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How well do linear and nonlinear time series models' forecasts compete with international economic organizations?

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Abstract

This paper evaluates the forecasting performance of linear and non-linear time series models of some macroeconomic variables viz a viz the forecasts outlook of these variables generated by leading international economic organizations i.e. the International Monetary Fund (IMF) and the Organization of Economic Cooperation and Development (OECD). In literature many time series and econometrics models are used to forecast financial and macroeconomic variables. The accuracy of such forecasts depends crucially on careful handling of nonlinearity present in the time series. These models use the past patterns of the economic time series to infer the parameters of the underlying stochastic process and use them to make forecasts. In doing so these models use only the information contained in the past data. However the economists working in professional international economic organizations not only look at the past trends but use the condition of local and global economy prevailing at the time and expected future path of economies as well as their professional expertise and judgment to arrive at forecasts of macroeconomic variables. However the specific underlying models and methodology used by the economists generating these forecast is usually not communicated to the public. In comparison, the time series models are well developed and accessible to researchers working anywhere around the globe. Thus it is an interesting task to compare the foresting ability of linear and nonlinear time series models with the forecast generated by the professional organizations. This will be another way to gauge the out sample forecast ability of the standard models. The nonlinear models employed in this study are quite well known namely the Self Exciting Threshold Autoregressive (SETAR) model and the Markov Switching Autoregressive (MSAR) model. The linear models employed are the AR and ARMA models. The paper have used annual data of three macroeconomic time series variables GDP growth, consumer price inflation and exchange rate of G7 countries i.e. Canada, France, Germany, Italy, Japan, United Kingdom (UK) and United States of America (USA) as well as an emerging south Asian economy namely Pakistan. Three forecast accuracy criteria i.e. Root Mean Square Error (RMSE), Mean Absolute Error (MAE)

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and Mean Absolute Percentage Error (MAPE) are employed and the statistical significance of difference in forecasts is assessed using the Diebold-Mariono test. The results show that the forecasting ability of nonlinear Regime Switching models SETAR and MSAR is superior to the linear models. Further, although the point forecasts of linear and nonlinear models are not superior to that of economic organizations but in more than 60 percent of the cases considered the forecasting accuracy of two sets of forecasts is not statistically significantly different.

Keywords: *Nonlinear models, Self-exciting threshold Autoregressive model, Markov-Regime Switching model, IMF, OECD.*

1. Introduction

Forecasting of relevant economic and financial variables is a key tool to facilitate decision makers in many fields such as finance, economics, business, investment and government. It is a fact that successful planning and decision making needs accurate modeling and forecasting of relevant macroeconomic and financial time series variables. The linear models predict the symmetric impact of positive and negative shocks which is inconsistent with some observed asymmetric response e.g. downward sticky prices. Anderson and Vahid (1998) point out that in some cases linear expectation models do not accommodate the stylized facts of data, e.g., linear VAR models do not account for a well-known phenomenon, that is many business cycles indicates that the recessions are sharp and short lived but expansions are mild and long lasting. Success in forecasting the macroeconomic variables is therefore, dependent on careful modeling of nonlinearity present in the data. The Box-Jenkins modeling strategy is the most influential in the forecasting research in linear time series models (Barbulescu & Bautu, 2012). However, the Box-Jenkins models do not possess the ability to identify the non-linearity in the data. From the literature, it is found in most cases that the important reason for the failure of the forecasting models is to ignore the parametric nonlinearity inherent in many economic variables. The regime-switching models have been used extensively and enjoyed some success in catching the attention of researchers as described in Franses and Dijk (2000). But neither out of sample nor in-sample fit of these models provide improvement as compared to the linear AR models (Clements & Smith, 1997). Diebold and Nason (1990), and De Gooijer and Kumar (1992) also discussed the forecasting performance of non-linear models and conclude that forecasting from the nonlinear models does not always yield up to mark performance against the linear AR models.

The literature on comparing performance of forecasts generated by economic organizations with time series models is quite limited especially with the non-linear models. To fill this gape in the literature, this paper provides the empirical evidence of forecasting performance of two of the most important international organizations namely International Monetary Fund (IMF) and the Organization for Economic Co-operation and Development (OECD) viz a viz linear and non-linear time series models. The international economic organizations report forecasts of many macroeconomic variables of different developed countries based on the expertise of their staff who have expertise and subjective view on the expectation of future path of economies in addition to historical time series data. Thus it is interesting to examine the forecasting accuracy of macroeconomic variable generated by these organizations with the time series models. The later models, which are generally accessible to researchers all over the world, employ only the historical pattern embodied in the macroeconomic variables. The predictions of the economic and financial variables of different developed countries from the IMF and OECD are published twice a year. The forecasts of different economic and financial variables from the IMF are published in the World Economic Outlook (WEO) in May and October in the same year while the forecasts from the OECD published in Economic Outlook in June and December in the same year. The forecasts are also reviewed with the political representatives of different countries present as members in organizations. According to Batchelor (2000), this long consultation process not only slows down the procedure of the forecast but also results in biasedness due to the influence of political pressures. The IMF and OECD continuously monitor the accuracy of their forecasts. The forecasting performance of these organizations is evaluated in many studies i.e. Kenen and Schwartz (1986), Artis (1988), Artis (1996), Barrionuevo (1993), Loungani (2000) and Ash and Smyth (1991). Batchelor (2000) concluded that the OECD forecasts are not as accurate as compared to the IMF. Also, the forecasts from the OECD are more biased as compared to IMF. According to Artis (1988), it is observed that the forecast from the OECD is not unbiased and also it is not much accurate as compare to the forecast from the IMF despite that they publish their forecast in different timings. Nearly all the studies in literature focus on the comparison of the official forecasts to forecast of some naïve models. Usually, these comparisons are not valid as most of the predictions from the naïve models are not reliable. In general, therefore, almost all the forecasts from the IMF and OECD outperform naïve models.

Several studies have been done to compare the forecasting performance of different worldwide and international organizations during recent years. These studies were focused on the forecasting of macroeconomic variables such as GDP and inflation of some of the countries using simple linear models such as, ARIMA, random walk models, ARCH, GARCH, VAR models etc. In this paper we investigate the forecasting performance of both the linear and nonlinear econometric and time series models vis-a-viz the forecast made by IMF and the OECD. The macroeconomic variables considered in this study include gross domestic product growth rate (GDP growth), inflation and exchange rate for the G-7 countries and an emerging south Asian economy namely Pakistan. These are the most important variables which are used to gauge the economic the stability and development of a country.

Following, this introduction section 2 presents literature review, linear models are described in section 3 and non-linear models are reviewed in section 4. Model estimation and forecasting performance are studied in section 5. Results and discussions on these forecasts are covered in section 6. Section 7 describe the data and their time series behaviors. Section 7 provides conclusion.

2. Literature Review

The extensive literature review indicates that there is unending dispute regarding the importance of the appropriate forecasting models for the macroeconomic time series (Swanson & White, 1994). Generally, the nonlinear models are considered better as compared to the linear models i.e. linear autoregressive (AR), autoregressive moving average (ARMA), and autoregressive integrated moving average (ARIMA) models but the literature does not provide conclusive evidence in this regard. See for example Clements and Krolzig (1997).

Clements and Krolzig (1997) compared the regime switching models and a linear model on the quarterly GNP data one from 1982 prices for the period 1948:1 to 1990:4, and second data from 1959:1–1996:2 at 1992 prices. They found that the Markov switching autoregressive model (MS-AR) and self-exciting threshold autoregressive model (SETAR) were more accurate as compared to the famous linear models. They emphasize that the nonlinear models are superior in identifying some special characteristics of a business cycle. Furthermore, they disagree that the nonlinear models have a superior forecasting power. In addition, the results are mixed as the accuracy of the forecasting suggests nonlinear modeling is helpful for some data sets while for other data sets the evidence totally opposed this fact. Similarly, Feng and Liu (2003) also compared the forecasting performance of nonlinear SETAR model and standard linear ARIMA model. They used Canadian real GDP data from the first quarter of 1961 to the last quarter of 2000. They used the forecast evaluation techniques to conclude their results regarding the forecast performances of the two models. They reveal that the SETAR model gives better forecast as compared to ARIMA model in the case of within-sample fit. Additionally, they also proved that the predictive power of SETAR model in case of out of sample forecasting is much superior to the linear ARIMA model. After this, Kostaer and Mosler (2006) investigates the forecasting performance of linear AR model and nonlinear autoregressive Markov Switching Models. They used German time series electricity spot prices taken from European Energy Exchange in Leipzig, Germany. Their results are lopsided towards the MS-AR model. Their study suggests that Markov regime-switching models are more accurate, superior and have better forecasting power as compared to the simple linear AR model. However, at the same time, the forecast performance of international organization also investigated. Batchelor (2000) compared the macroeconomic forecasts for G7 countries between the private sector economists with the OECD and IMF which were made in 1990. Their findings illustrate on the basis of two forecast accuracy criteria's namely MAE and RMSE that the forecasts from the private sector are much unbiased and more accurate as compare to the OECD and IMF. He used real GDP growth rates, expenditure of consumers, business investment and industrial production, the consumer price inflation rate and the unemployment rate for the US, Japan, Germany, France, UK, Italy and Canada from 1990 to 1999. Moreover, he found that the OECD and IMF contain very little information which is not enough to reduce the forecast error from the private sector using some formal comparison tests. But at the same time, Kreinin (2000) compared the two big giants of economic forecast organizations, OECD and the IMF by means of the accuracy of annual forecasts. He used real GDP growth rate, the GDP deflator, unemployment, and the trade balance. In 2000, eight countries were attached with OECD. He used all these eight countries to test the projections. Kreinin used twenty-five years of sample data approximately. He publicized that, none of the organization successfully gives accurate forecasting especially in the cases of cyclical turning points. Moreover, he was disagreed with the Batchelor (2000). According to his findings, the projections made by IMF and OECD are far better and superior to the projections made by the naïve models. Afterwards, Loungani (2001) and Blix et al. (2001) compare the forecast performance of IMF and OECD with private forecast. Loungani (2001) worked on the performance of forecasting from different private and official organization like OECD and IMF. He used the GDP growth for both the industrialized and developing countries. The sample data were used on monthly basis from 1989 to 1998 for 63 different countries. According to his findings, the forecasters does not predict recessions accurately. In more than seventy percent cases, the predictions made in October in the year is miscalculated the recession. He also found that the efficiency of the forecasts can be check using some standard tests. He concluded that the Private and IMF or OECD forecast accuracy are very close to each other. They are not really different from each other except few cases regarding the accuracy, bias and efficiency. Meanwhile, Blix et al. (2001) compared the forecasting performance of 250 institutions using the real GDP and inflation data sets from period 1991 to 2001. They picked developed countries i.e. US, Japan, France, Germany, Italy, and Sweden. They revealed that for some countries like US and Sweden, most of the time there has been an overestimation of inflation while the growth has been underestimated. According to them, many pieces of evidence are there which show that the forecasters have been unable to understand the growth rate pattern in many countries. Also, there are many cases which proved that the forecasters follow the herd behavior. They also appreciated the forecasting from the

Japan and Italy. Furthermore, they agreed with the Blix et al. (2001) on the basis of MPE and RMSE, that the forecasting from not much-renowned forecasters is much better as compared to the well-established economic organizations such as the IMF and the OECD. Later on, Keck et al. (2009) analyze the foresting performance using two well-known time series models namely ARIMA and ADL models. They developed a model with additional predictor using GARCH approach which gives better forecasting for long run horizon. According to the Keck et al. (2009), the forecasting ability of the both models ARIMA and ADL based on quarterly data from 1960 to 2009 are much better than the OECD forecasted data. They used the imports and GDP data. Their forecasting comparison results were based on the RMSFE and Theils U. They also suggest that the estimated model performs better especially for two step ahead i.e. two-quarter-ahead forecasts. Abreu (2011) compared the forecasting performance of three international organizations namely the IMF, the European Commission and the OECD with the mean forecasts of two private analyst's institutions namely the Consensus Economics and The Economist. According to him, the forecast of macroeconomic variables from the private analyst's institutions have gained popularity because these private institutions give forecast on monthly basis. He used the yearly data of real GDP growth and inflation projections for nine main advanced economies namely Germany, France, Italy, Spain, Netherlands, Belgium, the United Kingdom, the United States and Japan, over the period from 1991 to 2009. He found that the forecasting performance of the international organizations is approximately similar to private analysts. By examining the literature on the comparison of linear and nonlinear models and comparison of forecasts of organizations e.g. IMF and OECD, it is observed that the number of studies which compare the forecast of non-linear models with that of the economic organizations are very rare. The present paper aims at providing a contribution in the literature in this regards.

3. Linear Models

3.1 Autoregressive AR(p) models

The linear models are used for the modeling and forecasting for most of the time series. Generally, there are three kinds of linear models which are usually used: the linear autoregressive (AR), moving average (MA), and ARMA models. In this study, the traditional linear AR model is considered which belongs to a class of Box and Jenkins (1970) modelling approach. According to Kunst (2012), linear AR models are the most common linear time series models because they can be estimated using the ordinary least square regression. That is why, like other researchers, this paper restrict the model class to AR models. The autoregressive process is characterized the following:

$$y_t = \omega + \varphi_1 y_{t-1} + \alpha_t \qquad (1)$$

Where "ω" is an intercept parameter and is uncorrelated random error with mean zero and variance. "y_t" is seen to comprise two parts such that $\varphi_1 y_{t-1}$ is a carryover component depending on last period value of y_t and a_t is new shock to the level of economic variable in current period.

The AR lag order, p, is selected for the minimization of the AIC (Akaike, 1973)

$$AIC(p) = \ln\left(\hat{\sigma}^2(p)\right) + 2(p+2)/T$$

Where $\hat{\sigma}^2 = \hat{\mu}'\hat{\mu}/T$, and $\hat{\mu}$ denotes the vector of estimated error terms.

3.2 Moving average MA(q) models

A Moving Average (MA) model is one where the contemporaneous value of is influenced by past as well as contemporaneous values of the innovation term u_t i.e.

$$y_t = f\left(u_{t-1}, u_{t-2}, \ldots\right) + \alpha_t \qquad (2)$$

The general form of MA (*q*) is

$$y_t = \omega + \alpha_t - \vartheta_1 \alpha_{t-1} - \vartheta_2 \alpha_{t-2} - \ldots - \vartheta_g \alpha_{t-q} \qquad (3)$$

$$y_t = \omega + \vartheta(L) a_t \qquad (4)$$

Where, "ω" is the intercept term and "a_t" is white noise series

$$\vartheta(L) = 1 - \vartheta_1 L - \vartheta_2 L^2 - \vartheta_3 L^3 \ldots - \vartheta_g L^q \qquad (5)$$

and $\vartheta_1, \vartheta_2, \vartheta_3 \ldots$ are unknown parameters.

3.3 Autoregressive moving average ARMA (p,q) models

The Auto regressive moving average model (ARMA) is a mixture of AR and MA models. The ARMA model offers the basic tool in time series modeling. Makridakis and Hisonif (1997) revealed that if alternative approaches are utilized to remove and extrapolate the trend in the data, ARMA models outperform the corresponding methods involved in the great majority of cases.

The AR(*p*) and MA(*q*) models can be written in combination form, known as ARMA(*p*,*q*) model:

$$\varphi(L) y_t = \omega + \vartheta(L) \alpha_t \qquad (6)$$

Where $\varphi(L) = 1 - \varphi_1(L) - \varphi_2(L)^2 - \ldots - \varphi_p(L)^p$ (7)

and $\vartheta(L) = 1 - \vartheta_1 L - \vartheta_2 L^2 - \vartheta_3 L^3 \ldots - \vartheta_g L^q$ (8)

or

$$y_t = \omega + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \ldots + \varphi_p y_{t-p} + \vartheta_1 \alpha_{t-1} + \vartheta_2 \alpha_{t-2} + \ldots + \vartheta_q \alpha_{t-q} + \alpha_t \quad (9)$$

with $E(u_t) = 0, E(u_t^2) = \sigma^2, E(u_t u_s) = 0,\ t \neq s$

3.4 Autoregressive Integrated Moving Average ARIMA (p,d,q) Models

The ARIMA process contains with a characteristic root on unit circle. (i.e. a non-stationary process). A differenced *d* times on variable in a ARMA (*p*,*q*) model represents an ARIMA(*p*,*d*,*q*) model.The Box-Jenkins methodology regarding the ARIMA models are one of the most popular models for the forecasting since the 1970.

4. Nonlinear Regime-Switching Models

4.1 Threshold autoregressive models (TAR)

According to the Dijk et al. (2000), the models which allow for state dependent or regime-switching behavior are the most popular models in applications to economic time series. The threshold auto regression (TAR) introduced by Tong and Lim (1980) has received a certain attention. Since, it is the simplest generalization of an AR model and it allow different regimes for the time series which depends on its past observations. The TAR models have been successfully applied to model nonlinearities in financial variables.

Coakley et al. (2003) stated that the TAR models have also been used successfully to explore asymmetries of economic and financial time series variables over the course of the business cycle.

Directed by an observed variable, the movements between regimes are as TAR model:

$$\mathrm{y}_t = \begin{cases} \mathrm{u}_1 + \phi_1 \mathrm{y}_{t-1} + \mathrm{u}_{1t}\ if\ \mathrm{s}_{t-k} < r \\ \mathrm{u}_2 + \phi_2 \mathrm{y}_{t-1} + \mathrm{u}_{2t}\ if\ \mathrm{s}_{t-k} \geq r \end{cases} \quad (10)$$

Where s_{t-k} is the state determining variable. The integer *k* determines with how many lags does the state-determining variable influences the regime in time *t*.

4.2 Self-exciting threshold autoregressive models (SETAR)

The Threshold Auto Regression (TAR) model is the simplest nonlinear regression model that contains piecewise linear specifications and regime switching that occurs when an observed variable crosses an unknown thresholds. Threshold autoregressive methods were firstly studied by Tong (as cited in Tong and Lim, 1980, p.?). Self-Exciting Threshold Auto Regressive is a special case arises when the threshold variable r is taken to be a lagged value of the time series itself – that is, r = y_{t-d} for a certain integer d > 0. As in this case the regime is determined by the time series itself, the resulting model is called a Self-Exciting TAR (SETAR) model. SETAR model having a piecewise linear construction with a wide range of application area gets attention (Teksen et al., 2012). SETAR model can be presented as follows:

$$y_t = X_t\gamma^{(j)} + \sigma^{(j)}\epsilon_t \text{ if } \gamma_{j-1} < z_t < r_j \tag{11}$$

Where: $X_t = (1, y_{t-1}, y_{t-1}, \ldots\ldots, y_{t-p})$ is a column vector of variables

$-\infty = r_t < r_t < \ldots < r_t = +\infty$

are *k+1* non-trivial thresholds dividing the domain of z_t into *k* different regimes.

4.3 Markov regime switching models

In the economics, the Regime Switching is always the idea concerning non-linear models. The property of a switching variable is that it is a visible and continuous variable but it may also be an unobservable variable that obtains a restricted number of discrete values. It also independent of y_t at all lags (Terasvirta, 2006). A kind of this model is a Markov Regime Switching Autoregressive Model (MS-AR).

Where $\epsilon_t \sim NID(0, \delta^2)$ and the conditional mean $\mu(z_t)$ switches between two states (M=2) such that:

$$y_t = \begin{cases} \alpha_{0,1} + \alpha_{1,1} y_{t-1} + e_t \;\; if\; z_t = 1 \\ \alpha_{0,2} + \alpha_{1,2} y_{t-1} + e_t \;\; if\; z_t = 2 \end{cases} \tag{12}$$

Hence,

$$y_t = (\alpha_{0,Zt} + \alpha_{1,Zt} y_{t-1}) + e_t \tag{13}$$

For the completion of the above model, the specification is needed in the properties of the process S_t.

Hamilton (1989) created a Markov-Switching model (MSW) which is one of the most famous model in this class, in this model, the process model quarterly time series data which fits an order of lag four of auto regression such that q=4. In this model, the process is assumed to be a first-order Markov-process. Hence, the model is completed by defining the transition probabilities of moving from one state to the other,

$$P(z_t = 1 | z_{t-1} = 1) = q_{11},$$
$$P(z_t = 2 | z_{t-1} = 1) = q_{12},$$
$$P(z_t = 3 | z_{t-1} = 2) = q_{21},$$
$$P(z_t = 4 | z_{t-1} = 2) = q_{22},$$

Therefore, q_{ij} is equal to the probability that a Markov chain moves from state "*i*" at time t-1 to state j at time t. Defining the accurate probabilities for the q_{ij}'S, they must be positive, they should possess $q_{11}+q_{12}=1$ and $q_{21}+q_{22}=1$. In the Markov Switching models the unconditional probabilities that are in the process are in each of the regimes, therefore, P (z_t= i) for i =1, 2. In Markov Switching Autoregressive model the generation of regimes is an ergodic Markov chain with a finite number of states i.e.

$$P(z_t=1)=\frac{1-q_{22}}{2-q_{11}-q_{22}} \quad (14)$$

$$P(z_t=2)=\frac{1-q_{11}}{2-q_{11}-q_{22}} \quad (15)$$

5. Data and Their Sources

In this study, the Gross Domestic Product growth (GDP growth), inflation and exchange rate for the G7 countries i.e. Canada, France, Italy, Japan, Germany, United Kingdom (UK) and United States of America (USA) are used. The database of forecasts of economic and financial variables of G7 countries is well maintained by the economic organizations. G7 are the most developed among the world's largest economies. The yearly data of the above macroeconomic and financial variables are used in this paper. The frequency of the data depends on the availability of time period of the individual variable. But all the data covers the time period till 2015 for each and every variable. For the GDP growth, the data frequency is from 1961 to 2015 except for only USA which starts from 1948 and UK which starts from 1956. For inflation, the data frequency starts from 1956 except Canada which starts from 1950 and Pakistan which starts from 1961 till 2015. For the exchange rate investigation, Pakistan and only three G7 countries namely Canada, Japan, and UK are picked due to the exchange rate in US dollar. Also, Germany, France, and Italy transformed into same currency i.e. Euro in 2001, therefore, these countries are ignored because of discontinuity of exchange rate series. The main source for most of the data is International Monetary Fund (IMF). Also, some of the data are taken from Organization for Economic Cooperation and Development (OECD). The plots (Figure 1a to 1c) reveal that in general, these are quite erratic pattern with breaks and non-linear behavior especially in the exchange rate and inflation data.

6. Model Estimation and Forecasting Performance

The out of sample forecasting is the evaluation technique which is employed in this study to compare the relative forecast performances of the models. Sample is divided into two parts. In-sample and out-of-sample respectively. After estimating a model, the forecasted value is compared with the observed data. For one year ahead forecast, the data is used approximately from 1970 to 2000 for the specification and

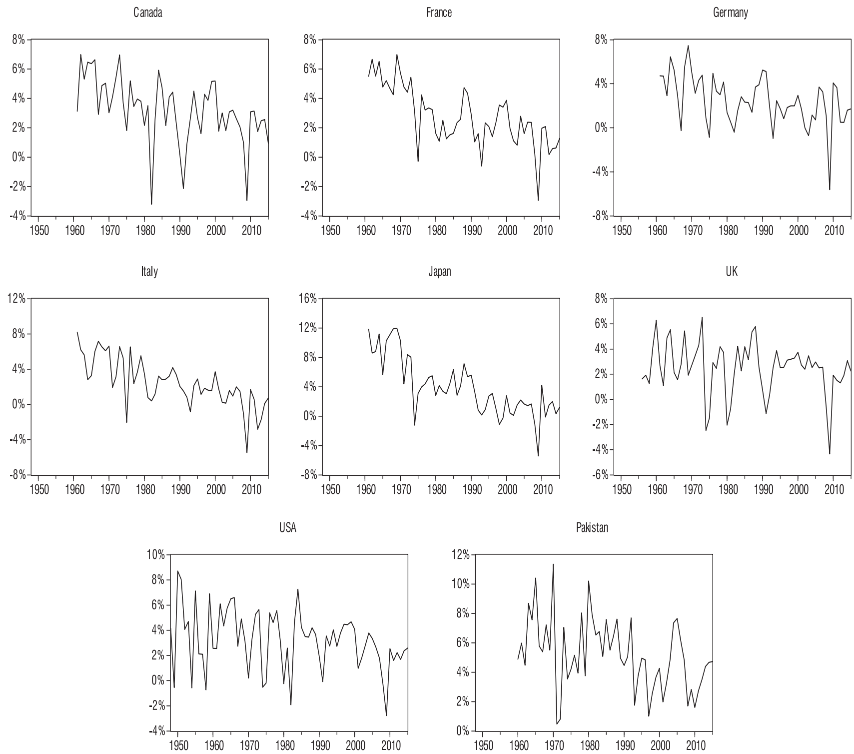

Figure 1a: Time Series Plots of Macroeconomic Variable GDP growth of G7 Countries

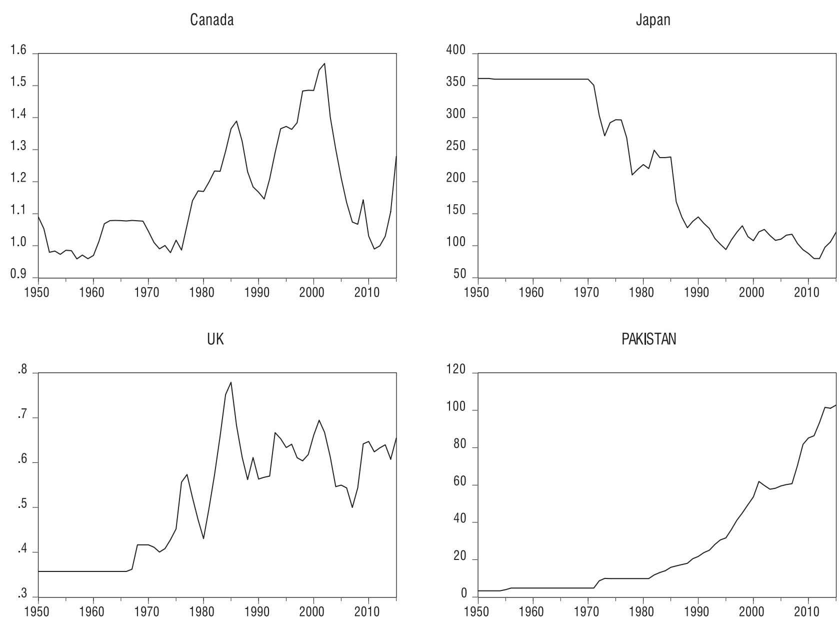

Figure 1b: Time Series Plots of Macroeconomic Variable Exchange rate of Canada, Japan, UK and Pakistan

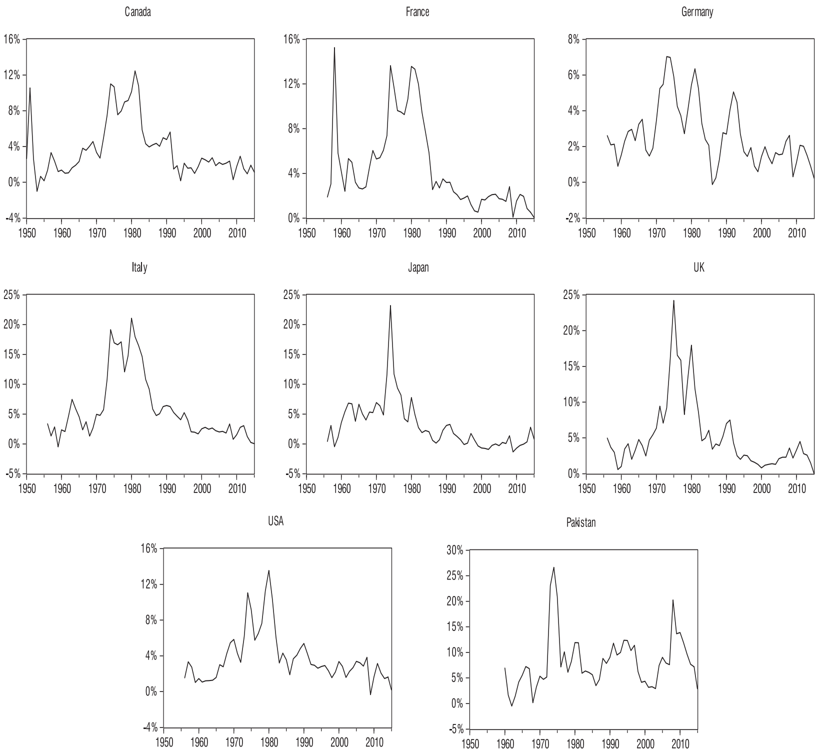

Figure 1c: Time Series Plots of Macroeconomic Variable Inflation rate of G7 Countries and Pakistan

estimation of the model. Order of all-time series models i.e. AR, ARMA, SETAR, MSAR depends on the least values of Akaike criterion (AIC) and Schwarz criterion (BIC). Forecast evaluation is conducted for the last fifteen observations i.e. 2001 to 2015. After the forecasting comparison of linear and nonlinear models, the forecasts are also compared from the linear and nonlinear models with the forecast made by the two important macroeconomic international forecast organizations namely International Monetary Fund (IMF) and Organization for Economic Co-operation and Development (OECD). OECD assessed the forecasts on the basis of model simulations using the NIGEM global model and short-term indicator models. While IMF uses Global Projection Model (GPM) which is the amalgamation of numerous models i.e. Quarterly Projection Model (QPM) and the Dynamic Stochastic General Equilibrium (DSGE) model. The complete specification is, however, not disclosed by these organizations. Our selection of forecast evaluation period follows Granger (1993), who suggested that at least 20 percent of any sample should be held back for a post-sample forecasting evaluation.

6.1 Recursive method

The recursive method is a popular time series forecast computation technique because of being computationally proficient. It can also takes into account any time variation in parameters. The recursive method has an advantage that they can handle the high fluctuations of a time series better than the classical models having the constant parameters. In this study, the whole sample data has total 'N' observations such that N=S+Q. According to the recursive method, the S observations are used to estimate the required model and the Q are used for only the forecasting purpose. Since the one step ahead forecast are generated, therefore, the estimation of the required model first using the N-Q observations and then find the forecast for the N-Q+1 observation. Again the same procedure is re-run, i.e. the model estimated on N-Q+1 observations and the forecast made for the N-Q+2 observations. By using this recursive method, one step ahead forecast is find out. In in this study, N depends on the frequency of the data i.e. depends on the availability of time period of the individual variable as discussed in the data and methodology section. For the GDP growth, N = 54 and S = 39 i.e. data from 1961 to 2015 except for USA which starts from 1948 i.e. N = 67 while S = 52 and UK which starts from 1956 i.e. N = 59 while S = 44. For inflation, the data frequency starts from 1956 i.e. i.e. N = 59 while S = 44 except Canada which starts from 1950 i.e. N = 65 while S = 50. For the exchange rate, N= 54 while S = 39. Q = 15 for all the variables. The reverse approach is used for splitting the data and reserve a certain sample length for model estimation i.e. >50 years and 15 years for out-of-sample forecast period. For details see (Hansen & Timmermann, 2012).

6.2 Forecast accuracy criteria

According to Brooks (2014), the forecasted values produced by out-of-sample period, would be compared with the actual values so that the errors can be accumulate. That is why, the errors which are actually the differences between the observed and fitted values, are evaluated using more than one criterion for robustness. Thus the forecast accuracy is examined by calculating three evaluation criteria's i.e. Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) which are given by:

$$MAE = \frac{1}{N}\sum_{t=1}^{N}\left|y_{t+s} - f_{t,s}\right| \quad (16)$$

$$MAPE = 100 \text{ x} \frac{1}{N}\sum_{t=1}^{N}\left|\frac{y_{t+s} - f_{t,s}}{y_{t+s}}\right| \quad (17)$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(y_{t+s} - f_{t,s})^2} \quad (18)$$

Where, $f_{t,s}$ as the forecast made at time *t* for *s* steps ahead (i.e. the forecast made for time *t+s*, and y_{t+s} as the realised value of *y* at time *t+s*.

6.3 The Diebold-Mariano (DM) test

The Diebold-Mariano (DM) test is used to test whether forecast accuracy from two forecasting models is significantly different. According to Diebold (2013), the DM test is very useful test to check the significant difference between two or more forecast. Mark (1995) used DM test for the comparison purpose of the forecast of nominal exchange rate data. Swanson and White (1997) also used DM test for comparing the forecasting ability of some flexible and fixed specification, linear and nonlinear models of some macroeconomic time series variables. Clark and McCracken (2003) used the DM test to compare the Predictive ability among the forecasts in the presence of structural breaks in the time series data. According to the null hypothesis of DM test, the forecasts from two different models have equal accuracy power and the difference between the two forecast errors from different models are not statistically significant at all. Therefore, the rejection of the null hypothesis clearly states that there is a significant difference between the two forecast and the predictive accuracy of one of the model is more accurate than the other.

Let X_t denotes a macroeconomic series to be forecast and suppose and are the two challenging forecasts of $X^1_{t+h|t}$ based on $X^2_{t+h|t}$. The forecast errors from any two estimated models can be written as according to Zivot (2004):

$$e^1_{t+h|t} = X_{t+h} - X^1_{t+h|t}$$

and $e^2_{t+h|t} = X_{t+h} - X^2_{t+h|t}$

The accuracy of the forecast can be measured by loss function i.e.

$$F\left(X_{t+h}, X^m_{t+h|t}\right) = LF(e^m_{t+h|t}) \quad (19)$$

Where m = 1,2 and *LF* are:

Squared error loss:) = $LF(e^m_{t+h|t}) = \left(e^m_{t+h|t}\right)^2$ (20)

Absolute error lost:) = $LF(e^m_{t+h|t}) = \left|\left(e^m_{t+h|t}\right)\right|$ (21)

The Diebold-Mariano test statistic is:

$$DMT = \frac{\overline{df}}{(\hat{a}\left(\overline{df}\right))^{1/2}} = \frac{\overline{df}}{\left(\widehat{LV}_{\overline{df}/T}\right)^{1/2}} \quad (22)$$

Where $\overline{df} = \frac{1}{T_0}\sum_{t=t_0}^{T} d$

and d *is the loss differential i.e.* $d = LF\left(e^{1}_{t+h|t}\right) - LF\left(e^{2}_{t+h|t}\right)$

also, $\widehat{LV}_{\overline{df}}$ is an estimator of asymptotic variance of $\sqrt{T}\ \overline{df}$ i.e.

$$\widehat{LV}_{\overline{df}} = \pi_0 + 2\sum_{i=1}^{\infty}\pi_i,\ \pi_i = cov\left(d, d_{t-i}\right) \qquad (23)$$

6.4 Break point unit root test

In macroeconomic time series, unit root tests are used to test the non-stationarity of economic time series. These tests have gained a lot of interest from the last two to three decades in both theoretical and applied research (Glenn et al., 2007). Perron (1989) described that when the time series also have some kind of structural breaks, the common unit root tests such as ADF (Dickey & Fuller, 1979 and 1981), Phillips and Perron (1988), and Kwiatkowski, Phillips, Schmidt, and Shin, 1992) are not capable to identify the unit root or non-stationarity in the time series data. The results of these tests are biased. According to Perron (1989), several macroeconomic time series do not contain a unit root. After small and regular shocks, they actually contain large and irregular shocks. That is why the Breakpoint unit root test is used to identify the unit root in the time series data. In this paper, two criterion are used to find the appropriate lag length of breakpoint unit root. Akaike criterion (AIC) and Schwarz criterion (BIC).

7. Results and Discussion

7.1 Break point unit root tests

The results of these tests may be biased. The results (Table 2a to Table 2c) suggest that the unit root are not present in macroeconomic variable GDP for all the G-7 countries as well for Pakistan. However, few countries contain the unit root for the other macroeconomic variables like exchange rate of Japan, Pakistan and inflation of France.

Table 2: Break point unit root evidence

GDP Growth					
S#	Breakpoint unit root	Schwarz		Akaike	
		Level	1st diff	Level	1st diff
1	Canada	-6.498a	-	-6.286 a	-
2	France	-6.128a	-	-6.128 a	-
3	Germany	-7.123 a	-	-7.111 a	-
4	Italy	-7.272 a	-	-7.271 a	-

5	Japan	-5.928 a	-	-5.982 a	-
6	UK	-6.917 a	-	-6.917 a	-
7	USA	-7.800 a	-	-7.704 a	-
8	Pakistan	-6.962 a	-	-6.952 a	-
Exchange rate					
1	Canada	-6.640 a	-	-6.640 a	-
2	Japan	-4.701	-7.322 a	-3.913	-10.173 a
3	UK	-6.117 a	-	-5.379 a	-
4	Pakistan	-1.495	-7.185 a	-1.495	-5.856 a
Inflation					
1	Canada	-8.141 a	-	-7.656 a	-
2	France	-5.083 b	-	-4.988 b	-9.766 a
3	Germany	-6.618 a	-	-6.618 a	-
4	Italy	-4.294	-8.484 a	-5.257 b	-
5	Japan	-7.766 a	-	-4.691	-10.399 a
6	UK	-5.178 b	-	-5.364 a	-
7	USA	-7.020 a	-	-7.020 a	-
8	Pakistan	-3.949	-8.471 a	-5.668 a	-

Note: a Significant at 1% b Significant at 5% c Significant at 10%

7.2 The Test of ARCH Effects

The above test present evidence of non-linearity or otherwise of the mean function of the times series. However, with time series data, test of non-linearity in variance function in the form of conditional heteroskedasticity may also present. To examine this possibility Table 3 presents, the LM test of conditional heteroskedasticity test of the residuals of the AR model of lag1 I through 4. The test has asymptotically Chi Square distribution with number of degrees of freedom as the number of lags used. It is observed that except for few cases of lag 1 of inflation series in Canada. Japan, UK and the US, the test generally does not indicate non-linearity in the variance process. We therefore focus more on modeling non-linearity in the mean process of the time series under study.

7.3 Out-of-sample forecast evaluation

Our first aim is to find out whether the nonlinear regime-switching models MSAR and SETAR give the better forecast of macroeconomic and financial variables i.e. GDP growth, Inflation and exchange rate as compare to the forecast from linear models

Table 3: The Engle's ARCH LM Test of Conditional Heteroskedasticity

Countries	Lags	1	2	3	4	1	2	3	4	1	2	3	4
	Indicators	**Exchange rate**				**Inflation**				**GDP**			
Canada	Chi-Square	0.070	0.259	1.046	1.676	9.718	28.535	6.779	1.262	0.006	0.011	1.441	2.092
	P-value	0.791	0.879	0.790	0.795	0.002	0.000	0.079	0.868	0.941	0.995	0.696	0.719
Japan	Chi-Square	0.158	1.026	1.190	1.670	10.565	12.554	12.460	12.329	0.092	0.987	5.134	7.935
	P-value	0.691	0.599	0.755	0.796	0.001	0.002	0.006	0.015	0.761	0.610	0.162	0.094
UK	Chi-Square	1.563	1.994	3.697	3.489	8.799	8.743	9.090	9.020	1.058	1.448	1.766	1.938
	P-value	0.211	0.369	0.296	0.480	0.003	0.013	0.028	0.061	0.304	0.485	0.622	0.747
France	Chi-Square	-	-	-	-	3.818	4.453	25.111	0.192	1.285	2.051	2.679	3.940
	P-value	-	-	-	-	0.051	0.108	0.000	0.996	0.257	0.359	0.444	0.414
Germany	Chi-Square	-	-	-	-	0.681	1.352	1.531	3.135	2.462	3.840	3.913	4.601
	P-value	-	-	-	-	0.409	0.509	0.675	0.536	0.117	0.147	0.271	0.331
Italy	Chi-Square	-	-	-	-	1.633	1.830	1.941	3.214	0.178	0.498	0.596	0.972
	P-value	-	-	-	-	0.201	0.401	0.585	0.523	0.673	0.780	0.897	0.914
USA	Chi-Square	-	-	-	-	4.100	5.365	5.304	5.296	3.215	4.029	3.265	8.073
	P-value	-	-	-	-	0.043	0.068	0.151	0.258	0.073	0.133	0.353	0.089
Pakistan	Chi-Square	4.114	4.678	4.585	4.571	0.578	0.711	1.409	1.878	1.901	1.797	4.996	6.122
	P-value	0.048	0.096	0.204	0.334	0.446	0.700	0.703	0.758	0.167	0.407	0.172	0.190

(AR, ARMA and ARIMA models) and the second aim is to compare the estimated forecasts with the forecasts from the IMF and OECD sources.

Following are the results (Table 3 through Table 5) which present the forecast comparison on the basis of information criterions i.e. RMSE, MSE and MAPE for the one step ahead forecast from all the linear (AR, ARMA, and ARIMA) and nonlinear models (SETAR and MSAR). Also, the forecasts from the two respective international organizations are present. Generally, the two general global financial and economic organizations dominate the forecast made from the both linear and nonlinear models for all the time series variables of all the G-7 countries and Pakistan as well in forecast accuracy.

Table 3: RMSE, MAE and MAPE for one year ahead forecast of GDP growth

Forecast	RMSE	MAE	MAPE	Forecast	RMSE	MAE	MAPE
Canada				**Japan**			
AR	1.956	1.378	74.513	AR	2.678	1.817	290.986
ARMA	1.969	1.42	76.146	ARMA	2.605	1.71	251.901
SETAR	2.195	1.488	76.775	SETAR	2.731	1.859	257.63
MSAR	1.931	1.359	74.954	MSAR	2.917	1.913	260.795
IMF	0.452	0.359	15.451	IMF	0.984	0.778	118.556
France				UK			
AR	1.818	1.402	233.671	AR	2.029	1.275	79.783
ARMA	1.801	1.393	213.163	ARMA	2.036	1.302	79.092
SETAR	1.777	1.27	178.608	SETAR	2.215	1.505	94.26
MSAR	1.613	1.315	257.677	MSAR	2.27	1.41	89.463
IMF	0.337	0.274	41.58	IMF	0.908	0.716	44.845
Germany				USA			
AR	2.802	1.898	6223.13	AR	2.146	1.516	152.147
ARMA	2.882	2.057	5569.58	ARMA	2.14	1.514	151.255
SETAR	3.68	2.521	4066.47	SETAR	2.465	1.691	103.951
MSAR	2.17	1.554	7779.22	MSAR	2.239	1.465	144.693
IMF	0.743	0.616	1282.51	IMF	0.561	0.332	52.366
Italy				Pakistan			
AR	2.431	1.793	253.037	AR	1.951	1.557	57.944
ARMA	2.304	1.636	263.621	ARMA	1.912	1.489	56.537

SETAR	3.364	2.447	261.641	SETAR	1.915	1.454	56.106
MSAR	2.534	1.838	272.923	MSAR	2.010	1.649	59.224
IMF	0.478	0.372	64.786	IMF	1.222	0.844	31.448

*[Note: The table summarizes the results of the comparison of the one step ahead forecast of macroeconomic variables of G7 countries from the linear models i.e. Autoregressive (AR) model, Autoregressive moving average (ARMA) model, nonlinear models i.e. Self-exciting Threshold Autoregressive (SETAR) model, Markov Regime Switching Autoregressive model and international organizations i.e. International Monetary Fund (IMF) and Organization for Economic Co-operation and Development (OECD). The estimated sample frequency covers the time period till 2000 (yearly). The one step ahead forecast covers the time period from 2001 to 2015. For this, the recursive method is used. This method has an advantage that it can handle the high fluctuations of a time series better than the classical models having the constant parameters. Forecast accuracy is examined by calculating three evaluation criteria's. Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE)].

The IMF yields the lowest forecast errors among all the forecasts from the linear and nonlinear models for the macroeconomic variables Inflation and GDP growth. While the OECD yields the lowest forecast errors for the exchange rates for Japan and UK. According to our findings, only the forecast from a linear model i.e. ARMA is better as compared to the OECD for exchange rate of Canada on the basis of RMSE, MSE, and MAPE. Unfortunately, OECD do not provide the projections of exchange rate of Pakistan. Therefore, forecasts of exchange rate of Pakistan with international organization is not included. Overall, the nonlinear SETAR and MSAR models showed better forecast performance as compared to the linear AR, ARMA and ARIMA models.

Table 4: RMSE, MAE and MAPE for one year ahead forecast of Exchange rate.

Forecast	RMSE	MAE	MAPE
Canada			
AR	0.080	0.060	5.012
ARMA	0.072	0.052	4.354
SETAR	0.091	0.069	5.625
MSAR	0.084	0.060	5.055
OECD	0.081	0.065	5.529
Japan			
AR	11.446	8.761	7.905
ARIMA	12.147	9.956	9.003
SETAR	18.177	14.274	13.316
MSAR	11.013	9.537	8.823

OECD	7.482	5.938	5.616
UK			
AR	0.041	0.035	5.790
ARMA	0.042	0.035	5.822
SETAR	0.036	0.032	5.317
MSAR	0.039	0.033	5.510
OECD	0.029	0.024	4.072
Pakistan			
AR	4.794851	3.727355	4.960736
ARMA	4.733553	3.673637	5.039151
SETAR	5.562896	3.897391	5.216726
MSAR	5.504754	4.364991	5.987625

7.3 Comparison of Linear and Non Linear Models

7.3.1 SETAR vs linear models

Table 3 shows that the SETAR model outperforms linear AR and ARMA models only in the GDP growth for France and Pakistan only. While the forecasts from linear models i.e. AR and ARMA models dominates SETAR model in all remaining countries for GDP growth. Hence, for the GDP growth of the G7 countries, the forecasting accuracy of linear models surpasses the SETAR models on the basis of RMSE, MSE and MAPE forecast evaluation criteria. The comparison of forecasting performance for the macroeconomic variable namely exchange rate is presented in Table 4. According to the results, the forecasting performance of SETAR model is better as compared to linear models for the United Kingdom. While for the Canada and Japan, both linear models AR, ARMA, and ARIMA outperforms the SETAR model. The results are same for the south Asian country Pakistan.

Table 3: RMSE, MAE and MAPE for one year ahead forecast of GDP growth

Forecast	RMSE	MAE	MAPE	Forecast	RMSE	MAE	MAPE
Canada				Japan			
AR	0.977	0.768	91.337	AR	1.295	1.037	858.706
ARMA	0.988	0.827	88.6	ARMA	1.125	0.872	600.148
SETAR	0.682	0.535	61.434	SETAR	1.461	1.157	728.833
MSAR	0.907	0.665	85.504	MSAR	1.303	1.039	864.635
IMF	0.227	0.157	11.457	IMF	0.152	0.128	187.374

France				UK			
AR	1.184	0.964	505.194	AR	1.186	0.974	44.531
ARIMA	1.091	0.846	474.423	ARMA	1.715	1.371	56.481
SETAR	2.641	1.814	903.476	SETAR	0.9	0.699	37.361
MSAR	1.462	1.229	643.683	MSAR	0.971	0.756	37.737
IMF	0.23	0.187	47.78	IMF	0.493	0.306	28.991
Germany				USA			
AR	0.91	0.708	114.134	AR	1.734	1.172	236.625
ARMA	0.826	0.587	104.836	ARMA	1.792	1.25	248.548
SETAR	0.858	0.568	113.775	SETAR	1.354	0.911	210.981
MSAR	0.83	0.638	107.714	MSAR	1.58	1.067	239.777
IMF	0.226	0.178	15.017	IMF	0.245	0.21	10.476
Italy				Pakistan			
AR	1.116	0.837	197.864	AR	3.869	2.426	37.986
ARIMA	1.125	0.832	143.94	ARIMA	4.104	2.617	39.842
SETAR	1.179	0.923	283.772	SETAR	4.511	2.995	48.983
MSAR	1.095	0.808	190.387	MSAR	4.181	2.716	41.110
IMF	0.17	0.14	37.066	IMF	3.044	1.984	22.677

*See note on Table 3

The forecasting ability of SETAR and linear models of the Inflation of G7 countries can be seen in Table 5. The results show that the forecasting performance of SETAR models are better than the linear models. As the forecast from SETAR model contains the lowest forecasting errors in five out of seven countries i.e. Canada, Germany, Italy, UK and USA for the Inflation, therefore, SETAR models have the better forecasting performance than linear models for the Inflation data.

7.3.2 MSAR vs linear models

The comparison of forecasting performance between the MSAR and linear models of the macroeconomic variable GDP growth are presented in Table 3. The MSAR model outperforms the linear AR and ARMA models for Canada, France, and Germany. Even the forecasting power of MSAR model is also superior for the remaining G7 countries. The results are based on the RMSE, MSE and MAPE criteria. Therefore, the forecasting performance of MSAR models is the better for the GDP growth as compared to the linear models.

The comparison of forecasting performance for the macroeconomic variable namely exchange rate is presented in Table 4. The results suggest that on the basis of RMSE, MSE, and MAPE that the forecasting performance of MSAR model is better as compared to linear models for all three countries i.e. Canada, Japan and the United Kingdom but not in case of Pakistan.

Finally, the forecasting ability of MSAR and linear models of the Inflation of G7 countries can be seen in Table 5. According to the results, the forecasting performance of MSAR models is superior to the linear models. As the forecast from MSAR model has the lowest forecasting errors in five out of seven countries i.e. Canada, Germany, Italy, UK, and USA for the inflation, therefore, the MSAR model appears to be the best forecasting performance for inflation data.

7.3.3 SETAR VS MSAR

The comparison of forecasting performance for both the nonlinear models namely MSAR and SETAR models for the time series macroeconomic variable GDP growth are shown in Table 3. The MSAR model outperforms the SETAR models by means of forecasting performance for Canada, Germany, Italy, UK and USA. The results are based on the RMSE, MSE and MAPE criteria. Therefore, the forecasting performance of MSAR models is the best for the GDP growth as compared to the SETAR models.

Table 4 presents the forecasting performance comparison for the macroeconomic variable namely exchange rate data. The results suggest that on the basis of RMSE, MAE and MAPE that the forecasting performance of MSAR model is better than the SETAR model for Canada and Japan while forecast performance of SETAR model is superior in case of United Kingdom and Pakistan.

Lastly, the forecasting ability of MSAR and SETAR models of the inflation of G7 countries can be seen in Table 5. According to the results, the forecasting performance of MSAR models is superior to the SETAR model. As the forecast from MSAR model has the lowest forecasting errors in five out of seven countries i.e. France, Germany, Italy and Japan for G7 and Pakistan as well for the inflation, therefore, MSAR model is found to be better forecasting technique for inflation data.

7.4 Forecast comparison with the IMF and the OECD

The IMF and OECD's forecasts are based on a forecast entry system. This system allows any country professionals to assess the data, any information and also revise their predictions. Moreover, they contain the individual forecast for many macroeconomic variables so that the local and international researchers can view the forecast and use them for their research work. The data are maintained and updated on a regular basis due to which the forecast from these two organizations becomes more reliable and trustworthy for the researchers.

The OECD use the macro-econometric model namely the National Institute Global Econometric Model (NIGEM) model of the British National Institute of Economic and Social Research for the estimation and forecasting of different economic variables.

The main task of NIGEM is to match the macroeconomic policy. NIGEM has some of features like the Dynamic Stochastic General Equilibrium (DSGE) model. But NIGEM is totally based on estimation using the historical data. OECD use this NIGEM model both for analysis of the policies as well as for predictions.

The IMF's estimations and forecasts depend on forecasting models which have some link with the World Economic Outlook (WEO), namely as Global Projection Model (GPM). The GPM is a combination of different economic model i.e. principally the Quarterly Projection Model (QPM) and the Dynamic Stochastic General Equilibrium (DSGE) model. Both are also macroeconomic models. IMF forecasts are improved through consultations with the professionals of IMF. According to Batchelor (2000), the forecasts from IMF are also reviewed with the political representatives present as members in organizations. This long consultation process not only slows the procedure of the forecast but also some biasedness is occurred due to the influence of governments.

7.4.1 Linear models vs IMF/OECD

According to our findings, presented in Table 3 to Table 5, using the multi-comparison criteria i.e. RMSE, MAE, and MAPE, the international forecast organization namely IMF and OECD outperform the forecast from the linear and nonlinear models for all the macroeconomic time series variables in this study. Furthermore, the forecast from linear ARMA model is better as compared to the IMF forecast for the exchange rate data of Canada only (Figure 2). Furthermore, this is the only forecast included in this study, which gives the better forecast as compared to any International organization.

7.4.2 Nonlinear models vs IMF/OECD

Our findings do not support the forecasting accuracy of the nonlinear models. The IMF and OECD totally dominant the forecasting performance of nonlinear models. The results are shown in Table 3 to Table 5. Also, the comparison can be seen in figure 2 to 5.

7.5 DM test

The forecast accuracy measure i.e. the RMSE, MAPE and MSE rank the models with respect to numerical values of the measures. However, forecast accuracy obtained from two or more models may not be practically or statistically different. The Diebold-Mariano (DM) test provides a test of significance of forecast accuracy of different models. The results of the Diebold-Mariano (DM) test are presented thorough Table 6 which presents the results for the inflation. The IMF forecast outperforms the linear and nonlinear regime switching models for some G7 countries. Meanwhile, the IMF forecast has the same forecasting ability in all the models for Germany, USA, and nonlinear models for Canada on the basis of MSE criteria. The IMF forecast outperforms all the models for Japan and UK on the basis of both MAE and MSE criteria. While in case of Pakistan, IMF forecasts are identical to all models on basis of MAE and MSE criteria.

For the exchange rate data, the predictive power of OECD and econometric models included in this study are same for the Canada and UK on MAE and MSE criteria. Also, the predictive power of linear models for Japan is same as compared to the OECD. The results are shown in Table 7.

For the GDP growth data, the forecasting accuracy linear AR model for Germany is equivalent to the IMF on basis of MAE criteria. Moreover, the forecasting ability is same for all models against the IMF for the Japan and USA on the basis of MAE criteria. While remarkably, the predictive power is same as the IMF forecast and all the linear and nonlinear models are same and identical for all the G7 countries i.e., Canada, Germany, France, Italy, Japan, UK, and USA on the basis of MSE criteria. In case of Pakistan, IMF forecasts are superior to all models on basis of MSE criteria only while results shows identical power between the forecasts of IMF and linear models on the basis of MAE criteria. The results are displayed in Table 8.

Table 6: DM test result for inflation

		MAE criteria				**MSE criteria**			
Country		**IMF vs AR**	**IMF vs ARMA**	**IMF vs MSAR**	**IMF vs SETAR**	**IMF vs AR**	**IMF vs ARMA**	**IMF vs MSAR**	**IMF vs SETAR**
Canada	DM-Test	2.424	2.546	2.203	2.522	1.782	1.801	1.714	1.734
	p-value	0.03	0.023	0.045	0.024	0.096	0.093	0.109	0.105
France	DM-Test	3.599	3.267	3.43	4.258	2.11	1.973	1.694	2.664
	p-value	0.003	0.006	0.004	0.001	0.053	0.069	0.112	0.019
Germany	DM-Test	2.062	2.477	2.376	2.307	1.566	1.583	1.514	1.703

	p-value	0.058	0.027	0.032	0.037	0.14	0.136	0.152	0.111
Italy	DM-Test	2.942	2.888	2.927	2.631	1.822	1.799	1.677	1.886
	p-value	0.011	0.012	0.011	0.02	0.09	0.094	0.116	0.08
Japan	DM-Test	1.361	1.356	1.379	1.474	1.369	1.273	1.511	1.557
	p-value	0.195	0.197	0.19	0.163	0.193	0.224	0.153	0.142
UK	DM-Test	0.969	1.021	1.23	1.109	1.208	1.217	1.369	1.376
	p-value	0.349	0.324	0.239	0.286	0.247	0.244	0.193	0.191
USA	DM-Test	2.889	2.887	2.426	2.313	1.723	1.717	1.557	1.491
	p-value	0.012	0.012	0.029	0.036	0.107	0.108	0.142	0.158
Paki-stan	DM-Test	0.441	0.632	1.011	0.732	5.705	7.578	11.085	8.212
	p-value	0.360	0.100	0.064	0.074	0.270	0.166	0.126	0.178

*Note: IMF indicates the International Monetary Fund, AR indicates the Auto Regressive, ARMA indicates the Auto Regressive Moving Average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov Switching Auto Regressive model.

Table 7: DM test result for exchange rate

Coun-try		MAE Criteria				MSE Criteria			
		OECD vs AR	**OECD vs ARMA**	**OECD vs SE-TAR**	**OECD vs MSAR**	**OECD vs AR**	**OECD vs ARMA**	**OECD vs SE-TAR**	**OECD vs MSAR**
Canada	DM-Test	-0.47	-1.122	0.307	-0.387	-0.111	-0.712	0.715	0.24
	p-value	0.646	0.281	0.764	0.704	0.913	0.488	0.486	0.814
Japan	DM-Test	1.869	2.648	2.892	3.744	2.09	2.119	2.241	2.756
	p-value	0.083	0.019	0.012	0.002	0.055	0.052	0.042	0.016
UK	DM-Test	2.017	1.715	1.87	1.795	1.751	1.658	1.519	1.606
	p-value	0.063	0.108	0.083	0.094	0.102	0.12	0.151	0.131

Note: OECD indicates the Organization for Economic Co-operation and Development, AR indicates the Auto Regressive, ARMA indicates the Auto Regressive Moving Average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov Switching Auto Regressive model.

Table 8: DM test result for GDP growth

Country		MAE criteria				MSE			
		IMF vs AR	IMF vs ARMA	IMF vs MSAR	IMF vs SETAR	IMF vs AR	IMF vs ARMA	IMF vs MSAR	IMF vs SETAR
Canada	DM-Test	2.424	2.546	2.203	2.522	1.782	1.801	1.714	1.734
	p-value	0.03	0.023	0.045	0.024	0.096	0.093	0.109	0.105
France	DM-Test	3.599	3.267	3.43	4.258	2.11	1.973	1.694	2.664
	p-value	0.003	0.006	0.004	0.001	0.053	0.069	0.112	0.019
Germany	DM-Test	2.062	2.477	2.376	2.307	1.566	1.583	1.514	1.703
	p-value	0.058	0.027	0.032	0.037	0.14	0.136	0.152	0.111
Italy	DM-Test	2.942	2.888	2.927	2.631	1.822	1.799	1.677	1.886
	p-value	0.011	0.012	0.011	0.02	0.09	0.094	0.116	0.08
Japan	DM-Test	1.361	1.356	1.379	1.474	1.369	1.273	1.511	1.557
	p-value	0.195	0.197	0.19	0.163	0.193	0.224	0.153	0.142
UK	DM-Test	0.969	1.021	1.23	1.109	1.208	1.217	1.369	1.376
	p-value	0.349	0.324	0.239	0.286	0.247	0.244	0.193	0.191
USA	DM-Test	2.889	2.887	2.426	2.313	1.723	1.717	1.557	1.491
	p-value	0.012	0.012	0.029	0.036	0.107	0.108	0.142	0.158
Pakistan	DM-Test	0.713	0.645	0.610	0.805	2,313	2.162	2.176	2.546
	p-value	0.068	0.065	0.072	0.059	0.014	0.012	0.016	0.0075

*See Note on Table 6.

8. Conclusions

The accuracy of linear models using the Box and Jenkins approach (1970) is often evaluated by the forecasting performance. However, many economic and financial time series are characterized by breaks and non-linearity for traditional linear time series models are not suitable. The evaluation of the forecasting performance of two important nonlinear regime switching models namely Self-Exciting Threshold Autoregressive (SETAR) models and Markov Switching Autoregressive (MSAR) models using one-step ahead forecasting technique. The forecasting comparison are made for these nonlinear models with the linear AR model and ARMA models. According to the Clements and Franses (2003), the forecasting abilities of nonlinear models are not much reliable. Many of the researches favor the nonlinear forecasting techniques but at the same time, there are also many studies present in literature which are totally against the forecasting performance of nonlinear models due to the complications in nonlinear models and supports the linear models for forecasting purpose on the basis of comparison of forecasting accuracy. On the basis of three forecasting accuracy evaluation measure namely MAE, MAPE and RMSE, the forecasting ability is evaluated. Overall, the forecasting accuracy of Markov Switching Autoregressive (MSAR) model is superior as compared to other nonlinear model e.g. SETAR as well as two linear models i.e. AR and ARMA models. Furthermore, the forecasting performance of all these models included in this study is also compared with international organizations which report a forecast on the yearly basis i.e. IMF and OECD. Only the forecasting ability of ARMA model for the exchange rate of Canada is better as compared to the predictive ability of international organizations. While none of the nonlinear regime switching models gave better forecast than the forecasts of IMF and OECD. For the GDP growth, the MSAR model yields better forecast as compared to the SETAR, the AR and the ARMA models on the basis of RMSE, MAE, and MAPE. Approximately in 72% cases in GDP growth data show that the forecasting power of MSAR model is better than the other linear and nonlinear models. The G7 countries in which the forecast from MSAR is better are Canada, France, Germany, France, and the USA. While for the other G7 countries i.e. Italy and UK, the predictive power of linear ARMA and AR models are better than the nonlinear models. Hence, it can be said that the non-linear Markov Switching Autoregressive model forecast is superior to the linear models i.e. the AR and the ARMA models. For the exchange rate, the forecast performance of only nonlinear SETAR model is superior to the forecast performance of linear models in case of UK and Pakistan on the basis of RMSE, MAE, and MAPE. Approximately in more than 60% cases show that the linear AR and ARMA models forecast better than the nonlinear regime switching models. The G7 countries in which the forecast from the AR and the ARMA is superior are Canada and Japan respectively. Hence, it can be said that the results are a mix regarding the forecasting ability of the linear and nonlinear models with respect to the exchange rate time series. For the inflation, the nonlinear models provide superior forecast as compared to the linear AR and ARMA for more than three G7 countries. Approximately 70% cases in inflation data shows that the forecasting power of the SETAR and MSAR models are better than the linear models due to the small forecast errors. The forecast from MSAR is more accurate for Italy and Germany while for SETAR model, the predictive ability is superior for the Canada, UK, and USA. For the other G7 countries i.e. France and Japan, the predictive ability of the linear ARIMA model using Box and Jenkins (1970) approach is better than the nonlinear models. Moreover, for Pakistan, the linear AR models is proved to be best forecast model among all. Hence, it can be said that the nonlinear regime-switching models forecasts are superior to the linear models i.e. AR, ARMA and ARIMA models. Finally, forecasting performance of all estimated linear and nonlinear time series models is compared with the two of the well-known sources of macroeconomic international organizations namely International Monetary Fund (IMF) and Organization for Economic Co-operation and Development (OECD). The predictive ability of the linear ARMA model for the exchange rate data of Canada is superior to the OECD. Overall, the forecasting performance of IMF for GDP growth and inflation for all the G7 countries along with a south Asian country is superior to the forecasting performance of linear and nonlinear models in this study on the basis of the low forecast errors. While for the exchange rate time series data, the predictive power of OECD is superior only for the Japan and UK. The forecast from the linear ARMA model appear to be superior to the forecast from OECD for the G7 country namely Canada. Since the forecasting performance of OECD and IMF are often slightly better than the linear and non-linear regime switching models, therefore, the Diebold and Mariano (1995) DM test with both MAE and MSE criteria's is used to examine whether the forecast from the models are statistically different. For all three series i.e. GDP growth, inflation and exchange rate, the IMF and OECD forecasts outperform the linear and nonlinear regime switching models but the predictive power of OECD and IMF are identical in most of the cases according to the DM test. Interestingly, it is found that IMF forecast has the same forecasting ability for inflation in all the models for Germany, USA and Pakistan. It is also found that the forecast performance is identical for nonlinear models for Canada. In case of exchange rate data, DM test indicates that the forecast performance of OECD and econometric models is not statistically significantly different for the Canada and UK. Unfortunately, OECD do not give forecast regarding the exchange rate of Pakistan, therefore, the results of exchange rate of Pakistan could not be compared with international organization. Additionally, the forecast from the linear models is also statistically identical to the OECD forecast for Japan. Lastly, for GDP growth, the forecast accuracy of linear AR model is statistical equivalent to the IMF on basis of DM test for Germany. Likewise, the forecasting performance is statistically same for all models with contrast to IMF for the Japan and USA. Remarkably, using MSE criteria, DM test indicate the forecast from all the linear and nonlinear models is statistically identical to the IMF forecast for all the G7 countries and Pakistan as well. These results shows no statistical difference in forecast on the basis of DM test. Especially, for the non-linear MSAR and SETAR models, in more than 60% cases the forecasting performance of non-linear model is similar to that of IMF and OECD. Thus, econometricians and statisticians who use these models in forecast have confidence in that their models which are based on only the past behavior of time series data are as good as that of professional economists who have much better exposure to research and also have expectations of future as per the ongoing economic condition of different economies.

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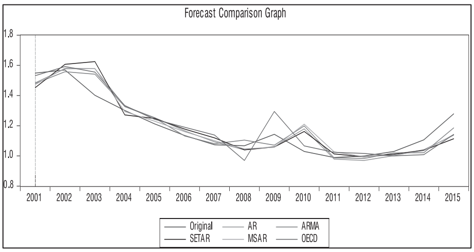
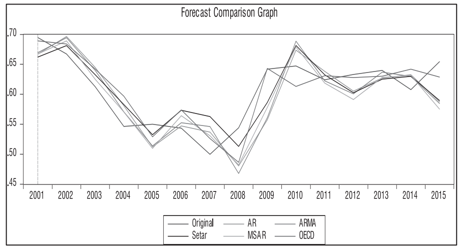
APPENDIX

Forecast Comparison

Canada



UK



Japan

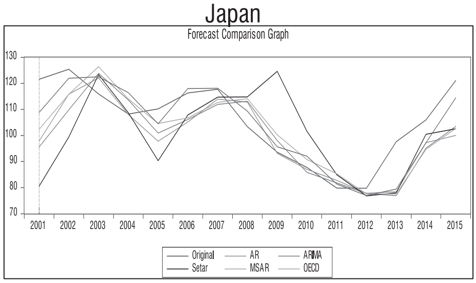


Figure 2: Forecast Comparison for one year ahead forecast of Exchange rate for G7 countries

Note: OECD indicates the Organization for Economic Co-operation and Development, AR indicates the Auto regressive, ARMA indicates the Auto regressive moving average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov switching auto Regressive model.

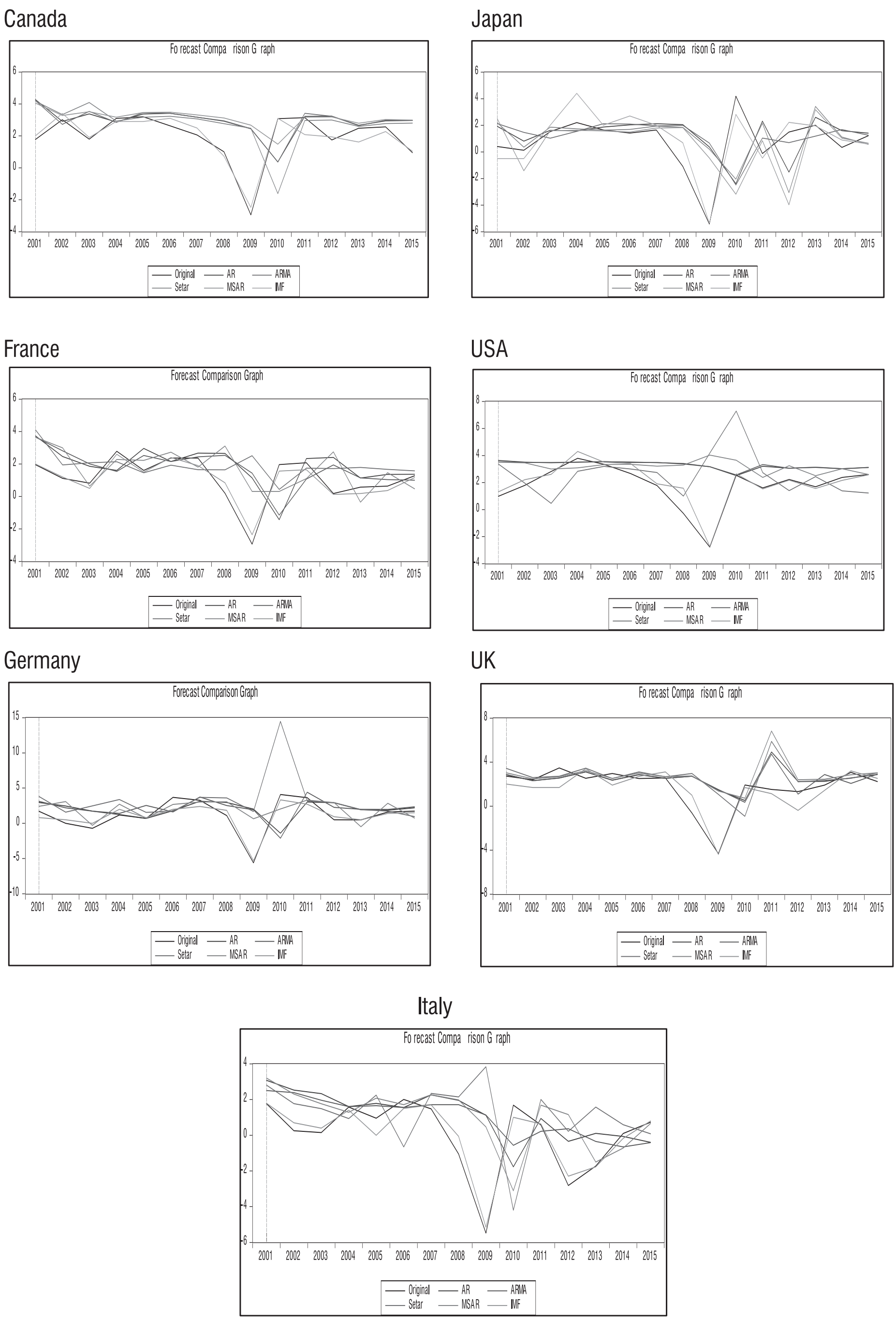


Figure 3: Forecast Comparison graphs for GDP growth for G7 countries

Note: IMF indicates the International Monetary Fund, AR indicates the Auto regressive, ARMA indicates the Auto regressive moving average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov switching auto Regressive model.

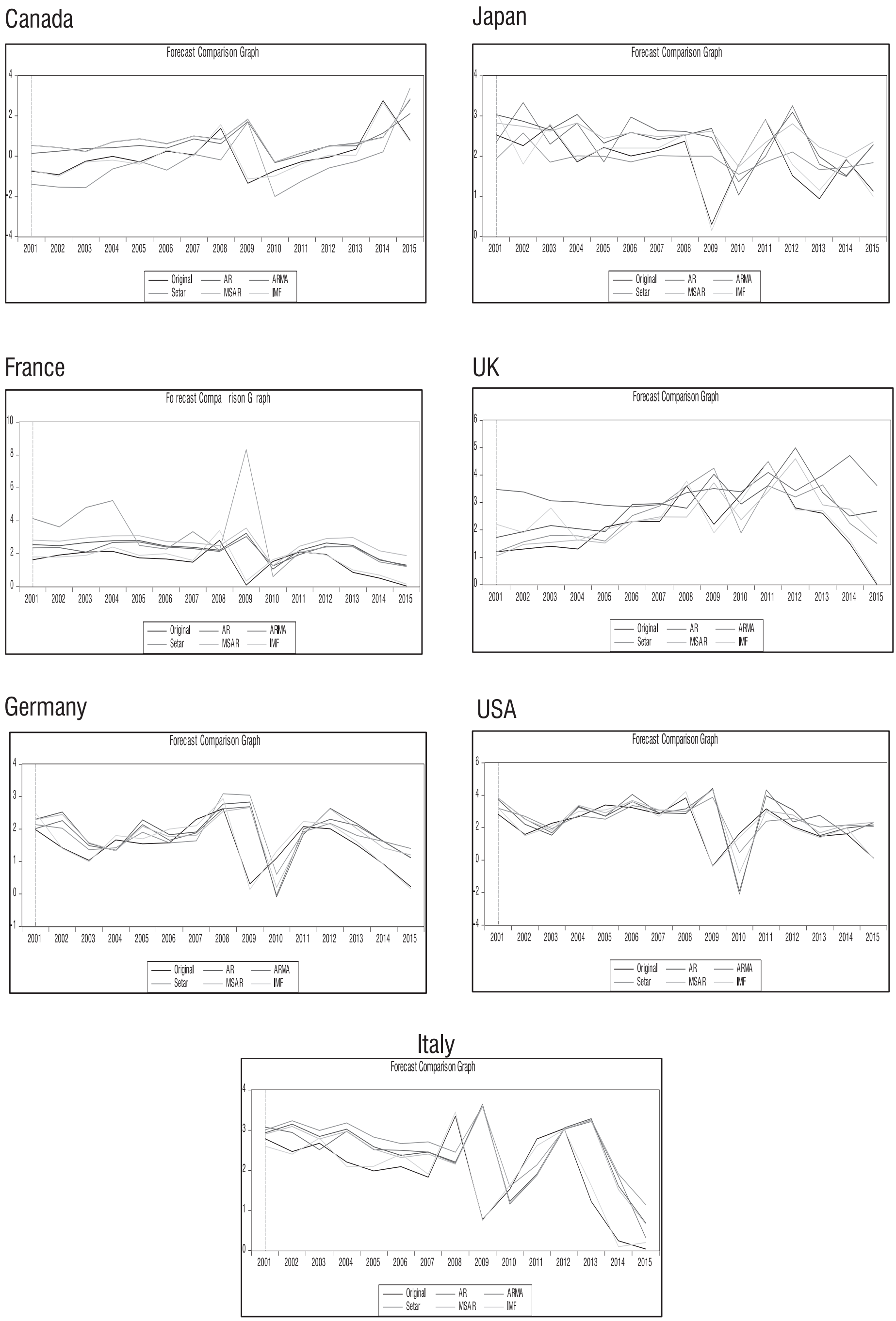


Figure 4: Forecast Comparison for One Year Ahead Forecast of Inflation for G7 countries

Note: IMF indicates the International Monetary Fund, AR indicates the Auto regressive, ARMA indicates the Auto regressive moving average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov switching auto Regressive model.

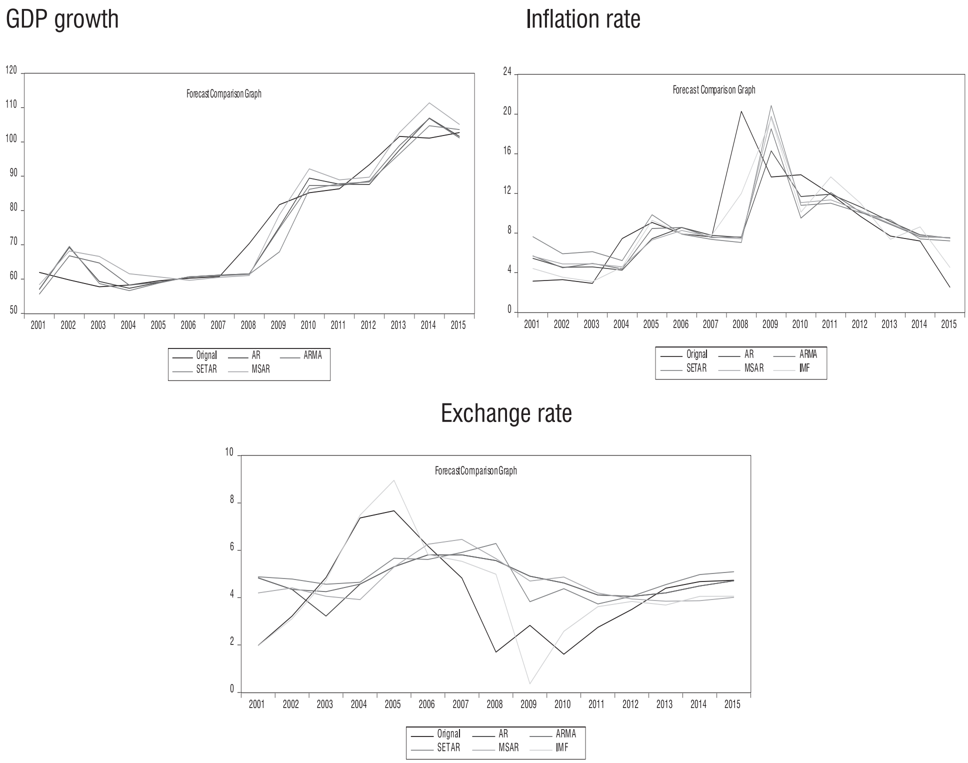


Figure 5: Forecast Comparison One Year Ahead Forecast of GDP growth, inflation and exchange rate of Pakistan

Note: IMF indicates the International Monetary Fund, AR indicates the Auto regressive, ARMA indicates the Auto regressive moving average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov switching auto Regressive model.

One Year Ahead Forecast for GDP growth, Exchange Rate and inflation of All Countries

Table 9a: One year ahead forecast of GDP growth for Canada

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.771	4.281	4.213	4.184	4.060	2.000
2002	3.010	2.903	2.724	3.337	3.281	3.400
2003	1.802	3.374	3.536	4.091	3.518	1.900
2004	3.086	2.875	2.850	2.936	3.171	2.900
2005	3.201	3.370	3.455	3.168	3.466	2.900
2006	2.623	3.410	3.413	3.225	3.487	3.100
2007	2.063	3.172	3.167	3.061	3.320	2.500
2008	1.000	2.927	2.942	2.767	3.123	0.724
2009	-2.950	2.443	2.460	2.476	2.674	-2.479
2010	3.084	0.365	0.356	-1.615	1.485	3.099
2011	3.141	3.218	3.415	2.965	3.170	2.080
2012	1.746	3.239	3.234	2.994	3.184	1.936
2013	2.475	2.659	2.645	2.594	2.789	1.612
2014	2.565	2.943	2.978	2.778	3.029	2.272
2015	0.942	2.971	2.981	2.798	2.987	1.041

Note: IMF indicates the International Monetary Fund, OECD indicates the Organization for Economic Co-operation and Development , AR indicates the Auto Regressive, ARMA indicates the Auto Regressive Moving Average, SETAR Self-Exciting Threshold Auto Regressive and MSAR indicates the Markov Switching Auto Regressive model.

Table 9b: One year ahead forecast of GDP growth for France

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.954	3.740	3.659	4.102	3.649	2.000
2002	1.119	2.458	2.813	1.948	2.994	1.200
2003	0.820	1.863	2.008	2.080	0.639	0.500
2004	2.786	1.607	1.544	2.137	2.275	2.600
2005	1.608	2.962	2.524	1.460	2.224	1.500
2006	2.375	2.157	2.155	1.928	2.733	2.400
2007	2.362	2.668	2.444	1.654	1.803	1.900
2008	0.195	2.652	2.532	1.639	3.104	0.837
2009	-2.941	1.147	1.440	2.516	0.309	-2.358
2010	1.966	-1.426	-1.152	0.441	0.309	1.565
2011	2.080	2.340	1.076	1.746	1.097	1.652
2012	0.183	2.407	1.943	1.724	2.754	0.122
2013	0.576	1.134	1.145	1.792	-0.350	0.186
2014	0.637	1.362	1.042	1.671	1.468	0.371
2015	1.274	1.372	1.006	1.582	0.474	1.160

*See note on Table 9a.

Table 9c: One year ahead forecast of GDP growth for Germany

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.704	2.955	3.109	3.820	2.416	0.800
2002	-0.003	2.460	2.192	1.573	3.096	0.500
2003	-0.715	1.720	1.723	2.475	-0.283	0.000
2004	1.173	1.248	1.397	3.389	2.709	2.000
2005	0.707	0.707	2.539	1.563	0.720	0.800
2006	3.695	1.802	1.630	1.732	2.677	2.000
2007	3.263	3.140	3.739	3.682	3.033	2.400
2008	1.087	2.961	2.520	3.600	3.050	1.850
2009	-5.624	2.013	1.921	1.696	0.647	-5.297
2010	4.085	-1.411	-2.115	14.457	2.041	3.332
2011	3.652	3.021	4.419	3.176	3.299	2.725
2012	0.499	2.907	2.258	2.914	2.938	0.936
2013	0.482	1.918	2.002	1.954	-0.491	0.491
2014	1.595	1.865	1.969	1.734	2.847	1.393
2015	1.726	2.199	2.354	0.956	0.748	1.509

*See note on Table 9a.

Table 9d: One year ahead forecast of GDP growth for Italy

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.772	3.083	2.503	2.811	3.200	1.800
2002	0.249	2.528	2.387	1.770	2.299	0.700
2003	0.151	2.326	1.960	1.489	1.758	0.400
2004	1.582	1.606	1.606	0.933	1.285	1.400
2005	0.950	1.775	1.658	2.250	2.078	0.000
2006	2.007	1.548	1.550	-0.651	1.710	1.500
2007	1.474	2.258	1.710	2.349	2.272	1.700
2008	-1.050	1.957	1.707	2.143	1.976	-0.060
2009	-5.482	1.117	1.136	3.838	0.473	-5.145
2010	1.687	-1.773	-0.569	-4.199	-3.111	1.003
2011	0.577	0.945	0.221	2.005	1.687	0.639
2012	-2.819	-0.345	0.363	0.220	1.158	-2.292
2013	-1.728	0.105	-0.348	1.577	-1.505	-1.776
2014	0.092	-0.073	-0.658	0.589	-0.720	-0.174
2015	0.732	-0.400	-0.409	0.078	0.661	0.802

*See note on Table 9a.

Table 9e: One year ahead forecast of GDP growth for Japan

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	0.406	1.924	2.135	2.196	2.492	-0.500
2002	0.118	0.815	1.469	0.356	-1.421	-0.500
2003	1.528	1.621	1.031	1.859	1.598	2.000
2004	2.205	1.573	1.542	1.735	1.623	4.400
2005	1.663	1.870	2.120	1.637	1.575	2.000
2006	1.420	2.039	2.093	1.695	1.496	2.700
2007	1.654	2.119	1.952	1.943	1.797	2.000
2008	-1.094	2.047	1.997	1.846	1.825	0.691
2009	-5.417	0.370	0.661	0.209	-0.454	-5.369
2010	4.192	-2.395	-2.486	-2.045	-3.179	2.824
2011	-0.116	2.318	1.043	2.147	0.847	-0.468
2012	1.495	-1.519	0.701	-3.063	-3.974	2.224
2013	2.001	2.607	1.187	3.417	3.178	1.953
2014	0.336	1.600	1.677	1.111	1.028	0.891
2015	1.219	1.412	1.251	0.566	0.657	0.591

*See note on Table 9a.

Table 9f: One year ahead forecast of GDP growth for UK

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	2.726	2.871	2.856	3.422	3.028	2.000
2002	2.397	2.317	2.313	2.585	2.475	1.700
2003	3.466	2.568	2.549	2.722	2.679	1.700
2004	2.528	3.106	3.101	3.452	3.219	3.400
2005	2.972	2.356	2.366	2.510	2.514	1.900
2006	2.503	2.873	2.856	3.100	3.004	2.700
2007	2.556	2.532	2.541	2.658	2.679	3.100
2008	-0.627	2.722	2.717	2.961	2.749	0.988
2009	-4.328	1.460	1.506	1.067	1.375	-4.385
2010	1.915	0.511	0.342	-0.922	0.722	1.702
2011	1.509	4.925	4.719	5.881	6.814	1.137
2012	1.313	2.246	1.100	2.208	2.394	-0.380
2013	1.911	2.262	2.874	2.343	2.445	1.433
2014	3.071	2.556	2.052	2.533	2.848	3.205
2015	2.222	2.874	2.918	3.029	3.022	2.517

*See note on Table 9a.

Table 9g: One year ahead forecast of GDP growth for USA

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	0.976	3.630	3.523	3.370	3.501	1.300
2002	1.786	3.500	3.484	1.951	3.455	2.200
2003	2.807	3.464	3.478	0.459	3.004	2.600
2004	3.786	3.490	3.513	2.838	3.089	4.300
2005	3.345	3.537	3.546	3.184	3.323	3.500
2006	2.667	3.515	3.481	2.999	3.347	3.400
2007	1.779	3.472	3.477	2.735	3.210	1.900
2008	-0.292	3.398	3.369	0.991	3.287	1.572
2009	-2.776	3.168	3.167	4.177	4.023	-2.730
2010	2.532	2.505	2.558	7.285	3.646	2.639
2011	1.602	3.204	3.329	2.724	2.372	1.527
2012	2.224	3.052	3.052	1.402	3.244	2.170
2013	1.677	3.119	3.136	2.431	2.498	1.560
2014	2.370	3.015	3.021	1.377	3.012	2.154
2015	2.596	3.102	3.113	1.220	2.588	2.568

*See note on Table 9a.

Table 9h: One year ahead forecast of GDP growth for Pakistan

Years	Original	IMF	AR	ARMA	SETAR	MSAR
2001	1.982	1.967	4.837	4.837	4.878	4.199
2002	3.224	3.112	4.346	4.346	4.785	4.411
2003	4.846	4.726	3.224	4.252	4.567	4.062
2004	7.369	7.483	4.573	4.573	4.649	3.916
2005	7.667	8.958	5.302	5.302	5.664	5.293
2006	6.178	5.818	5.804	5.804	5.611	6.259
2007	4.833	5.537	5.804	5.809	5.907	6.461
2008	1.701	4.988	5.571	5.571	6.290	5.653
2009	2.832	0.361	4.907	4.907	3.828	4.699
2010	1.607	2.581	4.619	4.619	4.382	4.867
2011	2.748	3.624	4.113	4.113	3.735	4.192
2012	3.507	3.837	4.053	4.053	4.061	3.943
2013	4.396	3.683	4.199	4.199	4.553	3.852
2014	4.675	4.053	4.497	4.497	4.977	3.874
2015	4.731	4.058	4.717	4.717	5.091	4.013

*See note on Table 9a.

Table 10a: One year ahead forecast of Exchange rate for Canada

Years	Actual	AR	ARMA	SETAR	MSAR	OECD
2001	1.549	1.484	1.480	1.452	1.472	1.531
2002	1.569	1.577	1.558	1.607	1.581	1.592
2003	1.401	1.578	1.541	1.624	1.578	1.555
2004	1.301	1.329	1.327	1.272	1.294	1.333
2005	1.212	1.254	1.251	1.248	1.230	1.242
2006	1.134	1.166	1.132	1.178	1.160	1.190
2007	1.074	1.093	1.081	1.120	1.100	1.138
2008	1.067	1.041	1.104	1.040	1.046	0.970
2009	1.143	1.062	1.071	1.059	1.057	1.295
2010	1.030	1.180	1.199	1.162	1.210	1.066
2011	0.990	0.979	0.987	1.014	1.027	1.024
2012	0.999	0.971	0.983	0.994	0.995	1.017
2013	1.030	1.002	1.019	1.011	1.006	1.000
2014	1.106	1.041	1.021	1.038	1.034	1.008
2015	1.279	1.137	1.186	1.114	1.141	1.143

*See note on Table 9a.

Table 10b: One year ahead forecast of Exchange rate for Japan

Years	Actual	AR	ARIMA	SETAR	MSAR	OECD
2001	121.529	97.928	95.559	80.588	102.348	108.800
2002	125.388	115.796	109.814	99.391	115.747	121.900
2003	115.933	122.061	123.805	123.369	126.395	122.500
2004	108.193	108.017	113.583	108.691	113.952	116.400
2005	110.218	97.816	100.935	90.327	104.595	104.500
2006	116.299	105.156	106.120	107.881	106.747	118.000
2007	117.754	113.900	111.890	114.707	112.647	118.100
2008	103.359	112.791	113.127	114.765	114.117	109.380
2009	93.570	93.117	98.059	124.578	100.242	95.690
2010	87.780	86.964	85.882	101.612	90.821	92.080
2011	79.807	82.793	81.788	84.898	85.271	81.390
2012	79.791	77.804	77.782	76.804	77.588	76.980
2013	97.596	78.454	76.906	78.009	77.631	79.420
2014	105.945	97.241	95.158	100.449	94.671	97.240
2015	121.044	100.046	103.449	102.575	102.685	114.450

*See note on Table 9a.

Table 10c: One year ahead forecast of Exchange rate for UK

Years	Actual	AR	ARMA	SETAR	MSAR	OECD
2001	0.695	0.667	0.670	0.662	0.667	0.689
2002	0.667	0.697	0.694	0.681	0.689	0.684
2003	0.613	0.645	0.640	0.633	0.625	0.642
2004	0.546	0.581	0.571	0.583	0.571	0.597
2005	0.550	0.512	0.514	0.533	0.510	0.529
2006	0.544	0.547	0.552	0.573	0.564	0.574
2007	0.500	0.537	0.546	0.563	0.531	0.526
2008	0.544	0.480	0.468	0.513	0.482	0.486
2009	0.642	0.557	0.561	0.586	0.578	0.643
2010	0.647	0.674	0.689	0.682	0.679	0.613
2011	0.624	0.638	0.622	0.632	0.619	0.631
2012	0.633	0.605	0.601	0.602	0.591	0.628
2013	0.640	0.627	0.637	0.625	0.628	0.630
2014	0.608	0.633	0.630	0.630	0.632	0.642
2015	0.655	0.587	0.585	0.589	0.575	0.629

*See note on Table 9a.

Table 10d: One year ahead forecast of Exchange rate for UK

Years	Orignal	AR	ARMA	SETAR	MSAR
2001	61.9272	57.00326	55.64998	57.13933	58.36938
2002	59.7238	69.24205	66.77379	69.58063	68.20439
2003	57.7520	59.31405	64.71931	58.68871	66.60777
2004	58.2579	57.32496	58.21116	56.63957	61.56529
2005	59.5145	59.02848	59.13894	58.89234	60.61582
2006	60.2713	60.63724	60.60529	60.68891	59.65635
2007	60.7385	61.15958	61.15441	60.99829	60.51959
2008	70.4080	61.48692	61.4948	61.41903	61.02762
2009	81.7129	75.2438	74.81272	67.92904	78.76064
2010	85.1938	89.45342	87.34231	86.2179	92.16465
2011	86.3434	87.66016	87.22909	87.82567	88.92528
2012	93.3952	87.5839	88.60837	88.33813	89.73115
2013	101.6289	97.71138	98.94432	96.49347	102.7386
2014	101.1001	106.9682	106.8402	104.7436	111.4366
2015	102.7693	101.6326	101.1905	103.6157	105.1116

*See note on Table 9a.

Table 11a: One year ahead forecast of inflation for Canada

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	2.525	3.027	2.344	1.933	2.821	3.100
2002	2.258	2.868	3.333	2.576	2.737	1.800
2003	2.759	2.650	2.295	1.849	2.620	2.800
2004	1.857	3.035	2.817	2.004	2.824	1.900
2005	2.214	2.320	1.857	1.995	2.443	2.200
2006	2.002	2.591	2.970	1.855	2.581	2.200
2007	2.138	2.415	2.633	2.014	2.484	2.200
2008	2.370	2.514	2.617	1.997	2.531	2.530
2009	0.300	2.690	2.463	1.997	2.621	0.147
2010	1.777	1.035	1.358	1.546	1.736	1.772
2011	2.912	2.203	1.997	1.853	2.337	2.905
2012	1.516	3.093	3.251	2.104	2.803	1.791
2013	0.938	1.988	1.802	1.661	2.224	1.146
2014	1.910	1.516	1.491	1.721	1.961	1.936
2015	1.130	2.280	2.279	1.836	2.353	0.997

*See note on Table 9a.

Table 11b: One year ahead forecast of inflation for France

Years	Actual	AR	ARIMA	SETAR	MSAR	IMF
2001	1.635	2.549	2.351	4.137	2.827	1.800
2002	1.923	2.482	2.370	3.626	2.760	1.800
2003	2.099	2.676	2.099	4.808	2.967	1.900
2004	2.142	2.788	2.680	5.230	3.084	2.400
2005	1.746	2.800	2.708	2.509	3.096	1.900
2006	1.675	2.466	2.413	2.279	2.747	2.000
2007	1.488	2.386	2.305	3.342	2.665	1.600
2008	2.813	2.214	2.138	2.212	2.487	3.413
2009	0.088	3.248	3.044	8.330	3.557	0.337
2010	1.531	1.068	1.256	0.600	1.266	1.640
2011	2.112	2.201	1.946	2.084	2.459	2.146
2012	1.954	2.646	2.454	2.411	2.921	1.924
2013	0.864	2.508	2.419	2.425	2.985	1.010
2014	0.510	1.617	1.649	1.501	2.175	0.700
2015	0.040	1.305	1.247	1.218	1.883	0.149

*See note on Table 9a.

Table 11c: One year ahead forecast of inflation for Germany

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.984	2.299	2.012	2.134	2.291	2.500
2002	1.421	2.525	2.257	2.024	2.449	1.400
2003	1.034	1.558	1.490	1.361	1.580	1.000
2004	1.666	1.332	1.349	1.423	1.332	1.800
2005	1.547	2.282	2.136	1.904	2.083	1.700
2006	1.577	1.824	1.655	1.571	1.761	2.000
2007	2.298	1.906	1.884	1.639	1.810	2.100
2008	2.628	2.767	2.622	3.084	2.542	2.940
2009	0.313	2.835	2.690	3.044	2.664	0.135
2010	1.104	-0.091	-0.039	0.603	0.204	1.321
2011	2.075	1.832	1.997	1.918	1.861	2.236
2012	2.009	2.635	2.302	2.172	2.622	2.152
2013	1.505	2.167	2.103	1.800	2.007	1.606
2014	0.910	1.613	1.611	1.616	1.414	0.896
2015	0.230	1.112	1.125	1.401	1.199	0.162

*See note on Table 9a.

Table 11d: One year ahead forecast of inflation for Italy

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	2.785	2.931	3.074	3.004	2.900	2.600
2002	2.465	3.146	2.941	3.234	3.093	2.400
2003	2.673	2.842	2.511	2.991	2.780	2.800
2004	2.207	3.021	2.973	3.179	2.967	2.100
2005	1.985	2.584	2.516	2.823	2.525	2.100
2006	2.091	2.369	2.497	2.665	2.316	2.400
2007	1.830	2.456	2.453	2.708	2.406	1.900
2008	3.348	2.205	2.176	2.451	2.153	3.449
2009	0.775	3.593	3.647	3.600	3.591	0.750
2010	1.526	1.224	1.163	1.595	1.186	1.627
2011	2.781	1.907	1.872	2.133	1.886	2.613
2012	3.041	3.054	3.024	3.014	3.048	3.014
2013	1.220	3.288	3.218	3.254	3.225	1.616
2014	0.240	1.610	1.848	1.913	1.520	0.095
2015	0.040	0.690	0.325	1.144	0.667	0.200

*See note on Table 9a.

Table 11e: One year ahead forecast of inflation for Japan

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	-0.740	0.537	0.137	-1.397	0.539	-0.700
2002	-0.924	0.431	0.250	-1.541	0.424	-1.000
2003	-0.257	0.234	0.380	-1.566	0.211	-0.300
2004	-0.009	0.703	0.423	-0.636	0.715	-0.200
2005	-0.283	0.860	0.526	-0.259	0.866	-0.400
2006	0.249	0.617	0.401	-0.698	0.603	0.300
2007	0.060	1.001	0.855	0.086	0.998	0.000
2008	1.380	0.831	0.619	-0.185	0.815	1.572
2009	-1.353	1.835	1.711	1.695	1.849	-1.134
2010	-0.720	-0.297	-0.322	-2.007	-0.292	-0.990
2011	-0.268	0.165	0.046	-1.230	0.152	-0.370
2012	-0.052	0.494	0.508	-0.590	0.477	0.042
2013	0.346	0.643	0.510	-0.267	0.623	0.045
2014	2.760	0.938	1.140	0.215	0.922	2.655
2015	0.790	2.810	2.111	3.381	2.856	0.727

*See note on Table 9a.

Table 11f: One year ahead forecast of inflation for UK

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	1.200	1.721	3.469	1.190	1.045	2.200
2002	1.300	1.933	3.384	1.567	1.465	1.900
2003	1.400	2.153	3.062	1.796	1.546	2.800
2004	1.300	2.041	3.021	1.777	1.630	1.600
2005	2.100	1.935	2.892	1.585	1.516	2.000
2006	2.300	2.927	2.842	2.519	2.289	2.300
2007	2.300	2.958	2.917	2.869	2.473	2.400
2008	3.600	2.789	3.358	3.600	2.464	3.780
2009	2.200	4.030	3.507	4.251	3.715	1.887
2010	3.300	2.942	3.387	1.889	2.368	3.078
2011	4.500	3.620	4.098	3.605	3.401	4.513
2012	2.800	4.993	3.425	3.201	4.598	2.732
2013	2.600	3.359	3.993	3.640	2.907	2.700
2014	1.500	2.504	4.709	2.238	2.750	1.631
2015	0.000	2.677	3.611	1.504	1.746	0.062

*See note on Table 9a.

Table 11g: One year ahead forecast of inflation for USA

Years	Actual	AR	ARMA	SETAR	MSAR	IMF
2001	2.826	3.729	3.825	3.193	3.839	3.200
2002	1.586	2.206	2.540	2.696	2.514	1.500
2003	2.270	1.538	1.681	1.943	1.845	2.100
2004	2.677	3.312	3.252	2.737	3.382	3.000
2005	3.393	2.704	2.713	2.519	2.916	3.100
2006	3.226	3.592	4.051	3.358	3.672	3.600
2007	2.853	2.917	2.897	3.084	3.091	2.700
2008	3.839	2.872	3.156	2.997	3.003	4.224
2009	-0.356	4.426	4.343	3.872	4.343	-0.391
2010	1.640	-1.901	-2.089	0.467	-0.784	1.417
2011	3.157	3.967	4.332	2.400	3.045	2.987
2012	2.069	3.086	2.360	2.566	2.784	1.967
2013	1.465	1.523	2.758	2.045	1.685	1.392
2014	1.620	1.979	1.603	2.157	2.170	1.976
2015	0.120	2.162	2.317	2.069	2.331	0.093

*See note on Table 9a.

Table 11h: One year ahead forecast of inflation for Pakistan

Years	Original	IMF	AR	ARMA	SETAR	MSAR
2001	3.148	4.409	5.431	5.687	7.626	5.654
2002	3.290	3.535	4.532	4.495	5.896	4.875
2003	2.914	3.104	4.577	4.930	6.108	4.893
2004	7.445	4.566	4.256	4.376	5.209	4.600
2005	9.063	9.277	7.436	8.463	9.840	7.296
2006	7.921	7.923	8.561	8.554	7.881	8.254
2007	7.599	7.770	7.778	7.553	7.348	7.599
2008	20.286	11.995	7.557	7.604	7.046	7.417
2009	13.648	19.566	16.299	18.522	20.870	19.786
2010	13.881	10.103	11.684	9.505	10.799	11.067
2011	11.917	13.661	11.922	12.084	11.008	11.350
2012	9.682	11.004	10.634	10.122	10.056	10.255
2013	7.692	7.361	9.147	8.871	9.324	8.949
2014	7.189	8.621	7.820	7.627	7.402	7.771
2015	2.529	4.525	7.480	7.529	7.215	7.469

*See note on Table 9a.