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The Mean Reverting Behavior of Inflation in the Philippines

Abraham C. CAMBA Jr.[1], Aileen L. CAMBA[2]

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Abstract

Central Bank authorities should carefully manage inflation rate uncertainties to achieve economic growth and development not only in the short-run but also in the long-run. Since inflation is a key macroeconomic variable, an increased understanding about its behavior is undoubtedly important. Thus, paper employs unit root with breakpoints to examine the mean reverting behavior of inflation rate in the Philippines using monthly data from 2002 to 2020. Empirically, the unit root breakpoint innovational and additive outlier tests favor the stationarity or mean reverting behavior of inflation in the Philippines. Also, results of standard unit root tests, ADF, PP, GLS-Dickey-Fuller, KPSS and NP, provide strong evidence of mean reverting processes. The mean reverting behavior of inflation rate reveals that the monetary policy using inflation targeting framework has succeeded in reducing chronic inflation persistence in the Philippines. Thus, this research supports inflation targeting policy that aims to maintain general price level stability for the Philippine economy's long-term growth and development prospects. The findings of this research remain important for the central bankers for not only providing them better understanding about the behavior of inflation rate, but also helping them formulate and implement policy reforms related to money, credit and banking.

Keywords: Additive Outlier Unit Root Test, Innovational Outlier Unit Root Test, Inflation Targeting, Mean Reverting Process

JEL Classification Code: C22, E31, E52

1. Introduction

Inflation rate, as a key macroeconomic indicator, has major impact on the macroeconomy, specific to the banking (Almansour et al., 2021) and financial sectors where prudent monetary policy should be geared toward its total stability. No matter if inflation rate is described as a stationary or a unit root process, has several economic implications (Basyariah et al., 2021). If inflation rate contains a systematic pattern that is unpredictable, a shock to it has a lasting effect, in such case effective inflation targeting is tough to realize. The nonstationary inflation rate implies that shocks have a permanent effect, and a high cost for disinflation policies. However, if it is described as a stationarity process, it will mean that the shocks impact will be temporary (Dias & Marques, 2010; Gregoriou & Kontonikas, 2006). Naturally, the stationary inflation rate will bring about a low cost for monetary authorities in the conduct of monetary policies (Hervé, 2018; Cecchetti et al., 2006). Thus, knowledge about inflation reverting to its mean value after a disturbance provides valuable information. As key macroeconomic variable, an increased understanding about its behavior is certainly significant.

Central banks through monetary policy promote future growth prospects of a country (Tran et al., 2021) by preventing inflation uncertainties (Adaramola & Dada, 2020). Manageable inflation levels have been a fact of economic life in the Philippines since 2002 (at least). There are instances that low and stable inflation coincides with prudent changes in the monetary policy framework. In the Philippines, the Bangko Sentral ng Pilipinas (BSP)

[1]First Author and Corresponding Author. Associate Professor 2, Department of Economics, College of Social Sciences and Development, Polytechnic University of the Philippines, Philippines. ORCID ID: 0000-0001-8938-7050. [Postal Address: A. Mabini Campus, Anonas Street, Sta. Mesa, Manila, 1016, Philippines] Email: accamba@pup.edu.ph

[2]Associate Professor 4, Department of Economics, College of Social Sciences and Development, Polytechnic University of the Philippines, Sta. Mesa, Manila, Philippines, ORCID ID: 0000-0002-5819-2303. Email: alcamba@pup.edu.ph

in January 2002 formally espoused inflation targeting as its basic framework to the monetary policy.

Inflation often has the tendency to revert towards its long-run equilibrium value resulting from a shock. Assessing the inflation mean reverting behavior is of no less significance in the case of a lower middle-income economy like Philippines. Our approach differs in several important respects. First, in terms of coverage, we started in January 2002 when the Bangko Sentral ng Pilipinas (BSP) officially espoused inflation targeting as its basic framework to the monetary policy. Thus, for the long-run we focused on the longest available time horizon of 19 years. Second, we used unit root breakpoint innovational and additive outlier tests along with applying standard unit root test, which is arguably necessary in our case since there is evidence of structural breaks in the inflation rate time series. Third, to ensure robust test performance we run both intercept and time trend the breakpoint and standard unit root tests. By introducing trend break functions in the unit root tests, we have established a link between the various breakpoints and the inflation rate time series.

This research statistically addresses the empirical mean reverting behavior of inflation in Philippines and what does it reveal about the adoption of inflation targeting as basic framework to the monetary policy. The objective of this paper is to test the inflation rate mean reversion process in Philippines. The main contribution of this study is the application of unit root breakpoint innovational and additive outlier tests along with standard unit root tests for the Philippines using monthly data between 2002 and 2020. The results, therefore, will be useful in assessing the effectiveness of a monetary policy meant to manage inflation volatility and its impact to the Philippine economy.

2. Literature Review

2.1. Inflation Persistence and Structural Break

Inflation persistence is when inflation converges gradually (or sluggishly) near its long-run value because of a shock, which causes inflation rate to move away from its long-run value (Altissimo et al., 2006). In less formal terms, inflation rate persistence refers to the extent it takes inflation rate returning to an equilibrium after an unanticipated change (Willis, 2003). Debelle and Wilkinson (2002) showed that persistence has weakened substantially in Australia, the United Kingdom, Canada and New Zealand, but in the United States there was a slight evidence of persistence weakening. Clark (2003) found that by permitting a break in the mean of inflation rate, inflation rate persistence in the United States reduced significantly. Similarly, Levin and Piger (2003) showed that permitting a structural break, the null hypothesis of a unit root for 29 of the 48-inflation series may be rejected at the 5 percent significance level. Bilke (2004) found evidence of a single mean break in France in the mid-1980s, while Corvoisier and Mojon (2005) found numerous significant breaks in OECD countries (i.e., late 1960s, early 1970s, the early-mid 1980s, and the early 1990s). More recently, Chen et al. (2016) considered testing the possibility of structural breaks and nonlinearity of inflation in Indonesia, Malaysia, the Philippines, Thailand, Singapore and India. Accordingly, inflation is shown to be a stationary process.

Another aspect of literature looked at the long memory persistence in the inflation rate process. For example, Belkhouja and Mootamri (2016) examined the long memory and structural changes in the G7 inflation dynamics. By allowing the baseline mean and volatility to be time-dependent, using logistic functions for G7 countries from 1995 to 2014 their finding is that neglecting structural changes in the inflation level and volatility seems to overestimate the long-run and GARCH persistence. In another study, Boateng et al. (2017) described the best fit for modelling the time-dependent heteroskedasticity and persistence in the conditional mean of inflation rate in Ghana and South Africa. Their results provide evidence of persistence, mean reverting though, and asymmetric effect of economic shocks on the conditional mean of inflation rate of the two countries. Caporin and Gupta (2017) extended the literature on long-memory models of inflation persistence for the US economy over the monthly period of 1920–2014, by developing an autoregressive fractionally integrated moving-average-generalized autoregressive conditional heteroskedastic model with a time-varying memory coefficient which varies across expansions and recessions. According to their findings, inflation persistence does vary across recessions and expansions, with persistence of inflation volatility being higher during expansions than in recessions. Gil-Alana and Gupta (2019) examined inflation over one century of data for 29 countries. The results suggest evidence of long-memory behavior in the inflation rates of 17 countries. Adelakun (2020) found a relatively low degree of inflation rate persistence since the advent of monetary union in West Africa Monetary Zone (WAMZ) after implementing a multivariate vector autoregressive moving average GARCH framework.

2.2. Stationarity and Mean Reversion of Inflation

The rational expectation (Cagan, 1956) specifies that steady money supply growth suggests stationary inflation unless there are disturbances, for instance bubbles. Likewise, the hypothesis of natural rate of inflation and the sticky price model (Taylor, 1979) assumed that inflation is stationarity. Cecchetti et al. (2006) made it clear that the cost of disinflation would be higher if inflation exhibit nonstationarity as shocks to inflation would have a

lasting effect. While an inflation rate that is stationary (or mean reverting) lowers the cost of controlling inflation as the shocks would have a transitory impact on inflation. Gil-Alana (2016) examined the inflation rates in the Group of Seven countries. They observed evidence of unit roots in the cases of the UK, Canada, France, Japan and the USA; for Germany, they found some evidence of mean reversion. Moreover, Bolat (2017) analyzed inflation rates dynamics in the Middle East and North African countries using quantile unit root test and concludes that negative shocks did not have long-lasting effects. Gaglianone et al. (2018) found that inflation rates of Brazil showed asymmetric behavior to shocks (i.e., positive and negative), and positive shocks seemed to have a greater dissipation time than the negative shocks. Osman (2021) investigated the dynamics of inflation in the Gulf Cooperation Council countries. After using a battery of tests, the findings convincingly support the view that not only the inflation rates of these countries are non-linear, but they are also characterized by mean reversion behavior.

2.3. Empirical Evidence from Univariate and Panel Unit Root Tests

A few studies that used panel data rejects the unit root hypothesis and offers a consensus around the stationarity of inflation rate. Culver and Papell (1997) investigated the unit root properties of 13 OECDs' inflation rate. Applying the Levin and Lin (1992) panel unit root test, the null hypothesis of unit root was rejected for the panel of all 13 countries. Lee and Wu (2001) examined the mean reversion of inflation rate for 13 OECDs. When using Im (2003) (IPS) panel unit root test, they rejected the null hypothesis of the unit root. Lee and Chang (2007) study favors stationarity (or mean reversion hypothesis) for 19 OECD countries using panel version of Lagrange Multiplier (LM) unit root. Lee and Chang (2008) examined the stationary of inflation rates in 11 OECD countries in Asia and presented some results to support the stationary inflation rates. Another study implementing the LM unit root belongs to Narayan and Narayan (2010) that obtained strong proof against the non-stationary.

Other studies conducted by a non-linear approach analyzing the stationarity of inflation rate. Henry and Shields (2004) for example, apply the Wald bootstrap approach. The results imply that the inflation rates in the United Kingdom and in Japan were described as a unit root with threshold two regimes process. However, for the United States, the threshold was insignificant and the shocks on the inflation rate seem to be infinitely persistent. Similarly, the work of Ho (2009) depicted evidence of unit root process covering 19 OECD countries using the non-linear statistics that takes into account the transversal dependence. Arize (2011) applied non-linear and linear unit root tests to the inflation rates of 34 African countries. The DF-GLS, ADF and KSS tests failed to reject the null hypothesis of stationary in 17, 13 and 25 cases, respectively. Gregoriou and Kontonikas (2009) used ADF and the non-linear ADF unit root tests on the inflation rates of 5 OECD countries adopting the inflation targeting. The results of the ADF unit root test showed that the null unit roots could not be rejected in all the countries. However, the results of the non-linear ADF test implied a unit root process in all the cases. Another researcher, Zhou (2013) used the unit root test that allows the non-linearity to explore the stationarity of inflation rates in 12 European countries. The non-linearity has been observed in 8 countries over 12 and, among them, 6 countries seemed to have a non-linear stationarity in their inflation rates.

Koenker and Xiao (2004) asserts that conventional univariate unit root tests either have meager power performance, or bias in favor of a unit root when the series has non-normal distribution. To overcome these shortcomings, recent studies applied quantile unit root, Fourier stationary tests, and structural breaks and nonlinearity. Tsong and Lee (2011) examined the inflation dynamic behavior in 12 OECDs using quantile unit root test finds evidence that inflation has asymmetric mean reverting properties. Chang (2013) applied a flexible Fourier stationary test to explore the mean reverting behavior of inflation in 22 OECD countries for the period 1961–2011. Although conventional unit root models gave mixed outcomes, empirical results from flexible Fourier stationary test show mean reversion of inflation in all 22 OECD countries. Also, Si and Li (2017) examined mean reverting properties of inflation rates in 7 Eastern European countries using Fourier quantile unit root test finds stationarity for Czech Republic, Bulgaria and Lithuania, while the inflation in Poland, Estonia, Romania, and Latvia, contained a unit root. Hervé (2018) analysis indicates rejection of that the null hypothesis of unit root in the inflation time series by the LLC, Breitung, Fisher and IPS unit root tests. Meanwhile, the PANIC tests and the Pesaran unit root test, confirms that inflation has mean reversion process. Likewise, the paper of Hadizadeh (2020) further validated the mean reverting properties of inflation in Iran's 25 provinces for the period 1990–2017 concluded that the quantile unit root test rejects the null hypothesis of the unit root in all inflation series.

3. Methodology

Intuitively, stationarity indicates frequent mean reverting movements. For instance, a period of accelerating inflation would be quickly followed by a period of disinflation, while nonstationarity suggests persistent and chronic inflation (Peng, 1995). Formally, the method to test the stationarity of inflation is the unit root test (Chen et al., 2016) using a variety of standard techniques: Augmented Dickey-Fuller (ADF)

(1979) and Phillips-Perron (PP) (1988), GLS-Dickey-Fuller (Elliott et al., 1996), Kwiatkowski et al. (1992), and Ng and Perron (NP) (2001) unit root tests. The standard univariate autoregressive (AR) process for representation of inflation time series takes the following form (O'Reilly & Whelan, 2004; Hondroyiannis & Lazaretou, 2004; Marques, 2004):

$$\mathrm{INF}_t = \alpha + \sum_{j=1}^{K} \beta_j \mathrm{INF}_{t-j} + \varepsilon_t \tag{1}$$

where INF_t is the relevant inflation time series at time t and ε_t is a random disturbance term (shock) with no serial autocorrelation but with possible heteroscedastic properties. The primary focus of equation 1 is the question whether inflation possesses a unit root. In case it is found that the inflation time series follows a unit root (or random walk), it is described as highly persistent because shocks have permanent effects on it and therefore the inflation process itself has no tendency to return to a long-run path.

However, standard unit root tests are biased toward a false unit root null when the data are trend stationary with a structural break (Perron, 1989). That is, due to the changes in the monetary policy or functioning of financial markets macroeconomic time series may contain structural breaks. Structural breaks are usually employed to control for something that was hard to anticipate, like regime shift (Österholm, 2009). In this study, we performed unit root test with breakpoints, that is, the innovation outlier and additive outlier with both intercept and trend break to ensure robust conclusions. The innovation outlier model can be expressed as follows:

$$\begin{aligned}\mathrm{INFL}_t &= \mu + \beta_t + \theta \mathrm{DU}_t(T_b) + \gamma \mathrm{DT}_t(T_b) + \omega D_t(T_b) \\ &\quad + \alpha \mathrm{INFL}_{t-1} + \sum_{i=1}^{k} c_i \Delta \mathrm{INFL}_{t-1} + u_{t'}\end{aligned} \tag{2}$$

where T_b is a specified break point date, β and γ are trend and trend break coefficients, θ is intercept break, ω the break dummy coefficients. To test for a unit root in the additive outlier framework, we have utilized the model with intercept and trend break as expressed in equation 3:

$$\begin{aligned}\mathrm{INFL}_t &= \mu + \beta_t + \theta \mathrm{DU}_t(T_b) + \gamma \mathrm{DT}_t(T_b) \\ &\quad + \omega D_t(T_b) + \mathrm{INFL}_t^*\end{aligned} \tag{3}$$

where INFL_t^* be the residuals obtained from detrending equation. The significance of innovational outlier and additive outlier tests is that we can establish important breakpoints usually associated with shocks on inflation time series.

The results of the above unit root tests, standard and breakpoint, provide strong evidence that inflation time series is mean reverting in nature by testing the null hypothesis of a nonstationarity unit root against the alternative hypothesis of stationarity. The monthly data of inflation in the Philippines from January 2002 to December 2020 were sourced from the online statistical database of the Bangko Sentral ng Pilipinas (BSP). The inflation rate time series is the headline inflation rate with 2012 as the base year.

4. Results and Discussion

4.1. Descriptive Analysis

Table 1 provides the descriptive statistics. Inflation rate in the Philippines has a mean value of 3.70 percent during January 2002–December 2020 period. The highest rate of inflation was experienced in August 2008 at 10.50 percent while disinflation was recorded in September and October 2015 at –0.40 percent and –0.20 percent, respectively. Inflation is generally stable with standard deviation of 1.99; besides, the skewness of inflation is 0.90 and the kurtosis is 4.00. The Jarque-Bera statistics reject the null hypothesis of normality at 1 percent significance level.

Figure 1 shows the monthly behavior of the inflation rate time series from January 2002 to December 2020. As shown in Figure 1, we found inflation rate has recorded increases between 2002–2008, between 2016–2018, and then declines between 2009–2015, and 2019–2020. There may be breaks in the slope of the trend function (Clark, 2003; Levin & Piger, 2003; Bilke, 2004; Corvoisier & Mojon, 2005; Chen et al., 2016).

4.2. Mean Reverting Behavior

In Table 1, the Jarque-Bera statistic showed non-normality of the inflation time series. It is likely that standard univariate unit root tests either have poor power performance or tend to bias in favor of a unit root when the series has non-normal distribution (Koenker & Xiao, 2004). Thus, the ADF, ADF-GLS, PP, KPSS, NP and breakpoint tests were run with an intercept and a time trend to improve their power and size. The results of applying these tests are reported in Table 2 and Table 3. The results of the ADF and GLS-DF tests reflect that

Table 1: Descriptive Statistics

Inflation (2012 = 100)			
Mean	3.70	Std. Deviation	1.99
Maximum	10.50	Skewness	0.90
Minimum	–0.40	Kurtosis	4.00
Jarque-Bera	40.60	Probability	0.00

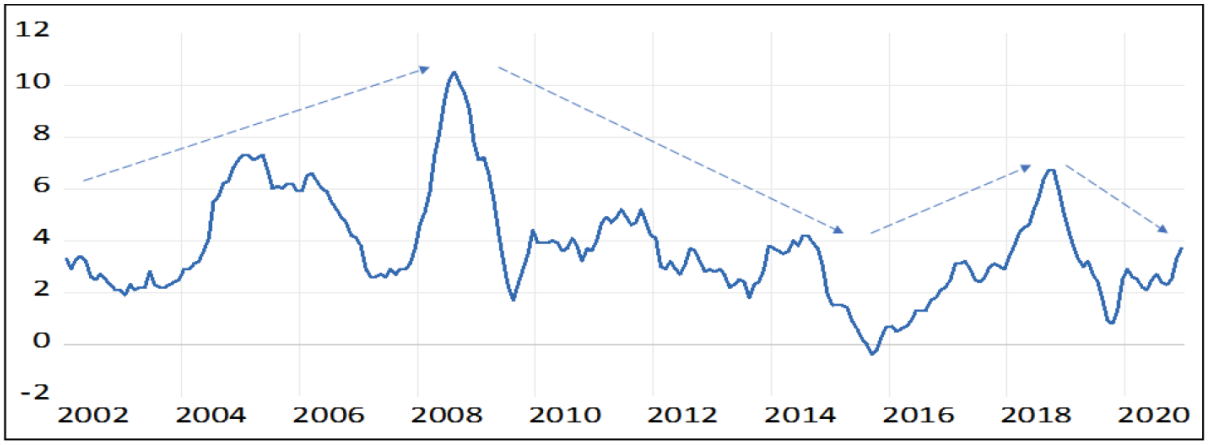

Figure 1: Behavior of Inflation Rate in the Philippines

Table 2: Standard Unit Root Tests

Constant, Linear Trend	*t*-statistic	Ng and Perron (NP)	
Augmented Dickey-Fuller (ADF)	–3.47**	MZ_a	MZ_t
GLS-Dickey-Fuller (GLS-DF)	–3.23**	–20.77**	–3.22**
Phillips-Perron (PP)	–3.12*		
Kwiatkowski, Phillips, Schmidt, and Shin (KPSS)	LM-stat.		
	0.11		

Note that the ADF, GLD-DF, PP and NP tests the null hypothesis of a unit root. The KPSS unit root test takes the null hypothesis of stationarity. (***)(**)(*) denotes significance at the 1%, 5% and 10% level.

Table 3: Unit Root Tests with Breakpoints

	Intercept and Trend		Intercept	
	Innovation Outlier	Additive Outlier	Innovation Outlier	Additive Outlier
Test Statistics	–4.99**	–4.97**	–4.87**	–4.94***
Breakpoint	2004:04	2011:04	2009:12	2008:02

Note that Breakpoint Innovation Outlier and Additive Outlier tests the null hypothesis of a unit root. (***)(**)(*) denotes significance at the 1%, 5% and 10% level.

inflation is stationary. That is, the null hypothesis of a unit root can be rejected at the 5 percent significance level. The Phillips-Perron (PP) test rejects the null hypothesis of non-stationarity of inflation at 10 percent significance level. The null hypothesis of the KPSS test shows that inflation time series which is stationary cannot be rejected. Furthermore, according to the NP test statistics MZ_a and MZ_t, the unit root hypothesis for inflation time series can be rejected at 5 percent level of significance, which suggests that there is stationarity. Thus, according to ADF, ADF-GLS, PP, KPSS, and NP tests, the inflation rate is a mean reversion process in Philippines.

In the presence of a structural break, the power to reject a unit root decreases if the stationary alternative is true and the structural break is ignored (Perron, 1989). To address the issues of breakpoints, the breakpoint innovational outlier and additive outlier tests were performed. Results of innovational outlier test in Table 3 reveals that the null hypothesis of a unit root is rejected at 5 percent significance level. Thus, inflation rate is found to be stationary with one

structural break in the intercept and trend in 2004:04, and intercept only in 2009:12. The results of the additive outlier test confirms the stationarity of inflation rate with only one structural break in the intercept and trend in 2011:04, and in the intercept only in 2008:02, as the null hypothesis of a unit root is rejected at 5 percent and 1 percent significance level, respectively. As we see from the above results, the breakpoint innovational outlier and additive outlier tests support the mean reversion of inflation rate in the Philippines.

Figure 2 provides the graphs of the Augmented Dickey-Fuller statistics and AR coefficients over the period

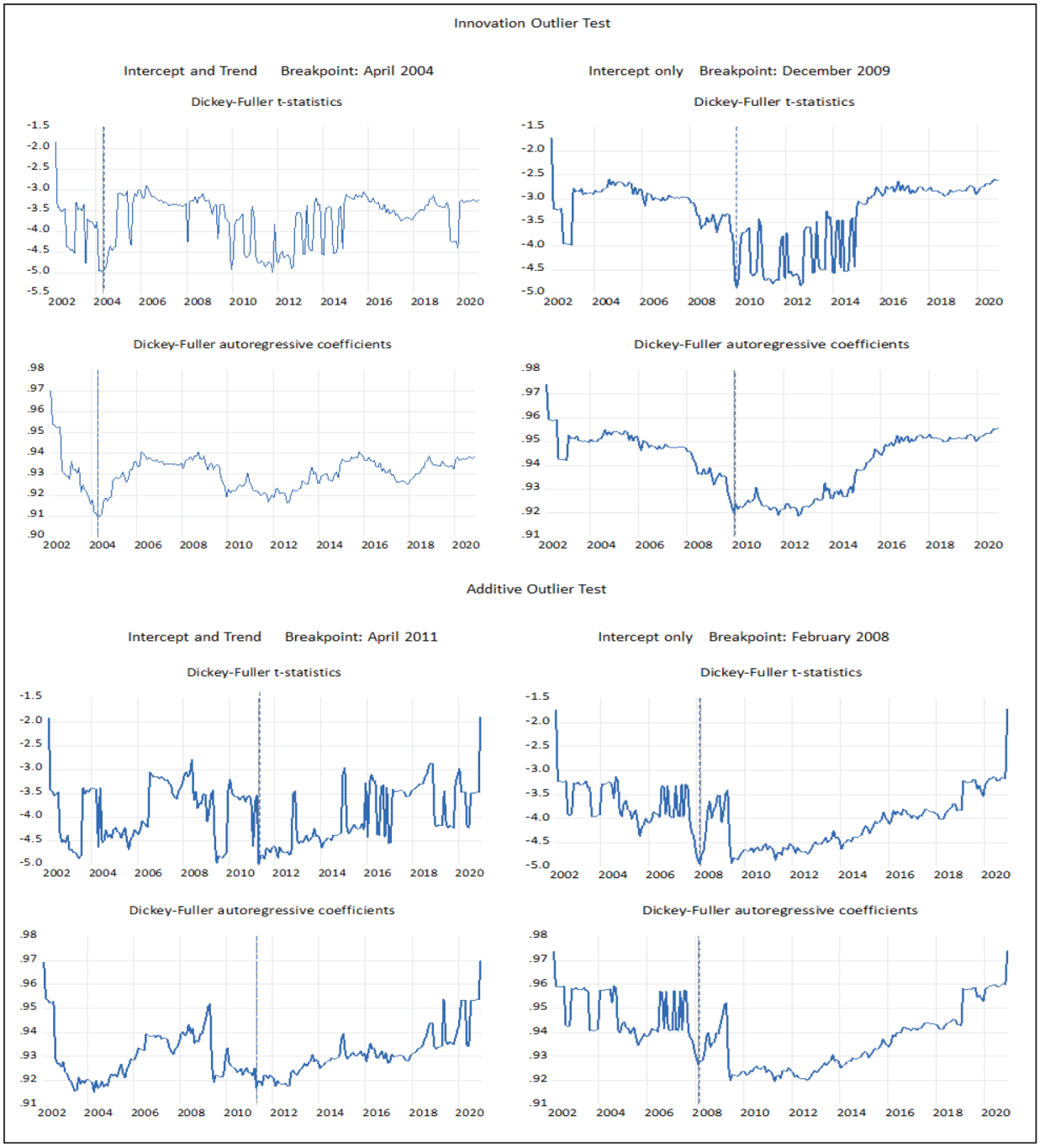

Figure 2: Test Statistics and AR Coefficients Graphs

January 2002–December 2020 with breakpoint dates in April 2004, April 2011, December 2009 and February 2008. The breakpoint dates correspond to the significant periods of global major economic events and monetary policy change shocks. For instance, the international price of Dubai crude oil rose in March 2004 on concerns over oil production cut by OPEC beginning April 2004. Similarly, in the futures market, the price of Brent crude increased, driven by the surging demand for oil in the United States and China coupled with concerns over the possible supply disruption given the volatile situation in the Middle East. These developments were captured by the April 2004 breakpoint observed in the inflation rate series. Moreover, the 2007 – 2008 United States sub-prime housing bubble crisis, and the 2008 – 2009 global financial crisis and the collapse of Wall Street was reflected in the inflation rate breakpoints of February 2008 and December 2009. The Bangko Sentral ng Pilipinas is well-known for its inflation targeting monetary policy. In its March and May 2011 meetings, the Monetary Board (MB) decided to raise the BSP's policy interest rates for the overnight RRP (borrowing) rate and for the overnight RP (lending) rate to control broadening inflation pressures in the economy. Hence, the breakpoint of April 2011, in inflation rate time series is a consequence of these upward reviews of monetary policy. Thus, by introducing trend break functions in the unit root tests without a priori information, we have been able to establish a good connection between the various breakpoints and the inflation rate time series. This is in line with previous works by Perron (1989, 1997), Clark (2003), Levin and Piger (2003), Bilke (2004), Corvoisier and Mojon (2005), Österholm (2009), and Chen et al. (2016).

Our analysis indicates that the null hypothesis of the unit root problem in the time series of inflation rate is rejected by unit root breakpoint innovational and additive outlier tests along with the standard unit root tests. The stationary process of inflation rate confirms a mean reverting behavior. The mean reverting behavior of inflation rate reveals that inflation targeting has succeeded in reducing inflation rate volatility in the Philippines, which is consistent with the central tenet of inflation targeting that it makes inflation stationary around the inflation target. Any positive or negative shock has a transitory rather than lasting (or permanent) effect on inflation (Cecchetti et al., 2006; Bolat et al., 2017; Gaglianone et al., 2018). Also, the mean reverting behavior of inflation rate agrees with the hypothesis of the natural rate of inflation and the sticky-price model (Taylor, 1979). To the contrary, if inflation rate time series possesses infinite memory it implies nonstationary, that is, contains a unit root. Since time series with infinite memory is not mean reverting such process will randomly drift away in any direction. Thus, any disturbance to a course (or process) with infinite memory can be predictable nor transitory (Cecchetti et al., 2006). In addition, when inflation is stationary conventional cointegration methods may not be suitable to study the validity of Fisher hypothesis and the integration of inflation (Lee & Wu, 2001).

The findings of this research remain more specifically important to the central bankers for not only providing them better understanding about the behavior of inflation, but also helping them formulate and implement policy reforms related to money, credit, and banking (Almansour et al., 2021).

5. Conclusion

This research empirically validates the mean reverting behavior of inflation in the Philippines using monthly data from 2002 to 2020 and applying unit root tests. Specifically, there were mean reverting properties of inflation. The ADF, GLD-DF, PP, KPSS and NP unit root tests provide strong evidence of mean reversion processes. Moreover, inflation rate has mean reversion processes according to additive and innovational outlier breakpoint tests. In conclusion, inflation in the Philippines followed mean reverting behavior from January 2002 to December 2020.

The policy implication of the above findings reveal that active monetary policies are not needed because random shocks will not have permanent effects, as they eventually disappear in the long run. If inflation exhibit mean reversion process, the task of monetary policy will be more relaxed. Simply, inflation may well fluctuate around the chosen target range requiring little action from the Bangko Sentral ng Pilipinas (BSP). Thus, inflation targeting has been beneficial for the Philippine economy in helping promote stability in the general price level. Under the inflation targeting framework, when BSP uses monetary policy tools for instance raising or lowering the overnight policy rate, issuance of securities, or sale or purchase of government securities, it should consider stabilizing prices as its top priority to protect the purchasing power of consumers, for businesses to thrive and create a favorable environment to achieve sustainable economic growth for the Philippine economy.

By introducing trend break functions in the unit root tests, we have established a link between the various breakpoints and the inflation rate time series. These dates represent critical periods of monetary policy changes and external shocks.

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