INFLATION PERSISTENCE: EVIDENCE FROM PAKISTAN

Waqqas Qayyum[1] and Asim Anwar[2]

Abstract

The study aims to estimate the degree of inflation persistence by utilizing the standard econometric tools and different measures of inflation persistence covering the period from 1957Q1 to 2015Q2. Inflation persistence is analyzed for both quarter on quarter and year on year inflation series by exploiting the autoregressive and mean reverting characteristics of these series. The results of the study are suggestive of reasonably high degree of inflation persistence in Pakistan and provoke further studies to be conducted to establish its link with fiscal and monetary policies followed in Pakistan and that will be the future agenda of our research.

Keywords: Inflation Persistence, Monetary Policy, Autoregressive Process, Mean Reversion.

JEL Classification: E310

Introduction

It is a profound fact of the current era that inflation is a serious cause of concern for many countries around the world. This concern is not because it is intrinsically a bad thing but because of its adversities above its threshold based on its link with many other macroeconomic variables. A vital issue for monetary policy makers and theorists to confront with is the persistence of inflation. The reasons for interest in inflation persistence is due to its important role in designing the monetary policy, as it will determine the level to which authorities could maintain a reasonable level of both output and inflation and thus, the performance of monetary policy (Levin & Williams, 2003; Amato, et al., 2007; Wolters & Tillmann, 2015). Secondly, estimation of exact level of inflation persistence usually guides us to what degree the diverse macroeconomic models are consistent with empirical evidence. Acknowledged with this fact, literature evolves by inculcating a critical aspect of 'Inflation Persistence' into its domain. Inflation persistence has been captured in various ways by different economists and broadly the consensus has been established in characterizing the impulse response, serial correlation and mean reversion features of inflation series as important measures for its determination. The said measures are quite pronounced in existing literature and can be explored in

[1] International Islamic University, Islamabad, Pakistan. Email: waqqas.qayyum@iiu.edu.pk

[2] Assistant Professor, Department of Management Sciences, COMSATS University Islamabad, Attock Campus, Pakistan. Email: asimm.anwar@gmail.com

various studies (Hassler and Wolters, 1995; Hsu, 2005; Lee, 2005; Noriega & Ramos-Francia, 2009; Cuestas & Harrison, 2010; Hassler & Meller, 2014; Antonakakis et al., 2016).

The diverse inflation patterns across the globe and even within an economic union have urged the researchers to identify the existence of inflation persistence and its underlying causes.[3] The study of various countries indicates that inflation truly is a persistent variable; moreover, the degree of persistence seems to be changing overtime (i.e. decades of low persistence followed by decades of high persistence) (Gali & Gertler, 1999). Economists tend to rationalize these varying episodes and different distinct patterns of inflation persistence in different economies; for this numerous factors are taken into account especially, policy regimes, regime shifts, historical background (i.e. pre and post war conditions[4], switch from gold standards to currency standards, episodes of monetary targeting), primitive or industrialized mode of economic setup are mentioned to be critical (Liven & Piger, 2003; Batini, 2002).

Monetary policy has been historically held responsible for ensuring price stability and reducing volatilities in terms of output gaps, interest rates and prices. Monetary policy rules, Central bank loss functions, Optimal monetary policy design embedded in hybrid New Keynesians micro based models, all reflect in one way or the other the emphasis on the role the monetary policy in targeting inflation (Gerlach & Tillmann, 2012; Cruijsen, et al., 2010). However optimal monetary policy design has often been found sensitive to the assumptions of the model about inflation. Empirical literature has mostly treated inflation persistence as exogenous within the framework of these models but current research is acknowledging this fact that endogenizing inflation persistence can change the results dramatically (Soderstrom, 2002; Levin & Williams, 2003; Levin & Moessener, 2005).

Researchers have also tried to establish a link between monetary policy regimes and inflation persistence. Modern literature is engulfed with numerous attempts of linking monetary policy regime shifts and their consequent impact on the degree of inflation persistence. Episodes of strict monetary policy stance usually yield an outcome in the form of low inflation persistence while loose stances correspondingly result in high inflation persistence (Doh & Davig, 2009).

In case of Pakistan's economy limited number of studies have focused on capturing the concept of inflation persistence. The study by Hanif et al. (2016) is the only prominent work in this dimension which explores the intrinsic nature of inflation persistence for Pakistan's economy. In that study the author utilizes monthly data to capture Inflation persistence through an AR process at overall and commodity level. Although our study is not destined on capturing inflation persistence at commodity level but at overall level it uniquely differs from the mentioned study on the following

[3] E.g. European Union where harmony exists in pursuance of a common monetary and other trade related policies.

[4] This argument has been used by researchers in various studies of inflation persistence in UK and US referred to pre and post World War II period. For instance, see Alogoskoufis and smith (1991).

accounts: 1. Our study utilizes quarterly data on inflation and to cross validate the results inflation persistence has been estimated for both Year on Year inflation and Quarter on Quarter inflationary measures. 2. Secondly, our study, besides employing conventional AR(p) process (to estimate inflation persistence), also verifies the results through mean reversion analysis of inflation series; both with constant and time varying mean as mark of reference. This provides us with a margin to fill up this literature gap in case of Pakistan; however, such work is quite pronounced in studies at international level (Marques,2004; Hondroyiannis & Lazaretou, 2007).

The study is organized as followed: The second section presents the data sources and empirical methodology, section 3 makes a discussion on estimation results and section 4 concludes the study based on the empirical results and findings.

Data and Methodology

Data and its sources

The data used for this research has been taken from International Financial statistics (2015). Quarterly data on CPI is used to calculate both Year on Year inflation and Quarter on Quarter inflation for the chosen sample of 57 years from 1957Q1-2015Q2.

Methodology

Conventional AR (P) process

This procedure involves considering inflation simply to follow an AR process where order of AR is decided based on Schwartz and Akaike Information criterion. This is the simplest way to take a glimpse of the existence of persistence. The baseline idea is to estimate an equation in autoregressive format. The conventional way to proceed is to assume that inflation follows a stationary autoregressive process of order "p" which is written as:

$$\pi_t = \alpha + \sum_{j=1}^{K} \beta_j \pi_{t-j} + \varepsilon_t \quad \text{.......................................} (1)$$

Where π is the inflation, $\sum\beta_j$ is the sum of autoregressive coefficients and ε_t is the serially uncorrelated error term. We can re-parameterize equation (1) as

$$\pi_t = \alpha + \sum_{j=1}^{K-1} \gamma_j \Delta\pi_{t-j} + \rho\pi_{t-1} + \varepsilon_t \quad \text{.......................................} (2)$$

The parameter ρ in the above equation is the measure of inflation persistence. Model like described above is frequently used in current literature for approximating persistence in a series as inflation in current context[5]. According to the specified model inflation persistence is the pace with which inflation series reverts back to its equilibrium value after being hit by a shock, alternatively one could contend that persistence is captured by the time required for a shock to completely die off. Therefore, the larger the value of the ρ longer will be the span over which the impact of the shock would be spread out. This feature is also sketched by Impulse response function.

Mean Reversion property of Inflation series

Capturing inflation persistence based on mean reversion property of inflation series is also a popular analytical technique employed by researchers, where mean reversion is figured out by the number of times inflation series tends to cross its mean over the sample range. The greater the frequency with which inflation series crosses its mean the less will be the inflation persistence and vice versa. The embedded exposition of this idea is delivered assuming a constant and time varying mean. The following model discusses a brief summary of the entailed idea.

Equation (1) and (2) are transformed in order to incorporate structure of mean within the defined domain of these equations. Equation (1) can be modified in following manner[6].

$$(\pi_t - \mu) = \sum_{j=1}^{K} \beta_j (\pi_{t-j} - \mu) + \varepsilon_t \quad \text{.....} \quad (3)$$

Equation (3) can be transformed as follows:

$$d\pi_t = \sum_{j=1}^{K-1} \delta_j \Delta\pi_{t-j} + (\rho - 1)(\pi_{t-1} - \mu) + \varepsilon_t \quad \text{.....} \quad (4)$$

It can further be rewritten for convenience as:

$$(\pi_t - \mu) = \sum_{j=1}^{K-1} \delta_j \Delta(\pi_{t-j} - \mu) + \rho(\pi_{t-1} - \mu) + \varepsilon_t \quad \text{.....} \quad (5)$$

[5] For instance see: Kota, (2011), Hondroyiannis and Lazaretou, (2004)

[6] The mean "u" can be accounted both for its constant pattern over time and time varying pattern. The study under discussion deals with both aspects.

Equation (5) can be estimated to acquire ρ which can further be utilized to calculate the term $\rho - 1$ as represented in equation (4). The term $\rho - 1$ represents the mean reversion, the higher the value of this term (absolute value), the stronger will be the mean reversion and the less persistent will be the inflation. Let us denote; $\eta = \rho - 1$, it can be observed that as $\rho \uparrow \ \eta \downarrow (in\ absolute\ terms)$ therefore we can say that inflation persistence term is inversely related with the mean reversion term (Marques, 2004).

Estimation, Results and Discussion

Quarter on Quarter Inflation

Estimating Inflation Persistence through AR (P) Process

To get a simple estimate of inflation persistence equation (2) has been estimated using simple ordinary least square. Numbers of lags for the difference term has been decided based on Schwartz or Akaike information criterion. Certain lags exclusion tests have been performed to select the appropriate numbers of lags. The estimated results of equation (2) are presented in table 1.

Table 1
Estimation Results AR(P) Process

Variable	Coefficient	Std. Error	T-Stat	Significance
Constant	0.7567	0.2132	3.348	0.000473
π_{t-1}	0.6096	0.0892	6.831	0.000000
$d\pi_{t-1}$	-0.2534	0.0879	-2.881	0.004357
$d\pi_{t-2}$	-0.3288	0.0754	-4.357	0.000020
$d\pi_{t-3}$	-0.2528	0.0655	-3.857	0.000150

Lags: 3 T-stat: 3.5487 The aic = 1492.13 and sbc = 1509.16
Durban Watson stats: 1.71

Inflation persistence is measured by the lagged inflation term . The value approximates to 0.61. This value reflects considerable amount of persistence in inflation patterns of Pakistan.

Mean Reverting Characteristics (Constant Mean Quarter on Quarter Inflation)

As explained before inflation persistence can also be traced by observing mean reverting patterns of inflation. The greater is the tendency of an inflation series to revert back to its mean value, the less persistence inflation will be and vice versa. In order to carry out this exercise structure

about mean should be properly analyzed. To give this discussion a more pronounced notion the visual inspection of the inflation series over the whole sample range will prove to be beneficial.

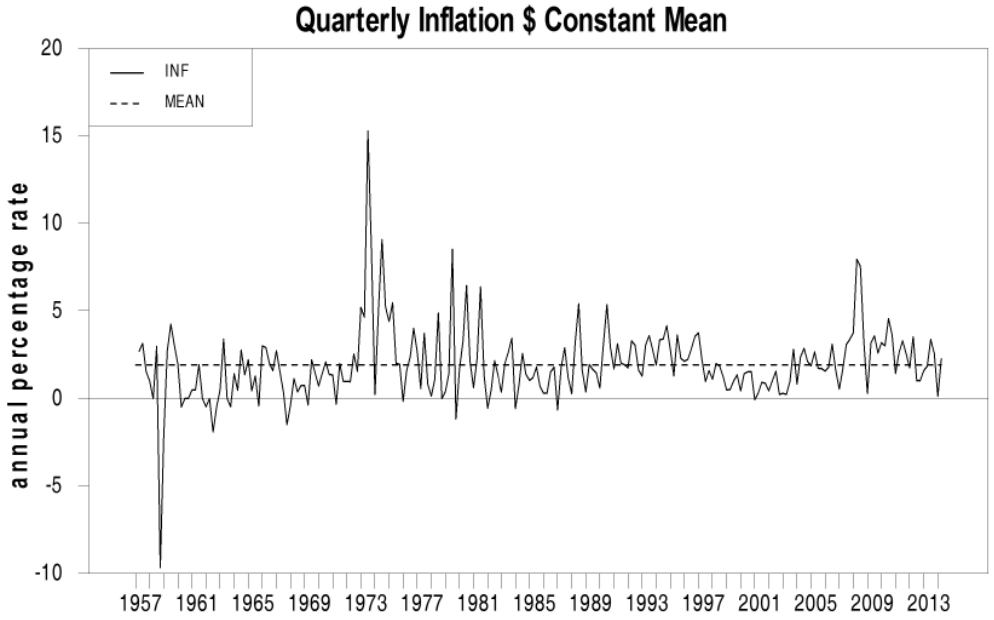

Figure 1: Graph I

A glimpse over the inflation series depicted in graph I reveals that over the sample range mean of this series be constant. Therefore, it is not harmful to examine the persistence property of this inflation series assuming a constant time trend or mean as represented by the dotted line pattern in the above mentioned graph. It is often referred that the mean reverting characteristics of a series also plays a critical role in analyzing its persistence. The frequent is the tendency of any series to revert back to its mean the less persistence will be the behavior of that particular series. In the same context equation (4) is estimated and the mean reversion term is observed to seek persistence of inflation in case of Pakistan economy. The results of estimated parameters represented in equation (4) are summarized in table 2 given below. Table 2 shows that the absolute value of coefficient of the mean reverting term is 0.40 which indicates that series display a scant tendency to revert to its mean. We can also find out inflation persistence term by adding 1 to the mean reverting term which comes out to be 0.60 nearly equal to what we had calculated using AR (p) process.

Table 2
Results Mean Reversion

Variable	Coefficient	Std. Error	T-Stat	Significance
$(\pi_t - \mu)$	-0.40185	0.0805	-4.99169	0.000001
$d\pi_{t-1}$	-0.21559	0.0795	-2.71075	0.00724
$d\pi_{t-2}$	-0.32370	0.0680	-4.75473	0.00000
$d\pi_{t-3}$	-0.24697	0.0591	-4.17817	0.00004

Lags: 3 T-stat: -4.99169 The aic =1437.65 and sbc = 1451.26
Durbin-Watson Stats: 1.90

Mean Reversion with Time Varying Mean (Quarter on Quarter Inflation)

Although the patterns of quarter on quarter inflation series are indicative of constant mean trend but to add more reliability to our estimates of inflation persistence we also estimate equation (3) using time varying mean. Time varying mean has been calculated by fitting a linear trend to the inflation series and using the fitted values as a proxy for time varying mean[7]. The results of the fitted equation are given in Appendix I. The estimates of equation (4) incorporating time varying mean are displayed in table 3.

Table 3
Mean Reversion results Time Varying Mean

Variable	Coefficient	Std. Error	T-Stat	Significance
$(\pi_t - \mu_t)$	-0.41524	0.08344	-4.34541	0.0000
$d\pi_{t-1}$	-0.20570	0.08113	-2.55579	0.0119
$d\pi_{t-2}$	-0.31669	0.06901	-4.04715	0.0000
$d\pi_{t-3}$	-0.24317	0.05945	-3.68876	0.0000

Lags: 3 T-stat: -4.97615 The aic = 1437.79 and sbc = 1451.40
Durbin Watson Stats: 1.89

The coefficient of mean reverting term $(\pi_t - \mu_t)$ has slightly increased in value in absolute

[7] The results are also tested by fitting a quadratic trend to the series but proved to be insignificant.

terms as compared to the previous model. Its value with constant mean was 0.40 and with time varying mean is 0.41. Thus the tendency for the series in terms of mean reversion is still weak. We can also ρ calculate our estimate to take account of inflation persistence, the value of ρ tracks out to be 0.59 which is slightly less than as compared to the previous case. Therefore, we can conclude that in the presence of inherent constant tendency of mean as reflected in graph I the amount of bias generated through the use of constant mean is not significant that is why the results without accounting for time varying pattern and results with time varying patterns do not differ considerably. The graphical visualization of quarterly inflation using time varying mean is presented in graph II.

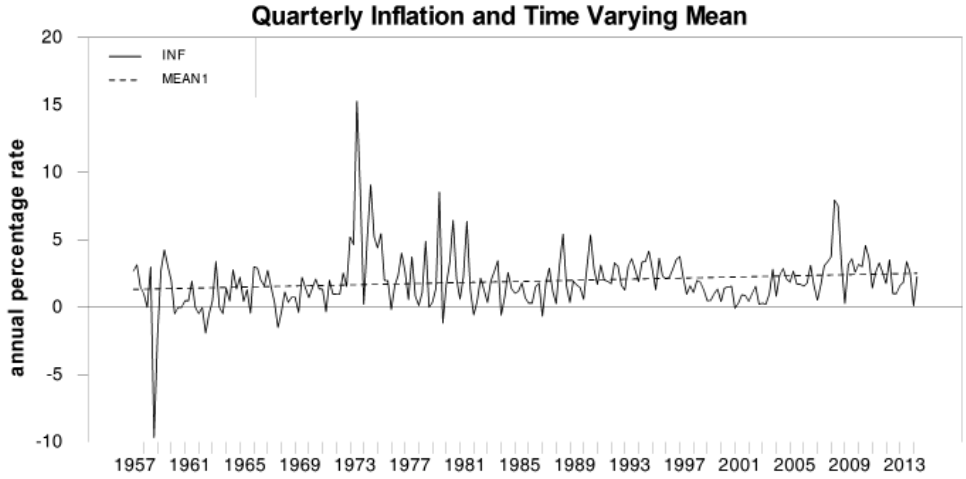

Figure 2: Graph II

Inflation Persistence AR (P) results (Year on Year Inflation)

It is now customary to exploit every possible dimension to explore the visible features of any concept from different angles. Therefore, it is suggestive to scrutinize inflation persistence based on the behavior of Year on Year inflation patterns apart from quarter on quarter patterns. This has an advantageous feature of depressing the impact of any seasonal effect in the series. The results of estimated equation (2) are displayed in table 4. Again, the coefficient of the lagged term reveals high degree of inflation persistence as represented by the value 0.87. The results are considerably different from what we had calculated in case of quarter on quarter inflation. This result is not surprising and specific to this study; numerous studies have observed similar variation in two different type of inflation series where the former indicates relatively low degree of persistence while later add more content to it.

Table 4
Inflation Persistence results AR (P) Process

Variable	Coefficient	Std. Error	T-Stat	Significance
Constant	1.06132	0.26611	3.988	0.00009
π_{t-1}	0.86876	0.02661	32.635	0.00000
$d\pi_{t-1}$	0.40466	0.06163	6.565	0.00000
$d\pi_{t-2}$	0.01488	0.07050	0.211	0.83305
$d\pi_{t-3}$	0.10288	0.06105	1.685	0.09341
$d\pi_{t-4}$	-0.33231	0.06159	-5.39	0.00000
$d\pi_{t-5}$	0.12579	0.06480	1.94	0.05359
$d\pi_{t-6}$	0.17825	0.06181	2.88	0.00434

Lags: 1 T-stat: 3.90625 The aic = 1469.77 and sbc = 1493.46
Durbin-Watson Statistic: 1.97

Inflation Persistence with Constant Mean (Year on Year Inflation)

The graph III presented below convincingly defines the sluggish behavior of inflation series in terms of mean reversion. We can compare the patterns of inflation series in the graph V with its behavior in graph I (quarter on quarter inflation). Once the series tends to deviate from its mean it takes quite a while for the inflation series to revert back again, this slack in the reversion process is indicative of high degree of persistence which is confirmed through estimated value of mean reversion term presented in table 5 subsequently after the graph III.

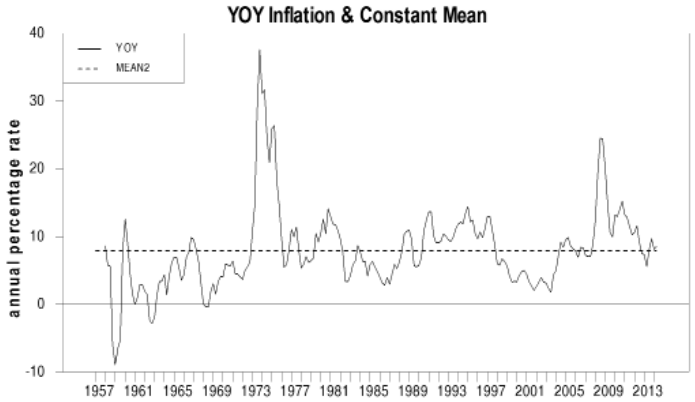

Figure 3: Graph III

Table 5
Inflation Persistence result with Constant Mean

Variable	Coefficient	Std. Error	T-Stat	Significance
$(\pi_t - \mu)$	-0.104	0.0266	-3.9062	0.00012
$d\pi_{t-1}$	0.426	0.0643	6.6267	0.00000
$d\pi_{t-2}$	0.014	0.0705	0.2110	0.83305
$d\pi_{t-3}$	0.102	0.0610	1.6852	0.09341
$d\pi_{t-4}$	-0.3323	0.0615	-5.3949	0.00000
$d\pi_{t-5}$	0.1257	0.0648	1.9409	0.05359
$d\pi_{t-6}$	0.1782	0.0618	2.8834	0.00434

The slack pattern of reversion of inflation series as evident from the above graph is fully testified with the parameter estimate of reversion term. The coefficient comes out to be 0.10 in absolute term which is smaller as compared to quarter on quarter inflation. The measure of inflation persistence traced out of this term is (1-0.10) = 0.90

Inflation Persistence with Time Varying Mean (Year on Year Inflation)

Since the pattern of year on year inflation as reflected in graph III portrays that it is not an appropriate strategy to assume a constant mean therefore it is desirable to fit a trend based on the movement of series overtime. After analyzing the significance of linear, quadratic and cubic trend fitted to the actual series results recommend the selection of cubic trend and treats the fitted values as a proxy for mean of inflation series. The whole exercise of determining the inflation persistence through its mean reversion characteristics as done before has been performed and visual and statistical results are reported in graph IV and table 6.

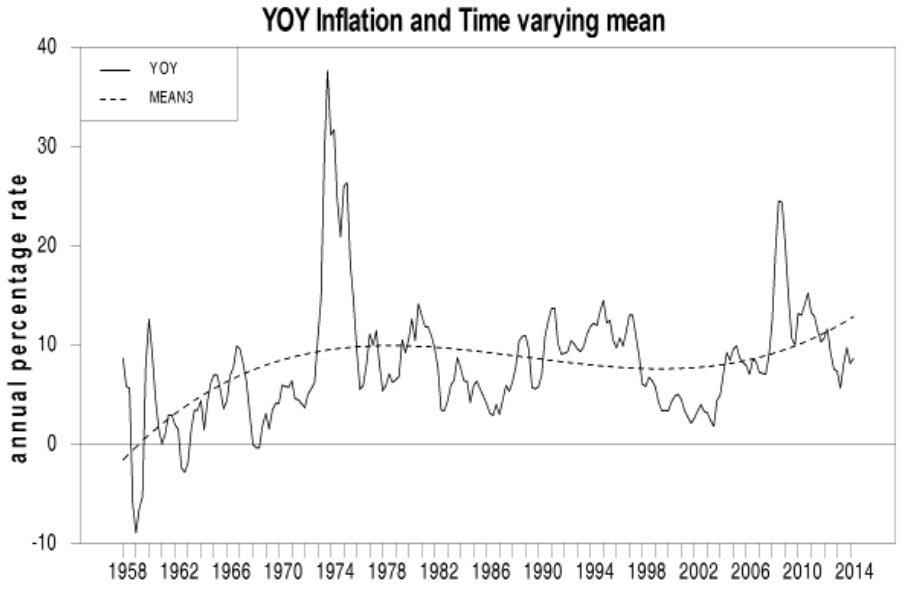

Figure 4: Graph IV

Table 6
Inflation Persistence Results: Time Varying Mean

Variable	Coefficient	Std. Error	T-Stat	Significance
$(\pi_t - \mu_t)$	-0.1440	0.0304	-4.728	0.00001
$d\pi_{t-1}$	0.4500	0.0639	7.034	0.00000
$d\pi_{t-2}$	0.0486	0.0706	0.688	0.49162
$d\pi_{t-3}$	0.1250	0.0607	2.059	0.04062
$d\pi_{t-4}$	-0.3053	0.0615	-4.964	0.00000
$d\pi_{t-5}$	0.1338	0.0638	2.095	0.03733
$d\pi_{t-6}$	0.2010	0.0615	3.268	0.00126

Lags: 6 T-stat: -4.728 aic = 1463.03, sbc = 1486.72 DW: 2.00

The patterns of the inflation series as evident from graph IV lead us to contend that the pace of mean reversion over different sample periods remained slow, especially in between 60's and 70's, 90's and 2000. A general impression is a weak tendency to revert back more often. The visual contention is confirmed from the absolute coefficient of mean reversion in table VII, which comes

out to be 0.14. Likewise, the persistence coefficient row can be inferred from this value that is, which is slightly less than what we had calculated in case of constant mean.

Inflation Persistence and Period by Period trend (Year on Year Inflation)

Another common way of resolving the issue of calculating time varying mean is to figure out period by period trend of inflation series and fitting the trend accordingly in compliance with the rising and falling patterns. The fitted values in turn are used as a proxy for mean. This method of calculating the time varying mean has been found in numerous studies. The procedure proceeds in following way:

$$\pi_t = \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3 + \alpha_4 T_4 + \alpha_5 T_5 \quad \text{..... (i)}$$

Where T1 is the time trend of inflation from 1958 Q1 to 1973 Q2, T2 is the time trend from 1973 Q3 to 1975 Q4, T3 is the time trend from 1976 Q1 to 1997 Q1, T4 is the time trend from 1997 Q2 to 2003 Q3 and finally T5 is the time trend from 2003 Q4 to 2014 Q2. Equation (i) is estimated and the fitted values are extracted to be used as a proxy for mean of inflation. The results of estimated equation (i) and graphical exposition of fitted inflation series are given below.

$$\pi_t = 0.11 T_1 + 0.38 T_2 + 0.07 T_3 + 0.02 T_4 + 0.05 T_5 \quad \text{..... (ii)}$$

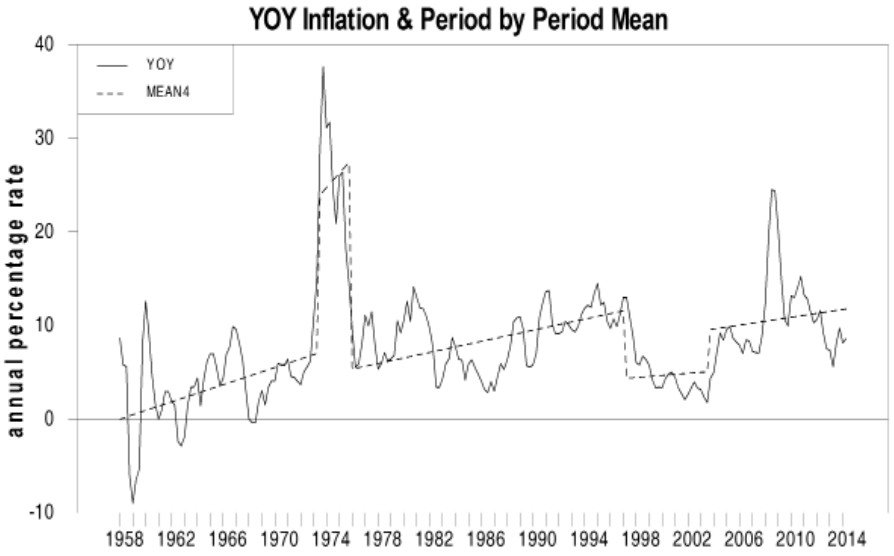

Figure 5: Graph V

Table 7
Period by Period Inflation

Variable	Coefficient	Std. Error	T-Stat	Significance
$(\pi_t - \mu_t)$	-0.24862	0.039	-6.22	0.0000000
$d\pi_{t-1}$	0.46862	0.061	7.57	0.0000000
$d\pi_{t-2}$	-0.0059	0.065	0.09	0.9273919
$d\pi_{t-3}$	0.1307	0.058	2.24	0.0259203
$d\pi_{t-4}$	-0.2743	0.059	-4.57	0.0000079
$d\pi_{t-5}$	0.1181	0.061	1.92	0.0559932
$d\pi_{t-6}$	0.1065	0.057	1.85	0.0653991

Lags: 5 T-stat: -6.22407 The aic = 1448.25 and sbc = 1471.94
Durbin Watson Stats: 1.91

The dotted line in graph V represents the fitted inflation series that has been driven out through the regression analysis of equation (i). Results of mean reversion behavior based on period by period fitted series are displayed in table 7.

Coefficient of mean reversion term in this case comes out to be 0.25 in absolute term, which again show low tendency of reverting behavior towards mean. However this value differs significantly from the mean reverting term in case of cubic fitted mean trend that was 0.14. The inflation persistence coefficient ρ inferred in this case is (1-0.25) = 0.75. The results of all cases discussed in this section are summarized in table 8.

Table 8
Summary

Method	ρ	$\lvert\rho - 1\rvert$
AR(P) QOQ Inflation	0.60	
AR(P) YOY Inflation	0.87	
Mean Reversion QOQ Inflation (Constant Mean)	0.60	0.40
Mean Reversion QOQ Inflation (Time Varying Mean)	0.59	0.41
Mean Reversion YOY Inflation (Constant Mean)	0.90	0.10
Mean Reversion YOY Inflation (Time Varying Mean)	0.86	0.14
Mean Reversion YOY Inflation (Period by Period Mean)	0.75	0.25

Conclusion

Every economic problem in the current era is analyzed with the use of systematic techniques and procedures. This modern tendency of the current era has contributed a lot to the ongoing research in economic perspective. Following the same rigor researchers are keen to explain various dimensions relevant to "Inflation". Inflation is an economic problem which has been debated and articulated from various angles. This articulation is meant to highlight the consequences of being ignorant from considering inflation as a major economic problem.

Inflation has become a serious cause of concern for many nations and finding its root causes and severity in principle and its detrimental effects (persistence) in general has become the supreme agenda of policy institutes. The current study is an exploratory exercise for examining the existence of inflation persistence in Pakistan. Not much literature was available on this topic, therefore this research is considered as an additive note to the available literature on this subject.

The study sought to extract the inflation persistence for Pakistan's economy with some of the conventional tools used for this analysis. Assuming the autoregressive behavior of inflation supplemented with the tool of mean reversion, this study reports reasonably high level of inflation persistence in Pakistan over the course of selected sample range. The results are confirmed by assuming various ways of extracting the mean behavior of inflation series although a slight differential has been observed with relevance to assumption about the mean behavior (i.e. constant, time varying, period by period trend fitting etc.). These results will certainly provide a stimulus for the literature to be evolved in this direction and help policy relevance to be incorporated as well.

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