

**MONETARY POLICY SHOCKS AND INFLATION PERSISTENCE:  
IN CASE OF PAKISTAN**



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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

## **DEDICATION**

*I want to dedicate this thesis to my mother for her endless love, support,  
encouragement and prayers.*

# ACKNOWLEDGEMENT

*In the name of Allah, the Most Gracious and the Most Merciful.*

*All praise for Almighty Allah, the cherisher and sustainer of the worlds and all Respect for Allah's Apostle (Peace be upon Him).*

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# Contents

Abstract.....	7
List of Tables: .....	8
List of Figures .....	9
Chapter 1.....	1
INTRODUCTION.....	1
1.1 Background .....	1
1.2 Research Gap:.....	3
1.3 Research Questions:.....	3
1.4 Objectives:- .....	4
1.5 Significance of the study: .....	4
1.6 Organization of the study: .....	5
Chapter 2:.....	6
Monetary policy and inflation dynamics in Pakistan .....	6
Inflation Persistence and its Types: .....	11
Chapter 3.....	13
Literature Review .....	13
<b>3.1 Theoretical Literature review:</b> .....	13
3.2 Empirical Literature: .....	16
3.2.1 Literature review for Pakistan:- .....	22
3.3. Summary of Literature: .....	23
Chapter 4.....	25
Data and Methodology .....	25
4.1 Introduction: .....	25
4.1.1 Data: .....	25
4.1.2 Selection of Variables: .....	25
4.1.3 Data sources:.....	27
4.2 Methodology: .....	27
Structural FIVAR Estimation Steps:.....	28
Stationarity Tests: .....	28
3.2.1 Estimation method of Fractional Integration parameter: .....	29
Structural Vector-Autoregressive method (SVAR): .....	31

Chapter 5:.....	37
Results and Interpretation .....	37
5.1 Introduction: .....	37
5.2: Trend Analysis:.....	37
5.3. Descriptive Statistics:.....	39
5.3.1. Unit Root Tests: .....	39
Estimation of Fractional Integration Parameter:.....	40
Estimation of Structural VAR: .....	43
Determination of Lags: .....	44
Vector Auto-regression: .....	44
Granger Causality: .....	46
Impulse Response Function: .....	47
Variance Error Decomposition: .....	49
Chapter 6.....	52
Conclusion and Policy Recommendation .....	52
References:.....	54

## **Abstract**

Inflation persistence has been major stress for economies during past few decades. Inflation is monetary phenomenon and the persistence of inflation has broadly attracted attention of economists all over the world. Inflation persistence shows the degree to which future values of inflation are associated to bygone shocks or, in other words, the speed of adjustment toward its long-run value. Indeed, inflation dynamics and the degree of persistence in inflation have been recognized as the most essential parameters for affecting monetary policy's performance. This study estimates the degree of inflation persistence and other macro-economic variables (under multivariate Approach). Secondly, this study allows the long memory property of inflation persistence to examining the effect of monetary policy shocks on Pakistan's economy. Knowing the degree of inflation, offers the vital information, to the central bank, about how to manage the interest rate in order to attain the targeted rate of inflation. The study employed Structural Fractional Integrated Vector Auto-regressive Model for the monthly data of 2004:07-2019:12. Parametric method used for the estimation of fractional integration parameter. The result of the study suggests that there is a high but mean reverting behavior of inflation persistence in Pakistan. Its means that monetary policy shock will affect the inflation for longer period of time and dissipate slower than it is under the assumption of stationarity. The results show the positive and significant impact of monetary policy shocks on inflation persistence.

**Keywords:** Monetary policy shocks, Inflation persistence, Structural FIVAR



**List of Tables:**

<b>Table 5.1: Unit Root test Results at Level .....</b>	<b>40</b>
<b>Table 5.2: Values of Fractional Integrated Parameter and its implication .....</b>	<b>42</b>
<b>Table 5.3: Estimation of Fractional Integration Parameter .....</b>	<b>42</b>
<b>Table 5.4: Lag Selection Criteria for VAR.....</b>	<b>44</b>
<b>Table 5.5: FI Vector Auto regression Estimates .....</b>	<b>45</b>
<b>Table 5.6: VAR Granger Causality/Block Exogeneity Wald Tests .....</b>	<b>47</b>
<b>Table 5.7: Variance Decomposition of IPI.....</b>	<b>49</b>
<b>Table 5.8: Variance Decomposition of Inflation.....</b>	<b>50</b>
<b>Table 5.9: Variance Decomposition of Interest Rate .....</b>	<b>50</b>

## List of Figures

<i>Figure 1.1 Monetary Policy and Inflation Dynamics in Pakistan.....</i>	<i>8</i>
<i>Figure 5.1: Inflation .....</i>	<i>37</i>
<i>Figure 5.2: Interest Rate .....</i>	<i>38</i>
<i>Figure 5.3: Industrial Production.....</i>	<i>39</i>
<i>Figure 5.4: Impulse Response of IPI and INF to Interest rate. ....</i>	<i>48</i>



# Chapter 1

## INTRODUCTION

### 1.1 Background

Monetary policy's central mandate is to manage macro-economic condition with achieving the goal of stable inflation in economy. The Policies of different country's central banks, including Pakistan, highly focused on price stability. One way to determine monetary policy's efficiency is, by determining its role in management of stable inflation rates by measuring the change in inflation persistence. Inflation persistence refers to an important statistical property of inflation, which means the current value of inflation rate is strongly affected by its history (Balcilar, 2004).

Inflation persistence indicates the degree to which future values of inflation are associated with bygone shocks or, in other words, the speed of adjustment toward its long-run value. Indeed, inflation dynamics and the degree of inflation persistence have been recognized as the most essential parameters for affecting monetary policy's performance. Rudebush (2002) states that: "...the nature of the inflation process and the degree of structural inertia has been identified as one of the most crucial parameters affecting the performance of monetary policy".

Inflation persistence has been major stress for economies during past few decades. Inflation is a monetary phenomenon and the persistence of inflation has broadly attracted attention of economists all over world. Because of its important role in determination of optimal monetary policy. It is essential to measure the inflation persistence degree for the central bank, to know that if any monetary policy decision will affect the inflation and then how long it will persist. Therefore, the measurement of inflation persistence is concern among policy makers and economists (Gerlach

and Tillman, 2012). Hence, for optimal monetary policy, it is key objective to know this important parameter of the economy.

From the perspective of monetary policy, the disinflation cost highly depends on amount of inertia that is present in inflationary process. Higher persistence in inflation takes longer time to adjust to a shock and increase the costs of monetary policy (in terms of product or unemployment) to keep inflation under control (Mishkin, 2007), monetary system may require to execute a policy to bring back inflation to its steady state level. Contrarily, low inflation persistence takes smaller time to come back to its equilibrium level after shock (Fuhrer, 2009).

If the shocks effects on inflation have a transitory effect then monetary policy should not react (Aoki, 2011). Hence, for optimal monetary policy, it is a key objective to know this important parameter of the economy. Globally, it becomes a huge problem for many developing countries (Batini, 2006).

Several countries have experienced very long periods of inflation. The discussion about the degree of inflation persistence has not been limited to developed countries only like US inflation. Rather, it includes different measures of inflation for different countries. For instance, at a theoretical level, the concept of inflation persistence has been linked to design of robust monetary policy (Benati, 2002).

Pakistan is one of the very typical among these countries, with a very long period of high inflation experience since the late 1970s. In Pakistan's history, fluctuations in inflation have always been a matter of concern. A high and sustained economic growth in combining with low inflation is the significant objective of macroeconomics policy. Low and stable inflation is the indicators of a stable macroeconomics environment (Agha et al., 2005).



To keep inflation low it is important to understand inflation dynamics. Monetary policy's instrument is considered as function of degree of inflation persistence (Walsh, 2003). The Intrinsic nature of inflation persistence for Pakistan's economy is concerned. There are various reasons for the inflation persistent that firm's decision of price setting is backward looking and rely on monetary and fiscal policy changings as well as their decision changing according to the changing in inflation targets and changings in exchange rate regime (Hanif, et al. 2016).

### **1.2 Research Gap:**

In the case of Pakistan, a finite number of studies have focused on the analysis of inflation persistence. Notable studies in this context include: Hanif *et al.*, (2016) & Qayyum and Malik (2019) did considerable work in this regard, which estimates the intrinsic inflation persistence for Pakistan under univariate approach. But did not consider establishing link between monetary policy actions and inflation persistence.

The current study contributes to the previously mentioned studies on the following ground: Firstly, this study estimates the degree of inflation persistence and other macro-economic variables (under multivariate Approach). Secondly, this study will allow the long memory property of inflation persistence to examining the effect of monetary policy shocks in Pakistan's economy. Thirdly, this study uses the structural fractional integrated VAR model that did not apply in earlier studies in context of Pakistan. This provide us margin to fill up this gap in case of Pakistan. However, such work is quite pronounced in studies at international level (Lovcha and Laborda, 2018).

### **1.3 Research Questions:**

- How much inflation is persistent in Pakistan?

- How monetary policy shock effect inflation in presence of long memory?

#### **1.4 Objectives:-**

- To measure the inflation persistence by allowing both long and short memory.
- To examine monetary policy shocks impact on high degree of inflation persistence in economy.

#### **1.5 Significance of the study:**

Inflation has been a major problem for many economies. Monetary policy decision's impact on the economy are highly affected by inflation dynamics. The dynamics of inflation make information available to policy makers, on short-term effects of monetary policy statements, or help to forecast the behavior of economy following a shock or major monetary policy pronouncement.

Ups and down in inflation effects economy's performance and an individual consumption choices as well. To keep check on inflation, it's crucial for policy makers to have better sense of inflation dynamics. The degree of inflation persistence can have significant importance for economy because of its effects on economic efficiency. Knowing the degree of inflation, offers the vital information, to the central bank, about how to manage the interest rate in order to attain the targeted rate of inflation (Sripinit, 2012).

The long memory model is used to quantify shock's effect on economy. Policy makers possibly will use fractionally integrated models, for inflation, to take good advantage in modelling inflation, and to forecasts short and long term path of inflation in future. Another attraction of long memory



models is that, they indicate different long run predictions and shocks effects to conventional approaches in macroeconomics. Which are essential for the execution of deflationary policies.

### **1.6 Organization of the study:**

This study comprises of 5 sections: Chapter 1 represent the background and introduction of the study. Chapter 2 states the monetary policy and inflation dynamics in Pakistan. Chapter 3 explains the related literature. Chapter 4 describes the Data, Methodology and explanation of the model used in this study. In Chapter 5, we discuss the results of analysis. Finally, Chapter 6 based on conclusion and some policy recommendations.

## **Chapter 2:**

### **Monetary policy and inflation dynamics in Pakistan**

Any country's monetary authority implements monetary policy through the interest rate or money supply management in the economy, to attain certain objectives i.e. price stability, and to control inflation. The achievement of these specific goals can only be possible if monetary policy actions are transferred effectively in the economy. The monetary policy view is the sustenance of price level in the economy, to always keep the main focus on social and economic planning (Idris, 2019).

Furthermore, it has been witnessed and discussed, by different monetarists, that money supply and inflation are intrinsically linked to one another. Conversely, it is also seeming that, how monetary policy actions affect economic progress either positively or negatively. That's why, it's important for monetary authorities to fully understand the behavior of any variable, and understanding the dynamic and response of any variable due to any change are always the hot debates dominant topic in the field of macroeconomic at different levels of the economic circle.

Out of all macroeconomic variable, stable inflation is the most crucial objective for monetary to attain that's why Conflicting to economists that believe on the traditional view that complete elimination of inflation from the economy is not possible, it is an ongoing and continued phenomenon, that is, inflation is present all the time in the economy (Khan and Ahmed, 2011).

The inflation rate experiences variations now and then concerning the prevalent situation. This is why the basic aim and interest of macro-economic policymakers are to regulate the inflation rate and to sustain it at a specific optimal level that mostly depends on the type of fiscal and monetary policy and the accessibility of genuine economic capability.

Pakistan's inflation is a multi-source phenomenon, but monetary authority always takes measures to keep it lower and stable level as it affects the poor disproportionately. Different sectors of the economy affect inflation differently. In Pakistan, inflation can be worse if it crosses will be double-digit. Different sources of inflation can be supplied (oil and food prices) and demand-side factors.

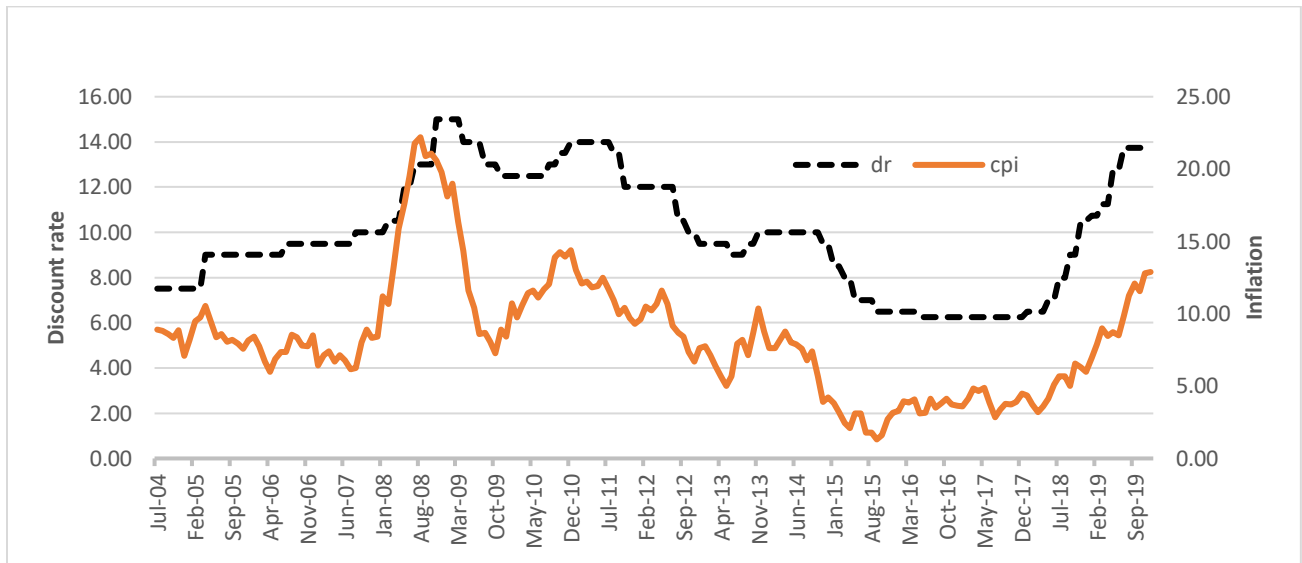
A reasonable rate of inflation around 3 to 6 % is mostly considered as the reasonable rate of inflation and consider its positive effects on the economy by encouraging investment which leads to increase production, that further thus lead to increase wages (i.e. increase consumption). But, inflation causes serious effects to the economy if it will cross its limit beyond 3-6% by decreasing the money's value which results in uncertainty in the value of gain and loss for lenders, borrowers, sellers, and buyers. This increase in uncertainty lowers saving and also investments.

High inflation can not only erode the gain from growth but also makes the poor worse-off and cause to broaden the gap between rich and poor. If a larger portion of the increase in inflation is due to food prices, it will be harmful to the poor more than other groups of the individual in the economy. Since more than half of the family's budget of low-income earners goes for the consumption of food. Second, it re-distributes income/earnings from fixed-income groups to asset owners and large variable income earners i.e. profits (Ramey, 1993).

The inflation situation in Pakistan is highly volatile from the start. In the 1960s inflation was recorded as 3.3% on average and increase to 11.9% in the 1970s. In the 1980s, inflation decrease to 7.5 %. But creates a serious problem for economists in the 1990s. As in the first 7 years of 1990s inflation was higher, showed double-digit. This high inflation was because of several reasons including; monetary policy, supply shocks, external shocks tax policy pricing policy, and people's expectations was the main factor of the high inflation prevailing in the economy. During the next



10 years, till 2007 inflation drop down to single digits from 3-9% because of the strict budgetary, improved supply, and low prices in the international market. The rate of inflation remained at the lowest level in 2002-03, i.e. 3.9 percent. This lowest level of inflation was achieved by strict fiscal restraint, output recovery, decrease in taxes, and exchange rate appreciation.



**Figure 1.1 Monetary Policy and Inflation Dynamics in Pakistan**

Above figure shows the monetary policy and inflation dynamics in case of Pakistan. As can be seen in figure 1.1 that during 2003-04, inflation reached high to 9.3% in 2005:06. This high inflationary situation was because of an increase in support price of wheat, unavailability of wheat and increase in international oil prices. In response to this hike in inflation, SBP implement strict monetary policy to ease demand. The SBP raised the discount rate from 9 -9.5%.

The rise in interest rate was aligned with international increasing trends in interest rates and inflationary pressures in the economy. The inflation during the period of July-April 2007-08 was 10.3% on average. High prices of food (n international market), fuel and other commodities and weaker Pakistani currency, rise in import prices was mainly responsible for the high prices year. The SBP continues with the tight monetary policy by increasing the discount rate to 12%.

At the start of 2008, inflation reached 20.3% at its highest level, but in late 2008, it started decreasing. But still prevailing double-digit inflation in the economy. Although, the price has shown a downtrend to 17.2% in April: 2009 after reaching a high level of 25.5% in August 2008. Then the monetary policy adjusted the discount rate upward in November 2008.

Then in 2009 inflation shows a decreasing trend to 13.6% and in 2010 reached 13.9% and then further decreased to 10.2% in 2012. Due to a positive base effect, and due to the change in the global commodity price. SBP respond with a more aggressive tightening from May 2008 by an increase in the discount rate. 15%. In November 2008, during the balance of payment crisis, the central bank has reduced the discount rate to 12.5%, in reaction to a gradual decrease in inflation, and the suppression of demand pressures.

The year 2010-11 was the period of high inflation and caused the alarming situation to macroeconomic stability. At the beginning of 2010-11, Pakistan faced several unfavorable aspects impacting the demand and supply situation, which creates imbalances in the economy. During 2010-11, the structural problems of Pakistan and international commodity price progression jointly gave a push to inflation in the latest months. SBP has maintained its bank rate at 14 percent unaltered during the last three policy statements after increasing the policy rate by 150 base points within three installments.

In July 2011, Inflation was at highest at 12.4%. However, by the end of 2011, it dropped to single digits at 9.7%. Thereafter, it increased and reached to 11.3% in April 2012. Both supply and demand-side factors were responsible for inflation escalation. These included supply-side disturbances as well as an upsurge in transportation cost because of high oil prices and on the demand side, the price increase was the consequence of the inflationary gap. During 2011-12, SBP

implemented an expansionary monetary policy. It cut the discount rate to 13.5% from 14%. However, the rate was further reduced to 12% in October 2011, to boost private sector credit and investment. During 2012-13 inflation started with single digits and remain at single-digit due to improvement in supply-side the discount rate remained unchanged at 9.5%.

Inflation shows an increasing trend in November 2013 to 10.9% because of electricity prices with supply disturbance of commodities. SBP reversed from accommodative to tight policy and maintained a discount rate of 10%.

Inflation starts decreasing to 2.1%, during 2014-15 because of government efforts and favorable policy measures achieved stable exchange rate position, better production of crops, and better commodity supply. The discount rate shows a decrease from 9.5% to 5.75% in May-2016. It was the lowest level during the last 44 years showing enhanced macroeconomic conditions to the end of 2016.

By the start of 2019, inflation started rising. It has increased to 5.8% in July-2018 and further increased to 6.8% in October 2018 as a result of high gas prices. The Oil and Gas Regulatory Authority (OGDCL) reviewed the sale prices of natural gas after holding them unaltered for nearly 2 years. SBP implemented policy rate reversal and steadily raised it since January-2018.

From May 2018, inflation starts increasing due to depreciation in the exchange rate and an increase in international prices of commodities. Monetary establishments took measures to lessen budget deficits and considerably tightened up the monetary policy. It enabled increased flexibility in the exchange rate modifications to control surplus aggregate demand and shift towards stabilization at the macroeconomic level.



## **Inflation Persistence and its Types:**

It is usually considered that inflation is habitually susceptible to various macroeconomic disturbances that mostly result in the diversion of the current rate of inflation from its mean value that is generally identified as the inflation target. Any shock in the economy can either be of a long-lasting manner or else they eternally affect inflation, e.g., because of the presence of rigidity in nominal prices, which usually leads to long-time deviation of inflation from its targeted level. That's the reason, the knowledge concerned with the lastingness of shocks and degree from which inflation deviates from fixed target plays a vital role from the central banks perspective, which finds that attaining stable inflation is a prominent goal. Regulation of current inflation, to its average value following an incident of shock can be characterized by the speed by which inflation comes back to its long-run level. The higher the speed, the less difficult for central banks is to pursue the maintenance of price stability (Christiano and Eichenbaum, 1992).

The degree of inflation persistence is characterized as one of the most important features to measure. According to Willis (2002), inflation persistence is defined as the "speed with which inflation returns to baseline after a shock".

In economic publications, two major approaches to measuring inflation persistence that is used frequently, named, structural measures and parametric measures. Amongst the parametric measures, several autoregression models are well-known, while for structural measures, methodologies based on the New Keynesian Phillips curve are found.

The notion of inflation persistence refers to the association between current and past inflation. Furthermore, Fuhrer (2009) discriminates intrinsic and inherited inflation persistence linked with factors that determine inflation persistence.

Benati (2002) differentiates three types of persistence in inflation which are, persistence that results from positive serial-correlation between variables taken into account for the calculation of inflation, persistence that results from time delays, between methodically carried out monetary policies of the central bank and the impact it has on inflation and persistence that result from the late reaction in inflation to nonsystematic actions of financial agencies of a country.

In contrast, according to Altissimo et al., (2006), 3 kinds of inflation persistence, named extrinsic inflation persistence, that results from a change in marginal costs (MC); intrinsic persistence, due to the association between current inflation with its previous values and lastly, expectation based persistence in inflation that is expected due to historical trends.

## **Chapter 3**

### **Literature Review**

There is great body of empirical and theoretical literature to measure monetary policy shocks innovation on inflation and economic aggregates. The present chapter includes the review of theoretical as well as empirical literature on measuring effects of monetary policy shocks and literature review related to inflation-persistence. This chapter consists of four sections. 1<sup>st</sup> section reviews theoretical literature on the long-term and short-term effects of monetary policy via transmission mechanisms. 2<sup>nd</sup> section reviews empirical literature. 3<sup>rd</sup> section explains the existing literature on impacts of monetary policy shocks in Pakistan and literature related to inflation persistence, and last section will cover the literature gap and summary of literature.

#### **3.1 Theoretical Literature review:**

Both Keynesian and Monetarist schools of thought agreed on the point that in the long run, monetary policy is neutral, but timing and magnitude of short-run effects are still open to discussion. So, before monetary policy implementation, it is necessary to explore the transmission mechanisms through which these effects occur. Monetary policy impact on the economy is the most relevant topic in research.

Policy adopted by monetary authorities / central bank to guarantee the price stability in the economy referred as monetary policy. The tools used by monetary authorities to fulfill their objective (of price stability) are interest rate and money supply. According to the Quantity theory of money, there exists a direct relation between the money supply and inflation. If the money



supply increases in the economy, the buying capacity (marginal value) decreases, so consumers have to pay more for the same commodity to purchase.

Ando and Modigliani (1963) life cycle's theory of consumption and Tobin's Q theory admit that monetary policy transmitting channel deals with interest rate to asset prices. But, Kamin et al., (1998) determine that, as compared to developed economies in developing countries asset-price channel is volatile and weak. Any shock in monetary policy affect the economy and macro-economic variables differently. The affect highly depends the persistence level of macro variable. From literature, inflation can be considered a high persistent macroeconomic variable. Which take longer time to dissipate. Gali and Gertler (1999) explain the reason that mostly firms set their prices by looking at past prices.

According to interest rate network decrease in interest rate by adopting contractionary monetary policy through increasing the bank reserve, works in conventional framework of macroeconomic model by changing interest rate (monetary policy). Decrease in the interest rate will decrease the savings of consumers. So this will lead to an increase in the proportion of consumption of consumers, as the consumption will increase in the economy so that AD will also increase and according to the demand law increase the demand will lead to increase in prices or higher inflation. (Romer and Romer, 1990; Ramey, 1993; Taylor, 1995) believe in the importance of interest rate mechanisms on the investment behavior of consumer and business.

The monetary policy action affects the transmission to the economy through different channels called "Transmission mechanism of monetary policy". Ireland (2010) Monetary policy transmission mechanism is the method with which policy changes in interest rates or the money

supply are transmitted into changes in inflation and other variables including output. Monetary policy controls inflation through different channels including interest rate channel, balance sheet channel, exchange rate channel and expectation channel. It has been proven by Agha, et al. (2005) that the interest rate network acts as a medium of monetary policy transmitting instrument in Pakistan.

In theory, the main channel for transmission of monetary mechanisms is the interest *rate channel*. It is an important channel of monetary policy, denoted as a leading mechanism, which works for conventional macroeconomic frameworks. Interest rate channel is based upon the mechanism of monetary policy, through which change is urged by the central bank, in short-run (nominal) interest rate, that affect price level, and as a result employment and output. Hence, a significant role played by this channel in transmission of monetary shocks to the economy (Agha et. al, 2005).

Asset price channel of monetary transmission mechanism works through change in value of the stock market of households and firm's wealth, and it works through domestic prices of different assets, such as bonds and shares. It executes significant impact in transmission of monetary policy. As, due to different shocks in the monetary policy, asset prices swing in an extreme dissimilar way.

According to the *Asset price* channel when the interest rate increases on bank deposits people will prefer to increase bank deposits rather than holding stocks or bonds etc. As demand for stocks and bonds decrease the wealth of these asset holders decrease. Decrease in wealth will decrease their expenditures, so that the demand of goods and services of the economy decreases as demand decreases so prices also (Agha et. al, 2005).

Another transmission mechanism channel is the expected price channel through which any expected news of high inflation by a credible bank in the economy will alter the decisions of the stockholders in the economy such that inflations will be low in near future.

### **3.2 Empirical Literature:**

Recent literature related to inflation persistence shadows 2 major paths. 1st path addresses macroeconomic methods which attempt to catch the inflation persistence in real world. The 2nd path, that is also a motivation for the present study, seeks out to measure inflation persistence empirically. A general approach is simply to implement univariate time series approach, in which inflation persistence is signified by the sum of autoregressive coefficients of AR model for inflation i.e. Pivetta e Reis (2007) and Baillie (1996).

Bratsiotis et al., (2002) states that extent of inflation persistence highly depends upon monetary policy objective, if monetary policy only goal is to get stabilize inflation we will get lower degree of inflation persistence after the study on Canada, Australia, Finland, Spain, Sweden and New Zealand for 1980- 1990.

Levin and Piger (2004) demonstrate that existence of increased extent of inflation persistence might be connected to alterations in normal inflation. They proved that the inflation persistence is not completely the trait of only economically developed countries. Franta et al., (2009) analyze degree of inflation persistence for new members of EU for 1993-2008. They conclude that intrinsic inflation persistence is higher in some countries i.e Poland and Hungary.

Balcilar (2004) examine the persistence in inflation for Turkish economy by using the data for CPI and WPI on monthly basis for the time span of 1982-2002. He measured the degree of inflation persistence by estimation of fractional difference parameter and come up with the results of very low degree of inflation persistence results at disaggregate level, and conclude that the high persistence is only because of aggregation.

Mishkin (2007) states that inflation persistence cause to increase in monetary policy cost to stabilize inflation in form of high unemployment. Benati (2002) analyzed that development of inflation persistence in different economies for various monetary regime, and measure degree of inflation persistence.

Kang et al., (2009) analyze the existence of inflation persistence in US by using impulse response function, and allowed multiple regime shifts for parameters. They used GDP deflator for 1959-2006 for this purpose. They concluded that, extent of inflation persistence relies upon absence and presence of well-established monetary policy.

Pincheira (2009) estimated inflation persistence for the economy of Chile and came to the conclusion that, it shows decreasing trend from past several years. However, this is a simplified procedure of analyzing variable that does not consider complete dynamics of inflation as it only depicts intrinsic persistence resulting from price and wage inflation.

Fuhrer (2011) comprehensively analyze inflation persistence concept in theory of macro-economics and suggests that main source of inflation is intrinsic factor. Large number of studies



indicates high persistence in developed countries, due to changes in inflation target, structural change, change in exchange rate or monetary policy shocks (Levin and Piger, 2004).

Gadea and Mayoral (2006) examined inflation persistence for 21 OECD countries. The methodology they used is fractional integration approach for the time period 1957:Q1-2003:Q4. They found that shocks do not effect permanently and inflation is persistent. While Benati (2004) analyses 20 OECD countries and see the evidence of low degree in inflation persistence. Burdekin et al., (1999) mention different factors including war, shocks or any reform in central bank policies effect the extent of inflation persistence.

Davig and Doh (2009) claims that inflation persistence can be curb by monetary policy by adjusting the interest rate in response to change in inflation. Batini (2001), study the monetary policy impact on inflation for UK and USA and conclude that monetary policy maximum effect on inflation in reduced form after a year of implementation.

Rangasmay (2009) examine the persistence in inflation for South Africa. The data used in that study are for core inflation since 1965 for both aggregate and disaggregate level. For aggregate level data set. The results conclude that persistence of inflation is higher in aggregate level than disaggregated level.

Oliveria and Petراسi (2010) examine inflation persistence in 23 industrial and 17 rising economies. They used the quarterly data set from 1995 by using SAR technique. They conclude that degree of inflation persistence in low in industrial economies that emerging economies. Zhang (2011) examines the relation for Inflation persistence, expectations regarding inflation, and monetary

policy in China by employing monthly data for the period of 1979 to 2009 and applied the autoregressive approach to estimate of inflation persistence. The research discovers that fundamental changes in inflation persistence are linked with change in expectations regarding inflation.

Gerlach and Tillmann (2012) examined the relation among inflation targeting and persistence of inflation in Asia. They used autoregressive method for monthly data for 1985:1-2010:1. They found decrease in inflation persistence after adopting for inflation targeting.

Meller and Nautz (2012) analyzed inflation persistence pre and post EMU. They used fractional integration approach for pre (1966 to 1998) and post EMU (1999-2007) the result shows in euro area inflation persistently decrease after EMU.

Milani and Treadwell (2012) employed a small-scale DSGE model in order to untangle unforeseen and foreseen monetary policy disturbances and examined their impacts. For the evaluation, likelihood-based Bayesian methodologies are used for US data ranging from 1960:q1 to 2009:q1. The variables used are output gap, inflation, and federal funds rate. They demonstrated that unforeseen monetary disturbances and shocks tend to have little and shorter-term effect on the output but a greater, retarded and prolonged impact because of foreseen policy disturbances or shocks. The general proportion of economic variations that may possible be assigned to monetary policy continued to be limited.

Pradana and Rathnayaka (2013) established link between economic growth and inflation, with aim of examining short-term and long-term correlation between them. The study focused on 3

Asian countries for 1980-2010 using Johansen's cointegration approach, Granger causality and vector error correction model (VECM). They conclude the negative and long run significant relationship among inflation and economic growth in Sri-lanka. While for china, they found significant and negative short run relationship.

Alagidede et al., (2014) investigate the persistence of inflation at aggregate and regional level in Ghana. The study also investigate the persistence across 13 sectors for core and headline inflation using fractional integration methods of GPH and ML. they conclude that high degree of persistence present in inflation and its components.

Caporin and Gupta (2017) examined the long run property of real interest rate. The study used the quarterly data for 1960-2010 for prices. They used the fractional integration model for the measurement of persistence. They also explain that fluctuation in interest rate is due to the monetary policy shocks. The results conclude that South Africa shows the high level of persistence but with mean reversion property.

Bratsiotis et al., (2015) examine that after the adoption of inflation targeting, inflation persistence reduces significantly. They used quarterly data for this purpose (1962:q2-2001:q2) and used autoregressive approach and the result shows inflation persistence decreases after adopting the inflation targeting policy. Inflation applies a positive pressure on economic growth by means of encouraged productivity, increased output level and promotion of total factor productivity (Umaru and Zubairu 2012)

Canarella and Miller (2016) also examined the impact of targeting inflation on inflation persistence using the Fractional integration approach. The result shows the decrease in inflation persistence after inflation targeting.

Mistral (2017) analyze inflation persistence in Croatian economy. The study used the BVAR model. The data used in the study was on monthly basis for the time span of 2005-2013 for CPI and PPI. The calculated inflation persistence shows the value of 0.88 which confirmed high inflation persistence in country. To understand the impacts of monetary policy on prices and output, it's essential for monetary authorities to accomplish the key goals of their major policies particularly stabilization of prices which is the chief aim of monetary policy in addition to growth. Central bank adopts different policy tools or disciplines to have its control over to manipulate money creation in the economy and the reserves of commercial banks. The nature of monetary regimes depends on this behavior of central bank. (Hetzel, 2017).

Moreira et al., (2018) applied fractional integration approach to measure the degree of persistence in emerging economy by using ARFIMA. The study conducted on the monthly data of 2004-2015 and found the high degree of inflation persistence. Lovcha and Laborda (2018) examine the persistence of inflation and other variables for US. The data used for their analysis include 1979:Q3-2007:Q4 by using VAR and FIVAR. They found inflation persistence remain stable across different sample periods.

Gill-Alana and Trani (2018) examined degree of inflation persistence by applying the methods of long memory. The study is done for the time period of 1660-2016 by using parametric and semi parametric methods for fractional integration. They prove the high degree of inflation

persistence in UK. Gil-Alana et al., (2018) examine persistence in in inequality of income for 26 OECD countries for a time period of 1963-2008 by using fractional integration and found highly persistence in income inequality.

### **3.2.1 Literature review for Pakistan:-**

Agha et al. (2005) examine the monetary policy transmitting mechanism with focus on monetary links that conduct shocks. He concluded the presence of powerful price puzzle and also concluded that the channel of bank lending is almost all significant channel of Pakistan. He also focused on tightening monetary policy leads to increase in inflation.

Khan (2008) analyzed the short-run effect of unforeseen change in monetary policy on macroeconomic variables in Pakistan. He concluded that positive nominal shocks will cause the output to increase in the shorter run but it will not last between 23 to 32 months timespan. It explains the long-run money neutrality phenomenon in case of Pakistan.

Hussain (2009) used methodology of VAR for analyze the effect of output and inflation in Pakistan. He concludes that from his finding that exchange rate channel is most important and significant ways for controlling inflation and output as compared to other channel.

Khan and Din (2011), studied Pakistan economy in the context of Dynamics of Macroeconomics Model. The period was from 1972 to 2009 and the main outcome of the analysis is that the important effect on the manufacturing side in the long runs by raw material and industrial machinery. Munir (2012) estimated the dynamic impacts of monetary policy on macroeconomic variables in Pakistan. The effects of monetary policy at aggregate level were measured by VAR



and FAVAR models. They found that the exchange rate channel worked efficiently in case of Pakistan. Moreover, it was evident that monetary policy affects output in short run.

Hanif et al., (2016) studied inflation persistence based on aggregate, group level CPI and individual prices of commodities. They use data for individual and group level from 2000-2011 and for overall inflation data goes from 1959-2011. They found that overall inflation shows less but considerable persistence. Looking group-wise, in the timespan of 2001-2011, food inflation does not demonstrate any considerable inflation persistence.

Qayyum & Anwar (2019) did noticeable work in this aspect which explores intrinsic inflation persistence for overall inflation on quarterly and yearly basis and found high level of intrinsic inflation persistence in Pakistan by using univariate approach.

### **3.3. Summary of Literature:**

The literature has provided motivation to explore inflation persistence, essentially because of its significance in decision making of monetary policy. A large number of studies analyze inflation persistence dynamics for some economies. Summary of literature review suggests that most of the studies consider a group of countries, particularly euro area (Meller and Nautz, 2012; Altissimo et al., 2009). Other group of countries that measure inflation persistence are: Organization for Economic Cooperation and Development (OECD) (Gadea and Mayoral, 2006; Gil-Alana et al., 2018; Canarella and Miller, 2016); for Asia (Gerlach and Tillmann, 2012); Central and Eastern European (see Cuestas and Harrison, 2010). On the other hand, few country specific studies on the analysis of inflation persistence. Noteworthy among the country-specific literature include Zhang (2011) & Lovcha and Perez-Laborda (2018).

In case of Pakistan, work of Hanif et al., (2016) and Waqqas and qayyum (2018) did considerable work but in terms of intrinsic inflation persistence.

### **Literature Gap:**

Most of the studies in literature only focused on the measurement of intrinsic inflation persistence by using Auto regressive method under univariate approach. This study tries to fill the gap using multivariate approach to measure the monetary policy shocks impact on economy by measuring the long range dependence in inflation persistence. Ups and down in inflation effects economy's performance and an individual consumption choices as well. To keep check on inflation, it's crucial for policy makers to have better sense of inflation dynamics. The degree of inflation persistence can have significant importance for economy because of its effects on economic efficiency. Knowing the degree of inflation, offers the vital information, to the central bank, about how to manage the interest rate in order to attain the targeted rate of inflation (Spulber, 2012).

## Chapter 4

### Data and Methodology

#### 4.1 Introduction:

This chapter include, 2 sections of data and methodology, section 3.1 discusses the data under which section 3.1.1 discusses detail about the selection of variables and section 3.1.2 includes the information about the source of data. Section 3.2 discusses the methodological steps.

##### 4.1.1 Data:

For analyzing the impact of monetary policy shocks and inflation persistence on the economy following variables are used:

1. Consumer Price Index as a measure of inflation.
2. Discount rate as proxy for interest rate.
3. Industrial production index as a proxy for the economic activity.

The data set consist of above mentioned variables choose with the help of existing literature.

##### 4.1.2 Selection of Variables:

Description of variables is given below:

##### **Inflation:**

There are various measures of inflation that are used in empirical analysis; the widely used measure of inflation is GDP deflator (Karras & Stokes 1999) and CPI (Aye & Gupta, 2012). We prefer CPI (consumer Price Index) for our study. As, data on GDP deflator is not available at the monthly

level, they are available only for quarterly basis. CPI includes the prices of imported goods which are not included in the GDP deflator and therefore it provides a better measure of prices prevailing in the economy. Symbolize as “INF”.

Inflation rate ( $\pi_t$ ) is estimated by taking the log difference of the consumer price index (CPI) multiplied by 100.

### **Interest Rate:**

Different papers use different measures of monetary policy stance e.g. broader money (Campbell et al., 1997; Aye & Gupta 2012), non-borrowed reserves (Christiano and Eichenbaum 1992), interest rate (federal fund rate) and Romer et al., (1990) to measure the monetary policy shocks. However, interest rate is the widely use measure of monetary policy in literature. In our study we use discount rate as interest rate. In our study we use discount rate as interest rate. Symbolize as “INT”.

### **Economic Growth:**

For determining the real activity of economy, existing literature provide choice between Gross domestic production and industrial production index (IPI). But IPI, available as large scale manufacturing index, is more favored measure than GDP (Munir, 2018).As, GDP is available only at annual frequency while industrial production index is available at monthly frequency.

Industrial production is an economic indicator, which calculates production of different sectors such as output production from and other sectors like electricity, gas and oil (Diebold and Inoue, 2001). The reason given by Lo & Piger (2003), while preferring IPI as measure of economic activity is that, manufacturing sector reacts more intensely to monetary shock than aggregate output. Apart from this reason, most of the studies for asymmetric effects of monetary policy have

used IPI, thus the use of this measure will make the results comparable to other studies as well as to existing empirical evidence in case of Pakistan.

#### **4.1.3 Data sources:**

The data used is time-series monthly data from 2005:09-2019:12 for Pakistan economy.

Selection of time span is based on data availability.

The data sources include the State Bank of Pakistan (SBP) and International Financial Statistics (IFS).

#### **4.2 Methodology:**

The study basically employed Structural fractional integrated Vector-Auto Regressive model (Structural FIVAR model). Large set of empirical work uses the structure Vector Auto Regressive model in examining the effects of monetary policy shocks. As, the Vector Auto Regressive model imposes stationarity assumption, indicates a rapid exponential decrease of the responses of the variables to the monetary policy shock (Taylor 1995).

In view of, high degree of inflation persistence and many different variables were included in these models. High inflation persistence is the widely discussed topic (Pivetta and Reis, 2007). To join the conflicting evidence evolving from testing of unit root, Ball (1993) and Wlsh (2003) proposed fractionally integrated (FI), process.



### **Structural FIVAR Estimation Steps:**

We followed two step estimation method:

*In the first step* we estimate the fractional order of integration for all the variables, and take the difference to make them stationary.

*In the second step*, we applied SVAR model in order to estimate the effect of monetary policy shocks.

### **Stationarity Tests:**

As, we are dealing with the monthly data so there is a possibility of seasonality; unit root in the data. To check the properties of time series data following test are use.

### **Augmented Dickey Fuller Test:**

First we check variables stationarity through Augmented Dickey Fuller (ADF) test.

$$\Delta Y_t = a_1 + a_{2t} + \beta Y_{t-1} + \sum_{i=1}^n \gamma_i \Delta \delta_{1=i} + \varepsilon_t \quad (1)$$

This ADF test equation applies to test the unit root. Whereas  $\beta$  shows the trend term in the model. The above equation shows both trend and intercept. The t-statistics value used to check the significance of coefficient ( $\beta$ ), for this purpose make null and alternative hypothesis (Gujarati, 2004).

$$H_0: \beta = 0 \text{ means series is } I(1)$$

$$H_o: \beta \neq 0 \text{ means series is not } I(1)$$

The Augmented Dickey-Fuller (ADF) test is the power of the test. It is very low if the process is nearly non-stationary which means the process is stationary but with a root close to the non-stationary boundary (Balcilar 2004).

**Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test:**

To avoid the constraint that ADF test always has a low power, Kwiatkowski, Phillips, Schmidt, and Shin (1992) suggested an alternative test.

$$Y_t = \beta + \gamma_t + \mu_t \tag{2}$$

$$H_0: \gamma = 0 \text{ means series is } I(0)$$

$$H_0: \gamma \neq 0 \text{ means series is not } I(0)$$

If the contradictive results are reached based on both ADF and KPSS tests, often regarded as a symptom of long memory in the data.

However, none of the above mentioned tests have command against FI.

**3.2.1 Estimation method of Fractional Integration parameter:**

Long memory/short memory property of a series shows that, the values of series observed in lags are co-related among them-selves or the effect of any event (i-e; shocks) can be determined.

Above mentioned unit root tests (ADF and KPSS), do not have power against the measurement of memory of any shock.

Different test used for the estimation of fractional difference parameter include: Heuristic methods (i-e. Hurst, 1951; Lo, 1991). Semiparametric methods (e.g. Geweke & Porter-Hudak, 1983). Maximum likelihood methods (e.g. Whittle, 1951; Sowell, 1992).

By following the first 2 categories; we can estimate, value of d, which is long memory parameter.

While, in last, we estimate the all parameters simultaneously.

In this study, we use the parametric method to estimate the parameter of long memory parameter.

The advantage of this approach is that it provides the opportunity to acquire an estimator that has good properties of robustness (Ando and Modigliani 1963).

This method is based on the statistic,

$$X_{(n)} = \frac{R_{(n)}}{S_{(n)}} = \frac{\max_{1 \leq x \leq n} \sum_{i=1}^x (Y_i - \bar{Y}_i) - \min_{1 \leq x \leq n} \sum_{i=0}^x (Y_i - \bar{Y}_i)}{n^{-1} \sum_{i=1}^x (Y_i - \bar{Y}_i)^2} \quad (3)$$

Where,

$$\bar{Y}_i = n^{-1} \sum_{i=1}^n Y_i$$

n = sample size this method allow us to estimate d (fractional integration).

### Transformation of series:

So after estimating the value of d (fractional difference), we make the series stationary to apply SVAR.

$$(1 - L)^d x_t = \mu_t \quad (4)$$

$$(1 - L)^d = \sum_{k=0}^{\infty} (-1)^k \binom{d}{k} L^k = 1 - dL + \frac{d(d-1)}{2} L^2 - \frac{d(d-1)(d-2)}{6} L^3 + \dots$$

L= Lag operator

$\mu_t = stationary$

d = any real value

$x_t = series$

### **Structural Vector-Autoregressive method (SVAR):**

For the estimation we used Structure Vector Auto Regression (SVAR) model. The SVAR model was widely used in the empirical works in past (Bernanke, 1996; Watson and Blanchard, 1994; Sims 1981 1986). The SVAR was the response of criticism on the basic VAR.

The VAR model was criticized because of its unrestricted tendency that allow model to absorb large number of parameters without any theoretical framework. To avoid that, error term of SVAR is channeled by restrictions that are approved from economic theory. The model undertakes that, error terms of all variables show recursive relationship. That is, error terms in regression are made to be uncorrelated to each other.

SVAR model is basically used to determine the shock effect. In this study as we are interested in in the estimation of monetary policy shock, so we applied SVAR mode. SVAR Based on measurement of inflation persistence data in which consider only a specific shock impact affecting inflation.

### ***General equation:***

$$AZ_t = B_0 + B_i Z_{t-i} + \varepsilon_t \quad (5)$$

A= square matrix (To capture effect of contemporaneous relation between variables)

$Z_t$ = vector of endogenous variables (k).

$i = 1 \dots N$ ;  $\varepsilon_t$  = structural shocks.

$\varepsilon_t$  Should satisfy conditions;

(1):  $E(\varepsilon_t)=0$ ; (2):  $E(\varepsilon_t \varepsilon'_t) = \Sigma_t$  and (3):  $E(\varepsilon_t \varepsilon'_t) = 0$

To get Reduce form equation of VAR, pre-multiply  $A^{-1}$  with eq. (6)

$$Z_t = A^{-1} B_0 + A^{-1} B_i Z_{t-i} + A^{-1} \varepsilon_t \quad (6)$$

$e_t = A^{-1} \varepsilon_t$  = reduce for residual of VAR; satisfies following conditions (1):  $E(e_t) = 0$ ,

(2):  $E(e_t e'_t) = 0$  and (3):  $E(\varepsilon_t \varepsilon'_{t-k}) = 0$ .

Structural shocks matrix of variance-covariance:

$$\begin{aligned} \Sigma_t &= E(\varepsilon_i \varepsilon_t) \\ &= E(A e_t e'_t A') = A E(e_t e'_t) A' \\ &= A \Sigma_e A' \end{aligned}$$

To make the system identified,  $n^2(n^2 - 1)/2$  restriction must be imposed for the recovery of all structural shocks of the reduced form VAR ( $e_t$ ) residuals.

The variance covariance matrix shows the estimated residual

### Structural Model:

Following the formula  $n^2(n^2 - 1)/2$ , “3” restriction imposed on A matrix to make the system identified. Contemporaneous effect of variables on each other, shows by “A” matrix. Diagonal of matrix shows the coefficients that are normalized to “unity”. All the “zeros” in matrix A shows the restrictions.

$$AZ_t = \begin{bmatrix} 1 & \delta_{12} & 0 \\ 0 & 1 & \delta_{23} \\ 0 & \delta_{32} & 1 \end{bmatrix} \begin{bmatrix} IPI_t \\ INF_t \\ INT_t \end{bmatrix} \quad (7)$$

First 2 restrictions (“0”) show that inflation and interest rate does not have contemporaneous relationship with economic growth. 3<sup>rd</sup> Restriction shows that no relationship exist between interest rate and economic growth.

**Reduced- form VAR:**

Reduced form equation (9) can be written in matrix form as:

$$\begin{bmatrix} IPI_t \\ INF_t \\ INT_t \end{bmatrix} = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix} \begin{bmatrix} 1 & \delta_{12} & 0 \\ 0 & 1 & \delta_{23} \\ 0 & \delta_{32} & 1 \end{bmatrix} \begin{bmatrix} IPI_{t-1} \\ INF_{t-1} \\ INT_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (8)$$

**Empirical Evidence of relationship between monetary policy and inflation persistence.**

In this study we used Structural FIVAR model to investigate the relationship between monetary policy shocks and inflation persistence. Structural FIVAR model merge the estimation of Fractional integration and structural VAR model to examine the link. All variables in VAR model treated as endogenous. The current values of variables depend upon the lag values of their own and the lag values of other variables including error term.

Reduced form VAR can be expressed in equation form as follows.

$$INF_t = \alpha_{31} + \sum_{i=1}^p a_{3i} INF_{t-i} + \sum_{i=1}^p \beta_{3i} INT_{t-i} + \sum_{i=1}^p \gamma_{3i} IPI_{t-i} + \varepsilon_{INFt} \quad (9)$$

In equation (12),  $INF_t$  shows the inflation depends on its own lag and lag of other variables including interest rate ( $INT_{t-i}$ ) and economic growth ( $IPI_{t-i}$ ).

Interest rate treated as the proxy of monetary policy shocks. Large number of studies used interest rate as monetary policy tool i.e. Agha et al (2005). Any monetary policy shock is expect to have inverse relation with inflation persistence. Decrease in the interest rate will decrease the savings



of consumers. So this will lead to increase the proportion of consumption of consumers, as the consumption will increase in the economy so that AD will also increase and according to the demand law increase the demand will lead to increase in prices or higher inflation (Romer et al., 1990).

Economic growth has a positive association with the level of inflation persistence in the economy. Economic growth is peroxide by industrial production. As, mostly studies used industrial production as economic growth i.e. Lo and Piger (2003). Higher economic growth leads to increase in inflation. If economy's aggregate demand exceed than supply it results into high inflation that persist in economy depends upon the degree of its persistence (Sripinit 2012).

$$IPI_t = \alpha_{11+} \sum_{i=1}^p a_{1i} IPI_{t-i} + \sum_{i=1}^p \beta_{1i} INF_{t-i} + \sum_{i=1}^p \gamma_{1i} INT_{t-i} + \varepsilon_{IPI_t} \quad (10)$$

The above equation (10) shows that the economic growth ( $EG_t$ ) depends on its own lag and lag of other variables including interest rate ( $INT_{t-i}$ ) and inflation ( $INF_{t-i}$ ). Inflation persistence and economic growth have the negative relation. High inflation persistence effect economic growth adversely (Benati, 2002)

Interest rate  $INT_t$  and economic growth  $IPI_{t-1}$  also exhibit negative relation. Increase in interest rate increase borrowing cost that lead to decrease in investment decrease consumer spending and lead to slow economic growth (Munir, 2018).

$$INT_t = \alpha_{21+} \sum_{i=1}^p a_{2i} INT_{t-i} + \sum_{i=1}^p \beta_{2i} IPI_{t-i} + \sum_{i=1}^p \gamma_{2i} INF_{t-i} + \varepsilon_{INT_t} \quad (11)$$

Above equation (11) shows that the interest rate depends on its own lag and lags of other variables including economic growth and inflation. According to the theory, Economic growth

and interest rate are positively related to each other. Increase in interest rate. On the other hand, inflation and interest rate also have the negative relationship. Increase in inflation persistence cause to decrease in interest rate and vice versa. Higher inflation means high level of money supply in economy so monetary policy increase interest rate. With increase in interest rate people start increase saving which lead to decrease in aggregate demand. As demand decrease prices also decrease and help to reduce inflation (Mishkin, 2007).

### **Identification of Lag length:**

Estimation of structural VAR is based on optimal length of lags selection. In this study Akaike information criteria (AIC) and Final prediction error (FPE) criterion is used to choose lags. Lowest values of above mentioned criteria are used to select lags length.

### **Granger causality test:**

Granger causality test examines causality among different variables and calculates future values, of one variable by using current and past values of other variable. In other words, Granger casualty test tells that if X and Y will be 2 variable of time series, and past value of X significantly determine to forecast value of Y, it means that X granger caused Y and vice versa.

### **Impulse Response Functions (IRFs):**

The Impulse response functions (IRF) used to identify the reaction of present and future values of each dependent variable, by one unit increase or we can say one time shock, in present value of the error term in the VAR system (Gujarati, 2011). It also pre-assuming that, this error turns back to “0” in the later periods, whereas remaining all errors terms are zero. The IRF generally proposed for VARs model. It creates shocks in error terms. This technique is useful to observe time series

data. However, effects of structural shocks on whole time period of endogenous structures produced via coefficient of impulse response.

**Variance decomposition in Frequency Domain:**

IRF shows variables reaction to monetary policy shocks but not consider as appropriate tool. So,

Variance decomposition in Frequency Domain used to measure the shock share in each variables.

This gives us the percentage contribution of shock to measure the fluctuations in each variable.

## Chapter 5:

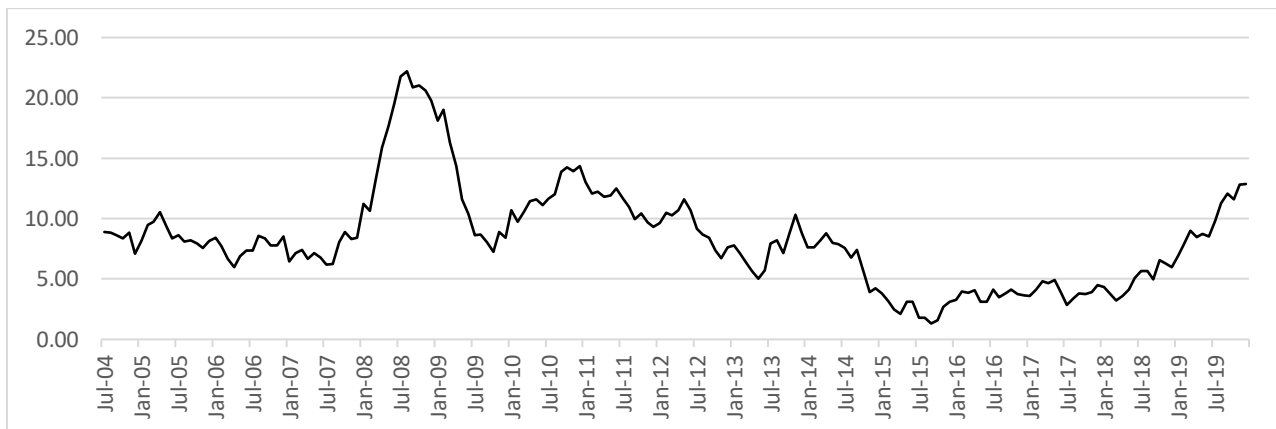
### Results and Interpretation

#### 5.1 Introduction:

This chapter starts with the trend analysis in which different series are plotted. Then in section 5.2 results of unit root test are presented, Fractional integration estimates are presented in 5.3. In section 5.4 the estimates of the Structural VAR model is applied to analyze the shock effect.

#### 5.2: Trend Analysis:

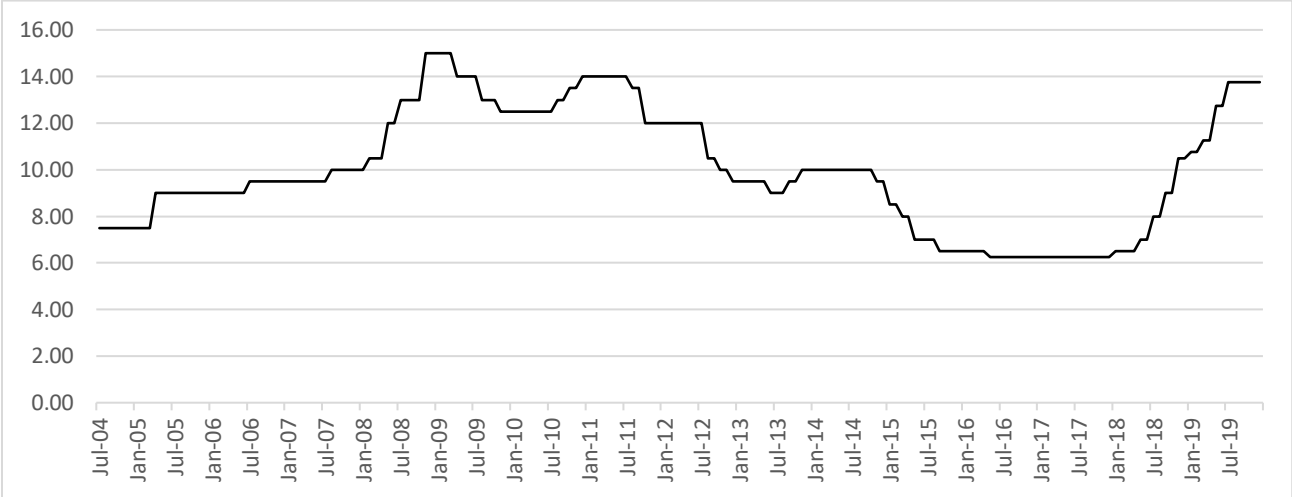
Before application of any test, series graphs plotted, to examine visual pattern of variables (i.e. Discount rate, Inflation and Industrial Production). It is usually the first step of the analysis of data. Behavior of different variable's series depicted in figures 1.1 to 1.3. Graphs of all variable plotted against the selected sample size.



*Figure 5.1: Inflation*

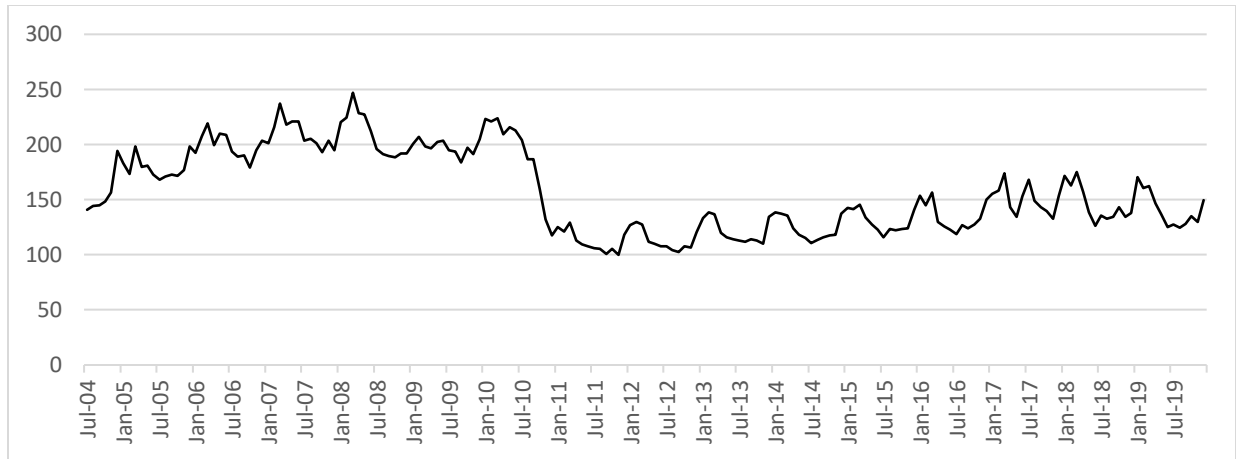
The graph of inflation in figure 1.3 given shows fluctuating trend. The movement of graph shows high inflation July: 2008 with the growth of 20.45 percent. The lowest inflation was seen in July: 2015 which could be effect of tight monetary policy. This

mix trend shows the presence of unit root in the inflation rate. Lowest inflation was seen in July: 2015 which could be effect of tight monetary policy. This mix trend shows the presence of unit root in the inflation rate.



**Figure 5.2: Interest Rate**

The above graph shows that, interest rate increasing trend till July: 2009 then shows the decrease till Sep: 2018. Due to a positive base effect, and due to change in global commodity price. SBP respond with a more aggressive tightening from May 2008 by increase in discount rate. 15%. In November 2008, during the balance of payment crisis, the central bank has reduced interest rate to 12.5%, in reaction to gradual decrease in inflation, and the suppression of demand pressures. This fluctuating trend indicate the presence of unit root in the data.



**Figure 5.3: Industrial Production**

The above graph shows the behavior of Industrial production (IPI). The series shows of IPI depict the increasing pattern till July: 2010 then we see the sharp decline till Jan: 2011. Afterwards, the series shows increasing trend till end.

All the series plots shows a persistent behavior, which could be confirm after applying the statistical test i.e., unit root testing.

### **5.3. Descriptive Statistics:**

#### **5.3.1. Unit Root Tests:**

As we are dealing with time series data in our study, so it is very important to test the Stationarity property of the data, which is essential and pre- requisite condition for before applying the any model on the time series data. To avoid spurious results, it is crucial to determine the stationarity of data. The unit root tests conducted to determine if variables under consideration are stationary or non-stationary. Implications of non-stationary data are expected to be no longer valid, because the test statistics will not follow “t or F distribution”.

Different test can be used to check the stationarity of the data, DF, ADF, KPSS, and PP etc. But we choose Augmented Dickey Fuller test (1979) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (1992) to test the stationarity. The results of these two test are presented in table 5.1.

*Table 5.1: Unit Root test Results at Level*

Null Hypothesis	Ho: series is I(1)		Ho: series is I(0)	
	ADF(1) With drift	ADF(2) With drift and trend	KPSS(1) With drift	KPSS (2) With drift and trend
<b>Interest rate</b>	<b>-1.92</b> (-2.88)	<b>-1.96</b> (-3.43)	<b>0.37</b> (0.46)	0.23 (0.14)
<b>Economic Growth</b>	<b>-1.86</b> (-2.87)	<b>-2.27</b> (-3.43)	0.91 (0.46)	0.20 (0.14)
<b>Inflation</b>	<b>-1.22</b> (-2.88)	<b>-1.28</b> (-3.44)	0.59 (0.46)	0.16 (0.14)

The above table shows the unit root results of different variables (i.e.; discount rate, industrial production and inflation). Both the ADF and KPSS test applied with drift and with drift + trend. The underlined figures of the table shows the t-statistics values while other figures in brackets show the critical values at 5% significance level. All the above mentioned figures in bold shows the rejection of Null hypothesis at 5% significance. Null hypothesis of ADF and KPSS is, series is integrated of order one i.e.; I (1) and series is stationary I (0), respectively.

### **Estimation of Fractional Integration Parameter:**

Limitation of both the test (ADF and KPSS) is that, they don't have the power the power to test degree of Fractional Integration parameter. Results from unit root tests didn't tell much. When series shows stationarity, it shows mean reverting behavior, but unit root tests are unable to tell, that how quickly, the process returns to mean level following shock, information that is important to decide about intervention of policy makers. In the same way, unit root test are un-able to tell, whether path of variable having unit root follow explosive path. Therefore, for appropriate



assessment of memory behavior of any variable, we moved further than the traditional approach of unit root by employing technique of fractional integration.

The parameter “d” directs long-run dynamics of variable. Time-series data, with different values of fractional integration provide different interpretations. Gadea et al., (2006) discussed several features of “d” measurement of persistence.

(i): The I (d) method permits comparison of extremely persistent series.

(ii): The parameter of “d” doesn’t affect short-run dynamics of data. As, autoregressive approach for the measurement of long-run dynamics closely relates to first-order auto-correlation of data, that responds both short-run & long-run dynamics. Unlike local unity parameter, in unit-root model, estimation of “d” consistently.

Campbell et al., (1997) and Christiano (1992) describe characteristics of I (d) process. Different test used to estimate the FI parameters “d”, that plays an important role in evaluation of persistence in inflation as it estimate dependence level of series (Gil Alana, 2008). Higher the value of d, higher will be the level of association and degree of persistence. Possible cases of d can be:

i) If  $d = 0$  it exhibits low persistence in fact can be describe as stationary.

ii).  $-0.5 < d < 0$  = short memory means that the shock effects will not persist for very long time and dissipate rapidly.

iii).  $0 < d > 0.5$  = long memory means that the shock effects will persist for very long time and decayed slowly.

iv). If  $d = 1$ , it shows that series is not mean-reverting, signifying that any shock will have permanent effect.

**Table 5.2: Values of Fractional Integrated Parameter and its implication**

$d$	<i>Duration of shock</i>	<i>Stationarity</i>
$d=0$	Short memory	Stationarity
$-0.5 < d < 0$	short-memory with fast mean-reversion	Stationarity
$0 < d < 0.5$	Long-memory with slow mean-reversion	Non-stationarity
$d = 1$	Long memory	Non- stationarity
$d > 1$	Long memory with non-mean reversion	Non- stationarity

We applied the parametric method to estimate the Fractional integration parameter ( $d$ ). Following table shows that estimated values of order of integration estimated with the method of Exact Maximum Likelihood, which is the most commonly method used in the literature (Gupta et al., 2014).

**Table 5.3: Estimation of Fractional Integration Parameter**

<b>Variables</b>	<b>Fractional integration parameter (d)</b>	<b>Range of “d”</b>	<b>Duration of Shock</b>	<b>Stationarity</b>
<i>Economic Growth</i>	0.38	$0 < d > 0.5$	Long memory with mean reversion	Non-Stationarity
<i>Inflation</i>	0.21	$0 < d > 0.5$	Long memory with mean reversion	Non-Stationarity
<i>Interest Rate</i>	0.31	$0 < d > 0.5$	Long memory with mean reversion	Non-Stationarity

Table (5.3) shows the estimated values for the order of fractional integration for the selected sample. All the above mentioned variables (economic growth, inflation and interest rate) shows the Long-memory property but mean reversion with estimated values for the order of integration (FI) of 0.38, 0.21 and 0.31, respectively. Which is the indication of high persistence, means that the shock effect will persist for longer period of time in case of Pakistan. The result is consistent with the study of Hanif et al., (2016) and Agha *et al.*, (2005).

Long memory specifies that the series exhibits strong dependence between observations. Unit root in interest rate cannot be rejected partly because of the reason that interest rates are being used in developing countries as a stabilizing policy, with the shocks being long term instead of transitory (Gil-Alana, 2008). While the presence of long memory in inflation and economic growth (peroxide by industrial production) is due to the reason that quite a big number of firms set their prices on the basis of past information (Gali and Gertler, 1999). In Pakistan 71% manufacturers use past information, while price setting. This gives increase to inflation persistence due to the fact that when a big number of firms use past information when setting price, inflation cannot easily transmit to a (new) lower steady state as an outcome of any monetary policy shock. This causes high level of inflation persistence in economy (Hanif et al., 2016).

#### ***Transformation of series:***

After estimating the fractional Integration for different series. We transform all the series by taking the difference of each variable series with the estimated fractional integrated parameter value.

#### **Estimation of Structural VAR:**

After taking the difference, we applied VAR on transformed series. As, to investigate the effect of monetary policy action on the economy under inflation persistence Structural Vector Autoregressive model is employed. But, it is not possible to directly estimate the structural VAR. so we followed the standard method, Firstly, we estimate VAR model and then imposed restriction to get the innovation through structural VAR.

Therefore, we estimate a reduced form VAR, and for the estimation of reduced form VAR the first step is the estimation of optimal lag length. After that, we applied Granger Causality test, impulse response function (IRF) and variance error decomposition.

### Determination of Lags:

Before estimation of VAR, first step is to estimate the optimal lag length of all variables. General mechanism for the selection of optimal lag length used AIC and SIC etc. the results from the lag selection criteria are shown in table (5.4).

*Table 5.4: Lag Selection Criteria for VAR*

<i>Lag</i>	<i>LogL</i>	<i>LR</i>	<i>FPE</i>	<i>AIC</i>	<i>SC</i>	<i>HQ</i>
0	-3875.540	NA	1.69e+15	43.57910	43.63272	43.60084
1	-3148.204	1421.981	5.29e+11	35.50791	<b>35.72242*</b>	35.59490
2	-3125.572	43.48382	4.54e+11	35.35475	35.73013	<b>35.50697*</b>
3	-3112.977	23.77519	4.36e+11	35.31435	35.85061	35.53182
4	-3098.830	26.22761	4.12e+11	35.25652	35.95365	35.53923
5	-3082.601	29.54118	<b>3.80e+11*</b>	<b>35.17529*</b>	36.03330	35.52324
6	-3074.814	13.91117	3.85e+11	35.18892	36.20781	s 35.60211
7	-3068.872	10.41452	3.99e+11	35.22329	36.40305	35.70171
8	-3057.468	<b>19.60623*</b>	3.90e+11	35.19626	36.53690	35.73993

Above table (5.4) shows the determination of Lag that is based on the minimum values of Final prediction error (FPE) and Akaike information criterion (AIC). Based on FPE and AIC we select 5 lag for this study.

### Vector Auto-regression:

Regression results for reduced form VAR shows in table (5.5). As, before the estimation of structural VAR, estimation of reduced form VAR is required and lag length choose through lag selection criteria i.e. 5 lag. The results show that interest rate and inflation shows inverse relationship at 5% level of significance with lags, consistent with the theory. As interest rate used as the proxy of monetary policy so any change in monetary policy effect the inflation rate prevailing in the market. In case of expansionary monetary policy (interest rate decreases), people

save less and consume more, which leads to increase the demand of goods. Increase in demand will cause to increase the prices (law of demand) and hence the inflation will increase (Mishkin, 2007).

Inflation shows the positive relation with interest rate with 5% level of significance at first lag. Higher inflation in economy lead to increase interest rate (contractionary monetary policy), to reduce the inflation prevailing in the economy. As monetary policy work with lag so situation of price puzzle will prevail in the economy (Khan, 2008).

Inflation shows the negative and significant impact on monetary policy decision with lags at 5%. With passage of time, people realize that higher interest rate means high cost of borrowing. Which lead to decrease in borrowing, make lesser availability of money supply in economy so that people will have less money to spend, demand of goods and services will decrease. As demand decreases prices decrease so this will cause decrease in inflation. These results are consistent with the study of Hussain (2009).

*Table 5.5: FI Vector Auto regression Estimates*

	EG	INF	INT
EGI(-1)	0.920013* (0.07734) [ 11.8959]	9.95E-05 (0.00037) [ 0.27050]	-0.000125 (0.00015) [-0.81342]
EG(-2)	0.107938 (0.10337) [ 1.04417]	0.000501 (0.00049) [ 1.01844]	0.000220 (0.00021) [ 1.06843]
EG(-3)	0.057711 (0.10412) [ 0.55429]	0.000227 (0.00050) [ 0.45919]	-0.000308 (0.00021) [-1.48308]
EG(-4)	-0.280856** (0.10432) [-2.69221]	-0.000223 (0.00050) [-0.45041]	0.000538** (0.00021) [ 2.58745]
EG(-5)	0.158386** (0.08009) [ 1.97754]	-0.000277 (0.00038) [-0.72716]	-0.000259 (0.00016) [-1.62179]
INF(-1)	-19.01302 (15.9256) [-1.19387]	1.088986* (0.07575) [ 14.3764]	0.110338* (0.03174) [ 3.47672]
INF(-2)	24.82613	-0.060513	-0.151483*

	(23.6088)	(0.11229)	(0.04705)
	[ 1.05156]	[-0.53888]	[-3.21981]
INF(-3)	-22.97668	0.100461	0.061572
	(24.6064)	(0.11704)	(0.04904)
	[-0.93377]	[ 0.85836]	[ 1.25566]
INF(-4)	30.66516	-0.048239	0.072677
	(24.7234)	(0.11759)	(0.04927)
	[ 1.24033]	[-0.41022]	[ 1.47513]
INF(-5)	-12.08137	-0.212030**	-0.078687**
	(16.8020)	(0.07992)	(0.03348)
	[-0.71904]	[-2.65314]	[-2.35008]
INT(-1)	-35.38935	0.226330	0.908126**
	(37.9729)	(0.18061)	(0.07567)
	[-0.93196]	[ 1.25312]	[ 12.0009]
INT(-2)	24.57413	-0.010243	0.254725**
	(50.0090)	(0.23786)	(0.09966)
	[ 0.49139]	[-0.04306]	[ 2.55602]
INT(-3)	19.05288	0.056294	-0.228777**
	(49.8372)	(0.23704)	(0.09931)
	[ 0.38230]	[ 0.23748]	[-2.30355]
INT(-4)	-33.36445	-0.556798**	0.187172**
	(48.1939)	(0.22923)	(0.09604)
	[-0.69230]	[-2.42901]	[ 1.94890]
INT(-5)	18.02116	-0.407361**	-0.156856**
	(35.5159)	(0.16893)	(0.07078)
	[ 0.50741]	[ 2.41146]	[-2.21624]
C	1602.419	-9.943482	1.187844
	(961.435)	(4.57295)	(1.91593)
	[ 1.66670]	[-2.17441]	[ 0.61998]
R-squared	0.911507	0.962676	0.979722
Adj. R-squared	0.903462	0.959283	0.977879
F-statistic	113.3030	283.7167	531.4588

Standard errors in ( ) & t-statistics in [ ], \*, \*\*, \*\*\* shows the level of significance at 1, 5 and 10%.

### Granger Causality:

The results of granger causality are presented in table (5.5). In this study, to examine the causality granger causality/ Block Exogeneity Wald test applied. The outcomes show that industrial production (IPI) is granger caused by discount rate and inflation at 5% level of significance, its means both the Interest rate and inflation help us to forecast the economic growth. Inflation does not granger caused by IPI (proxy of economic growth) but significant causality present between interest rate and inflation means increase in inflation will affect the interest rate. Similarly, there

is no granger casual effect of IPI on interest rate (monetary policy decisions) but monetary policy decision is Granger caused by inflation.

**Table 5.6: VAR Granger Causality/Block Exogeneity Wald Tests**

Dependent variable: EG			
Excluded	Chi-sq	df	Prob.
INF	3.765201	5	0.5837
INT	1.512214	5	0.9117
All	5.930612	10	0.8211
Dependent variable: INF			
Excluded	Chi-sq	df	Prob.
EG	13.04830	5	0.0229
INT	16.71448	5	0.0051
All	28.22039	10	0.0017
Dependent variable: INT			
Excluded	Chi-sq	df	Prob.
EG	9.483116	5	0.0913
INF	27.47448	5	0.0000
All	42.85422	10	0.0000

**Impulse Response Function:**

Diebold and Inoue (2001) explained that IRFs as “tends to trace out the response of current and future values of each of the variables to one–unit increase in current values of one of the VAR residual, assuming that the error returns to zero in subsequent periods and all other errors are equal to zero. The implied thought experiment, of changing one error while holding the others constant, makes most sense when the errors are uncorrelated across equations”. IRF present, behaviors of variables due to any shock in other variable. To find more accurate results, structural restrictions are applied.

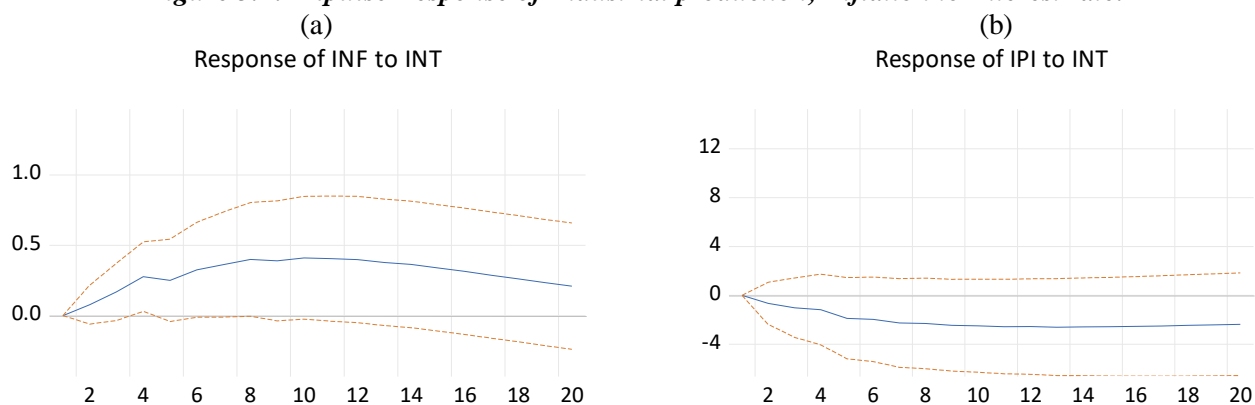


Figure (5.4, a) shows the response of inflation in economy because of monetary policy shock i.e. interest rate. Monetary policy shock look like to die off for inflation in longer period, suggesting its high degree of inflation persistence consistent with the study of Qayyum and Anwar (2018). FIVAR response shows the positive sign inflation, and statistically significant. Consistent with estimated orders Fractional Integration, convergence to zero is very slow, that remain significant for longer period. Provide the evidence of high degree in inflation persistence.

Due to monetary policy shock, inflation diverge from its steady state level saving increase consumption decrease so the prices decrease and level of inflation decrease in the economy. This result is in line with interest rate setting mechanism in Pakistan where monetary authorities set interest rate and then money supply is adjusted and not the otherwise.

Figure (5.4, b) shows the FIVAR response of IPI to monetary policy shock (shock in interest rate). IRF show that, positive shock in interest rate lead to deviation in IPI in initial period as increase in interest rate decrease the IPI. This shows the long high degree of persistence property in IPI with high degree memory of shock effect on the output level i.e. IPI in the economy. These finding findings are consistent with the Fractional degree estimates of IPI consistent with study of Hussain (2019).

**Figure 5.4: Impulse Response of Industrial production, Inflation to Interest rate.**



### Variance Error Decomposition:

IRF shows reaction of the variables in response to monetary policy shock but not an appropriate method to analyze contribution of each shock. VED allows measuring of the share of shock.

Table provide the contribution of monetary policy shock

Table (5.7) explains the variance decomposition of IPI, it shows that maximum proportion of error variance forecast of IPI is explained by IPI itself 77% in month 6. Only 1% attributed to DR. (monetary policy shocks, and 8 % attributed to inflation greater than monetary policy shock. The contribution of discount rate and prices in explaining the variances of IPI increases after 4 months and that of IPI itself decreases to a certain degree. This suggests that, due to tight monetary policy has the potential to reduce IPI if tight monetary policy is persistent. This also provides support for our a priori decision to exclude asset prices from money supply rule in the macroeconomic model.

*Table 5.7: Variance Decomposition of IPI*

Period	S.E.	IPI	INF	DR
1	2795.168	99.51097	9.61E-10	0.489027
2	3649.131	98.50206	1.197268	0.300669
3	4356.420	93.78260	5.676073	0.541322
4	4951.408	90.28141	8.533280	1.185307
5	5563.609	82.04334	16.82779	1.128870
6	5881.786	77.89296	21.07326	1.033786
7	6182.879	75.95797	22.45252	1.589508
8	6356.704	75.76332	22.29867	1.938013
9	6450.901	75.85880	21.81339	2.327809
10	6528.236	76.08074	21.56779	2.351470

Result in table shows that monetary policy shocks have the high effect on inflation. These outcomes, interestingly suggest that, even at 6<sup>th</sup> month, major portion of error forecasting in inflation can be recognized due to monetary policy shock consistent with findings of (Chuku, 2009).

**Table 5.8: Variance Decomposition of Inflation**

Period	S.E.	IPI	INF	DR
1	16.24202	0.000000	1.97E-07	100.0000
2	26.47921	0.344072	1.170421	98.48551
3	34.87414	0.436344	1.665065	97.89859
4	43.90203	0.781291	2.328260	96.89045
5	52.44520	1.054836	1.920802	97.02436
6	58.38997	1.502170	1.605013	96.89282
7	63.23050	2.235655	1.401978	96.36237
8	67.19946	2.789836	1.275300	95.93486
9	70.06003	3.072377	1.183808	95.74382
10	72.45145	3.673339	1.412089	94.91457

Table (5.9) shows the results of Variances decomposition for interest rates is presented. These results are of high interest as it's directly associated to one of main objective of study. It can be seen that high variance in DR is because of inflation and then dissipate slowly with time, and increase slowly with interest rate as increase in time horizon but not as IPI and INF. These results are consistent with the study of Khan et al., (2011).

**Table 5.9: Variance Decomposition of Interest Rate**

Period	S.E.	IPI	INF	INT
1	7.542702	0.000000	98.37182	1.628177
2	10.75750	0.048517	93.45000	6.501484
3	13.83475	0.174788	93.21178	6.613437
4	16.17858	0.134388	92.69750	7.168109
5	18.78980	0.472056	88.33267	11.19527

6	21.00531	0.390817	84.25145	15.35773
7	23.35101	0.655248	81.64311	17.70164
8	25.76951	0.555140	78.31089	21.13397
9	28.25600	0.667574	75.44967	23.88276
10	30.49599	0.785670	74.05654	25.15779

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## Chapter 6

### Conclusion and Policy Recommendation

Understanding the monetary policy shocks effects on economy is the most crucial element to achieve the objective of stable inflation and higher economic growth. To achieve these objectives, policy makers are required to have better understanding of the dynamic properties of inflation persistence. As, high persistence in inflation can increase the monetary policy cost to keep it low. To best of my knowledge, this is the first study that estimate the monetary policy shocks effect on economy in presence of inflation persistence by using structural FIVAR model.

The result of this study shows that, Pakistan is the country where inflation persistence is so high. Its means that any shock will affect the inflation for longer period of time and dissipate slower than it is under the assumption of stationarity. The results show the positive and significant impact of monetary policy shocks on inflation persistence. We estimated the impulse response function for monetary policy shocks. The results of long memory are also confirmed by IRF results which show high persistence in inflation having the long memory.

Degree of inflation persistence can have significance importance for economy, because of its impact on distribution of wealth and efficiency of economic. The vital properties of inflation have influential implications for the behavior of private agents. It is essentials to be highlighted that monetary policy decision must be controlled if it cause to long-lasting rise in rate of inflation in economy is to be avoided. Forecast's accuracy depends greatly on the forecaster's capability to effectively forecast pattern of shocks absorption.

Major policy implications which are drawn from the study are:

- In policy terms, the central banks that pursue inflation targeted monetary policy should also bring under consideration the possible impacts of monetary policy shocks and in addition to that implement interest rate smoothing policy in order to prevent large fluctuations in macroeconomic variables.
- In upcoming researches, it will be helpful to provide a clear consideration to the obligations and different incentives of central bank and to examine different ways to enhance the reliability of monetary policy regime and make it more transparent.
- A deflationary policy is reliable, provided that it is put into immediate action to lower inflation and vice versa. The degree of inflation persistence shows the velocity of inflation in response to change in monetary policy. Nevertheless, those measures of reliability that do not take into account the persistence might not be sufficient. As a sound variable, the persistence of inflation discloses the reliability of central bank. The credibility allows the central bank to regulate the inflation regarding expectations of the public and to achieve its disinflation target more quickly. As a result, a decline in inflation persistence indicates that the credibility of central bank has been achieved.

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