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RESEARCH PAPER

Pragmatic Deportment under Non-Stationarity to Ascertain Vigorous Drivers of Inflation

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ABSTRACT

Inflation is one of the root causes of major economic problems in Pakistan. The report's focal purpose is to contribute to the literature of the evaluation of inflation flux root causes in small open Pakistan's economy structure. The whole set up relies on three statistical practices i.e., DSGE method, VAR Cointegration and VECM Model to ascertain the main determinants of inflation rate empirically. The DSGE model extracted from VAR finite-order representation which follow each of the five non-stationary exogenous state variables to explain the endogenous variable. This research work has incorporated variables such as: inflation rate, joblessness rate, currency quantity growth proportion, interest rate, labor output growing frequency and the output gap in Pakistan. The time series data from 1980 to 2018 is used. This manuscript provides well-rounded evidences for the existence of short-run & long-run co-movements between inflation rate and its regressors in a concise way. Findings suggest that revolution of financial policies is crucial to achieve price stability.

Introduction

Inflation alludes to an expansion in the value level that is sustained over a noteworthy period. Inflation is a dangerous circumstance for any economy since it faces an emergency concerning the meager supply of items through the interest in merchandise and enterprises are on the ascent (IMF, 2017). Steady uptick in inflation rate of Pakistan along with external imbalances had a bearing on the economic policy decisions during Jul-Mar FY17. Main constraints obstructing the economy from accomplishing price stability goal i.e. domestic demand factors, expansion of monetary policy in terms of interest rate and money supply, low wage level and irrepressible unemployment rate, Global oil prices variations, power supply shortage and security situation. Arby and Ali (2017) have also demonstrated said matter while reporting Pakistan's economic outlook.Broom (2015) assessed the circumstances and the diverse elements concerning swelling of prices. The examination is also founded on specific industries conveyed by the central bank of Pakistan. Benigno (2015) has analyzed inflation in new Keynesian perspective while another study by Bardsen et al. (2004) also illustrates econometric evaluation of Keynesian tradeoff between inflation and unemployment.

The constant rise of prices in Pakistan has been a point to ponder for economic policy-makers. The more inconsistent the rate of increase in inflation in a country, the more the unstable the economy of the country becomes (IMF, 2017). Thus, it is expedient to study inflation rate with an accurate modeling approach. To serve the purpose, Dynamic Stochastic General Equilibrium (DSGE) with the blend of VAR- cointegration approaches are taken into consideration. DSGE models have turned into a work-horse for strategy makers and nationwide financiers for contrasting the conceivable upshot of various approach situations. Some evaluators of these models i.e., Herbst and Schorfheide (2015), Berzoza and Kolasa (2013) and Schorfheide (2011) guarantee that DSGE models are appropriate for duplicating some adapted business cycle certainties, for numerous created and developing economies, and are additionally not subject to the Lucas Critique. Other econometric models that are VAR and VECM are also essential in inflation modelling. Vector autoregressive model (VAR) is a probabilistic approach used to capture straight line interdependencies in multiple time series. Vector error correction model (VECM) is a representation of the cointegrated VAR (Colander, 2010). These models have been rationally effective in emulating business cycles highlights of created economies and have augmented remarkable significance for approach investigation and determining inflation/ unemployment dynamic issues around the world (Roberts & Sattar, 2015).

Over the most recent two decades, a considerable lot of the rising economies are concentrating on developing DSGE models for their nations incorporating pertinent highlights of their economies. The New-Keynesian mode to deal with DSGE models widened the real business cycles (RBC) writing by presenting rigidities in cost and wage setting. Rotemberg and Woodford (1997) were the first to present such a structure. The combination of New-Keynesian and RBC models ended up being fruitful concerning coordinating monetary hypothesis to observational confirmation (De Vroey, 2016). With the progression of time, a more extensive arrangement of conceivable suppositions was brought into DSGE models. For instance, money related area rigidities, helter-skelter data, propensity determination in utilization, alteration costs in speculation and variable capital use, exogenous variable shocks, technological advancement impacts and client hold-up effects (Benchimol, 2015).

The determinants, causes of inflation, and the relationship between the proportion of the increase in commodity prices and some macroeconomic factors have been investigated by some researchers. Brief glimpse of literature of the DSGE, VAR and VECM models is also provided. This study contemplates five vital exogenous state variables to analyses inflation determinants of Pakistan.

According to Thanh (2015), inflation has become a mutual sensation in the country since the administration continually increases the values of vital commodities; thereby making the living conditions of common masses miserable. Shah, Aleem, and Arshed, (2014) and Alam and Rizvi (2017) found that several factors including money supply,

unemployment, interest rates and labor productivity has an impression on the rate of inflation in Pakistan. The inflation level is openly relative to money development. Similar specification of inflation model with monetary policy was found in study of Gali (2015). Stated determinant of inflation for Pakistan is also investigated by Gertler and Karadi (2011), Hossain (2015) and Asghar et al. (2013).As the level of interests in Pakistan is decreased, more individuals will tend to lend more money resulting in economic growth and inflation to rise (Tams & Tietie, 2012). The converse is true that when the interests increases. Laubach & Williams (2016) and Crowder & Hoffman (1996) have attempted to estimate inflation in relation to interest rate.

The association between unemployment levels and inflations rates is inverse. If the relationship can be put on the graph, it would mean that the current Phillips curve is L-curved. (Shah et al. 2014). Nabli (2011) found out that inflation is affected unemployment level, commodity prices, and supply of money and bank interests' rates. Ideally, if administrators in association with policymakers get the precise unemployment level equal to NAIRU, Pakistan economy will be efficient at its highest level of output without reducing the available resources. There will be zero output gap as well as zero inflation rate in the mentioned scenario (Selgin, Beckworth and Bahadir, 2015). In a flourishing economic situation, the output increases beyond its possible level, yielding to a positive gap that leads to inflationary pressure and inverse happens in developing countries in the form of negative gap with low inflation rate. Fernald (2015) has studied relationship between inflation and output gap and found a durable impact of out gap in influencing inflation rate. The studies of Taylor (2010) and Azam and Rashid (2015) describes the direct association Labor productivity with the wage level. If nominal wages rise more rapid than the increase in productivity of labor, the economy would have inflation equals to that differential indicating indirect relationship.

Some recent empirical manuscripts like Giacomini (2013), Ratto etal. (2009), Dib (2003), Del and Schofheid (2006), Gupta and Steinbach (2013), Rabanal (2007) and Kolasa et al. (2012) have inspected DSGE models with different statistical specifications to inspect inflation relationship with other macro variables. Combination of Co-integration techniques with VAR analysis and VECM is incorporated by Cologni and Manera (2008) to examine inflation dynamics through interest rate for G-7 countries and by Kim (2003) to find impact of exchange rate on price fluctuations. Khan and Ahmed (2011), Bashir et al. (2011) and Jorgensen (2016) have reported empirical search by using VAR representations to explain inflation dynamics.

Conferring to the literature review, most research has been conducted primarily targeting the use of quantitative or qualitative VAR analysis, DSGE models and co-integration techniques separately. To fill the gap, efforts will be put in place to combine DSGE model and VAR Co-integration analyzing techniques in evaluating inflation in Pakistan by incorporating prime determinants of inflation like unemployment rate, cash source growing

proportion, interest rate, labor efficiency development aggregate and output gap where, Co-integration vectors are determined by trace & eigenvalue statistics. Another novelty of the study lies in VECM approach. Vector error correction was established uniquely by measuring parameter coefficient involving two different types of estimated cointegration equations. This study also employs ADF & PP unit root tests, Granger causality test and CUSUM plot analysis to portray real scenario of the relationship between inflation and its predictors. This prognosis will aid us to get insight of Pakistan's inflation stance, causes and remedies in an idiosyncratic way.

Material and Methods

Inflation Analysis comprises a rich portrayal of the components that supervise inflation. In this piece of work, we intend to scrutinize the long run and short run association between inflation rate, joblessness rate, currency quantity growth proportion, interest rate, labor output growing frequency and the output gap in Pakistan.

We have endeavored to utilize datasets accessible from Federal Bureau of Statistics, for example, State Bank of Pakistan (SBP), International Labor Organization Statistics (ILO-STAT), World Development Indicators (WDI) & IMF statistics and compiled effectually at the statistical platform. The aggregates of output gap are calculated by subtracting actual GDP of Pakistan from potential GDP while, the aggregates of labor productivity are in fact labor productivity growth rates calculated from per labor cost data. Inflation rate is derived from CPI level with base year 2000 and unemployment rate reflects the count of jobless civilians (ages 15-24) of Pakistan. Whereas, Money supply series is the broad money growth rates and for the interest rates series, call money rate in Pakistan is used as a proxy variable. All aggregates are made real with the help of GDP deflator. The assortment of specific sample of annual data from 1980 to 2018 is because of availability of data. Description of variables measurement and their sources detail is portrayed in table 1.

Table 1. Details of Data Measurement (Time series 1980-2018)

Variables	**Description & Sources**
Inflation Rate	Consumer price index, year-over-year change at base year 2010 (Average consumer prices) (WDI)
Interest Rate	Percentage per annum of Call Money Rate. (SBP)
Labor Productivity	Percentage change in Output per Worker at 2005 PPP (ILO-STAT)
Money Supply	Annual percentage change in broad money measured in local currency units of Pakistan. This series is calculated by taking average of quarterly data. (SBP)

Output Gap	Annual Growth rate of output gap calculated from real GDP by deducting real GDP from Potential GDP. (IMF)
Unemployment Rate	Young jobless civilians Percentage of total labor force ages 15-24. (ILO-STAT)
GDP Deflator	Inflation GDP deflator Index measure, Year-over-year change (Base year=2010) is used to correct all variables from inflation rate. (SBP)
GDP	Gross domestic product based on purchasing-power-parity (PPP) valuation of Pakistan's GDP (IMF)

Augmented Dickey-Fuller test was used to check the stationarity of the data. No stationarity was found. A finite order VAR-DSGE model extraction approach is considered to critique financial strategy linked to inflation ailment of Pakistan. Many researchers showed the relationship which exists between VAR and DSGE models from the point of view of model validation and approximation (Giacomini, 2013). The mapping between VAR and DSGE models were broken down into three levels that is from DSGE to state-space approach, from state-space model to VAR and from VAR for finite order VAR which is equivalent to DSGE model.

The Johansen Cointegration test was then used to identify Cointegration vectors among exogenous and endogenous variables. Number of vectors is decided through the criteria of trace value statistics and Eigen value statistic. Since the VAR was cointegrated (Juselius, 2006), the study designs the model as VECM with non-stationary sequences which are known to be cointegrated (Hatemi-J, 2003). Granger causality is performed to conclude that VECM verifies the short-run and long run relationship between variables. Further check on the stability of model and variable relationships is completed by CUSUM & CUSUM-square plots and some diagnostic tests.

The trend graph is useful in displaying the pattern of each variable with time. Figure 1 shows the trend of all the variables included in the model from 1980 to 2018.

The money supply growth rate has shown the highest observations according to the graph. The trend graph is plotted here to form the basis of the analysis and to diagnose features of time series data. It can be identified that series do not exhibit mean reversion pattern because random up and down movement is shown with no tendency to get back to any specific point. Unlike other variables, out gap is reflecting negative values and relatively steadiness during this period. Whereas, labor productivity has also declined for couple of years. Many macro variable series evolve over time so it's essential to investigate that these series are stationary or non-stationary before attempting any econometric estimation technique.

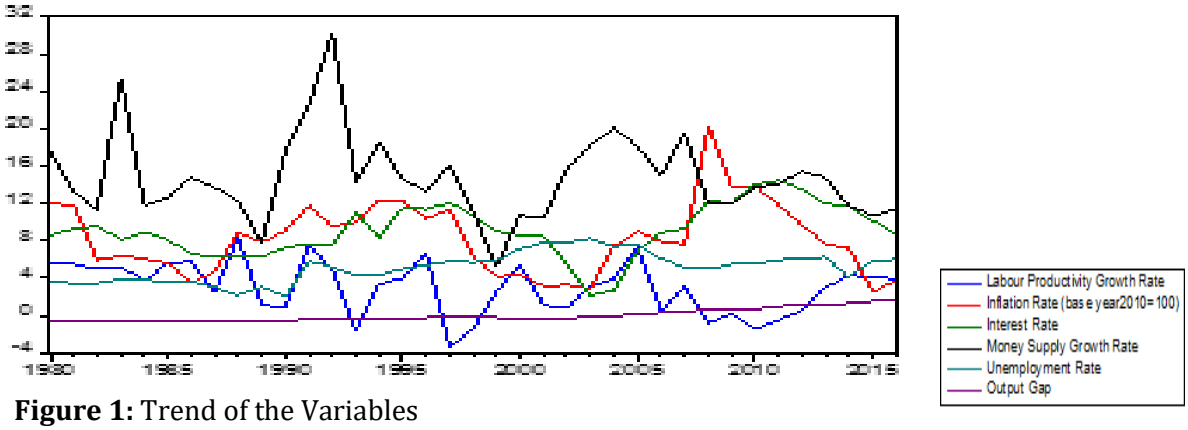

Figure 1: Trend of the Variables
Source: Author's calculation

Econometric Model Specification

This study specifies inflation model by incorporating a combination of financial stimulators and labor market variables. To regress inflation rate of Pakistan, five chief macro regressors are used that is, money supply (S), interest rate (I), output gap (O), labor productivity(L) and unemployment rate(U). The statistical econometric model can be inscribed as follows.

$$INF_t = \alpha + \beta I_t + \gamma L_t + \lambda S_t + \phi O_t + \omega U_t + \varepsilon_t \quad (1.1)$$

Where;

INF is inflation rate and I, L, S, O and U are the predictors with their coefficients β, γ, λ, ∅, ω respectively. ϵ is the error term of this regression line that is presumed to be stationary. Signs of parameters will be determined after estimation of model.

To estimate, slope coefficients, Unit root test is conducted at first with null hypothesis, unit root exists and hence series is non-stationary. OLS is recommended if null hypothesis is rejected on the other hand, difference operator will be used if presence of unit root is identified. Two tests are used to check for the presence of unit root.

The stationarity of the data or mean-reverting tendency for the six variables was evaluated via the Augmented Dickey-Fuller (ADF) test. In the same way, Phillips-Perron test of unit root non-stationarity has also performed revealed in table 2. According to both tests the no evidence was found to reject null hypothesis and concluded that the time series variables have unit root and data is non-stationary. That is, the moments of the stochastic process of time series depend on t and mean & variance of series are changing overtime.

Table 2. Unit Root Test Results

Variables	**ADF Statistic**	**PP Statistic**
INF	-1.78*	-1.66*
I	-1.29*	-1.04*
L	-0.81*	-0.92*
S	-2.24*	-2.18*
O	-2.01*	-2.9*
U	-1.36*	-1.02*

- *shows rejection of alternative hypothesis of no unit root at 5% level of significance.
- Values are calculated by author through E-views

Linear regression technique was used to derive the mathematical model (1.1) and the slope coefficients are derived from OLS estimation technique by using time series data from 1980 to 2018 in table 3. According to the estimated econometric model displayed in table 3 money supply have significant positive correlation with Pakistan's inflation rate. On the other hand, labor productivity, output gap, interest rate and unemployment level have negative association with inflation rate where these regressors are also significant statistically at 5% level of significance. Use of OLS relies on stochastic process being stationary but here this process is identified as non- stationary, so the estimates have no economic meaning even with high t-statistics and good R-square values. Unbiased linear relationship among variants in levels is not found. It concludes that modelling of these variables must be done in differences instead to render it stationary regression like if INF_t series is I(1) then the series $D(INF_t) = INF_t - INF_{t-1}$ is I(0) means stationary series.

Table 3. Econometric Model Estimation

Variables	**Estimated coefficients**	**t-statistic**

I	-0.250645*	5.46
L	-0.143301*	-3.67
O	-0.896497*	-4.89
S	0.286920*	2.42
U	-0.350403*	-4.91
C	-1.612687*	-5.38

- *demonstrations statistical significance of parameter coefficients of interest rate and money supply at 5% level.
- In above table, I = Interest rate, L= Labor productivity, O= Output gap, S= Money supply, U= Unemployment rate and C denotes constant term.
- Other obtained statistics from this assessment process are significant F-stat (4.58), Adjusted R-squared (0.84) and D.W (1.29) depicting structural elements of this model.
- Estimated regression line Eq. (1.1a) is as follows: INF = -1.612687 - 0.250645It - 0.14330Lt - 0.896497St + 0.286920Ot - 0.350403Ut + εt

DSGE-VAR Model

The above estimated regression Eq. 1.1a does not signify the dynamics of Pakistan's inflation rate by its core macro variables according to threshold probability. Still, there might be a long-run association between series and detrending series will not provide solution because of stochastic characteristic of the data. Thus, study investigates relationship between inflation and its regressors by assimilating DSGE-VAR model derived from Eq. (1.1).

The analysis started by approximating an unrestricted VAR applying the same procedure as (Andreasen et al. 2013). Akaike's AIC criteria were applied to find the lag length of the VAR framework. Nevertheless, two lags were required according to the Akaike's AIC technique to find an approximated model without autocorrelation.

Let Z_t is a vector of endogenous variables for DSGE model e.g., inflation rate or CPI and y_t is a vector of exogenous variables e.g., labor productivity, unemployment, money supply, output gap and interest rate. For a set of n time series variables $y_t = (y_{1t}, y_{2t,}, ..., y_{5t})$, a VAR model of order p (VAR (p)) can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t \quad (1.2)$$

Where A_t's are coefficient matrices and $u_t = (u_{1t}, u_{2t}, ..., u_{nt})$ is an unobservable i.i.d. zero mean error term. A_1..., A_p is k*k matrices of lag constants to be approximated. In DSGE model, y_t refers as shocks but from econometric point of view, y_t is exogenous state variables and u_t are structural shocks.

If shocks y_t follows an AR(1) process

$$y_t = Ay_{t-1} + \varepsilon_{yt} \tag{1.3}$$

Then solution for endogenous variable will take the form

$$z_t = Bz_{t-1} + Ay_t + \varepsilon_{yt} \tag{1.4}$$

Where A & B are the coefficients matrices.

For instant, Consider a two-variable VAR (1) with k=2.

$$y_t = b_{10} - b_{12}z_t + c_{11}y_{t-1} + c_{12}z_{t-1} + \varepsilon_{yt} \tag{1.3a}$$

And for inflation Z_t,

$$z_t = b_{20} - b_{21}y_t + c_{21}y_{t-1} + c_{22}z_{t-1} + \varepsilon_{zt} \tag{1.4a}$$

with $\varepsilon_{it} \sim i.i.d(0, \sigma_{ai}^2)$ and $\text{cov}(\ \varepsilon_y, \varepsilon_z\ ) = 0$

here, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots, \varepsilon_{kt})$ is a k*1 white noise innovation process and Z_t represents inflation.

Any value of $\varepsilon_t \geq 0$ effects the inflation rate permanently so deviation from regression line of Eq. (1,1) will be non- stationary stated by unit root hypothesis. Hence, the reduced form of vectors will take finite order VAR representation generally so DSGE model, illustrating combination of endogenous variables, exogenous variables and shocks, can be represented by VAR finite-order model.

Findings

This study estimates VAR model with five variables in table 4. Table 4 shows the structural approach to time series data designing via the application of economic theory to frame the association between the response and the predictor factors.

Table 4. Estimation Output of VAR (p) Model for Endogenous and Exogenous Variables

	D(INF)	**D(I)**	**D(L)**	**D(S)**	**D(O)**	**D(U)**

D(INF)	-0.227151 (-1.18)	-0.072717 (3.35)*	-0.103618 (2.50)*	0.195701 (-3.63)*	- 2.003755 (-4.92)*	-0.930377 (4.53)*
D(I)	-0.090244 (3.23)*	-0.284625 (1.97)	-0.60874 (-3.83)*	-0.067381 (-2.09)*	0.005742 (0.62)	0.046569 (3.36)*
D(L)	-0.173404 (2.42)*	0.121203 (1.43)	-0.391133 (-2.11)*	-0.116600 (-2.41)*	0.003112 (0.83)	0.067438 (1.30)
D(S)	0.195699 (3.92)*	0.130032 (2.34)*	-0.133678 (-1.09)	-0.409515 (-2.22)*	0.004697 (4.92)*	0.025078 (3.73)*
D(O)	-2.069054 (4.27)*	1.014650 (3.27) *	2.585555 (4.32)*	-0.860592 (-0.07)	- 0.450961 (2.81)*	-1.880012 (-2.87)*
D(U)	-0.731568 (-4.23)*	-0.326040 (-1.93)	-0.429605 (-2.68)*	1.718927 (1.80)	- 0.025007 (-1.97)	-0.355995 (-2.91)*
c	-3.349808 (-0.46)	-2.031476 (-3.08)*	-3.171911 (-1.91)	-4.244953 (-0.20)	1.038651 (2.39)*	4.229635 (1.02)

- *reflects significance of coefficients of different VAR models at 5% level according to absolute t-statistic value criteria. t-statistic is displayed in parentheses.
- D(INF) variable is generated by using up-to two lags to estimate VAR(p) and analogous way is followed to produce rest of the series.
- C denotes intercepts of each VAR model.

To judge on the association between the response and the predictor variable, the coefficients are observed. A positive constant implies that the association is positively correlated. For instance, the effect of money supply on inflation is positively correlated since the coefficient represented by this relationship is 0.09 & 0.19. For a negative association, we take the connection between price rises frequency and the unemployment rate or effect of output gap on inflation. The coefficient indicating the strength of output gap effecting inflation rate of Pakistan is negative implies that the output gap of Pakistan is negative and diminution in this gap is stimulating inflation rate. It reflects Pakistan's actual GDP is less than the potential GDP yielding negative output gap. The coefficient which represents the association between the unemployment rate and price rises proportion is -0.73 and the coefficient represents interest rate and labor productivity correlation with inflation are -0.09 & -0.17 respectively. This implies that increases in unemployment, interest rate and labor productivity cause a decrease in the inflation rate. The estimated VAR equation for inflation rate extracted from table 4 is mentioned below.

$$INF_t = -3.34 - 0.09I_t - 0.17L_t + 0.19S_t - 2.06O_t - 0.73U_t + \varepsilon_t \qquad (1.1b)$$

Above estimated model explains significantly better insight of inflation fluctuation causes. Except intercept, all coefficients of said variables are appearing with correct signs that give the impression of their factual macroeconomic relationships with inflation rate. On similar outlines, more VAR models with alternative dependent variables can also be extracted. This study's focal point is inflation analysis that's why inflation model outcomes are retrieved for discussion purpose. It is found that output gap and unemployment have relatively strong effect to influence the inflation rate. On balance, all variants contribute to the fit of the regression and counting a constant seems to have a trifling effect because it is not significant for most of the regressions.

From the VAR (p) decomposition, a DSGE model can be estimated using the impulse responses criteria. The impulse criteria states that if the VAR (p) model is of finite order, then it can act as a DSGE model (Giacomini, 2013). Then the resultant mathematical DSGE model is equivalent to the VAR (p).Eq. 1.1b as the VAR (p) model is of finite order. The model results (Eq. 1.1b) retrieved from table 4 is a brief capture of DSGE model where five coefficients are estimated.

Co-integration Test

A theoretical dynamic stochastic model equilibrium (DSGE) model is examined in the vector autoregressive model (VAR) via the co-integrated (CVAR) approach for better empirical prognoses of the causes of Pakistan's inflation rate fluctuations. Null hypothesis of no integration among variables is tested. Cointegration method is used here to determine the association between variables having unit roots where OLS is no longer consistent and test statistics are not valid.

Johansen Cointegration results in table 5 show two diverse tests namely unobstructed integration rank examination trace and extreme Eigenvalue to test null hypothesis (H_o: r = 0) against H_1: r > 0. The columns for test statistics examine the H_o of r (period r association) cointegrating associations between the alternate of r+1 (period r+1 association) cointegrating associations for five variables where each significant statistic characterized a stationary relation. The p-values of the two tests are less than 0.5 thus we discard the H_o and make a conclusion that there are five cointegrating vectors exists.

Table 5. Cointegration Rank Test Results

Null hypothesis	**Prob.**	**Maximal Eigen value statistics**	**Prob.**	**Trace statistics**
r = 0	0.0000	76.520*	0.0000	168.59*
r ≤ 1	0.0003	34.437*	0.0437	92.07*

r ≤ 2	0.0045	26.037*	0.0780	57.76
r ≤ 3	0.0001	17.913*	0.0133	31.66*
r ≤ 4	0.0900	8.683	0.0313	13.75*
r ≤ 5	0.0243	5.073*	0.0224	5.07*

*implies significant at 5% level

The initial block statement, referred to as maximum Eigenvalues figures, reveals significant existence of five co-integration vectors while the subsequent block of trace statistics exposes similar result with little contradiction. But in long-run, model indicates five co-movements among variables. It also implies that any change in inflation rate of Pakistan can be caused by five predictors. After assessing cointegration vectors, VEC model is likewise examined to authenticate casual association between regressors and inflation rate.

Granger Causality Test

The grander causality examination is an arithmetical proposition inspection for evaluating if only a single time succession is applicable in predicting the other. Multivariate granger-causality test is applied to fit the VAR representation to the time series data with time lags and to recognize the pattern of correlation among variants.

Results of Granger causality are stated in table 6 where, F-statistic values are reported for each causality along with its probability. Since the time series are non-stationary, the test is performed on first difference variables instead of level values that is indicated by number of observations involved. Null hypothesis is tested for each pair of variables uttering no causal bond among these variables against the alternative that neither variable cause the other variable. Given that p-value is less than 0.5 & 0.01, the H_1 will be accepted. Most of the relationships are statistically significant. This implies that changes in inflation of Pakistan are instigated by all quantified predictors i.e. interest rate, labor productivity, output gap, money supply and unemployment level of Pakistan. Unidirectional and bidirectional relationships are found between some regressors voiced in table 6.

Table 6. Granger Causality Test

Null Hypothesis	**Observation**	**F-statistic**	**Probability**
I does not Granger Cause INF	35	11.7150	0.0197*
INF does not Granger Cause I		8.83777	0.0510
L does not Granger Cause INF	35	6.20999	0.0118*
INF does not Granger Cause L		2.77081	0.0787

O does not Granger Cause INF	35	3.38391	0.0485*
INF does not Granger Cause O		4.12924	0.0792
S does not Granger Cause INF	35	3.52472	0.0041**
INF does not Granger Cause S		8.01962	0.0806
U does not Granger Cause INF	35	4.43280	0.0227*
INF does not Granger Cause U		6.13533	0.0487*
L does not Granger Cause INT	35	10.2486	0.0015**
INT does not Granger Cause L		11.8765	0.0007 **
O does not Granger Cause INT	35	10.4767	0.0254*
INT does not Granger Cause O		2.70542	0.0831
S does not Granger Cause I	35	4.38460	0.0214*
I does not Granger Cause S		5.51897	0.0053**
U does not Granger Cause I	35	5.09465	0.0100*
I does not Granger Cause U		10.4178	0.0325*
O does not Granger Cause L	35	11.0740	0.0042**
L does not Granger Cause O		8.26706	0.0474*
S does not Granger Cause L	35	7.26164	0.0105*
L does not Granger Cause S		7.15240	0.0398*
U does not Granger Cause L	35	9.06266	0.0082**
L does not Granger Cause U		3.84630	0.0926
S does not Granger Cause O	35	9.17543	0.0001**
O does not Granger Cause S		1.31299	0.0326
U does not Granger Cause O	35	1.73146	0.1943**
O does not Granger Cause U		0.28319	0.7554 *
U does not Granger Cause S	35	1.50988	0.2373**
S does not Granger Cause U		4.11597	0.0263

*, and ** illustrates rejection of Null hypothesis at 5% and 10% respectively.

VECM Specification and Estimation

Afterward estimation of unrestricted VAR model and testing cointegration using Johansen test, VECM is formed and analyzed. In a relationship of variables, there are numerous linearly autonomous cointegrating vectors. According to the coefficients output on the VAR models, the predictor variables have a linear connection with the response factor. To embed the idea of cointegration in the VAR model (Eq. 1.2) with slight modification, we assume that the moment when all distinct variables are I (1) or I (0) and the inflation is a k-dimensional VAR (p) process; then the following equation holds true.

$$Y_t = A_1 Y_{t-1} + \ldots\ldots\ldots + A_p Y_{t-p} + V_t + \varepsilon \tag{1.5}$$

If the Eq. 1.5 does not have deterministic factors, subtracting Y_{t-1} on both sides of it will result in a VECM.

$$Y_t - Y_{t-1} = (A_1 Y_{t-1} + \ldots\ldots + A_p Y_{t-p} + V_t) - Y_{t-1} + \varepsilon \quad (1.6)$$

Where Y_t is used for inflation (INF) and V_t represents the vector of five predictor variables having a long-run stochastic trend.

VECM is a theoretically derived approach used here to guesstimate short run and long run connection of inflation regressors with the inflation rate by adding error correction features to VAR model (1.5). Hence, the speed is assessed at which the inflation rate gets back to its equilibrium after fluctuations in five determinants. There are five cointegrating vectors exists, all variables are taken as endogenous and assessed for long term where errors of the regression model are stationary.

According to the VECM output, there is a considerable relationship between inflation rate and the five predictor variables. Cointegration vector equation is referred as equation (1) in above table where parameters are estimated at first difference. This equation indicates long run association with inflation rate of Pakistan. The coefficients of estimated equation (2) in table 7 are the speed of corrections which alter the specific variable by nonconformity from the previous time. Then, factors of Eq. 1.6 should lie between 0 and -1.

Table 7.VECM Model Output

Cointegration Eq.	**INF (-1)**	**I (-1)**	**L (-1)**	**O (-1)**	**S (-1)**	**U (-1)**
1. **Cointegration Vector in long-run**	1.000000	-1.359441 (0.151) [-8.975]	-0.324628 (0.157) [2.206]	-2.796612 (0.718) [3.893]	0.299971 (0.063) [-4.707]	-0.247293 (0.162) [-4.707]
Error	D(INF)	D(I)	D(L)	D(O)	D(S)	D(U)

Correction						
2. **Speed of Adjustment**	0.331950 (0.423) [0.783]	-0.376220 (0.198) [6.892]	-0.107915 (0.411) [2.264]	-0.026390 (0.008) [2.972]	1.430932 (0.719) [2.988]	-0.604003 (0.129) [-3.046]
C	0.558155 (0.936) [0.595]	0.214499 (0.439) [0.488]	-1.131866 (0.908) [-1.24]	-0.059686 (0.019) [3.04]	0.561692 (1.595) [0.353]	-0.021940 (0.285) [-0.076]

*standard error in ( ) and t statistics in [ ]

The estimated statistical VEC model can be exemplified as follows.

$$INF_t = \alpha + V_t = 6.4604 + V_t + \varepsilon_t \tag{1.7}$$

where, α is the constant term and V_t is a vector of regressors

$$INF_t = 6.4604 + (1 + 1.35)I_t - (1 + 0.32)L_t + (1 - 0.29)S_t - (1 + 2.79)O_t - (1 + 0.24)U_t + \varepsilon_t \tag{1.8}$$

The coefficients are obtained from table 7 for Eq. 1.7. The coefficients in Eq.1.8 are added or subtracted from one as a long run correction factor. The long-term variants those elucidate inflation rate of Pakistan are unemployment rate, money supply, output-gap, labor productivity and interest rate, and the parameter coefficient which explicate the extent of fluctuations in inflation rate in the long run, attained from variations in these explanatory variables, are measured as product of the coefficients of cointegration vector equation (1) with the coefficients of equation (2) of speed of adjustment from table 7. The resultant model is a true reflection of the long run association between inflation and the five predictor variables extracted form Eq. 1.1.

$$INF_t = \alpha - \beta_1\beta_2 I_t - \gamma_1\gamma_2 L_t + \lambda_1\lambda_2 S_t - \phi_1\phi_2 O_t - \omega_1\omega_2 U_t + \varepsilon_t \tag{1.9}$$

Where, $\beta_1\beta_2$ is the product of two coefficients of cointegration equation (1) and co-integration equation (2) from table 7. The calculated coefficients are placed in Eq. 1.10.

$$INF_t = \alpha - (-1.35)(-0.37)I_t - (-0.32)(-0.107)L_t + (0.29)(1.43)S_t - (-2.79)(-0.02)O_t - (-0.24)(-0.6)U_t + \varepsilon_t \quad (1.10)$$

Consequently, Long run cointegration equation suggests that the impact of money supply is positive on inflation rate in long run, whereas, unemployment rate, labor productivity interest rate and output-gap effect inflation negatively illustrated by their signs in Eq. 1.1c.

$$INF_t = \alpha - 0.5I_t - 0.03L_t + 0.41S_t - 0.05O_t - 0.14U_t + \varepsilon_t \quad (1.1c)$$

Subsequent equation shows signs of all variables consistent with macro-economic theory with considerable explanatory strength. Strong influence of regressors is explained by the findings of long-run inflation model. Positive relationship among variables reflects adverse effects for the economy when the inflation rate is high and negative impact of variables such as, unemployment rate, out gap, interest rate and labor productivity is desirable to reduce the inflation rate in Pakistan. This shows that to cure current ramble of inflation of Pakistan, the policy makers should consider said variables in an adequate manner.

Table 8 abridged the statistical techniques used in this study to find determinants of inflation rate of Pakistan when regressor series were non-stationary. In other words, Time series behavior of inflation is governed by the behavior of regressors and error term.

Table 8. Estimation Techniques to Analyze Inflation Causes in Pakistan

Regressors	Error	Dependent variable	Estimation Approach
V at levels, non-stationary	ε is stationary	INF is regressed	Linear regression is estimates via OLS technique with biased results.

V is I(1)	ε is I(0)	INF regression is extracted from VAR(p).	VAR(p) is assessed, DSGE model is deduced.
V is I(1)	ε is I(0)	INF is determined by V in long-run	Cointegration vectors are identified via Trace & Eigenvalue statistics. Granger causality is inspected.
V is I(1)	ε is I(0)	INF is caused by five predictors in short run and long run.	VECM model is evaluated.

*V denotes vector of I, L, S, O & U. and I (1) signifies Integrated of order one.

Diagnostic Tests

Data has been gone through many diagnostic tests to certify nonappearance of robustness of outcomes. Data has shown no signs of heteroscedasticity by Breusch Pagan Geoffrey test. Multicollinearity and serial correlation between six variables was also found absent. Stability of regression model is tested by using Cusum and Cusum Square tests plotted in figure2.

Figure 2: Cusum Test and CusumSquare Tests
Source: Author's calculation

The Cusum & Cusum squares evaluation is founded on the test statistics by Brown, Durbin, and Evans (1975) under the hypothesis of parameter constancy. The Cusum examination shown in figure 2 is founded on the increasing addition of the recursive factors. In this chart, schemes of the increasing amount in association with the five percent precarious outlines are presented. The inspection locates constraint variability if the additional quantity goes beyond the location amongst the two precarious streaks. The evaluation in figure 2 shows uncertainty in the equation throughout the time period. The findings indicate that monetary aggregates and labor market variables must be controlled by respective authorities because movement of these variables at level shows instability overall.

Figure 2 provides a Cusum of squares evaluation which displays a graph of expected value of S_t against t together with a pair of 5% precarious outlines. Cusum evaluation lies within the precarious region outlines, thus it is an indication of the stability of residual variance of parameters. Thus, its safe to conclude that the entire aggregates specified via VAR and VECM equations are stable enough in long-run and short -run to provide unbiased results.

In this study, empirical analysis is performed to find causes of Pakistan's inflation flux by using VAR representation of regression equation, approximation of DSGE model from finite-order VAR (p), cointegration test to find co-movement between aggregates and VEC models to find long run and short run relationships after confirming biasedness of OLS technique for estimating variables at level. Assessment outcomes for three approaches have revealed that exogenous variables are statistically significant and remained consistent in all statistical techniques. Since the coefficients are small for some of the regressors indicates that the correlation is subject to change in the long term and it's may not be stable in the short run.

Five cointegration vectors are identified by Johansen cointegration test and further authentication was ended by VECM approach in a distinctive manner. Long run as well as short run association is found for inflation rate of Pakistan and its predictor aggregates that is, interest rate, unemployment rate, money supply, output-gap and labor productivity. The link between inflation to money supply is positively correlated but with other regressors, it is negatively correlated which is a factual explanation of Pakistan's economy structure and supports theoretical illustration. It states that, if the Pakistan economy is working at less than full employment that is there is presence of unemployment, there will be decrease of labor productivity caused by less wage rate and because of less interest rate and negative out gap inflationary pressure is stimulated. Consequently, when the unemployment rate is high, labor costs as well as other resources bid will rise, short run overall supply will be decreased and put pressure on commodity price to rise in the long run.

None of the factor is stable enough to keep its current trend tested by Cusum data plot. In the long run, five predictor variables are expected to shift their current effects on inflation. It suggests, study should avoid using particular time series to forecast inflation rate of Pakistan without continual monitored control on changes in these variables.

Recommendations

Analysis clearly reveals the necessity of dynamic regulations that instability of macro variables must be addressed by concerned state bank of Pakistan with the help of government and other concerned authorities for better formulation of economic and monetary policies to normalize or reduce inflation variations.

On the factual side, certain highlights of an economy like Pakistan cannot be protected from the aftereffects of comparable highlights from the created world because of particularly extraordinary creating nature of developing economies (Brauer and Gissy, 2017). Therefore, the sketch of models attained from advanced economies may not work for these economies without aligning them with appropriate financial structure in economy (Aman et al. 2017). To retain the constancy of prices, the financial policy must be perfect, and the Pakistan administration should consider reformulating or if required may even revolutionize the financial strategies to level the prices of commodities in the country. A persistent determination is crucial to keep the steadiness in the regions of Pakistan where Rupee is the medium of the trade (Hossain, 2015).

References

Adolfson, M. Laséen, S. Lindé, J. & Villani, M. (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, *72*(2), 481-511.

Alam, N. & Rizvi, S. A. R. (Eds.). (2017). *Islamic Economies: Stability, Markets and Endowments*. Springer.

Aman, Q. Ullah, I. & Khan, M. I. (2017). Linkages between exchange rate and economic growth in Pakistan (an econometric approach). *European Journal of Law and Economics*, *44*(1), 157-164.

Andreasen, M. M. Fernández-Villaverde, J. & Rubio-Ramírez, J. (2013). *The pruned state-space system for non-linear DSGE models: Theory and empirical applications* (No. w18983). National Bureau of Economic Research.

Arby, M. F. & Ali, A. (2017). *Threshold Inflation in Pakistan* (No. 94). State Bank of Pakistan, Research Department.

Asghar, N. Jaffri, A. A. &Asjed, R. (2013). An empirical investigation of domestic and external determinants of inflation in Pakistan. *Pakistan Economic and Social Review*, 55-70.

Azam, M. & Rashid, S. (2015). The monetarist hypothesis of inflation in Pakistan–a critique. *Journal of the Asia Pacific Economy*, *20*(4), 559-576.

Bårdsen, G. Jansen, E. S. &Nymoen, R. (2004). Econometric evaluation of the New Keynesian Phillips curve. *Oxford Bulletin of Economics and Statistics*, *66*(s1), 671-686.

Bashir, F. Nawaz, S. Yasin, K. Khursheed, U. Khan, J. & Qureshi, M. J. (2011). Determinants of inflation in Pakistan: An econometric analysis using Johansen co-integration approach. *Australian Journal of Business and Management Research*, *1*(5), 71.

Benchimol, J. (2015). Money in the production function: a New Keynesian DSGE perspective. *Southern Economic Journal*, *82*(1), 152-184.

Benigno, P. (2015). New-Keynesian Economics: An AS–AD View. *Research in Economics*, *69*(4), 503-524.

Brauer, J. &Gissy, W. G. (2017). *The Economics of Conflict and Peace*. Taylor & Francis.

Broome, A. (2015). Back to basics: the great recession and the narrowing of IMF policy advice. *Governance*, *28*(2), 147-165.

Brown, R. L. Durbin, J. & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society. Series B (Methodological)*, 149-192.

Brzoza-Brzezina, M. &Kolasa, M. (2013). Bayesian evaluation of DSGE models with financial frictions. *Journal of Money, Credit and Banking*, *45*(8), 1451-1476.

Colander, D. (2010). The economics profession, the financial crisis, and method. *Journal of Economic Methodology*, *17*(4), 419-427.

Cologni, A. &Manera, M. (2008). Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries. *Energy economics*, *30*(3), 856-888.

Crowder, W. J. & Hoffman, D. L. (1996). The long-run relationship between nominal interest rates and inflation: the Fisher equation revisited. *Journal of money, credit and banking*, *28*(1), 102-118.

De Vroey, M. (2016). A history of macroeconomics from Keynes to Lucas and beyond. Cambridge University Press.

Del Negro, M. &Schorfheide, F. (2006). How good is what you've got? DGSE-VAR as a toolkit for evaluating DSGE models. *Economic Review-Federal Reserve Bank of Atlanta*, *91*(2), 21.

Del Negro, M. Giannoni, M. P. &Schorfheide, F. (2015). Inflation in the great recession and new keynesian models. *American Economic Journal: Macroeconomics*, *7*(1), 168-196.

Dib, A. (2003). An estimated Canadian DSGE model with nominal and real rigidities. *Canadian Journal of Economics/Revue canadienned'économique*, *36*(4), 949-972.

Fernald, J. G. (2015). Productivity and Potential Output before, during, and after the Great Recession. *NBER Macroeconomics Annual*, *29*(1), 1-51.

Galí, J. (2015). *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*. Princeton University Press.

Gertler, M. &Karadi, P. (2011). A model of unconventional monetary policy. *Journal of monetary Economics*, *58*(1), 17-34.

Giacomini, R. (2013). The relationship between DSGE and VAR models. In *VAR Models in Macroeconomics–New Developments and Applications: Essays in Honor of Christopher A. Sims* (pp. 1-25). Emerald Group Publishing Limited.

Gupta, R. & Steinbach, R. (2013). A DSGE-VAR model for forecasting key South African macroeconomic variables. *Economic Modelling*, *33*, 19-33.

Hansen, B. E. (1992). Testing for parameter instability in linear models. *Journal of policy Modeling*, *14*(4), 517-533.

Hatemi-J, A. (2003). A new method to choose optimal lag order in stable and unstable VAR models. *Applied Economics Letters*, *10*(3), 135-137.

Herbst, E. P. &Schorfheide, F. (2015). *Bayesian Estimation of DSGE Models*. Princeton University Press.

Hossain, A. A. (2015). *Central banking and monetary policy in Muslim-majority countries*. Edward Elgar Publishing.

International Monetary Fund (2017). *Global Financial Stability Report: Potent Policies for a Successful Normalization,*Washington, April.

International Monetary Fund (2017). *World Economic Outlook: Gaining Momentum*? Washington, April.

International Monetary Fund (2017a). *Macroeconomic developments and prospects in low-income developing countries – 2016.* Washington, DC. Retrieved from https://www.imf.org/en/Publications/Policy-Papers/Issues/2017/01/13/PP5086-Macroeconomic-Developments-and-Prospects-in-Low-Income-Developing-Countries-2016

Jorgensen-Dahl, A. (2016). *Regional organization and order in South-East Asia*. Springer.

Juselius, K. (2006). *The cointegrated VAR model: methodology and applications*. Oxford university press.

Khan, M. A. & Ahmed, A. (2011). Macroeconomic effects of global food and oil price shocks to the Pakistan economy: A structural vector autoregressive (SVAR) analysis. *The Pakistan Development Review*, 491-511.

Kim, K. H. (2003). Dollar exchange rate and stock price: evidence from multivariate cointegration and error correction model. *Review of Financial economics*, *12*(3), 301-313.

Kolasa, M. Rubaszek, M. &Skrzypczyński, P. (2012). Putting the New Keynesian DSGE Model to the Real-Time Forecasting Test. *Journal of Money, Credit and Banking*, *44*(7), 1301-1324.

Laubach, T. & Williams, J. C. (2016). Measuring the natural rate of interest redux. *Business Economics*, *51*(2), 57-67.

Nabli, M. K. (2011). *The great recession and developing countries: Economic impact and growth prospects*. World Bank.

Rabanal, P. (2007). Does inflation increase after a monetary policy tightening? Answers based on an estimated DSGE model. *Journal of Economic Dynamics and Control*, *31*(3), 906-937.

Ratto, M. Roeger, W. &in't Veld, J. (2009). QUEST III: An estimated open-economy DSGE model of the euro area with fiscal and monetary policy. *economic Modelling*, *26*(1), 222-233.

Roberts, J. M. & Sattar, H. (2015). *Pakistan's Economic Disarray and how to Fix it*. Heritage Foundation.

Rotemberg, J. J. & Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy. NBER macroeconomics annual, 12, 297-346.

Schorfheide, F. (2011). Estimation and evaluation of DSGE models: progress and challenges (No. w16781). National Bureau of Economic Research.

Selgin, G. Beckworth, D. &Bahadir, B. (2015). The productivity gap: Monetary policy, the subprime boom, and the post-2001 productivity surge. *Journal of Policy Modeling*, *37*(2), 189-207.

Shah, M. A. Aleem, M. &Arshed, N. (2014). Statistical analysis of the factors affecting inflation in Pakistan. Middle-East Journal of Scientific Research, 21(1), 181-189.

Tams, C. J. & Tietje, C. (Eds.). (2012). Documents in international economic law: trade, investment, and finance. Oxford University Press.

Taylor, L. D. (2010). Capital, Accumulation, and Money: An Integration of Capital, Growth, and Monetary Theory. Springer Science & Business Media.

Thanh, S. D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A Panel Smooth Transition Regression approach. *Journal of Economics, Finance and Administrative Science*, *20*(38), 41-48.

Watson, M. W. (1994). Vector auto regressions and cointegration. *Handbook of econometrics*, *4*, 2843-2915.

World Bank. (2017). *World Bank Development Indicators.* World Bank