08	-6.258***	7
South Korea	1991:12	2000:09	-5.357***	6
Thailand	1999:01	2004:08	-6.690***	5
China	1990:08	1996:04	-3.798**	12
Hong Kong	1993:12	1999:04	-4.723***	6
Malaysia	1992:08	2005:07	-6.927***	7
Singapore	1992:06	2007:03	-5.051***	12

Notes: ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively. TB1 and TB2 denote the first and second break dates respectively, and *k* is the lag length. The 1, 5 and 10% critical values for the minimum LM test with two breaks are -4.545, -3.842 and -3.504, respectively.

Table 5. Quantile ADF unit root results for Asian countries, January 1987-November 2013

Country	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Indonesia	$\rho_0(\tau)$	0.338	0.010	0.238	0.344*	0.263	0.461**	0.697***	0.840***	1.104***
	p-value	0.203	0.961	0.205	0.057	0.141	0.010	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.155***	-0.077***	-0.067***	-0.055***	-0.024	-0.027*	-0.025*	-0.009	0.003
	p-value	0.000	0.000	0.000	0.002	0.141	0.067	0.063	0.525	0.876
	$\beta(\tau)$	$-0.2x10^{-3}$	$0.2x10^{-3}$	$-0.2x10^{-3}$**	$-0.4x10^{-3}$**	$-0.4x10^{-3}$	$-0.5x10^{-3}$	$-1.0x10^{-3}$	$-1.0x10^{-3}$	$-1.1x10^{-3}$
	p-value	0.135	0.270	0.033	0.016	0.141	0.617	0.414	0.452	0.396
	Half-lives	4.121	8.642	9.999	12.340	∞	25.724	27.866	∞	∞
	QKS/*p*-value	11.732(0.000)***								
Philippines	$\rho_0(\tau)$	0.272	0.297*	0.290*	0.567***	0.643***	0.756***	0.723***	0.879***	1.433***
	p-value	0.196	0.093	0.077	0.000	0.000	0.000	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.110***	-0.082***	-0.063***	-0.062***	-0.057***	-0.057***	-0.032	-0.032	-0.037
	p-value	0.000	0.000	0.002	0.001	0.000	0.002	0.149	0.190	0.142
	$\beta(\tau)$	$-1.3x10^{-3}$***	$-1.1x10^{-3}$***	$-1.0x10^{-3}$***	$-1.7x10^{-3}$***	$-1.7x10^{-3}$**	$-1.6x10^{-3}$**	$-1.5x10^{-3}$*	$-1.6x10^{-3}$*	$-3.0x10^{-3}$**
	p-value	0.004	0.001	0.001	0.001	0.000	0.040	0.076	0.074	0.001
	Half-lives	5.945	8.084	10.616	10.741	11.823	11.883	∞	∞	∞
	QKS/*p*-value	6.100(0.001) ***								
South Korea	$\rho_0(\tau)$	-0.210	-0.208	0.142	0.365***	0.491***	0.679***	0.814***	0.791***	1.602***
	p-value	0.303	0.222	0.334	0.007	0.000	0.000	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.080**	-0.053*	-0.065**	-0.073***	-0.072**	-0.071***	-0.075***	-0.047	-0.102***
	p-value	0.043	0.087	0.021	0.009	0.000	0.007	0.004	0.144	0.009
	$\beta(\tau)$	$-0.2x10^{-3}$**	$0.3x10^{-3}$	$-0.6x10^{-3}$***	$-1.1x10^{-3}$***	$-1.3x10^{-3}$**	$-1.7x10^{-3}$***	$-1.6x10^{-3}$***	$-1.3x10^{-3}$*	$-3.2x10^{-3}$***
	p-value	0.044	0.279	0.002	0.000	0.000	0.004	0.009	0.055	0.000
	Half-lives	8.300	12.720	10.298	9.204	9.285	9.477	8.900	∞	6.461
	QKS/*p*-value	4.001(0.027)**								
Thailand	$\rho_0(\tau)$	-0.249	-0.083	-0.040	0.217*	0.205*	0.309***	0.546***	0.706***	1.256***
	p-value	0.168	0.543	0.747	0.063	0.077	0.008	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.117**	-0.065**	-0.055*	-0.058**	-0.041*	-0.034	-0.046*	-0.036	-0.107***
	p-value	0.012	0.040	0.053	0.026	0.077	0.175	0.078	0.181	0.003
	$\beta(\tau)$	$-0.4x10^{-3}$**	$-0.5x10^{-3}$**	$-0.2x10^{-3}$*	$-0.7 x10^{-3}$**	$-0.4x10^{-3}$	$-0.5x10^{-3}$	$-0.9x10^{-3}$	$-1.1x10^{-3}$*	$-0.7x10^{-3}$
	p-value	0.045	0.018	0.068	0.020	0.077	0.249	0.119	0.084	0.368
	Half-lives	5.549	10.280	12.220	11.638	16.537	∞	14.837	∞	6.115
	QKS/*p*-value	4.072(0.022)**								

Notes: All the *p*-values are calculated with the bootstrap method with 5000 replications. For $\hat{\rho}_0(\tau)$ the null of zero is tested with the student-*t* test, while for $\hat{\rho}_1(\tau)$, the unit-root null is tested with the $t_n(\tau)$ statistic. ***, ** and * denote significance at the 1, 5 and 10% levels.

Table 5. (Continued)

Country	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
China	$\rho_0(\tau)$	-0.499**	-0.239	0.027	0.143	0.275**	0.474***	0.716***	0.836***	1.627***
	p-value	0.031	0.185	0.862	0.313	0.048	0.001	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.071***	-0.052***	-0.048***	-0.036***	-0.028**	-0.023	-0.019	-0.003	-0.024
	p-value	0.000	0.000	0.000	0.005	0.048	0.160	0.297	0.775	0.156
	$\beta(\tau)$	-0.8x10^{-3}**	-0.8x10^{-3}**	-0.8x10^{-3}**	-0.6x10^{-3}*	-0.7x10^{-3}	-1.0x10^{-3}	-1.2x10^{-3}	-1.1x10^{-3}	-2.9x10^{-3}**
	p-value	0.048	0.013	0.013	0.053	0.048	0.590	0.406	0.330	0.024
	Half-lives	9.394	13.079	14.190	19.039	24.023	∞	∞	∞	∞
	QKS/*p*-value	5.343(0.005)***								
Hong Kong	$\rho_0(\tau)$	-0.246	-0.288*	-0.144	-0.004	-0.020	0.167	0.382***	0.525***	0.865***
	p-value	0.216	0.055	0.292	0.976	0.874	0.190	0.004	0.001	0.000
	$\rho_1(\tau)$	-0.035	-0.006	-0.009	-0.018	-0.004	-0.015	-0.020	-0.022	-0.036
	p-value	0.102	0.654	0.561	0.304	0.874	0.427	0.303	0.350	0.161
	$\beta(\tau)$	-3.0 x10^{-3}***	-1.0x10^{-3}***	-0.9x10^{-3}***	-0.5x10^{-3}**	0.1x10^{-3}	-0.0x10^{-3}	-0.2x10^{-3}	0.3x10^{-3}	0.4x10^{-3}
	p-value	0.000	0.004	0.005	0.031	0.874	0.797	0.770	0.956	0.935
	Half-lives	∞	∞	∞	∞	∞	∞	∞	∞	∞
	QKS/*p*-value	2.172(0.641)								
Malaysia	$\rho_0(\tau)$	-0.076	0.143	0.198**	0.147	0.273***	0.383***	0.537***	0.645***	0.770***
	p-value	0.517	0.150	0.033	0.103	0.002	0.000	0.000	0.000	0.000
	$\rho_1(\tau)$	-0.118***	-0.135***	-0.116***	-0.076***	-0.085***	-0.088***	-0.086***	-0.090***	-0.088**
	p-value	0.005	0.000	0.000	0.005	0.002	0.003	0.003	0.008	0.037
	$\beta(\tau)$	-0.1x10^{-3}*	-0.1x10^{-3}**	-0.3x10^{-3}**	-0.1x10^{-3}	-0.3x10^{-3}	-0.5x10^{-3}	-0.8x10^{-3}*	-0.7x10^{-3}	-0.7x10^{-3}
	p-value	0.057	0.025	0.012	0.145	0.002	0.197	0.058	0.209	0.256
	Half-lives	5.537	4.784	5.615	8.751	7.764	7.554	7.665	7.357	7.534
	QKS/*p*-value	5.576(0.000)***								
Singapore	$\rho_0(\tau)$	-0.341***	-0.083	-0.012	-0.025	0.058	0.136**	0.184***	0.271***	0.473***
	p-value	0.000	0.268	0.848	0.679	0.329	0.024	0.005	0.000	0.000
	$\rho_1(\tau)$	-0.100***	-0.101***	-0.074***	-0.053*	-0.053**	-0.065**	-0.055*	-0.037	-0.052
	p-value	0.001	0.000	0.005	0.053	0.329	0.013	0.075	0.366	0.236
	$\beta(\tau)$	0.0x10^{-3}	-0.3x10^{-3}**	-0.2x10^{-3}**	0.3x10^{-3}	0.3x10^{-3}	0.4x10^{-3}	0.7x10^{-3}	8.0x10^{-3}	0.9x10^{-3}
	p-value	0.237	0.017	0.022	0.388	0.329	0.968	0.999	1.000	0.998
	Half-lives	6.576	6.535	8.988	12.842	12.665	10.272	12.262	∞	∞
	QKS/*p*-value	4.743(0.011)**								

Notes: All the *p*-values are calculated with the bootstrap method with 5000 replications. For $\hat{\rho}_0(\tau)$ the null of zero is tested with the student-*t* test, while for $\hat{\rho}_1(\tau)$, the unit-root null is tested with the $t_n(\tau)$ statistic. ***, ** and * denote significance at the 1, 5 and 10% levels.

Table 6. Robustness check for quantile ADF unit root results for Asian countries, January 1987-December 2007

Country	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Indonesia	$\hat{\rho}_0(\tau)$	0.386	-0.060	0.181	0.156	0.170	0.381*	0.631***	0.808***	0.928***
	p-value	0.219	0.802	0.410	0.460	0.417	0.070	0.004	0.001	0.001
	$\hat{\rho}_1(\tau)$	-0.157***	-0.074***	-0.069***	-0.047***	-0.027	-0.029*	-0.022	-0.019	-0.013
	p-value	0.000	0.001	0.002	0.005	0.417	0.096	0.155	0.332	0.483
	$\hat{\beta}(\tau)$	-0.2×10^{-3}	0.4×10^{-3}	0.5×10^{-3}	0.8×10^{-3}	0.6×10^{-3}	0.2×10^{-3}	-6.0×10^{-3}	5.0×10^{-3}	1.9×10^{-3}
	p-value	0.153	0.244	0.302	0.402	0.417	0.841	0.707	0.968	0.981
	Half-lives	4.049	8.993	9.729	14.310	∞	23.214	∞	∞	∞
	QKS/*p*-value	10.334(0.000) ***								
Philippines	$\hat{\rho}_0(\tau)$	0.359	0.130	0.398**	0.694***	0.695***	0.902***	0.947***	1.049***	1.904***
	p-value	0.177	0.550	0.045	0.000	0.000	0.000	0.000	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.123***	-0.071***	-0.071***	-0.073***	-0.054**	-0.055***	-0.045**	-0.029	-0.063**
	p-value	0.000	0.003	0.001	0.000	0.000	0.005	0.043	0.220	0.033
	$\hat{\beta}(\tau)$	-1.6×10^{-3}**	-0.4×10^{-3}**	-1.4×10^{-3}***	-2.4×10^{-3}***	-2.3×10^{-3}**	-2.9×10^{-3}***	-2.6×10^{-3}**	-3.2×10^{-3}***	-5.7×10^{-3}***
	p-value	0.012	0.046	0.002	0.004	0.000	0.008	0.024	0.005	0.000
	Half-lives	5.270	9.377	9.419	9.087	12.489	12.233	14.999	∞	10.583
	QKS/*p*-value	5.776(0.001) ***								
South Korea	$\hat{\rho}_0(\tau)$	-0.251	-0.120	0.321*	0.449***	0.699***	0.713***	0.827***	1.159***	1.975***
	p-value	0.321	0.568	0.075	0.008	0.000	0.000	0.000	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.076	-0.056	-0.082**	-0.084**	-0.097***	-0.071**	-0.073**	-0.090***	-0.136***
	p-value	0.108	0.163	0.018	0.012	0.000	0.018	0.018	0.007	0.006
	$\hat{\beta}(\tau)$	-0.1×10^{-3}*	-0.2×10^{-3}*	-1.2×10^{-3}***	-1.5×10^{-3}***	-2.1×10^{-3}**	-1.9×10^{-3}**	-1.9×10^{-3}**	-2.9×10^{-3}***	-5.2×10^{-3}***
	p-value	0.070	0.052	0.000	0.003	0.000	0.039	0.044	0.006	0.000
	Half-lives	∞	∞	8.085	7.938	6.821	9.463	9.147	7.375	4.747
	QKS/*p*-value	4.594(0.006) ***								
Thailand	$\hat{\rho}_0(\tau)$	-0.378**	-0.067	0.004	0.191	0.290**	0.366***	0.497***	0.686***	0.873***
	p-value	0.042	0.639	0.973	0.108	0.013	0.002	0.000	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.088**	-0.062**	-0.050*	-0.054**	-0.050*	-0.029	-0.034	-0.021	-0.030
	p-value	0.018	0.028	0.065	0.034	0.013	0.296	0.182	0.369	0.286
	$\hat{\beta}(\tau)$	0.6×10^{-3}	-0.5×10^{-3}**	-0.5×10^{-3}**	-0.8×10^{-3}**	-0.8×10^{-3}	-1.0×10^{-3}	-1.0×10^{-3}	-1.3×10^{-3}*	-1.2×10^{-3}
	p-value	0.442	0.020	0.019	0.024	0.013	0.166	0.146	0.067	0.143
	Half-lives	7.541	10.742	13.386	12.502	13.430	∞	∞	∞	∞
	QKS/*p*-value	3.052(0.129)								

Notes: All the *p*-values are calculated with the bootstrap method with 5000 replications. For $\hat{\rho}_0(\tau)$ the null of zero is tested with the student-*t* test, while for $\hat{\rho}_1(\tau)$, the unit-root null is tested with the $t_n(\tau)$ statistic. ***, ** and * denote significance at the 1, 5 and 10% levels.

Table 6. (Continued)

	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
China	$\hat{\rho}_0(\tau)$	-0.547**	-0.188	-0.015	0.128	0.211	0.414**	0.465***	0.970***	1.642***
	p-value	0.038	0.361	0.932	0.441	0.194	0.013	0.009	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.052***	-0.045***	-0.036**	-0.026	-0.021	-0.011	-0.008	0.003	-0.019
	p-value	0.003	0.004	0.017	0.100	0.194	0.634	0.797	0.947	0.283
	$\hat{\beta}(\tau)$	-1.4x10^{-3}**	-1.4x10^{-3}***	-1.2x10^{-3}***	-1.1x10^{-3}*	-0.7x10^{-3}	-1.0x10^{-3}	-0.4x10^{-3}	-2.0x10^{-3}	-4.1x10^{-3}**
	p-value	0.028	0.005	0.007	0.060	0.194	0.662	0.884	0.411	0.041
	Half-lives	12.865	15.096	19.118	26.788	∞	∞	∞	∞	∞
	QKS/*p*-value	4.277(0.084)*								
Hong Kong	$\hat{\rho}_0(\tau)$	-1.125***	-0.425**	-0.179	-0.027	-0.016	0.188	0.560***	0.803***	1.310***
	p-value	0.000	0.022	0.275	0.863	0.916	0.223	0.001	0.000	0.000
	$\hat{\rho}_1(\tau)$	0.038	0.003	-0.009	-0.015	-0.006	-0.014	-0.029	-0.034	-0.065***
	p-value	1.000	0.956	0.699	0.444	0.916	0.565	0.214	0.110	0.002
	$\hat{\beta}(\tau)$	1.9x10^{-3}	0.1x10^{-3}	-0.3x10^{-3}**	-0.4x10^{-3}*	0.1x10^{-3}	-0.4x10^{-3}	-1.4x10^{-3}	-2.0x10^{-3}	-3.0x10^{-3}*
	p-value	0.822	0.169	0.037	0.059	0.916	0.729	0.424	0.210	0.052
	Half-lives	∞	∞	∞	∞	∞	∞	∞	∞	10.345
	QKS/*p*-value	3.524(0.053) *								
Malaysia	$\hat{\rho}_0(\tau)$	-0.153	0.051	0.053	0.179**	0.229***	0.332***	0.426***	0.490***	0.662***
	p-value	0.258	0.621	0.573	0.046	0.009	0.000	0.000	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.086*	-0.099***	-0.068**	-0.077***	-0.067**	-0.074**	-0.054	-0.041	-0.046
	p-value	0.067	0.001	0.023	0.008	0.009	0.019	0.200	0.381	0.433
	$\hat{\beta}(\tau)$	-0.3x10^{-3}**	0.0x10^{-3}	0.0x10^{-3}	-0.3x10^{-3}**	-0.5x10^{-3}*	-0.6x10^{-3}	-1.0x10^{-3}	-0.9x10^{-3}	-0.6x10^{-3}
	p-value	0.043	0.157	0.134	0.030	0.009	0.221	0.118	0.249	0.510
	Half-lives	7.706	6.634	9.834	8.683	10.066	8.998	∞	∞	∞
	QKS/*p*-value	3.872(0.055) *								
Singapore	$\hat{\rho}_0(\tau)$	-0.334**	-0.008	0.032	0.073	0.128	0.184**	0.249***	0.463***	0.727***
	p-value	0.021	0.940	0.734	0.404	0.134	0.035	0.008	0.000	0.000
	$\hat{\rho}_1(\tau)$	-0.082	-0.092	-0.085	-0.068	-0.059	-0.063	-0.062	-0.076	-0.076
	p-value	0.309	0.107	0.100	0.233	0.134	0.284	0.302	0.205	0.345
	$\hat{\beta}(\tau)$	-0.4x10^{-3}**	-1.0x10^{-3}***	-0.6x10^{-3}***	-0.4x10^{-3}**	-0.4x10^{-3}	-0.0x10^{-3}	0.3x10^{-3}	-0.3x10^{-3}	-0.9x10^{-3}
	p-value	0.010	0.001	0.002	0.015	0.134	0.886	0.991	0.793	0.545
	Half-lives	∞	∞	∞	∞	∞	∞	∞	∞	∞
	QKS/*p*-value	2.959(0.444)								

Notes: All the *p*-values are calculated with the bootstrap method with 5000 replications. For $\hat{\rho}_0(\tau)$ the null of zero is tested with the student-*t* test, while for $\hat{\rho}_1(\tau)$, the unit-root null is tested with the $t_n(\tau)$ statistic. ***, ** and * denote significance at the 1, 5 and 10% levels.

Figure 1. Quantile intercepts (rho 0), autoregressive coefficients (rho 1).
Notes: The dashed lines signify the 95% confidence levels.

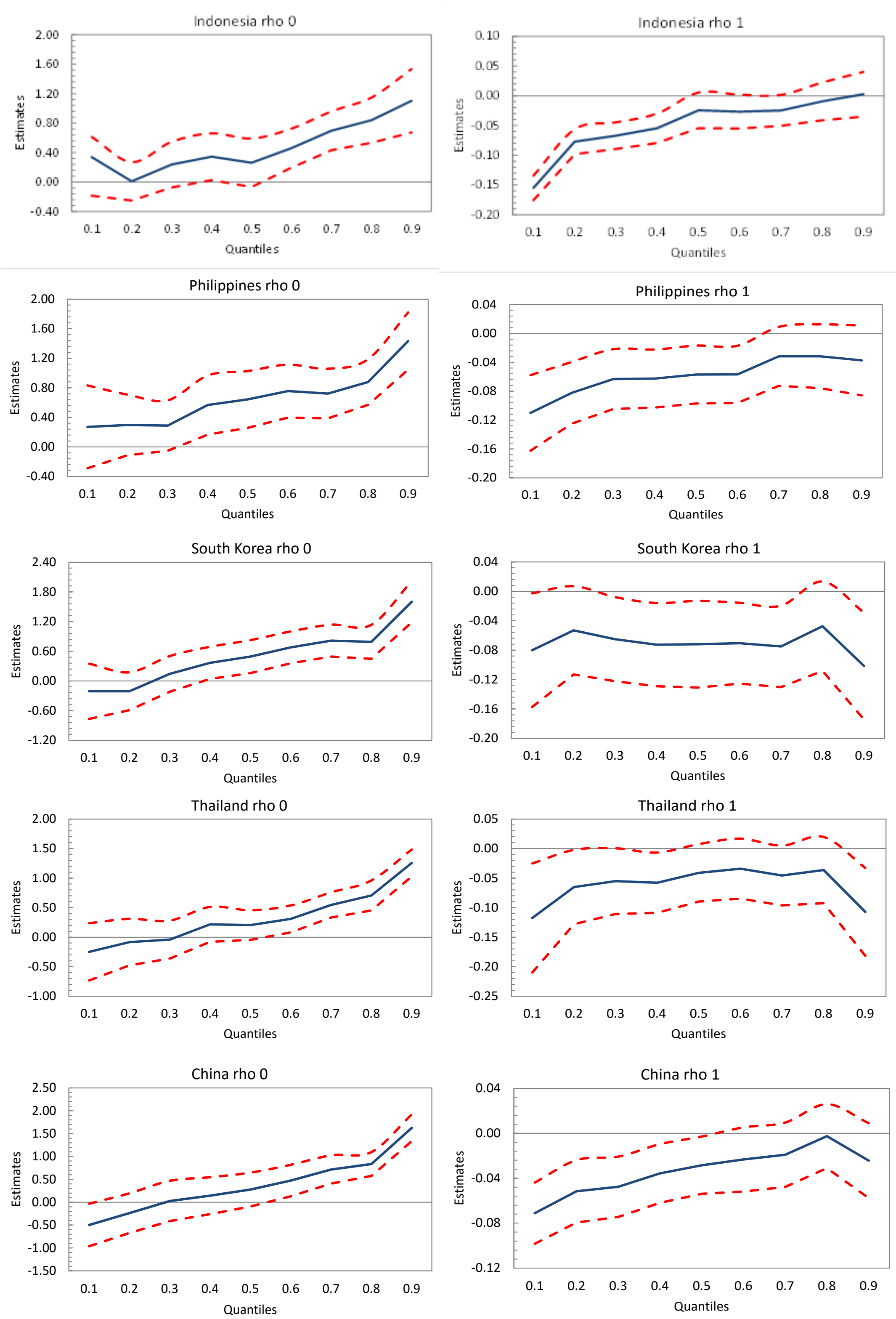


Figure 1. (Continued)

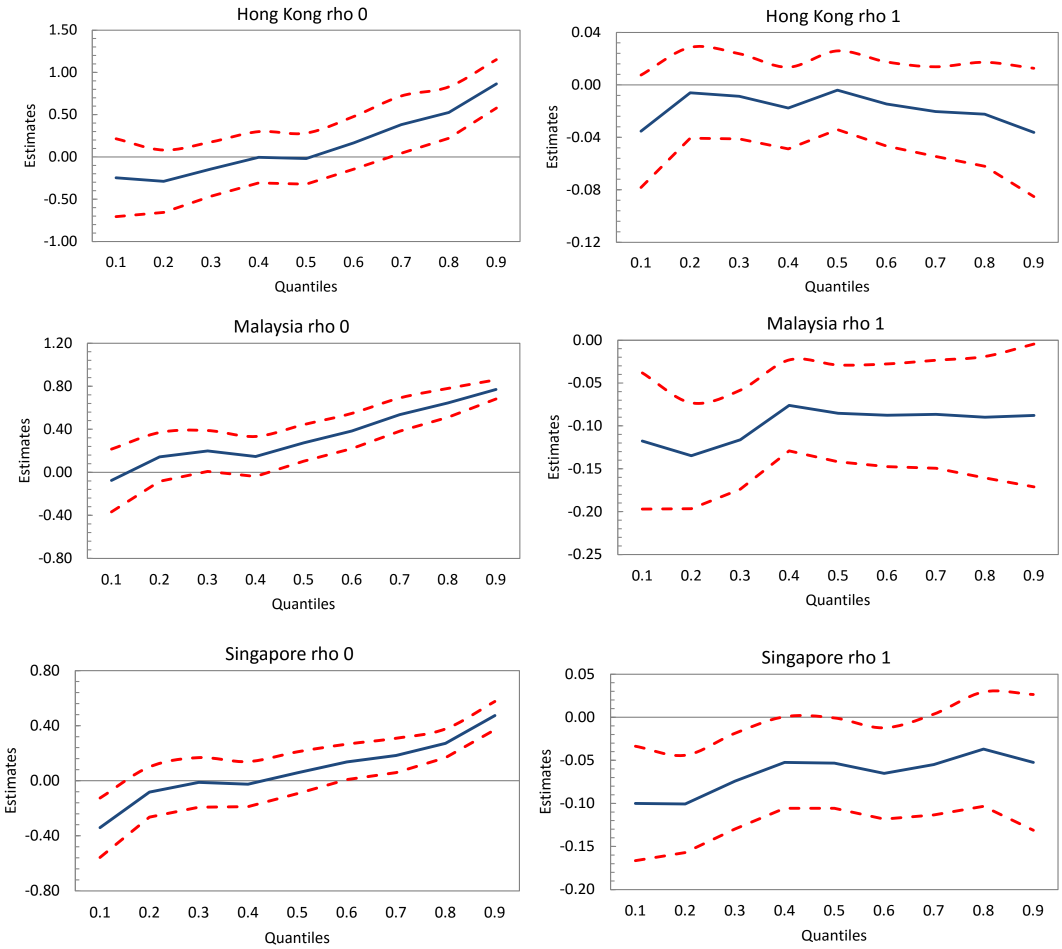


Figure 2. Quantile trend coefficients (beta).
Notes: The dashed lines signify the 95% confidence levels.

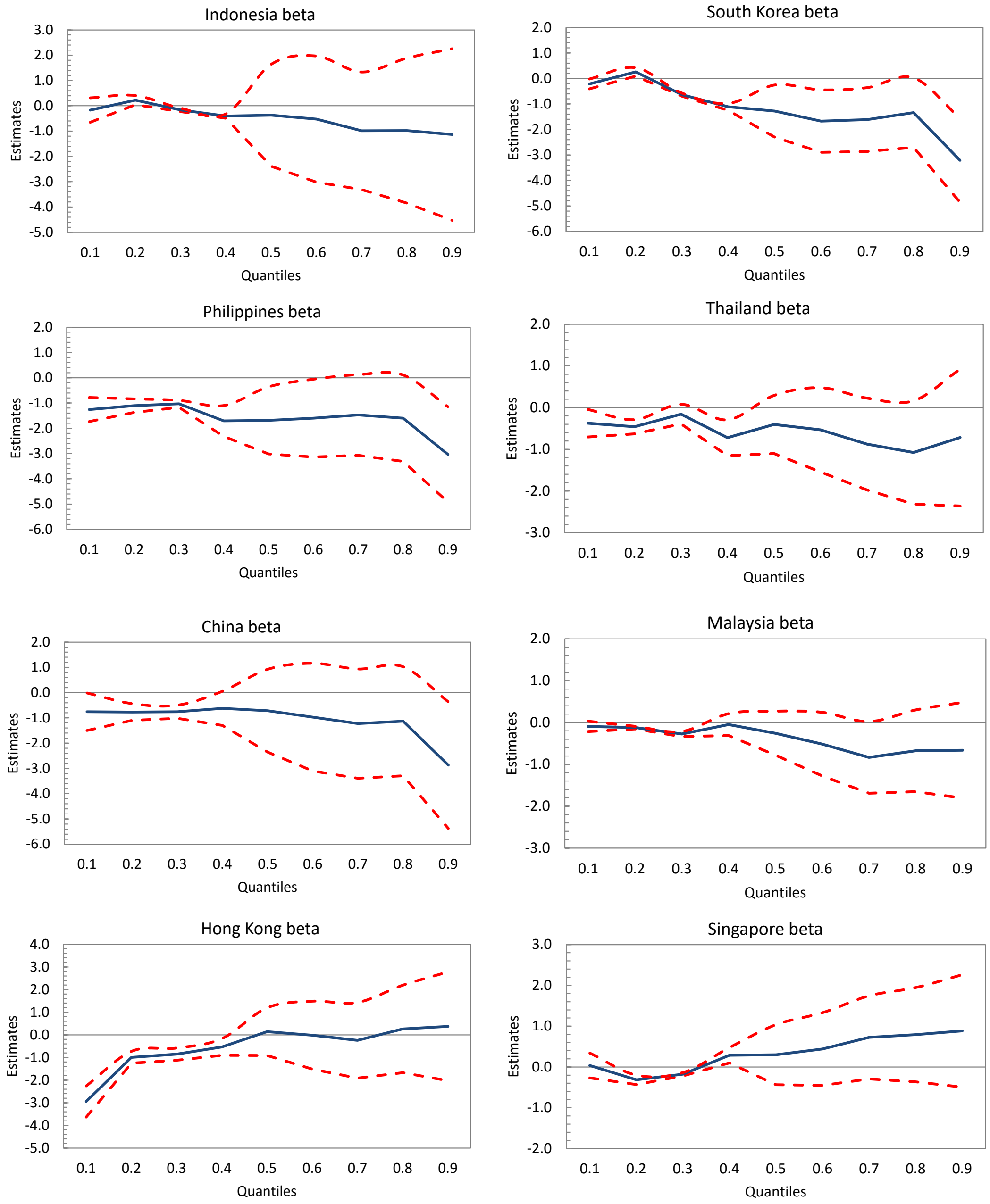
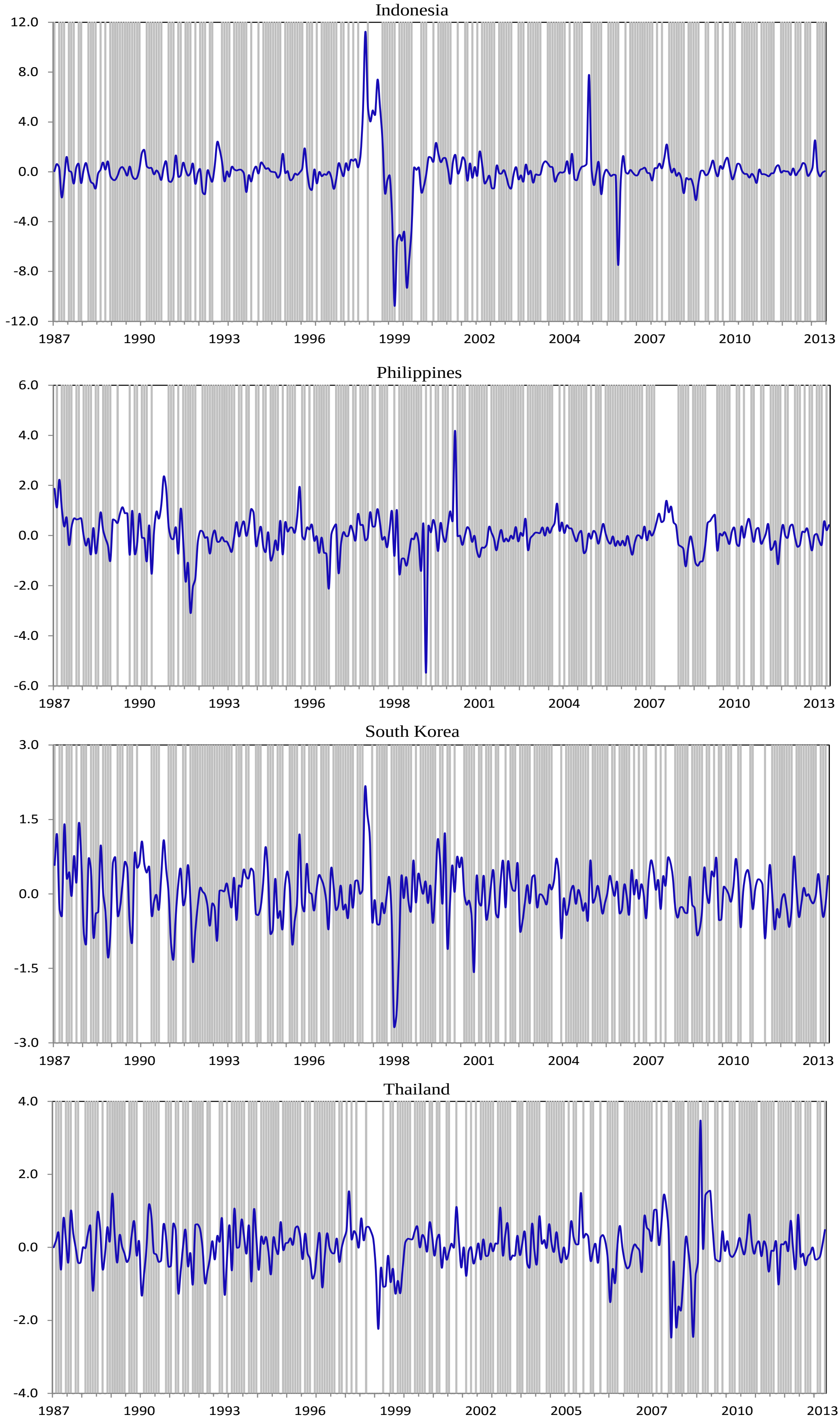
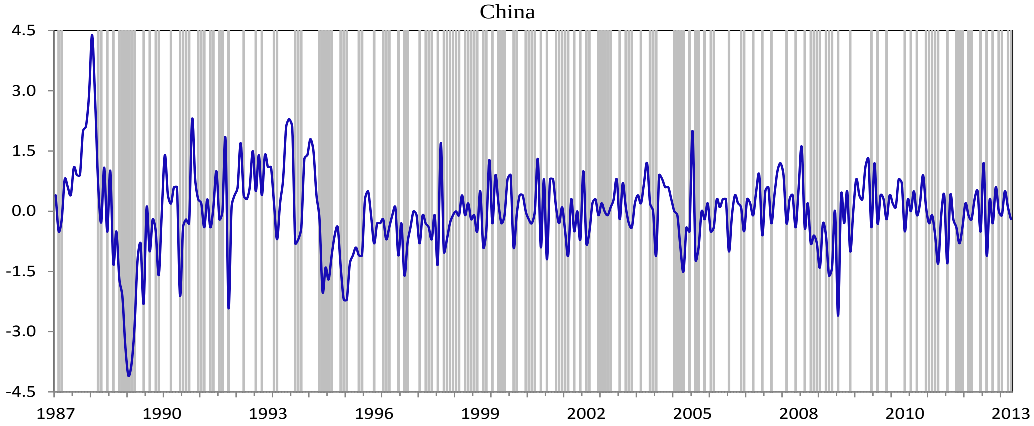


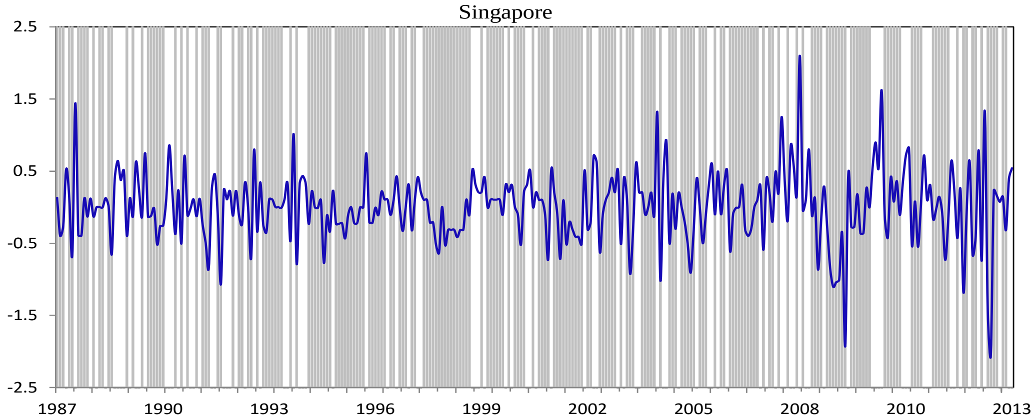
Figure 3. Threshold for changes in inflation rate



Notes: The shadowed areas in the figure indicate the stationary months for inflation rate.

Figure 3. (Continued)





Notes: The shadowed areas in the figure indicate the stationary months for inflation rate.