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Inflation convergence among the next eleven economies: Evidence from asymmetric nonlinear unit root test

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Abstract. *The purpose of the present paper is to investigate whether or not inflation convergence exists among the Next-Eleven (N-11) country members which are Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, the Philippines, Turkey and Vietnam, employing the asymmetric nonlinear unit root procedure of Sollis (2009). The data set involves monthly consumer price indices of N-11 countries for the period from January 1995 to April 2015 and the inflation rate differential of each country is calculated in order to test inflation convergence. The empirical results indicate that there exists inflation convergence among the economies of Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam. It is suggested that a common monetary policy would be designed and a successful monetary union would be constituted for these countries.*

Keywords: inflation convergence, asymmetric nonlinear unit root test, next-eleven countries.

JEL Classification: C22, E31.

1. Introduction

Price stability and effective monetary policies are the major issues for both developed and developing countries in terms of economic development. The Central Banks of the countries implement effective monetary policies that aim at the maintenance of the price stability and the encouragement of macroeconomic stability in general. As mentioned by Kisswani and Nusair (2014), inflation convergence serves as an indicator of the degree of good markets integration and is taken by policy-makers to mean reduction in inflation rate differentials between countries. The integration of good markets provides the inflation convergence and so inflation rates and prices do not differ across a group of similar countries.

In other respects, the inflation rate differential is associated with the growth rate differentials and because of the differences in the level economic development, the level of prices could be different across a group of similar countries. According to Cuestas and Ramlogan-Dobson (2013), if there are differences in the rate at which inflation returns to its baseline following a shock, policymakers will be confronted with the design of a monetary policy for diverse or even conflicting economic environments. Consequently, policy aimed at stimulating growth may not jeopardize price stability in one country but has the opposite effect in another with further knock-on effects in that country.

The convergence hypothesis of inflation relies on unit root tests in time series framework. The rejection of the unit root indicates that any shock to inflation rate differentials that causes deviations from the equilibrium dies out and is expressed as the empirical evidence that the inflation rate differentials are converging to their equilibrium situation.

The Next-Eleven (hereafter, N-11) economies were first identified by the Goldman Sachs Investment Bank and Jim O'Neil in 2005 as an alternative to BRIC (Brazil, Russia, India and China) economies. The N-11 grouping involves Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, the Philippines, Turkey and Vietnam. The main criteria that Goldman Sachs used for the N-11 grouping were macroeconomic (price) stability and openness of trade and investment policies. The main characteristics of N-11 economies are that they share growing populations associated with remarkable industrial potential. N-11 economies also have common features in terms of high economic potential.

The extant literature on inflation convergence is mostly interested in many advanced economies and Organization of Economic Co-Operation and Development (OECD) economies. Especially, most of the studies investigate inflation convergence in European Union and Euro Area economies. In other respects, there exist a few serious attempts to test inflation convergence hypothesis for the other economies. Although inflation convergence has been well studied in advanced economies there do not exist any contributions to inflation convergence in N-11 economies. Therefore, this study attempts to fill the gap by testing inflation convergence in N-11 economies.

The main goal of the present paper is to investigate whether or not inflation rate differentials in N-11 economies are persistent, in other words, whether or not inflation convergence exists among the N-11 country members. The present paper differs from the extant literature in the following way: to the best of our knowledge, it is the first study that examines the issue of inflation convergence in the context of N-11 economies, employing the asymmetric nonlinear unit root procedure of Sollis (2009) to investigate the stationary of inflation rate differentials.

The remainder of the paper is organized as follows: in Section 2 we discuss the literature review and in Section 3 we present the econometric methodology. Section 4 contains the data description and empirical results of the study. The fifth and last section includes conclusions.

2. Literature review

As mentioned above, there exist fewer empirical studies on inflation convergence in the other economies except the advanced economies such as those of the European Union and the Euro Area. Korenda and Papell (1997) investigated the inflation convergence for the European Union using panel regression approach and reported that there exists inflation convergence within the European Union.

Holmes (2002) also examined the long-run inflation convergence among the European Union countries using panel unit root and cointegration approach and found out strong evidence of inflation convergence for the sample countries during 1983-1990. Spiru (2008) used the univariate and panel unit root tests to explore the inflation convergence for Central and Eastern European (CEE) economies and remarked that the inflation rate differentials of CEE economies, as candidate economies, are converging to the European Union economies.

Busetti et al. (2007) investigate the convergence of inflation rate differentials among the European Union economies using the standard Augmented Dickey-Fuller (ADF) unit root test. They divided the sample period into two: 1980-1997 and 1998-2004 and they found out evidence of inflation convergence only over the 1980-1997 period. Kiswani and Nusair (2011) also used linear and nonlinear unit root tests the inflation convergence for Asian economies, i.e. China, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea and Thailand, relative to the United States and Japan. Their empirical findings support the validity of inflation convergence among Asian economies.

Gregoriou et al. (2011) investigated inflation convergence among the Euro Area economies using linear and nonlinear unit root tests and remarked that there exists inflation convergence among the Euro Area economies according to the results of nonlinear unit root test. Lopez and Papell (2012) also examined the inflation convergence among the Euro Area economies using panel unit root test. Their empirical findings support the strong empirical evidence for inflation convergence among the Euro Area economies.

Giannellis (2013) used threshold unit root test to explore inflation convergence for the Euro Area economies. The empirical findings of Giannellis's (2013) study indicated that there did not exist inflation convergence for some of the Euro Area economies, i.e. Germany and France.

Cuestas and Ramlogan-Dobson (2013) explored the inflation convergence for the Caribbean economies using linear and nonlinear unit root tests. They reported that inflation convergence was in existence for the Caribbean economies. Anoruo and Murthy (2014) used nonlinear unit root tests to investigate the issue of inflation convergence for the Central African Economic and Monetary Community (CEMAC), i.e. Cameron, Central African Republic, Chad, Equatorial Guinea, Gabon and the Republic of Congo. Their findings suggest strong evidence of inflation convergence among the economies within CEMAC.

3. Econometric methodology

Empirically, the issue of inflation convergence could be investigated by exploring the stationarity of the inflation differentials series through the unit root tests. If the inflation differential series follows a unit root process, it would imply that the inflation rate of a country differs persistently from the average inflation rate of all countries. It is well known that conventional unit root tests such as Augmented Dickey-Fuller (ADF) have weakness in terms of persistent failure to reject the null of a unit root.

Kapetanios et al. (KSS) (2003) develop a new strategy of testing for a unit root in the nonlinear exponential smooth transition autoregressive (STAR) framework. Hereunder, in KSS test, the null hypothesis of the unit root is tested against the nonlinear exponential smooth transition autoregressive (ESTAR) but globally stationary process. Furthermore, the nonlinear behavior of the series displays symmetric adjustments for positive and negative deviations towards the equilibrium level.

Sollis (2009) proposes an alternative to KSS nonlinear unit root test, referred to as an asymmetric ESTAR (AESTAR) model, which allows for symmetric or asymmetric stationary ESTAR nonlinearity under the alternative hypothesis. The main advantage of the Sollis (2009) test is that the nonlinear behavior of the series displays symmetric or asymmetric adjustments for positive and negative deviations towards the equilibrium level.

The AESTAR model of Sollis (2009) employs both an exponential function and a logistic function as follows:

$$\Delta y_t = \left[1-\exp\left(-\theta_1 y_{t-1}^2\right)\right]\left\{\left[1+\exp\left(-\theta_2 y_{t-1}\right)\right]^{-1}\gamma_1 + \left(1-\left[1+\exp\left(-\theta_2 y_{t-1}\right)\right]^{-1}\right)\gamma_2\right\} y_{t-1} + \varepsilon_t$$
$$\theta_1 \geq 0, \quad \theta_2 \geq 0 \tag{1}$$

where: ε_t is i.i.d. random variable with zero mean and unit variance, y_{t-1} is the transition variable and θ_1 is the transition parameter which determines the speed of mean reversion between two regimes. On the other hand, if $\gamma_1 \neq \gamma_2$, the nonlinear behavior of the series displays asymmetric adjustment for positive and negative deviations towards the equilibrium level.

The unit root hypothesis can be tested against the alternative hypothesis of globally stationary symmetric or asymmetric ESTAR nonlinearity by testing $H_0 : \theta_1 = 0$. Under the null hypothesis γ_1, γ_2 ve θ_2 parameters are unidentified, so testing the null hypothesis $H_0 : \theta_1 = 0$ is not feasible and we cannot use the conventional methods. To overcome this problem, Kapetanios et al. (2003) suggest taking first-order Taylor series approximation to derive an auxiliary regression and Sollis (2009) follows the same strategy to get the auxiliary regression computing a first-order Taylor series approximation to the AESTAR model under the null. The auxiliary regression is obtained as following computing the first-order Taylor expansion around $\theta_1 = 0$:

$$\Delta y_t = \delta_1 y_{t-1}^3 + \delta_2 y_{t-1}^4 + \varepsilon_t \tag{2}$$

Henceforth, the null hypothesis $H_0 : \theta_1 = 0$ becomes $H_0 : \delta_1 = \delta_2 = 0$ in the preceding representation. The auxiliary regression model can be estimated using OLS method and lagged values of Δy_t could be added to model (2) to eliminate the autocorrelation problem in residuals and ensuring "white noise" errors.

The null hypothesis of unit root is tested against the alternative hypothesis of stationary symmetric or asymmetric ESTAR nonlinearity using an F-type test. Sollis (2009) highlights that the standard critical values cannot be used and derives the asymptotic distribution of the F-test of $H_0 : \delta_1 = \delta_2 = 0$.

Once the null hypothesis of unit root has been rejected against the alternative stationary of symmetric or asymmetric ESTAR nonlinearity, then, the null hypothesis of symmetric ESTAR nonlinearity can be tested against the alternative of asymmetric ESTAR nonlinearity using model (3) by testing $H_0 : \delta_2 = 0$ against $H_1 : \delta_2 \neq 0$ with a standard F-test. The standard F critical values can be asymptotically applicable if and only if OLS estimate of δ_1 is negative.

As mentioned Kapetanios et al. (2003), the modelling deterministic components such as intercept and intercept/trend in auxiliary regression model (in nonlinear models) is obvious, so we use de-meaned and de-trended data. From this point of view, there also exist three cases of F-test statistic for Sollis (2009) test: i) raw data case $\left(F_{AE}\right)$; ii) de-meaned data case $\left(F_{AE,\mu}\right)$ and iii) de-trended data case $\left(F_{AE,t}\right)$. Similarly, in the test of symmetric ESTAR nonlinearity versus asymmetric nonlinearity is referred to F_{as}, $F_{as,\mu}$ and $F_{as,t}$ for raw data, de-meaned data and de-trended data cases, respectively.

4. Data and empirical results

The data set involves monthly consumer price indices (2010=100) of N-11 countries for the period from January 1995 to April 2015, a total of 244 observations and consists of Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, the Philippines, Turkey and Vietnam. The data are obtained from the International Financial Statistics (IFS) database. We calculate inflation rates from consumer price indices of N-11 countries using the $\ln\left(P_t/P_{t-1}\right)\times 100$ formula where P_t denotes the value of the consumer price indices of each country at time t and finally, in order to test inflation convergence, we define the inflation rate differential of each country as following:

$$d_{i,t} = \pi_{i,t} - \overline{\pi}_t \tag{3}$$

where: $d_{i,t}$ represents the inflation rate differential of *i.* country at time t, $\pi_{i,t}$ denotes the inflation rate of *i.* country at time t and $\overline{\pi}_t$ is the average rate of inflation for N-11 countries during the same period.

The descriptive statistics for the inflation rate differentials of each country are reported in Table 1. As seen in Table 1, the mean values for inflation rate differentials ranged from a low of -0.576 percent for South Korea to a high of 1.283 percent for Turkey. The standard deviation values of inflation rate differentials ranged from a low of 0.493 percent of the Philippines to a high of 1.958 percent for Turkey. Furthermore, the inflation rate differentials are positively skewed with the exception of Bangladesh, South Korea, Pakistan and the Philippines. The Jarque-Bera test statistics are statistically significant at the 5% level with the exception of Pakistan. Also, the plots of inflation rate differentials are presented in Figure 1.

Figure 1. *Plots of inflation rate differentials*

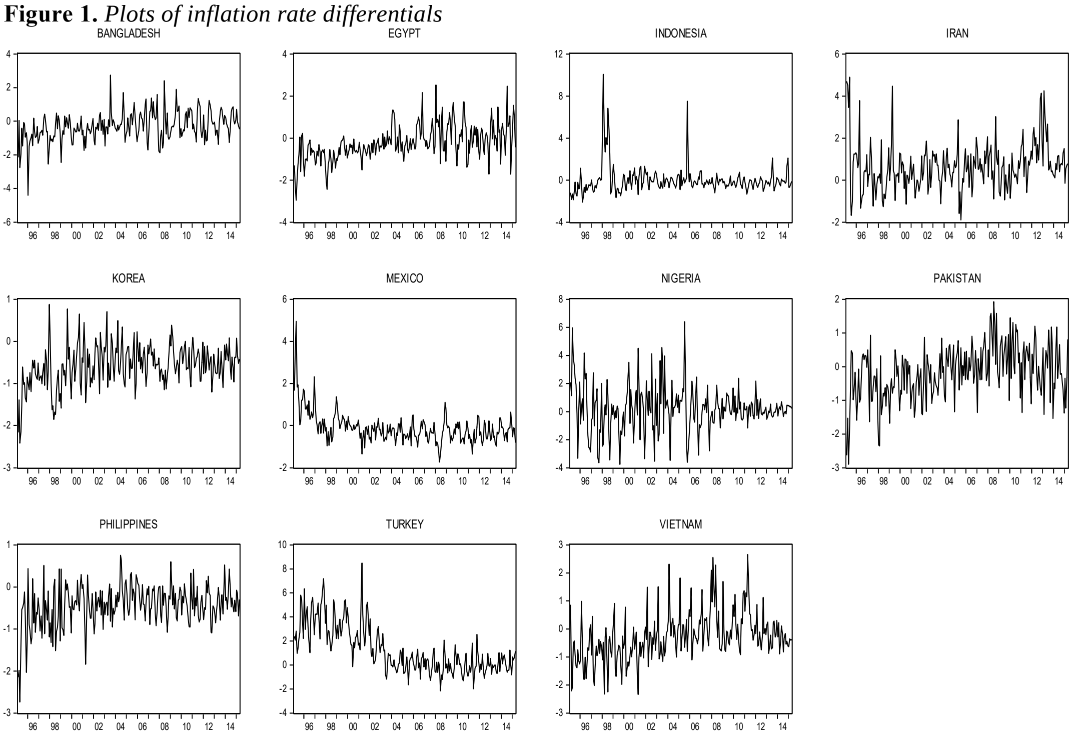

Table 1. *Descriptive statistics for inflation rate differentials*

	Bangladesh	Egypt	Indonesia	Iran	South Korea	Mexico	Nigeria	Pakistan	the Philippines	Turkey	Vietnam
Mean	-0.31379	-0.22481	-0.01673	0.64750	-0.57624	-0.11094	0.19986	-0.17262	-0.43836	1.28354	-0.27742
Median	-0.36983	-0.32670	-0.20615	0.54289	-0.55852	-0.18452	0.14667	-0.20330	-0.41388	0.79501	-0.34866
Maximum	2.74614	2.53005	10.05247	4.89376	0.87370	4.94854	6.39176	1.92732	0.74843	8.49337	2.65800
Minimum	-4.39971	-2.95866	-2.08050	-1.88675	-2.41327	-1.73193	-3.75872	-2.89694	-2.73839	-2.14515	-2.34333
Std. Dev.	0.85143	0.82054	1.31108	1.11484	0.49776	0.71781	1.60148	0.79132	0.49370	1.95857	0.85801
Skewness	-0.17424	0.33204	3.93831	1.10867	-0.31656	2.45792	0.37294	-0.27494	-0.81076	0.97798	0.59693
Kurtosis	5.54846	4.07545	24.73313	5.56857	4.12280	15.23258	4.74932	3.34456	5.25613	3.42367	4.21093
Jarque-Bera	66.98797	16.17541	5410.496	116.58040	16.82284	1759.738	36.61661	4.26359	78.15902	40.55331	29.27783
Probability	0.00000	0.00031	0.00000	0.00000	0.00022	0.00000	0.00000	0.11862	0.00000	0.00000	0.00000
Observations	243	243	243	243	243	243	243	243	243	243	243

We employ the Sollis (2009) nonlinear asymmetric unit root $\left(F_{AE}\right)$ test using raw data for inflation rate differentials of N-11 country members and also investigate whether shocks have symmetric or asymmetric effects for countries in which the unit root test is rejected using F_{as} test. We summarize the empirical results in Table 2.

Table 2. *The results of Sollis nonlinear asymmetric unit root test for raw data*

	Lag length	$\hat{\delta}_1$	$\hat{\delta}_2$	F_{AE}	F_{as}
Bangladesh	2	-0.10836	-0.01722	16.44997*	14.15238**
Egypt	11	-0.03849	-0.00892	1.66060	-
Indonesia	7	-0.01672	0.00114	13.74844*	3.08127
Iran	12	-0.07869	0.01540	4.02349*	3.21717
South Korea	11	-0.54041	-0.35199	8.23678*	16.47191**
Mexico	11	-0.08746	-0.00134	4.62164*	0.00620
Nigeria	11	-0.01162	0.00095	0.71278	-
Pakistan	11	-0.03460	-0.00314	0.38292	-
The Philippines	5	-0.43296	-0.20741	5.10069*	6.39498**
Turkey	0	-0.00261	-0.00044	12.62672*	0.38354
Vietnam	2	-0.08246	-0.00455	9.95074*	0.37042

Note: * and ** denote the rejection of the null hypothesis of unit root and the rejection of the null hypothesis of symmetric ESTAR nonlinearity, respectively at the 5% significance level. The numbers of maximum lags are determined as 12 and the optimal lag lengths are determined through Akaike Information Criterion (AIC).

The results presented in Table 2 indicate that the null hypothesis of unit root is rejected for the cases of Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam at the 5% significance level. On the other hand, the null hypothesis of unit root cannot be rejected for the cases of Egypt, Nigeria and Pakistan. Thus, the results state the rejection of null hypothesis of unit root, on the side of a nonlinear and globally stationary process in all cases, except Egypt, Nigeria and Pakistan.

Based on the empirical results, inflation does not have persistent characteristics in N-11 economies except Egypt, Nigeria and Pakistan, so there exists inflation convergence among the economies of Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam. It is possible to design a common monetary policy and to constitute a successful monetary union for these countries. But the inflation is more persistent for Egypt, Nigeria and Pakistan, so the monetary policies which are convenient for the other countries might not be appropriate for Egypt, Nigeria and Pakistan.

According to the empirical results of F_{as} test, symmetric ESTAR nonlinearity versus asymmetric nonlinearity cannot be rejected for Indonesia, Iran, Mexico, Turkey and Vietnam, but is rejected for Bangladesh, South Korea and the Philippines at the 5% significance level. This implies inflation rates of Indonesia, Iran, Mexico, Turkey and Vietnam display symmetric adjustments for positive and negative deviations towards the equilibrium level. On the other hand, inflation rates of Bangladesh, South Korea and the Philippines show asymmetric adjustments for positive and negative deviations towards the equilibrium level.

5. Conclusions

The purpose of present paper was to investigate whether or not inflation rate differentials in N-11 economies are persistent, in other words, whether or not inflation convergence exists among the N-11 country members. The data set involves monthly consumer price indices (2010=100) of N-11 countries for the period from January 1995 to April 2015. First, we calculate inflation rates from consumer price indices of N-11 countries and then calculate the inflation rate differential of each country in order to test inflation convergence.

The present paper differs from the extant literature in the following way: to the best of our knowledge, it is the first study that examines the issue of inflation convergence in the context of N-11 economies, employing the asymmetric nonlinear unit root procedure of Sollis (2009) to investigate the stationary of inflation rate differentials.

The empirical results indicate that the null hypothesis of unit root is rejected for the cases of Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam, and the null hypothesis of unit root cannot be rejected for the cases of Egypt, Nigeria and Pakistan. Therefore, there exists inflation convergence among the economies of Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam.

According to these results, it can be implied that inflation rates across N-11 countries appear to be converging over time. Besides, it can be implied that it is possible to design a common monetary policy and to constitute a successful monetary union for Bangladesh, Indonesia, Iran, South Korea, Mexico, the Philippines, Turkey and Vietnam. There exists a suitable and necessary condition to establish a common central bank for these countries.

On the other hand, inflation rates of Indonesia, Iran, Mexico, Turkey and Vietnam display symmetric adjustments for positive and negative deviations towards the equilibrium level, but inflation rates of Bangladesh, South Korea and the Philippines show asymmetric adjustments for positive and negative deviations towards the equilibrium level. These results support that the effect of a negative shock is different from a positive shock for Bangladesh, South Korea and the Philippines. Consequently, policymakers should be especially watchful when a negative shock occurs.

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