Sindh Univ. Res. Jour. (Sci. Ser.) Vol.44 (2) 267-272 (2012)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Vector Auto-Regression Application on Macroeconomic Variables of Pakistan's Economic Growth

M. Z. ALTAF, I. A. ARSHAD* M.R. ILYS**

Department of Statistics, Allama Iqbal Open University, Islamabad

Corresponding author, I. A. ARSHAD, Email: irshad.ahmad@iiu.edu.pk Cell. No. +923335181807

Received 8th January 2012and Revised 16th April 2012

Abstract: The main purpose of this article is to determine the significance of macroeconomic variables on Pakistan's economic growth with the application of vector autoregression (VAR) modelling using annual time series data. The quantitative evidence shows that real per-capita income growth is caused by money-supply. Exchange rate policies, government spending and money supply are significant in the regression of Investment. Similarly, exports and exchange rate policies affect the growth of real per-capita money supply. Forecast errors have been generated for both models using Variance Decomposition (VDC) analysis.

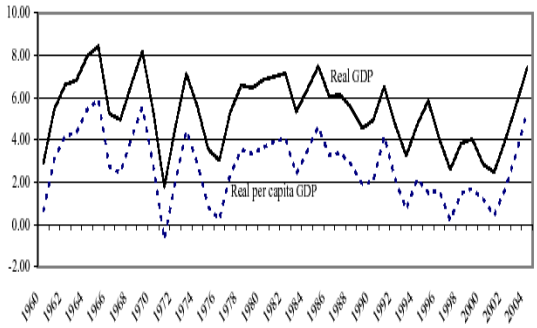
Keywords: Time series. Variance Decomposition. Forecast errors.

1. INTRODUCTION

The main concern for the policy makers and the donor agencies is the stability in the economic growth of a country. Unfortunately, the economic growth of Pakistan remained unsustainable for the last many years. The main reasons of this instability are the political and law & order situation of the country, inflation rate, fiscal deficit and the less interest of foreigners in the Pakistani products.

According to IMF report on Pakistan 2005, average economic growth in Pakistan was recorded as 5.5% per year since 1960. During this period, the real incomes have more than tripled because the average real per capita GDP growth was about 2.75% per year. During this period i.e. since 1960, Pakistan has experienced two earlier sustained growth accelerations, first started in 1961 and second in 1977 with per capita real growth rates consistently exceeding 2 % per year, lasting for 10years and 12years respectively. The growth rates had fallen to an average of 3 % per year in the 2nd half of the 1990s and exceeding the population growth. With sound fiscal and monetary policies of the then government and with the help of international support, the economy had a drastic increase and accelerated over 8% in 2004-05.

The direction of causation between export growth and economic growth has been investigated by Khan et al (1995) by using the Granger Causality test and found a one way stable relationship between output and primary exports, but stable and long run



Source: IMF Report for Pakistan

Fig. 1.1 Pakistan's Economic Growth 1960-2004.

two way relationship between export and output. By using the annual time series data for 1950-1994 of the South Korea, Ghatak (1998) estimated the Bayesian vector autoregressive (BVAR), vector Auto-regression (VAR), and vector error-correction models (VECMs). The author found proof supporting the view that growth of real per capita income had been aided by government spending policies, investment, and income and export growth and also by the exchange rate policies. The VECMS had forecasting advantage over the other two techniques for both short term and long term predictions. Pakistan economic growth outcomes of the macroeconomic variables were examined over the period 1959-60 to 1996-97 by Iqbal and Zahid (1998). They used the multiple regression frameworks to separate out the effect of key macroeconomic factors on growth. They conclude that the primary education is an important prerequisite to accelerate the economic growth. They recommended to rely on domestic resource to finance

* Department of Mathematics and Statistics, Allama Iqbal Open University, Islamabad.

**Department of Statistics, University of Sindh, Jamshoro

growth is the best alternative as the external debt is negatively related to growth.

(Feasel *et al.,* 2001) used the impulse response analysis and variance decomposition and suggested that the investment rates and growth rates of exports had significant short run effect on the growth rate of per capita output. They employed Vector auto-regression (VAR) analysis on the data of Korea for the period 1956-1994 and found the dynamic relationships among investment rates, output growth and export growth. To examine the impact of financial development on economic growth in china, Shan (2003) used Vector Auto-Regression technique. He found that after contribution of labor input financial development came as the second force in leading economic growth in China.

(Kandil and Mirzaile 2004) used the data of nine developing countries in the Middle East and applied the empirical model include three policy variables: government spending, the money supply and the exchange rate. They found that there is asymmetry in the cyclical behavior of private consumption. The stabilizing function of policy shock appeared to asymmetric within countries and varied across countries. To maximize the policy effect on desired private consumption, the policy stance carefully designed which is the largest growing component of aggregate demand in many developing countries. The financial development leads to economic growth or vice versa examined by the (Ang and McKibbin 2005) in the small open economy of Malaysia. They highlighted importance of country specific studies and argued that the result obtained from cross country were not able to address this issue. They used time series data from 1960 to 2001 to assess the finance growth link by taking investment, trade, saving and real interest rate into account. Their result supported the view that output growth caused financial depth in long run in contrary to conventional findings.

In order to examine the effect of key macroeconomic variables on the economic growth of Pakistan, the present study was initiated. For this purpose vector auto regression scheme was applied on the annual time series data available from 1974-75 to 2004-05. In order to generate the forecast errors, Variance Decomposition analysis was employed.

2. MATERIALS AND METHODS

There are number of factors that contribute to Pakistan's economic growth in the period 1974-75 to 2004-05. Exports, investment, government spending, money supply, interest rate and exchange rate are the most important variables that need to be considered. These variables can be regarded as the main policy instruments. According to (Kandil and Mirzaie 2004) Interest Rate should be taken, as Discount Rate and Money Supply is equal to Broad Money. IMF report 2005 for Pakistan illustrates that Investment = Gross Fixed Capital Formation (Private Sector + Public Sector + General Government) + Direct Investment Abroad + Import of Machinery (Machinery non-electrical, electrical and transport equipment) + Commercial Credit (Bank Credit to Private & Public Sector) + Change in Stocks.

An annual time series data from 1974-75 to 2004-05 were taken from the Federal Bureau of Statistics (FBS). We decided to apply the vector autoregression (VAR) methodology with time series data due to the following reasons:

Firstly we treat each variable symmetrically and allow feedback among them due to the simultaneous relationship between the variables. Secondly, VAR analysis is in capturing the long-run dynamics of variables in single equation approach and thirdly it is much more helpful in estimation and forecasting. In estimating the VAR models, all variables other than interest rate and exchange rate have been expressed in natural logarithm, as change in the logarithm of any variable yields the respective growth rate (Box and Tiao, 1975).

The variables used for the analysis purpose are Exports (X); Interest Rates (I); Exchange Rates (E); Investment (V); Money Supply (M); Government Spending (T) and Real Per Capita Income (Y).

VARs are the useful systems of equations that examine the inter-relationships between economic variables.

A reduced form VAR process of order p is as follows:

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_p y_{t-p} + e_t, t = 1,.., T \quad (1)$$

The model (1) can be written, using the lag operator notation:

$$\left(I_n - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^p\right) y_t = c + e_t$$

$$\Phi(L) y_t = c + e_t$$

The length of lags can be chosen using the Akaike Final Prediction Error (FPE) criterion.

The log likelihood for the entire sample is as follows:

$$L(\theta) = \ln\left(\prod_{t=1}^{T}(2\pi)^{-\frac{n}{2}}|\Omega|^{-\frac{1}{2}}\exp\left(-\frac{1}{2}(y_t-\Pi' x_t)'\Omega^{-1}(y_t-\Pi' x_t)\right)\right)$$
$$= -(Tn/2)\ln(2\pi) + (T/2)\ln|\Omega^{-1}| -$$
$$(1/2)\sum_{t=1}^{T}\left[(y_t-\Pi' x_t)'\Omega^{-1}(y_t-\Pi' x_t)\right] \quad .....(2)$$

The one period ahead forecast of the vector of endogenous variables ($\hat{y}_{t+1}$) is obtained by substituting past and current values in periods *t* to t+1-*p* into equation (3):

$$\hat{y}_{t+1} = A_1 y_t + A_2 y_{t-1} + ... + A_p y_{t+1-p} \quad \ldots (3)$$

Similarly, two periods ahead forecast for the vector of variables ($\hat{y}_{t+2}$) is obtained by substituting ($\hat{y}_{t+1}$) and the observed values of the variables in periods *t* to t+2-*p* into equation (4):

$$\hat{y}_{t+2} = A_1\hat{y}_{t+1} + A_2 y_t + ... + A_p y_{t+2-p} \qquad (4)$$

Forecast errors can be obtained from Variance Decomposition of each VAR model. The k step forecast error variance can be computed as follows:

$$y_{t+k} - E(y_{t+k}) = \Psi_0 e_{t+k} \Psi_1 e_{t+k-1} + ... + \Psi_{k-1} e_{t+1}$$
$$\text{var}_t(y_{t+k}) = \Psi_0\Psi_0' + \Psi_1\Psi_1' + ... + \Psi_{k-1}\Psi_{k-1}'$$
$$w_{k,r} = \sum_{j=1}^{k-1}\Psi_j I_T \Psi_j'$$

3. RESULTS AND DISCUSSIONS

The length of lags is determined using the procedures: **(Table-1)** sequential modified LR test statistic (LR), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn information criterion (HQ) each test at 5% level of significance and the results are as follows.

Table-1: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-10.72416	NA	8.01e-09	1.222356	1.552393	1.325719
1	211.0696	321.2185*	5.93e-14	-10.69445	-8.054159*	-9.867547
2	272.2337	59.05505	5.01e-14*	-11.53336*	-6.582808	-9.982910*

* indicates lag order selected by the criterion

It is apparent from the above table that VAR Lag Order is 2

We have two sets of variables

SET A ------- Y, V, T, X, M and E.

SET B ------- Y, V, T, X, E and I.

The reason for not including money supply and interest rates in the same model is that only one of these can be used as a policy instrument at a time.

3.1 The unrestricted versus restricted model:

The unrestricted model includes two lags of each of the six variables --- Y, V, T, X, M, E in set A and Y, V, T, X, E, I in set B and the restricted model includes two lags of each of the five variables in each set, excluding one variable from the list at each step. The significance of the lagged values of a variable in each regression has been judged with the p-value and p-values are given in brackets in Table 2. If p-value is lower than 0.05 implying that the lagged variables excluded from an equation are significant. The Chi-square values when excluding lagged values of a variable for sets A and B are given in **(Table 2)**.

Table 2: Chi-square values when excluding lagged values of variables from each regression

Variables excluded												
	Model 1A						Model 1B					
	Y	V	T	X	M	E	Y	V	T	X	E	I
Y	-	0.746869 [0.6884]	0.011612 [0.9942]	0.328059 [0.8487]	7.124603 [0.0284]	1.898165 [0.3871]	-	0.232464 [0.8903]	0.395872 [0.8204]	0.635901 [0.7276]	0.091430 [0.9553]	1.553462 [0.4599]
V	2.718070 [0.2569]	-	4.376125 [0.1121]	3.983743 [0.1364]	5.597658 [0.0609]	8.456421 [0.0146]	0.353126 [0.8381]	-	0.754406 [0.6858]	6.388318 [0.0410]	8.785438 [0.0124]	1.837650 [0.3990]
T	1.104046 [0.5758]	0.413136 [0.8134]	-	2.379090 [0.3044]	6.520982 [0.0384]	0.365503 [0.8330]	4.813465 [0.0901]	0.334257 [0.8461]	-	3.751217 [0.1533]	0.690616 [0.7080]	1.093514 [0.5788]
X	2.853061 [0.2401]	1.364560 [0.5055]	1.164129 [0.5587]	-	0.048547 [0.9760]	1.953915 [0.3765]	3.430526 [0.1799]	1.478904 [0.4744]	1.333878 [0.5133]	-	1.234851 [0.5393]	0.075027 [0.9632]
M	0.601012 [0.7404]	0.439523 [0.8027]	2.206175 [0.3318]	5.409252 [0.0669]	-	5.903301 [0.0523]	-	-	-	-	-	-
E	3.010429 [0.2220]	3.404582 [0.1823]	1.711487 [0.4250]	5.727271 [0.0571]	7.971815 [0.0186]	-	0.075694 [0.9629]	2.875741 [0.2374]	0.992942 [0.6087]	0.464785 [0.7926]	-	4.152578 [0.1254]
I	-	-	-	-	-	-	2.259969 [0.3230]	1.185721 [0.5527]	0.506332 [0.7763]	2.119984 [0.3465]	2.253221 [0.3241]	-

The values for Model 1A indicate that, the term M is significant in the regression of Y, implying that real per-capita income growth is caused by this variable. At 5% level of significance the term E, and at 10% level of significance the term M are

significant in the regression of V, implying that investment is caused by these variables. In the regression of T, the term M is significant. In the regression of M, the terms X and E are significant, implying that real per-capita money supply growth is caused by these variables. Similarly in the regression of E, the terms X and M are significant. Model 1B shows that the terms X and E are significant in the regression of V, implying that investment is caused by these variables. At 10% level of significance the term Y is significant in the regression of T.

3.2 Forecast Errors

Variance Decomposition analysis was used to calculate the forecast errors and are given in the following **(Table 3).**

Table 3: Standard forecast errors of VAR Model 1A and 1B for 1, 2, ... , 10 periods ahead.

Variables												
Forecasting periods ahead	Model 1A						Model 1B					
	Y	V	T	X	M	E	Y	V	T	X	E	I
1	0.0393	0.0420	0.0413	0.0891	0.0334	1.3173	0.0451	0.0462	0.0474	0.0890	1.4367	1.3793
2	0.0453	0.0688	0.0520	0.1022	0.0534	2.2948	0.0603	0.0686	0.0658	0.1034	2.3762	2.1209
3	0.0509	0.0893	0.0623	0.1243	0.0714	3.0837	0.0696	0.0813	0.0802	0.1202	2.9667	2.5249
4	0.0559	0.1048	0.0692	0.1487	0.0880	3.6841	0.0750	0.0874	0.0856	0.1399	3.3615	2.7373
5	0.0594	0.1201	0.0754	0.1705	0.1026	4.1730	0.0792	0.0964	0.0896	0.1560	3.6392	2.9270
6	0.0642	0.1353	0.0858	0.1896	0.1158	4.4624	0.0842	0.1084	0.0979	0.1670	3.8551	3.0936
7	0.0698	0.1470	0.0963	0.2069	0.1276	4.6210	0.0902	0.1200	0.1079	0.1764	4.0423	3.2448
8	0.0757	0.1555	0.1045	0.2226	0.1384	4.7262	0.0958	0.1296	0.1155	0.1868	4.2088	3.3728
9	0.0824	0.1625	0.1127	0.2357	0.1483	4.8032	0.1008	0.1379	0.1215	0.1971	4.3514	3.4768
10	0.0903	0.1686	0.1219	0.2453	0.1568	4.8951	0.1057	0.1459	0.1281	0.2059	4.4807	3.5609

The results show that the Model 1A is better than model 1B for a 10-periods-ahead forecast for growth of real per capita output, growth of government spending. Model 1B is better than model 1A for a 10-periods-ahead forecast for growth of investment, growth of exports and exchange rates. Overall Model 1A is to be considered the better forecast errors than Model 1B. A characteristic of VAR models is that the forecast errors may change, depending on the ordering of the variables. This is because of the correlation among the shocks of different variables included in the model.

3.3 Variance Decomposition Analysis

The variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR. The forecasted values of model 1A and model 1B using VDC over one period to ten periods are shown in figures 1 and 2 respectively. **(Fig. 1and 2)** reveals Variance Decomposition of Y, V, T, X, M and E.

Forecasted values at One-period of Y is 100 and is period wise decreasing and at 10-period it becomes 41.80 but in all other variables of Model 1A forecasted values are period-wise increasing. At One-period in all variables is 0.00 except Y.

Forecasted values of Y are decreasing from 1-period to 4-period and then increases till 10-period. Forecasted values of V are decreasing from 1-period to 3-period rapidly and then slowly till 6-period. From 6-period onward forecasted values increase till the last period. Forecasted values of all other variables are 0.00 at period-1. In variable T forecasted values increase till 10-period. In the variable X forecasted values decrease upto 5-period and then increase till 10-period. Forecasted values of M and E are increasing upto 6-period and then decrease till 10-period.

The trend of forecasted values of Y and T is approximately the same i.e. decreasing from period-1 till the last period. Forecasted values of variables V and X are of mixed nature i.e. decreasing and increasing in different periods. One-period forecasted values of variables X, M and E is 0.00. The trend of forecasted values of the variable E is increasing upto period-10. Forecasted values of M are increasing upto 5-period and then decreasing till 10-period.

Forecasted values of variables Y and V are of mixed nature i.e. decreasing and increasing in

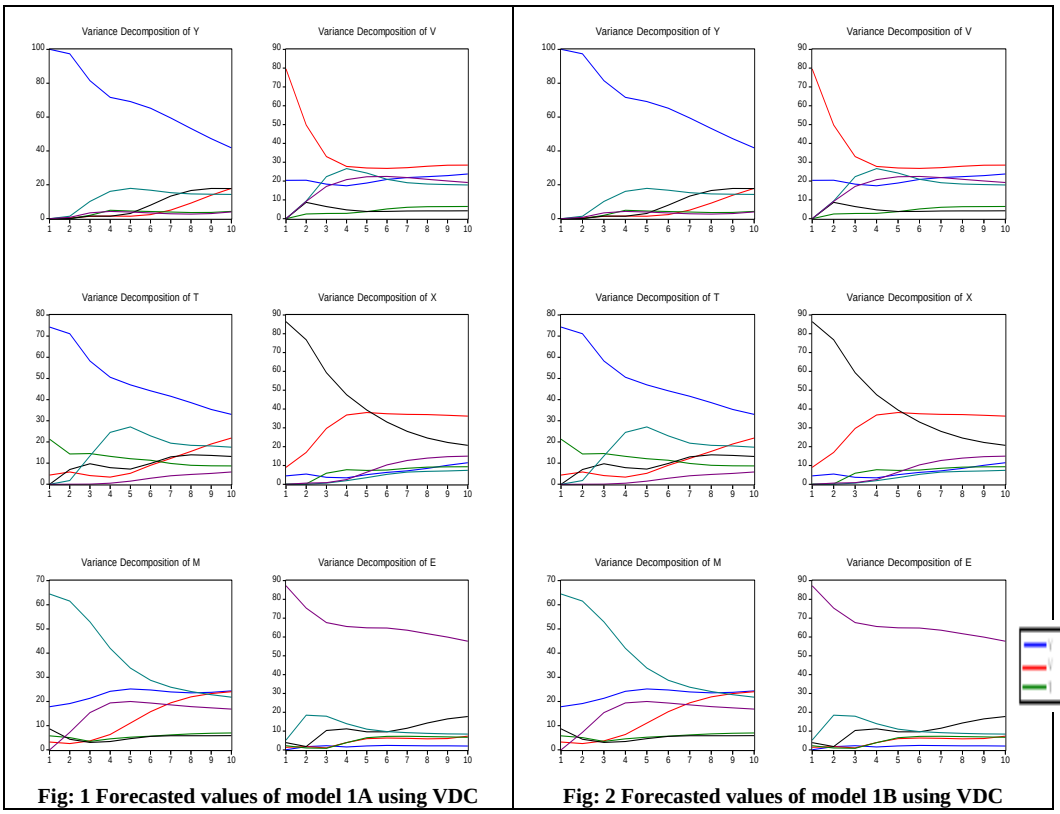


Fig: 1 Forecasted values of model 1A using VDC

Fig: 2 Forecasted values of model 1B using VDC

different periods. Variables T, M and E have same increasing trends of forecasted values till 10-period. Forecasted values of X are decreasing from period-1 to period-10.

Forecasted values of variables Y, V, T and X are of mixed nature i.e. decreasing and increasing in different periods. In the variable M forecasted values are decreasing till 10-period, starting values at 1-period is 64.4528. In the variable E, forecasted values are increasing till 6-period and then decreasing upto 10-period.

Forecasted values of variables Y, V, T and X are of mixed nature i.e. decreasing and increasing in different periods. In the variable M, forecasted values increase till 2-period and then decree till 10-period. Forecasted values of E are decreasing from 1-period to 10-period. Fig. 2 showed that Variance Decomposition of Y,V, T, X, E and I.

A forecasted value at One-period of Y is 100 and is period wise decreasing and at 10-period it becomes 71.756. Forecasted values of V, T and X variables are increasing upto 10-period. In the variable E and I, forecasted values are increasing upto 6-period and then decreasing till 10-period.

Forecasted values of Y are mixed in nature i.e. increasing and decreasing at different periods. Forecasted values of V are decreasing from One-period to 10-period. Forecasted values of the variable T are increasing upto 6-period and then decreasing till 10-period. Forecasted values of X and I are increasing through 10-periods. Forecasted values of E are increasing upto 4-period and then decrease till 10-period.

The trend of forecasted values of Y and T are decreasing till 10-period. Forecasted values of variables V, X and I are increasing till 10-period. In the variable E, forecasted values are increasing upto 6-period and then decreasing till 10-period.

Forecasted values of variables Y and T are of mixed nature i.e. decreasing and increasing in different periods. In the variable V, forecasted values are increasing and then decrease till 10-period. Forecasted values of X are decreasing till 10-period. In the variables E and I forecasted values are increasing upto 10-period.

Forecasted values of variable Y are increasing upto 4-period and then decrease till 10-period. Forecasted values of V and X are mixed in nature i.e. increase and decreases in different periods. In the variable T, forecasted values increase upto 2-period and then decrease, forecasted values of E and X are decreasing and increasing respectively upto 10-period.

Forecasted values of variables Y and I are decreasing upto 10-period. V and T variables forecasted values are increasing upto 7-period and then decreasing till 10-period. Forecasted values of X and E variables are increasing till 10-period.

4. CONCLUSION

In this study two models were developed to explain Pakistan's economic growth. The empirical results of Chi-square values of VAR model 1A have revealed that in Pakistan's economic growth, Money Supply is the only significant variable in the regression of Y, implying that real per-capita income growth is caused by this variable. As far as investment is concerned the results have revealed that Exchange rates, Government spending and Money supply are significant in the regression of Investment, implying that investment is caused by these variables. In the regression of Government spending, Money supply is significant. In the regression of Money supply, Exports and Exchange rates are significant, implying that growth of real per-capita money supply is caused by these variables. Similarly in the regression of Exchange rates, Exports and Money supply are considered significant. Exports and Exchange rates are considered significant in the regression of investment for model 1B.

We have estimated forecast errors by Variance Decomposition Analysis. The minimum forecast error for the growth of real per capita output is generated by model 1A for a one-period-ahead forecast. Forecast errors have increased for longer forecasts. Model 1A has generated the smallest forecast errors among two models for a one-period-ahead forecast. Model 1B has generated the smallest forecast errors for the growth of Exports and Exchange rates for 1 to 10 period-ahead forecasts. Overall Model 1A provides better forecast errors than Model 1B.

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