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Testing for Inflation Convergence: What Do the Data Reveal?

Abstract:

In this study, we examine the inflation performance in three groups of economies, namely the European Monetary Union (EMU), the developed and the developing inflation targeting (IT) economies empirically. Our main and first objective is to detect the improvement or reduction in the average inflation between the pre- and post- inflation targeting (or monetary union) periods. Secondly, we also seek to test the convergence of inflation of three groups of economies over different time frames using panel unit-root tests. Our results reveal that developed and developing IT countries experience larger improvement/ reduction in inflation rates on average relative to the EMU countries. Besides, we also detect convergence of inflation in these groups of economies over different time frames.

Keywords: Convergence of Inflation, Inflation Targeting, Monetary Union, Unit-Root Test, Policy Regime, Inflation Differential.

1 Introduction

Stability in price or low inflation rate is one of the main policy goals pursued by policymakers in many countries, especially in those countries where inflation targeting regime is adopted. Price stability is of concern as it enhances low inflation expectation and reduces economic fluctuation which is good for economic growth and development. The monetary policy is effective if the inflation converges to a low and steady rate. Many studies claim that countries that implementing inflation targeting regime have experienced substantial falls in inflation rates on average and the decline in inflation rate is due to inflation targeting regime. However, some authors argue that this phenomenon could be explained by the high initial inflation rates in inflation targeting countries relative to industrialized countries. This phenomenon is termed by Ball and Sheridan (2005) as inflation convergence.

The reveal of inflation convergence implies the lower inflation rate and the effectiveness of monetary policy to control the price levels. In this study, we explore the concept of inflation convergence and compare the inflation rates between the pre- and post- inflation targeting (or monetary union) periods in a groups of economies. In particular, we compare the results of inflation convergence in three groups of economies, namely the European Monetary Union (EMU), the developed inflation targeting and developing inflation targeting economies. We also seek to investigate if there inflation convergence in these economies over different time frames. The results show that developed and developing IT countries experience larger improvement in inflation rates on average in compare to the EMU countries. Besides, applying panel unit-root tests, we detect inflation convergence in all groups of economies over different time frames. The results provide evaluation and better understanding on the inflation performance between the two sub-periods.

2 The concepts and approaches to study inflation convergence

Inflation convergence acts as an indicator to reveal the differences of structural between countries. Inflation convergence is one of the critical requirements to be fulfilled in entering the currency union and it is defined by Maastricht criteria to be (Westbrook, 1998):

“When inflation differentials are very large, monetary and inflation convergence will largely coincide, but when inflation differentials are more moderate, inflation convergence may require that monetary growth rates diverge slightly, depending upon differences in output growth, velocity, or shifts in preferences for tradeable goods”.

The empirical study on the convergence of inflation is broad. In general, one can categorize the studies into two main groups, i.e. time series approaches and panel studies (Spiru, 2008). The first group applies estimation techniques such as principal components method cointegration and unit-root analysis and unobserved dynamic factor model. The second group applies panel unit root and cointegration tests. In general, unit-root and cointegration test is the main technique applied by majority researchers.

In the empirical study, the concept of convergence of inflation borrows the idea from the convergence of growth (Spiru, 2008). The two definitions of convergence of growth are absolute and conditional growth. The absolute convergence is the condition where the level per capita income of the poor countries catch-up to the level of the rich countries regardless their initial income levels. The conditional convergence occurs when each country is converging to its own steady state conditional on country-specific factors and it is assumed that all growth rates will be equalized in the long run (Spiru, 2008).

There are two approaches used to test for growth convergence i.e. cross-sectional data (α and β convergence) and time series approach (stochastic convergence). The first approach is based on the theoretical growth model while the second notion of growth is tested using the unit-root tests. Based on the second notion of growth, economies $1, 2, \dots, N$ are said to converge to a common trend a_t with finite parameters $\mu_1, \mu_2, \dots, \mu_N$ exist such that

$$\lim_{i \rightarrow \infty} E_t (y_{n,t+1} - a_{t+i}) = \mu_n \quad (1)$$

for $n=1, 2, \dots, N$ and $y_{n,t}$ is the per capita income of country n during period t . The parameter μ_n is the level of economy n 's parallel growth path. Convergence is achieved when all the economies have identical structure with the same growth path so that this parameter is zero.

Using the second approach to test the convergence of inflation, we seek to reveal if inflation has a trend to decline to a low and stale rate in the long run.

2.1 Inflation convergence – a review

Many studies have been conducted to detect the convergence of inflation. Majority studies focus the analyses within European countries and monetary union. Previous studies report quite different results. Among these studies, majority studies report convergence in inflation and only few studies report non stable price level or persistency high inflation rate. For instance, Drine & Rault (2006), Lopez & Papell (2011), Rogers (2002) and Kishor & Ssozi (2010) are among studies that detect the existence of inflation convergence. On the other hand, Hyvonen (2004) explores the convergence

condition across OECD countries using the approach of Ball and Sheridan shows that inflation convergence across OECD countries is unstable over time.

It is important to study the convergence of inflation as the achievement of inflation convergence is a crucial condition in many situations which can be discussed into 3 ways. First, inflation convergence acts as indicator on the price stability and inflation performance of an economy. The reveal of convergence implies the decline of inflation rate to a lower and stable rate. Previous studies also compare the convergence of inflation between the pre- and post- inflation targeting periods. These studies claim that substantial drops on average inflation rates could be due to the implementation of inflation targeting regime (e.g. Bernanke *et al.* (1999) and Corbo *et al.* (2002)). On the other hand, Ball and Sheridan (2005) argue that the drops in inflation rate could due to high initial inflation rate of these countries.

Second, inflation convergence is used to measure the similarity or as one of the requirements to form monetary union. The detection of inflation convergence implies the fulfillment of one of the conditions to enter the monetary union/ integration. This is because inflation convergence is one of the requirements incorporated in the Maastricht treaty to enter the European Monetary Union (EMU). A currency union is viable if there is sufficient similarity in their national inflation rates (Hofmann & Remsperger (2005)). According to Kočenda & Papell (1997), EMU requires that the inflation rate of a member cannot exceed 1.5 percentage points higher than the average of the three lowest inflation rates in European Monetary System (EMS). Differences in inflation rates across the regions will lead to variation in terms of trade and current account disequilibria which may cause to exchange rate variations. Therefore, the primary role of the monetary union central bank is to stabilize inflation of its region members (Kishor & Ssozi (2010)).

Many empirical studies are conducted to investigate the convergence of inflation in EMU or monetary union. Among them are Cuestas *et al.* (2012), Kishor & Ssozi (2010), Lopez & Papell (2011), Drine & Rault (2005), Bursetti *et al.* (2006), Kočenda & Papell (1997). Kishor & Ssozi (2010) apply an unobserved dynamic factor model analysis to study the inflation convergence within the East African Community (EAC) criteria to become a currency union. Their results reveal that variations in inflation have increased substantially in the post-Treaty period. Apart from this, Bursetti *et al.* (2006) investigate the inflation convergence condition of EMU over year 1980 – 2004 using univariate and multivariate unit-root tests. Comparing the results of pre- and post- Euro, they find evidence of convergence in the pre-Euro period but detect divergence in the post- Euro period. They also detect two convergence club, i.e. one group with lower inflation rate and another group with higher inflation rate. On the other hand, Beck & Weber (2003) conduct a convergence analysis using the data of US, Japan and Europe over the period 1981 – 2001. Their results detect higher dispersion of inflation in European countries than that of U.S. and Japan.

Third, inflation convergence shows the similarity in economic structure. Variation in inflation rates implies differences in structural between countries. Therefore, variation in inflation is used as indicator to determine the structural differences between countries or regions. Differences in inflation could due to the Balassa-Samuelson effect, i.e. differences in the productivity growth of tradable versus non-tradable sectors and other factors. The convergence of inflation rates across regions is important as differences in the inflation rates across regions leads to disparities in real interest rates. Under a common national exchange rate, variation in inflation rates for the regions with higher productivity will experience depreciation in real exchange rate and gain competitiveness in trade than others (Yilmazkuday (2009)). Egert (2007) investigates the factors

that drive inflation in Europe. The analysis reveals that Balassa-Samuelson effect only contributes to a limited impact in transition economies but these economies are sensitive to oil price developments. Changes in tradable and nontradable sectors could explain the convergence in price level in Europe.

3 Data

We focus the study in three groups of economies namely the European Monetary Union (EMU), developed inflation targeting economies and developing inflation targeting economies. The countries are classified into developed and developing groups following the classification by International Monetary Fund (IMF). This study includes 15 EMU countries, 8 developed IT countries and 13 developing IT countries which total up to 36 countries. The details of the countries are as summarized in Table 1.

Consumer price index (CPI) is used to construct the inflation rate. The data is from 1970M1 to 2011M12, some countries may have shorter data. The data are collected from Datastream. The inflation rate is defined to be $\pi_t = \ln(CPI_t - CPI_{t-12}) \cdot 100$ which is the annualized inflation rate using monthly data. We divide the data into four main sub-periods, i.e. 1971M1 – 1980M12, 1981M1 – 1990M12, 1991M1 – 2000M12 and 2001M1 – 2011M12. Table 2 summarizes the descriptive statistics.

Table 1: Classification of countries

EMU		Developed IT economies		Developing IT economies	
Country	EMU since	Country	Date adopt IT	Country	Date adopt IT
Austria	1999M1	Canada	1991M2	Brazil	1999M6
Belgium	1999M1	Czech Republic	1997M12	Chile	1990M9
Cyprus	2008M1	Iceland	2001M3	Columbia	1999M10
Finland	1999M1	Israel	1992M1	Guatamala	2005M1
France	1999M1	Korea	1998M4	Hungary	2001M8
Germany	1999M1	Norway	2001M3	Indonesia	2005M7
Greece	2001M1	Sweden	1993M1	Mexico	1995M1
Ireland	1999M1	UK	1992M10	Peru	2002M1
Italy	1999M1			Philippines	2002M1
Luxembourg	1999M1			Poland	1998M6
Malta	2008M1			Africa	2000M2
Netherlands	1999M1			Thailand	2000M5
Portugal	1999M1			Turkey	2006M1
Slovenia	2007M1				
Spain	1999M1				
Total	15 countries		8 countries		13 countries

Table 2: Descriptive statistics

Variable/ country	1971M1 – 1980M12		1981M1 – 1990M12		1991M1 – 2000M12		2001M1 – 2011M12	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
<u>Inflation</u>								
EMU	9.8361	5.6122	12.4161	30.1580	4.9155	11.8293	2.5728	1.9675
Developed	15.0357	13.8286	18.0896	29.0209	4.3634	3.9555	2.7053	2.2055
Developing	23.8395	32.3660	34.2671	53.7060	24.4970	46.2771	5.3529	5.3131

It is observed that EMU has lower inflation rate on average relative to developed IT and developing IT countries. Developed IT countries have lower inflation rate on average relative to that of developing IT countries. Developing IT countries have relatively high inflation rates on average but the rates have declined significantly after year 2000. The standard deviation of inflation rate is very high in developing IT countries, implying very large differences on the inflation rates within the group.

4 Methodology

The investigation of convergence can be divided into two main parts. In the first part of analysis, we apply the unit root approach. In the second part of analysis, we apply the approach of Ball & Sheridan (2005) in which the convergence of inflation is constructed based on the difference of average inflation rates between the pre- and post- inflation targeting periods as shown in equation (7). The dummy value of 0 indicates a country belongs to EMU and value 1 indicates a country is adopting inflation targeting regime. Besides, we also estimate equation (7) excluding the dummy variable for each group of country:

4.1 Unit root test

The convergence equation can be written as:

$$\begin{aligned}\Delta y_{i,t} &= \gamma + (\phi - 1)y_{i,t-1} + \eta_{i,t} \\ \Delta y_{i,t} &= \gamma + \beta y_{i,t-1} + \eta_{i,t}\end{aligned}\quad (2)$$

Where $y_{i,t}$ is the inflation rate series for country i over period t and Δ denotes the differential operator. The Augmented Dicky-Fuller (ADF) test is used to test the convergence of inflation:

$$\Delta y_{i,t} = \gamma + \beta y_{i,t-1} + \alpha \sum_{k=1}^n y_{i,t-k} + \eta_{i,t} ; \quad (3)$$

The hypotheses tests are:

$$H_0 : \beta = 1$$

$$H_1 : \beta < 1$$

Where $\beta = \phi - 1$. The acceptance of null hypothesis implies a unit-root. Therefore, the rejection of the null hypothesis implies existence of convergence. Convergence of inflation differentials is used to investigate the convergence of inflation in monetary union across members. The inflation differential is the deviations of country i 's inflation rate from the monetary union's average rate over time, i.e. $d_{i,t} = \pi_{i,t} - \bar{\pi}_t$

The average inflation rate of the group is obtained by $\bar{\pi}_t = \frac{\sum_{i=1}^N \pi_{i,t}}{N}$. The convergence of inflation differentials is assumed to be modelled in AR(1) process:

$$\begin{aligned}\pi_{i,t} - \bar{\pi}_t &= \rho(\pi_{i,t-1} - \bar{\pi}_{t-1}) + \varepsilon_{i,t} \\ d_{i,t} &= \rho d_{i,t-1} + \varepsilon_{i,t}\end{aligned}\quad (4)$$

ρ is the persistency of inflation differential. In the second part of analysis, we conduct the panel unit-root test for inflation differentials for EMU countries using the following equations:

$$\Delta d_{i,t} = \gamma_i + \beta_i d_{i,t-1} + \alpha_{ij} \sum_{p=1}^{k_i} d_{i,t-p} + \eta_{i,t}\quad (5)$$

$$d_{i,t} = \pi_{i,t} - \bar{\pi}_t$$

To test the panel unit-root for inflation convergence for three groups of economies, we based on the following equation:

$$\Delta \pi_{i,t} = \gamma_i + \beta_i \pi_{i,t-1} + \alpha_{ij} \sum_{p=1}^{k_i} \pi_{i,t-p} + \eta_{i,t}\quad (6)$$

The selection of lag length is based on the Schwarz criterion.

4.2 Ball & Sheridan (2005) approach

Ball & Sheridan (2005) examine the convergence of condition by comparing the average of inflation between the pre- and post- inflation targeting periods across countries. The inflation convergence equation is:

$$\bar{\pi}_i^{post} - \bar{\pi}_i^{pre} = \alpha + \beta_1 \bar{\pi}_i^{pre} + \beta_2 D_i + \varepsilon_i\quad (7)$$

The endogenous of $\bar{\pi}_i^{post} - \bar{\pi}_i^{pre}$ shows the difference of average inflation between pre- and post-inflation targeting periods for country i . D is the dummy variable with value one to denote inflation targeting countries. Hyvonen (2004) has modified the model of Ball & Sheridan (2005) to $\bar{\pi}_{i,t} - \bar{\pi}_{i,t-1} = \alpha + \beta_1 \bar{\pi}_{i,t-1} + \varepsilon_i$ where $\bar{\pi}_{i,t}$ and $\bar{\pi}_{i,t-1}$ are the average inflation rates for post- and pre-inflation targeting respectively.

$$\bar{\pi}_i^{post} - \bar{\pi}_i^{pre} = \alpha + \beta_1 \bar{\pi}_i^{pre} + \varepsilon_i\quad (7*)$$

5 Results

Table 3 summarizes the results of the average differences between the mean inflation rates of the two sub-periods. The differences are negative because the mean inflation rate of post is higher than the average rate in the pre- sub-periods. The difference is the highest in developing IT countries, followed by the developed IT countries. The developing IT countries show higher differences and this can be explained by two reasons. The first reason is due to higher initial inflation rates of developing IT countries (see Table 2). Second, developing IT countries benefit much large reduction in inflation relative to other countries (see Table 4). The average values summarized in

$$\frac{(\bar{\pi}_i^{post} - \bar{\pi}_i^{pre})}{\bar{\pi}_i^{pre}} \cdot 100$$

Table 4 is obtained by

Table 3: Average of mean inflation differentials, $\bar{\pi}_i^{post} - \bar{\pi}_i^{pre}$

Value	EMU	Developed	Developing
Mean	-7.9676	-11.4429	-26.4770
Median	-4.8877	-6.6226	-14.4984
Standard deviation	10.6298	13.4462	35.4214

Table 4: Mean % reduction in inflation (pre versus post- periods)

EMU		Developed IT		Developing IT	
Country	% reduction	Country	% reduction	Country	% reduction
Austria	52.92	Canada	70.14	Brazil	95.35
Belgium	54.95	Czech Republic	70.90	Chile	88.10
Cyprus	32.01	Iceland	66.48	Columbia	72.15
Finland	73.75	Israel	89.98	Guatamala	39.24
France	72.72	Korea	65.92	Hungary	68.48
Germany	55.12	Norway	67.67	Indonesia	35.33
Greece	75.30	Sweden	80.35	Mexico	66.67
Ireland	66.78	UK	76.66	Peru	87.81
Italy	75.98			Philippines	56.94
Luxembourg	38.15			Poland	92.22
Malta	57.42			Africa	48.84
Netherlands	49.52			Thailand	52.13
Portugal	81.17			Turkey	92.26
Slovenia	83.60				
Spain	39.07				
Average	61.42		73.51		68.88

It is observed that developed IT countries experience the largest reduction in mean inflation of 73.51% on average. For individual countries, the largest reduction in mean inflation is achieved by the developing country of Brazil, i.e. 95.35%, followed by Turkey and Poland. On the other hand,

Indonesia only achieves 35.33% improvement in inflation. This rate is relatively low among the developing IT countries. In general, we can say that the inflation performance of developing IT countries varies across countries due to different initial inflation rates (some are very high but some are lower) and different date to adopt IT.

5.1 Panel unit-root test

First, we discuss the results of panel unit-root test (equation 5 and 6). We conduct the test for inflation differential and inflation convergence for EMU countries the test of inflation convergence is applied for other IT countries. The inflation differential test is suitable for monetary union case but not for individual country.

Table 5: Differential in inflation - EMU

	1971M1 – 1980M12	1981M1 – 1990M12	1991M1 – 2000M12	2001M1 – 2011M12
Fisher chi-sq	2078.92***	278.086***	1611.82***	2321.01***

Note: *** denotes 1% significant level

Table 6: Inflation convergence

Country	1971M1 – 1980M12	1981M1 – 1990M12	1991M1 – 2000M12	2001M1 – 2011M12
EMU	576.426***	547.087***	911.557***	713.049***
Developed	336.340***	275.888***	321.374***	329.939***
Developing	267.966***	317.244***	346.955***	445.681***

Note: *** denotes 1% significant level

Table 5 reports the result of convergence of inflation differential. The result reveal if the inflation rate of each member country convergences to the mean inflation rate of the group. We conduct the test for 4 sub-periods and the panel unit-root test detects convergence in inflation differential for all sub-periods. Our result reveal evidences of convergence in inflation differential of EMU members over different time frames. EMU has fulfilled the pre-condition of monetary union.

Table 6 summarizes the results of inflation convergence using panel unit-root test. The values mentioned are the Fisher chi-squares which are significant at 1% level in all cases. The results detect convergence in inflation rate for all groups of economies over the periods 1971M1 to 2011M12.

5.2 Results of inflation convergence – Ball & Sheridan (2005)

The results of inflation convergence using the approach of Ball & Sheridan (2005) are as summarized in Table 7. Our results reveal that the coefficient of β_1 or mean inflation of pre- period (see equation (7) and (7*)) is highly significant and negative, indicating an increase in the mean inflation of pre- period leads to larger negative value in the differential of $(\bar{\pi}_i^{post} - \bar{\pi}_i^{pre})$. The negative value of the coefficient is negative due to the larger mean inflation of pre- period than the value of post- period. The absolute value of β_1 coefficient in both groups of IT countries is larger

than that of EMU countries, implying higher improvement or convergence in mean inflation between the two sub-periods in IT countries. Larger reduction in mean inflation can be explained by high initial inflation rate or it could also due to the effective monetary policy that has successfully reduced the inflation rate. As discussed in Table 2 to 4, we see that IT countries have higher initial inflation rates which have contributed to larger reduction of $(\bar{\pi}_i^{post} - \bar{\pi}_i^{pre})$ in developing IT countries.

If we include all countries in the analysis using dummy (0 for EMU and 1 for IT countries) using equation 7, the result shows that the coefficient of dummy is significant at 10% level and is positive. The result fails to show that IT countries perform better than EMU. Although from the descriptive statistics, we observe that IT countries in general experience higher $\bar{\pi}_i^{post} - \bar{\pi}_i^{pre}$, however, the standard deviation is relatively high especially in the IT developing countries which indicate very large differences in the performance of inflation across developing IT countries. Not all IT countries perform well and achieve large improvement in inflation relative to EMU's.

Table 7: Ball and Sheridan approach - convergence rate

All		EMU		Developed IT		Developing IT	
Variable	Coefficient	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
C	1.0400	C	-0.3025	C	2.0304**	C	5.0505***
PRE	-0.9625***	PRE	-0.8190***	PRE	-0.9277***	PRE	-0.9908
Dummy	2.4830*						
R square	0.9788	R square	0.7885	R square	0.9926	R square	0.9966***
D-W stat	1.9830	D-W stat	2.2973	D-W stat	2.0260	D-W stat	1.7962

Note: *** denotes 1% significant level; ** indicates 5% significant level and * shows 10% significant level

6 Conclusion

In this study, we conduct empirical analyses to compare the performance of inflation in three groups of economies, namely the EMU, developed and developed inflation targeting economies, for the period of 1970M1 – 2011M12. The investigations apply the inflation convergence approach of Ball & Sheridan (2005) and the panel unit-root tests. Results from the first approach reveal that both developed and developing inflation targeting economies experience higher convergence in inflation relative to that of EMU countries. No evidence show that inflation targeting economies perform better than EMU in terms of larger improvement in inflation between the two sub-periods. This is because although inflation targeting countries exhibit very large reduction in inflation on average, the performance of inflation by individual countries are very different, constrained by the initial inflation rates and also the date to adopt inflation targeting regime. Apart from this, our panel unit-root tests detect evidences of inflation convergence across economies and over different time frames. We also detect convergence of inflation differentials in EMU countries over time.

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