

Forecasting Inflation Using Univariate and Multivariate Time Series

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Abstract

The purpose of the study is to forecast inflation in Pakistan from January to June 2008. This study set out to redress the deficiency and explicitly use of time series techniques solely for forecasting purposes. The analysis based on the time series available from July 1995 to December 2007. Inflation is a trending series with the possibility that the trend is time varying. It is also plausible that monthly inflation could move around a time varying mean. Forecasting inflation is a difficult but essential task for the successful implementation of monetary policy. Inflation forecasts are central to macroeconomic analysis. There are a number of approaches available for forecasting economic time series. One approach, which includes only the time series being forecast, is known as univariate forecasting. An alternative approach is multivariate time series forecasting. To forecast inflation in Pakistan on monthly basis, we segregated our study in two parts, univariate with ARIMA Model and multivariate with VAR Model. Forecasted inflation for the month of January-08 and February-08 are close to the actual inflation, while in March 2008 there is found significant differences in forecasted and actual values of inflation. The reason of the high rate of actual inflation in March 2008 is the rise in oil prices.

Key words: *Forecasting, consumer price index, quasi money, CMR, ARIMA & vector autoregressive model.*

1. Introduction

The State Bank of Pakistan formulates and regulates Pakistan's monetary policy with the primary objective of maintaining price stability. The broad money stock or direct inflation targeting, the provision of optimal and timely inflation forecasts represent a key ingredient in designing monetary policies which are geared toward the achievement of price stability. According to the State Bank's monetary policy statement (Jan-June 2008), the SBP strives to keep headline inflation, measured by the average growth in consumer price index (CPI), at its targeted level while keeping an eye on the growth prospects of the economy through its prudent and timely use of monetary policy instruments and other related measures. Inflation is a trending series with the possibility that the trend is time varying. It is also plausible that monthly inflation could move around a time varying mean. In either case, this suggests that, at least for certain parts of the sample period, monthly inflation could be a non-stationary process.

Background of the Study

Forecasting inflation is a difficult but essential task for the successful implementation of the monetary policy. Inflation forecasts are central to macroeconomic analysis. Monthly inflation indicates non-normality in the form of either occasional big shocks or marked changes in the

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level of the series. The primary focus of monetary policy, both in Pakistan and elsewhere, has traditionally been the maintenance of a low and stable rate of aggregate price inflation as defined by commonly accepted measures such as the consumer price index (CPI). The underlying justification for this objective is the widespread consensus, supported by numerous economic studies, that inflation is costly insofar as it undermines real, wealth enhancing, and economic activity.

The Box-Jenkins methodology is an iterative approach incorporating model estimation and diagnostic checking in addition to model identification. Theoretically, Box-Jenkins (1976) model identification is relatively easy if one has a pure AR or a pure MA process. However, in the case of a mixed ARMA models, Box-Jenkins identification becomes a highly subjective exercise depending on the skill and experience of the forecaster. Random noise in time series, especially price data, makes Box-Jenkins model identification even more problematic.

Problem Statement

In past studies of inflation, the emphasis has been on testing economic theory and on empirical analysis. Even though some of these studies have been used as an input into the forecasting process within the economy, they have not been subject to rigorous forecast evaluation techniques. This study will set out to redress this deficiency and will explicitly use time series techniques solely for inflation forecasting purposes.

1.3 Study objectives

The main objective of this study is to forecast inflation in Pakistan on a monthly basis. We have segregated our study in two parts. In first part, we will forecast inflation in Pakistan using univariate model. For this, we will use the Box Jenkins approach and vector auto-regressive (VAR) model. In the second part, we will use multivariate modeling technique and will apply Philips curve on monthly data.

1.4 Research Methodology

Two alternative approaches to model identification are considered: i) the traditional Box-Jenkins approach which can be highly subjective; and, ii) vector auto-regressive (VAR) model to forecast inflation. The basic approach and methodology for the identification, estimation, diagnostic checking, and forecasting for seasonal time series models are similar to those developed for non-seasonal time series models. The primary difference is that for a seasonal time series, the model needs a seasonal ARIMA component in addition to a non-seasonal ARIMA component. This extension of ARIMA models, largely attributable to Box and Jenkins (1976), greatly increases the flexibility and usefulness of the models, but it also makes the identification of seasonal ARIMA models more complicated. The use of VAR models in applied economics has increased significantly in recent years. A more practical consideration favouring VAR models is the ease, relative to structural econometric models, with which they can be built and used, and then specification does not require the laborious process of incorporating restriction implied by economic theory. VAR models make it possible to consider all variables to be endogenous in order of forecast. Modeling exogenous indicators in a VAR would be inconsistent.

1.4.1 Proposed Model

$$\Pi_t = \beta_0 + \beta_1 QM_t + \beta_2 CMR_t$$

The model developed to study the impacts of Quasi Money (QM) and Call Money Rate (CMR) on change in inflation rate ' Π ' for the months from January 2008 to June 2008. β_0 is intercept, β_1 and β_2 are the coefficients while ' t ' is time factor.

1.4.2 Data source

Our database covers the period July 1995 to December 2007 on a monthly basis. For analysis, secondary data on inflation and other variables has derived from the international publication International Financial Statistics (IFS) and from different local publications including Federal Bureau of Statistics' publications on CPI and publications of the State Bank of Pakistan (Banking Statistics, Monthly Bulletin and FSA). Historical data are available on the behavior that is to be predicted (e.g., monthly data on inflation from 1995-2007).

2. Literature Review

2.1 Inflation Forecasting in General

According to Francis (2006), adequate modeling of the seasonal structure of consumer prices is essential for inflation forecasting. The author suggested a new econometric approach for jointly determining inflation forecasts and monetary policy stances, particularly where seasonal fluctuations of economic activity and prices are pronounced. Kim (2006) examined the role of information variables with regard to inflation forecasting. He selected 42 individual economic indicators from the real, external, price and financial-market sectors that are widely used in the process of inflation forecasting by monetary policy authorities, and formed a factor model that uses information taken through principal component analysis. Dean Croushore (2006) examined the inflation forecasts from the Livingston Survey and the Survey of Professional Forecasters, using the real-time data set for macroeconomists. The author looked at the magnitude and patterns of revisions to the inflation rate based on the output price index and described what data to use as 'actuals' in evaluating forecasts. Todd and Michael (2006) were of the view that the commonly-used VAR models of output, inflation, and interest rates may be prone to instabilities and thus a variety of estimation or forecasting methods might be used improving the accuracy of forecasts from a VAR model. Although each individual method could be useful, the uncertainty inherent in any single representation of instability could mean that combining forecasts from the entire range of VAR estimates will further improve forecast accuracy. They examined the effectiveness of VAR forecasts made with real-time data.

2.2 Inflation Forecasting in Pakistan

Bokil (2006) applied three empirical approaches to forecasting inflation in Pakistan. The preferred one was the leading indicators model (LIM) in which broad money and private sector credit growth lead inflation by more than six months. The model is used to assess the potential parameter instability on account of fundamental changes in Pakistan's economic system by restricting sample to more recent observations. They also considered the aspects of Gregorian and Islamic calendar seasonality using twelve-month averages. Their preferred forecasting models were largely driven by statistical properties and less by economic intuition.

Bokhari and Mete (2006) used a number of approaches in forecasting inflation in Pakistan. ARIMA and VAR models are used to assess the four different indices, SPI, CPI, WPI and GDP deflator to focus on the problem of macroeconomic forecasting. They found that the ARIMA (2, 1, 2) performed better than VAR models. They concluded that large models may solve problems, so that formal statistical models can play a major role in the economic forecasting and macroeconomic policy. Feridun and Mete (2006) attempted to outline the practical steps which need to be undertaken to use ARIMA time series models for forecasting Pakistan's inflation. They drew a framework for ARIMA forecasting. On the basis of in-sample and out-of-sample forecast, they concluded that the model has sufficient predictive powers and the findings confirm other such studies.

Khalid argues that there is a growing debate in the emerging market on the choice of an appropriate monetary or exchange rate policy that could lead to a sustainable economic growth. He said that the Inflation targeting has become one of these policy alternatives and has recently been implemented in some of the emerging markets in Asia and Latin America.

He emphasized that given the recent remarkable economic performance of Pakistan, this issue has also been discussed at various policy forums in the country. Riaz and Khan (2002) investigated the detection of calendar and seasonal effects in time series data. As the behavior of Islamic societies incorporates seasonal effects of both Gregorian and Islamic calendars, the conventional seasonal adjustment methods will yield distorted results. In this paper they extended the standard ARIMA modeling to incorporate Islamic calendar effects.

3. Analysis

3.1 Unit Root Tests

Consumer_Price Index (CPI=i): Where i=LOG (CPI)

t-statistics in () at 95% level of significance	With Constant	lag	Without Constant	lag	Trend	lag
Level	-0.36422 (-2.8808)	0	10.9168 (-1.9429)	0	-1.3439 (-3.4403)	0
First Difference	-5.4534* (-2.8813)	2	-2.8823 (-1.9432)	2	-5.4382 (-3.4409)	2

*The log of CPI could not pass the unit root test at level, while at first difference, it has passed the test.

Call Money rate (CMR=cm) : Where cm=LOG (CMR)

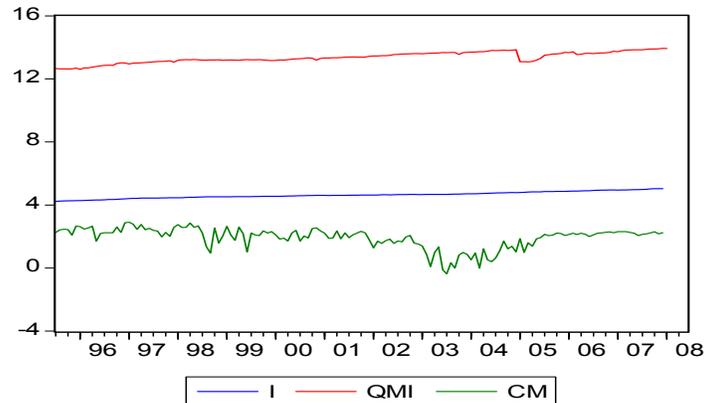
t-statistics in () at 95% level of significance	With Constant	lag	Without Constant	lag	Trend	lag
Level	-2.2247 (-2.8811)	2	-0.7269 (-1.9430)	2	-2.1821 (-3.4407)	2
1st Difference	-13.3668* (-2.8811)	1	-13.4127 (-1.9430)	1	-13.3445 (-3.4407)	1

*The log of CMR could not pass the unit root test at level, while at first difference, it has passed the test.

Quasai_Money (QM=qmi): Where qmi=LOG (QM)

t-statistics in () at 95% level of significance	With Constant	lag	Without Constant	lag	Trend	lag
Level	-1.7051 (-2.8811)	0	0.9536 (-1.9430)	0	-3.2499 (-3.4407)	0
1st Difference	-12.6279* (-2.8811)	0	-12.5006 (-1.9430)	0	-12.5946 (-3.4407)	1

*The log of QM could not pass the unit root test at level, while at first difference, it has passed the test.



Using Unit root test, we checked the stationarity of these variables and removed the non-stationarity of data. All three variables have $i(1)$ order and passed the co-integration and power tests.

The correlogram of $i=\log(\text{CPI})$, at level, points out some outliers which are becoming cause of non-stationarity of the data (see annexure-1). The correlogram of $i=\log(\text{CPI})$, at first difference, shows some outliers which are becoming cause of non-stationarity of the data. We remove these ARs' and MAs' to have stationary data (see Annexure-2).

All the series were transformed by taking natural log. In checking for the order of integration, unit root testing, simple unit roots were applied. It was found that CPI was of $I(1)$ (integrated of order one). Finally, ARIMA of orders AR (1), AR (3), MA (1), MA (12) and MA (16) showed significant probabilities. Now this has become our final ARIMA model for CPI at first difference.

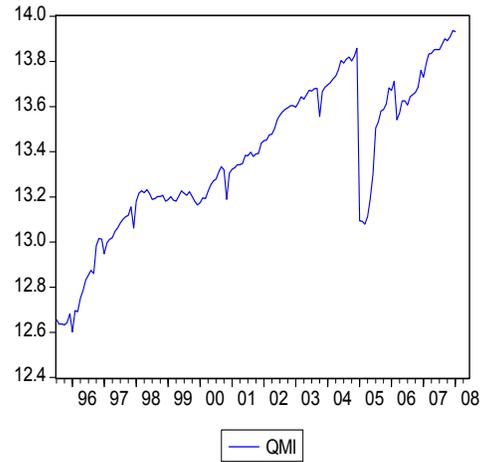
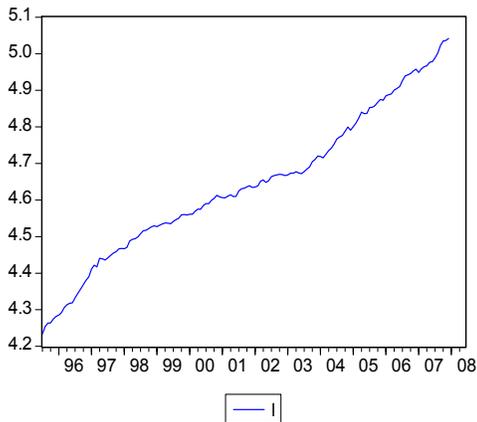
In Annex-3, measure of central tendency shows that the average price change 4.64, clearly reflects that mean of the Quasi Money was significantly higher than the mean of the other two variables while the standard deviation of Call Money is higher than the other two parameters of the model.

The skewness of 150 observations depict that the consumer prices are positively skewed while the quasai money and call money are negatively skewed. Thus, on average, the distribution of price changes is skewed

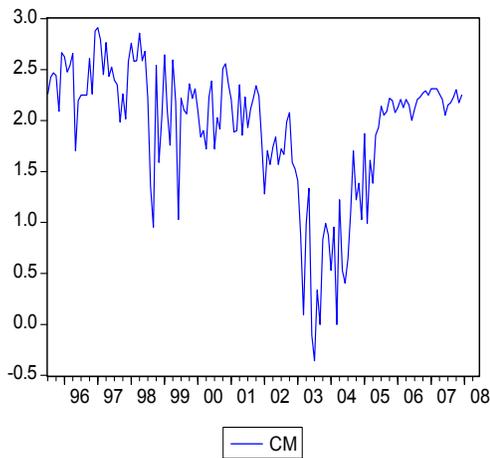
Over the entire period, average degree of kurtosis in the distribution of consumer price change was 2.31, indicating considerable excess kurtosis compared to a normal distribution. This indicates that the distribution of price changes has considerably fatter tails than a normal distribution, implying that mean rate of headline inflation is likely to be distorted frequently by extreme movements in some prices. In statistical terms, the high kurtosis of the distribution implies that the CPI mean inflation rate is not a robust or efficient measure of the general or central tendency of inflation.

3.2 Decomposition and Recomposition

Decomposition methods identify four separate components of the basic underlying pattern that characterize economic and business series. These are the seasonal, trend, cycle and irregular components.



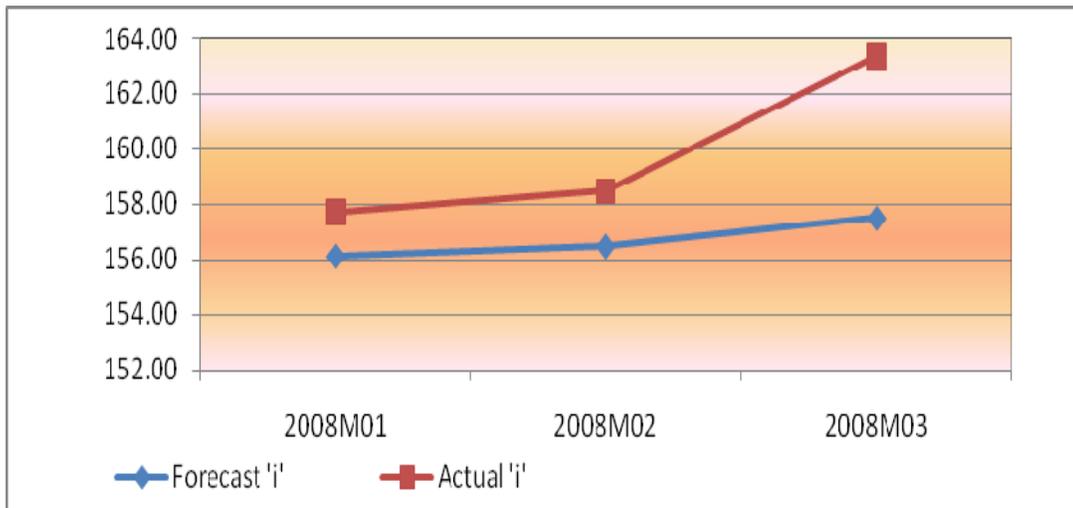
The original series of response variable CPI gave the upward trend with respect to time while the explanatory variables Quasi Money and Call Money Rate gave mixed trends.



2008	Forecast	Actual
January	156.12	157.73
February	156.48	158.50
March	157.51	163.38*
April	158.67	N.A
May	158.15	N.A
June	160.09	N.A

3.2 Univariate Model

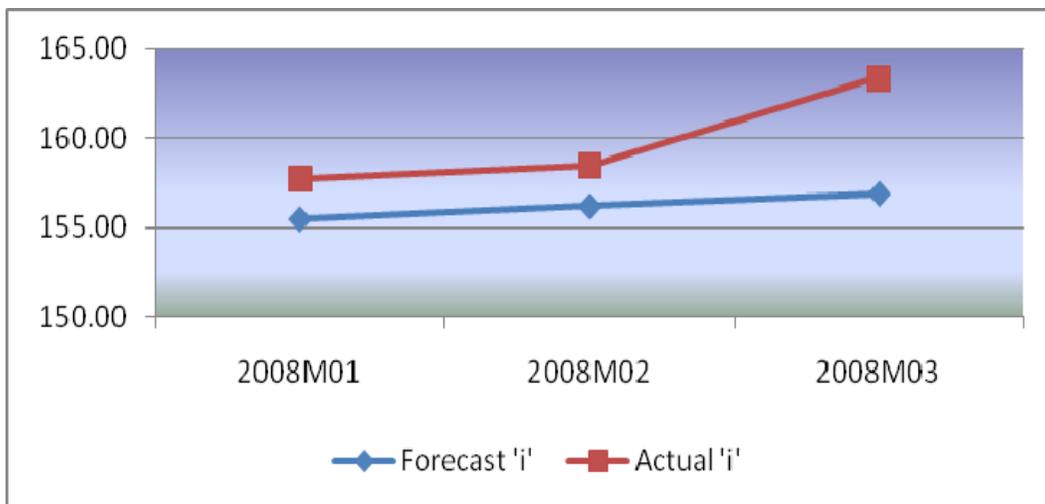
We applied univariate test and found the series I (1). The correlogram, showed significant probabilities which removed the non-stationarity of the data. This has become our final ARIMA model for CPI at first difference. Forecasted inflation for the month of January 2008 and February 2008 are close to the actual inflation.



The fitted model satisfies all the diagnostic tests required for the suitability of the model. Forecasted inflation for the month of January 2008 and February 2008 are close to the actual inflation. The forecasting efficiency of the model is satisfactory.

The plot of the series indicates that the forecasted values of January 2008 and February 2008 are close to actual value except March 2008, which is probably due to the rise in oil prices.

3.3 Multivariate Model Following the same pattern of testing of univariate test, we found that the explanatory variables QMI and CM passed unit root test at first difference. Taking into account this result, we developed a VAR model to forecast inflation for January-June 2008. Forecasted inflation for the month of January 2008 and February 2008 are close to the actual inflation.



For February 2008 and March 2008, significant differences are found in forecasted and actual values of inflation. The reason of the high inflation in these months is the rise in oil prices.

4. CONCLUSION AND RECOMMENDATIONS

Pakistan's economic data permits quantitative forecasts of inflation. High frequency data for Pakistan is largely restricted to monetary data. Only few sector variables are available at a sub-annual and monthly basis. We found that the available data from July 1995 onward is sufficiently rich to allow inflation forecasting in Pakistan. As economic relationship in Pakistan firms up, a structural VAR approach to inflation forecasting should become feasible, as this would yield a richer forecast that will also allow an analysis of the impact of monetary policy instrument.

A large number of studies is available on the inflation and monetary policy relationship in Pakistan. Some studies are based on samples going back as far as the 1950s, but most start in 1972, using either annual or non-structural quality data. Most studies employ either co-integration techniques or estimate VAR models (often in first difference). All studies are in the business of model building and none attempts to use their results for forecasting. Most studies find economic relationship to hold in a compilation framework, a few fail to find co-integration which could suggest structural breaks in particular samples. Even though some of the studies have been used as an input into the forecasting process within the economy, they have not heretofore been subject to rigorous forecast evaluation techniques.

This study set out to redress this deficiency and explicitly use time series techniques solely for forecasting purposes. We use the Box-Jenkins approach and VAR model to forecast inflation in Pakistan. In our study, we applied univariate and multivariate approaches to forecast inflation in Pakistan for six months from January-June 2008. The systematic investigation of large monthly economic indicators tends to indicate that some of them have forecasting contents. It is not guaranteed that the models, even with higher accuracy, use the information available in the data in an optimal way. Hence, the difference between our exercise and the job of forecasting inflation in real time is that in the later case, the numeric results of the models, the judgment of the forecaster and additional information on future likely events affecting inflation, such as oil prices or raw material prices, money demand or market rate. This implies that prediction accuracy, although vital, is not the only determinant for selecting the type of models to be used in forecasting inflation in Pakistan.

Forecasted inflation for the months of January and February 2008 are close to the actual inflation, while in March 2008, significant differences are found in forecasted and actual values of inflation. The reason of the high rate of actual inflation in March 2008 is the rise in oil prices.

The prediction accuracy can be achieved by seasonal adjustment of the data. Twelve-month moving averages are likely to be less volatile than monthly observation that can be subject to temporary exotic shock e.g. rapid increase in oil prices in March 2008. The adjustment of oil prices may provide encouraging results. It is recommended to proceed with the seasonal adjustment of the data to forecast inflation in Pakistan to have close results from March 2008 onward.

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