Sectoral Volatility and National Output Fluctuations in Indian Economy: An ARCH and GARCH Approach

Khadija Malik Bari, Rana Ejaz Ali Khan and Nadia Mahtab

Abstract: The study empirically investigated the impact of sectoral volatility on the economic growth of India using annual time series data for the years 1970-2011. It is attempted to find out that to what extent volatility in economic growth rate of India is associated with volatility in growth rate of different sectors. ADF unit root test is used to check the stationarity of the data. Autoregressive Conditional Heteroscedasticity (ARCH) and General Autoregressive Conditional Heteroscedasticity (GARCH) have been used for estimating the volatility in growth rate of GDP and sectors. To see the impact of sectoral volatility on economic growth rate Ordinary Least Square (OLS) has been used. Finally to estimate the stability of the model Cumulative Sum (CUSUM) and Cumulative Sum of Square (CUSUMSQ) tests have been employed. The results explain the existence of volatility in economic growth rate to a greater extent. The agriculture sector, exports and imports also fluctuate to a greater extent. The results have also shown that lagged period of growth rate of output, agricultural sector as well as services sector affects the current period’s growth rate of output. Furthermore, the results revealed that volatility in services sector contributes highest towards volatility in economic growth rate as compared to other sectors and volatility in exports sector influence the economic growth fluctuations negatively.

JEL Classification: E32, O14, O40

Key words: Economic Growth • Industrial Sector • Agricultural Sector • Volatility in Growth

INTRODUCTION

The high economic growth rate is an indicator of good functioning of an economy. Shares of economic sectors in Gross Domestic Product (GDP) have been recognized as key parameters for economic growth rate as well as economic development of the countries. The share of agriculture in GDP has traditionally been dominated in a pre-industrialized economy while the other two prominent sectors, i.e. industry and services remained comparatively modest. Since the 1970s Asian countries have experienced remarkable structural changes through industrial development. Indian economy has also experienced remarkable structural transformation in composition of GDP. However, the growth of GDP has not revealed a smooth upward trend over a long period. Rather the growth of economy has been accompanied by tremendous volatility and instability not only at the national level but also at cross state level. In course of structural transformation the services sector enjoyed a comparative advantage in playing a leading role towards the achievements of remarkable GDP growth rate such that the services sector led growth has been inaugurated as “service sector revolution” in Indian economy [1, 2].

The macroeconomic scenario of Indian economy instigates the researchers to explore deeper into fluctuations in economic growth and role of volatility in sectoral growth rate. The present study will attempt to examine the effect of sectoral volatility on fluctuations in GDP growth of Indian economy. The core objective of the study is to investigate that volatility of which sector and at what extent contributes to the fluctuations in economic growth in India and to frame the policy proposals for smoothening the fluctuations in GDP.

The literature evidenced that volatility in sectors in which the economies are specialized have a significantly large effect on the production and trade of the developed and developing economies [3, 4]. A number of studies can be cited discussing the experience of sectoral volatility and its effect on economic performance of countries...
[5-10]. Some of them have shown positive association between volatility and growth [11-13], while others expressed negative association between volatility and growth [14-16]. Such type of contradicting findings may be due to varying econometric techniques nature of the economies and sociopolitical differences make the relationship between sectoral volatility and economic growth a puzzle.

A cross country analysis between volatility and growth rate of economies has been investigated by Ramey and Ramey [5]. They calculated the mean and standard deviation of per-capita annual growth rate over the time period for each country and found that economies of higher volatility had lower economic growth rate. The study also revealed that the investment share of GDP played little part in association between volatility and economic growth rate. It has also been found a negative impact of government spending volatility on economic growth that contradicts with the findings of Alesina et al. [17].

In the case of Pakistan the impact of sectoral volatility on economic development has been investigated by Azid, et al. [8]. Volatility was estimated by using rolling variance of the series and GARCH. They found that every sector has a significant impact on the volatility in output growth except financial sector. They further revealed that there was no long-run relationship between volatility of growth rate of output and volatility of growth rate of different sectors of country. Conversely, an association exists for the short-run time period.

The relationship between sectoral volatility and economic growth across countries has been probed by Imbs [13]. The study used the data of yearly value added of different sectors, employment and contents of factor of production in manufacturing activities. It was concluded that economies with fluctuated activities grow rapidly. The study also found that across countries the relationship between economic growth and volatility was positive while across sectors it was negative.

The relationship between share of different sectors and economic growth has been estimated by Linden and Mahmood for 15 Schengen countries. Panel data for the years 1970-2006 was utilized for analysis. The study employed Error Correction model (ECM), Co-integration technique and Granger Causality approach in panel settings. The results of co-integration technique revealed that services sector had been improved at the cost of agriculture and industrial sector but an affirmative association was found between industrial and agricultural sectors. The Granger Causality test disclosed that a two-way causality exists among growth rate of GDP per-capita and industrial sector, as well as among growth rates of GDP per capita and services sector. The study also revealed that long-run associations exist among major sectoral shares of economy in Schengen countries [18].

Koren and Tenreyrohave investigated the volatility, diversification and development in economies of Gulf Cooperation Council (GCC). They concluded that GCC countries are more fluctuated as compared to other countries at the same level of economic development and it is due to their high dependence on oil. They also concluded the positive covariance among sectoral shocks and country specific shocks. The high levels of country specific fluctuations suggested that macroeconomic policies should be framed to alleviate fluctuations [19].

Pradhan [9] has analyzed the association among exports and output growth of Indian economy. The study used the annual time series data for the years 1970-71 to 2009-10 and employed unit root test, Granger causality test and vector autoregression (VAR). Residual-based co-integration test on log levels between exports and GDP confirmed that there exists long-run association between variables. The direction of causality from export growth to GDP growth was demonstrated by the Granger causality test. Uniqueness of the study is that it has gone farther from traditional neo-classical theory of production function by estimating an augmented Cobb-Douglas functional form.

Different studies have applied various econometric techniques to find association between volatility and economic growth. We will estimate the relationship between sectoral volatility and fluctuations in economic growth rate by employing ARCH, GARCH and OLS on fresh data of India. So it will be an addition to the existing literature in the subject area.

**MATERIALS AND METHODS**

For the analysis time series data has been used for the period 1971 to 2011 obtained from World Development Indicators. Time-series data is often containing a unit root or is non-stationary. Ordinary least square estimates are useless if in a model all the variables are non-stationary on level or if integration orders of all the variables are not zero. To check stationary properties of the data Augmented Dickey Fuller (ADF) unit root test has been applied. The volatility of the variables under discussion i.e. growth rate of national output, growth rate of value added in agriculture, growth rate of value added in industry, growth rate of value added in services, growth
rate of exports and growth rate of imports are estimated by Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH). After estimating volatility in all the variables Ordinary Least Square method is used to check the relationship between volatility in growth of different sectors of the economy and volatility in growth of national output.

To measure the volatility in the variables, GARCH (1, 1) model [20] has been employed. The general form of GARCH (p, q) model is:

\[ Y_t = \alpha + \beta X_t + u_t \]

\[ u_t | \Omega_t \sim N(0, h_t) \]

\[ h_t = \gamma_0 + \sum_{j=1}^{p} \delta_j h_{t-j} + \sum_{j=1}^{q} \gamma_j u_{t-j}^2 \]

It explains that the value of \( h_t \) (i.e. variance parameter) depends on past values of the shocks (expressed by the lagged squared residuals terms) and on past values of variance (expressed by lagged \( h_t \) terms). GARCH (1, 1) is the simplest form of GARCH (p, q) model. Variance equation for GARCH (1, 1) model is:

\[ h_t = \gamma_0 + \delta_1 h_{t-1} + \gamma_1 u_{t-1}^2 \]

where \( p \) shows the order of GARCH term and \( q \) shows the order of ARCH term. In our model the variance equation for growth rate of national output is:

\[ \text{GRY} = \beta_0 + \beta_1 \text{GRY}_{t-1} + u_t \]  

In the same manner GARCH (1, 1) model is applied to estimate the volatility in growth rate of different sectors under analysis.

Ordinary Least Square (OLS) method for estimating the impact of volatility in sectors on national output in given as:

\[ \text{VOL}_\text{GDP} = \alpha_0 + \alpha_1 \text{VOL}_\text{AGR} + \alpha_2 \text{VOL}_\text{IND} + \alpha_3 \text{VOL}_\text{SER} + \alpha_4 \text{VOL}_\text{EXP} + \alpha_5 \text{VOL}_\text{IMP} \]  

Where:

\[ \text{VOL}_\text{GDP} = \text{Volatility in growth rate of national output} \]

\[ \text{VOL}_\text{AGR} = \text{Volatility in growth rate of value added by agriculture} \]

\[ \text{VOL}_\text{IND} = \text{Volatility in growth rate of value added by industry} \]

\[ \text{VOL}_\text{SER} = \text{Volatility in growth rate of value added by services} \]

\[ \text{VOL}_\text{EXP} = \text{Volatility in growth rate of exports} \]

\[ \text{VOL}_\text{IMP} = \text{Volatility in growth rate of imports} \]

**RESULTS**

To check the stationarity properties of time series data, we have employed ADF unit root test. The variables are checked for stationary with trend and intercept type of equations. The results of ADF unit root test are reported in Table 2. The results express that all the variables are stationary at level. The ADF test statistics are found significant at 1% according to MacKinnon critical values.

**Volatility in Variables:** Empirical results of volatility in variables under analysis obtained through ARCH and GARCH process are reported in Table 3.

From the results in Table 3 the variance equation obtained from GARCH (1,1) for GR_GDP is:

\[ h_t = 0.628827 + 1.103432 h_{t-1} - 0.176331 u_{t-1}^2 \]  

The empirical results reported above are obtained from GARCH (1, 1) model. For convenience we have denoted ARCH parameter by \( \alpha \) and GARCH parameter by \( \beta \). To check the volatility the value of ARCH and GARCH coefficients are added, i.e. \( (\alpha + \beta) \), if the sum is very close to 1, it indicates that volatility shocks are persistent to a greatest extent and if the sum is very close to 0 it indicates that there is slight persistent of volatility shocks.

Variance equation shows that the sum of the lag squared error term and lagged value of variance i.e. \( (\alpha + \beta) \) is equal to 0.92 which indicates the existence of volatility shocks in growth rate of output to a greater extent. The ARCH and GARCH coefficients are also statistically significant.

Similarly variance equation for GR_AGR is:

\[ h_t = 38.55935 + 0.698670 h_{t-1} - 0.090373 u_{t-1}^2 \]

The above equation shows that the sum of the lagged square error term and lagged value of variance is equal to 0.79, which indicates that volatility shocks in growth rate of agriculture is persistent.

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\(^1\)However, in the literature the studies have also analyzed the other sectors, for instance, government spending [17] and financial sector [8].
Table 1: Operational Definitions of the Variables Used in the Model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Operational Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR_GDP (Growth Rate of Output)</td>
<td>Annual percentage growth rate of Gross Domestic Product (GDP) at market prices based on constant local currency</td>
</tr>
<tr>
<td>GR_AGR (Growth rate of value added by agriculture)</td>
<td>Annual growth rate for value added by agricultural based on constant local currency</td>
</tr>
<tr>
<td>GR_IND (Growth rate of value added by industry)</td>
<td>Annual growth rate for value added by industrial based on constant local currency</td>
</tr>
<tr>
<td>GR_SER (Growth rate of value added by services)</td>
<td>Annual growth rate for value added by services based on constant local currency</td>
</tr>
<tr>
<td>GR_EXP (Growth rate of exports)</td>
<td>Annual growth rate of exports of goods and services based on constant local currency</td>
</tr>
<tr>
<td>GR_IMP (Growth rate of imports)</td>
<td>Annual growth rate of imports of goods and services based on constant local currency</td>
</tr>
</tbody>
</table>

Table 2: Unit Root Estimation (ADF test).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Order of Integration</th>
<th>Test Equation Type</th>
<th>ADF Test Statistics</th>
<th>Mackinnon Critical Values</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR_GDP</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-7.854202</td>
<td>-4.198503</td>
<td>I (0)</td>
</tr>
<tr>
<td>GR_AGR</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-11.18646</td>
<td>-4.198503</td>
<td>I (0)</td>
</tr>
<tr>
<td>GR_IND</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-5.018656</td>
<td>-4.198503</td>
<td>I (0)</td>
</tr>
<tr>
<td>GR_SER</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-4.424028</td>
<td>-4.226815</td>
<td>I (0)</td>
</tr>
<tr>
<td>GR_EXP</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-7.185424</td>
<td>-4.198503</td>
<td>I (0)</td>
</tr>
<tr>
<td>GR_IMP</td>
<td>Level</td>
<td>Trend and Intercept</td>
<td>-6.746773</td>
<td>-4.198503</td>
<td>I (0)</td>
</tr>
</tbody>
</table>

Table 3: Variance obtain from GARCH (1, 1) model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>z- statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: GR_GDP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.628827</td>
<td>13.16054</td>
<td>0.0000</td>
</tr>
<tr>
<td>RESID (-1)^2</td>
<td>-0.176331*</td>
<td>-2.516620</td>
<td>0.0118</td>
</tr>
<tr>
<td>GARCH (-1)</td>
<td>1.103432*</td>
<td>11.95081</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

| Dependent variable: GR_AGR | | | |
| Variance Equation | | | |
| Constant | 38.55935 | 2.516855 | 0.0118 |
| RESID (-1)^2 | -0.090373 | -0.820390 | 0.4120 |
| GARCH (-1) | 0.696870* | 2.105788 | 0.0352 |

| Dependent variable: GR_IND | | | |
| Variance Equation | | | |
| Constant | 4.717368 | 0.627015 | 0.5306 |
| RESID (-1)^2 | -0.151702 | -0.781862 | 0.4343 |
| GARCH (-1) | 0.677786 | 1.039833 | 0.2984 |

| Dependent variable: GR_SER | | | |
| Variance Equation | | | |
| Constant | 1.970354 | 0.477236 | 0.6332 |
| RESID (-1)^2 | -0.087395 | -0.571554 | 0.5676 |
| GARCH (-1) | 0.536982 | 0.518251 | 0.6043 |

| Dependent variable: GR_EXP | | | |
| Variance Equation | | | |
| Constant | 0.087674 | 0.009317 | 0.9926 |
| RESID (-1)^2 | -0.196464 | -0.814695 | 0.4152 |
| GARCH (-1) | 1.119480* | 3.628094 | 0.0003 |

| Dependent variable: GR_IMP | | | |
| Variance Equation | | | |
| Constant | 19.65295 | 2.178487 | 0.0294 |
| RESID (-1)^2 | -0.296664** | -1.773022 | 0.0762 |
| GARCH (-1) | 1.166993* | 7.541093 | 0.0000 |

No. of observations = 41, * represents 5 % level of significance and ** represents 10 % level of significance.

Table 4: Regression analyses of volatilities in growth rate of GDP and growth rate of sectors.

<table>
<thead>
<tr>
<th>Model</th>
<th>Coefficient(Prob.)</th>
<th>t-values</th>
</tr>
</thead>
</table>

C -18.79796 (0.000) -9.568915
VOL_AGR 0.358966* (0.000) 6.122559
VOL_IND 0.775307* (0.000) 5.760812
VOL_SER 0.919375* (0.028) 2.295167
VOL_EXP -0.010156* (0.091) -1.743054
VOL_IMP 0.003761 (0.372) 0.905515

R^2 = 0.974, Adj.R^2= 0.967
F-stat =147.703, DW stat=1.999
Dependent Variable: VOL_GRY
* indicates 5% level of significance.

The GARCH coefficient is also significant.

Variance equation for GR_IND is:

h_t = 4.717368 + 0.677786 h_(t-1) – 0.151702 u_t^2

The sum of the lagged square error term and lagged value of variance is 0.52, but ARCH and GARCH coefficients are statistically insignificant. It explains that the conditional variance of GR_IND is not affected by lag squared stochastic term.

Variance equation for GR_SER is:

h_t = 1.970354 + 0.536982 h_(t-1) – 0.087395 u_t^2

In the above equation the sum of the lagged square error term and lagged value of variance is equal to 0.44, which indicates that volatility shocks in growth rate of services are persistent but not to a greater extent.
However, the ARCH and GARCH coefficients are statistically insignificant.

Variance equation for GR_EXP is:

\[ h_t = 0.087674 + 1.119480 h_{t-1} - 0.196464 u_{t-1}^2 \]  

(7)

The sum of the lagged square error term and lagged value of variance is 0.87, which indicates that volatility shocks in growth rate of imports are persistent. The estimates of GARCH coefficients are also statistically significant.

Variance equation for GR_IMP is:

\[ h_t = 19.65295 + 1.166993 h_{t-1} - 0.296664 u_{t-1}^2 \]  

(8)

In the case of imports the sum of the lagged square error term and lagged value of variance is 0.87, which indicates that volatility shocks in growth rate of imports are persistent. The estimates of ARCH and GARCH coefficients are also statistically significant.

**OLS Regression Analysis:** To estimate the relationship between volatility in growth rate of different sectors and volatility in growth rate of GDP, OLS model is applied. The results of regression analysis are presented in Table 4. We have regressed multivariate regression analysis. Dependent variable is volatility in growth rate of GDP and independent variables are volatility in growth rates of different sectors.
The results show that volatility is growth rate of agriculture, industry, services and exports have significant effect on volatility in national output.

**DISCUSSION**

**Volatility in Growth of Agriculture Sector:** The volatility in national output growth is positively influenced by the fluctuations of growth in agriculture sector. It may be due to the fact that agriculture sector is a key for overall economic development in India. It plays an important role by generating income, creating employment, ensuring self-reliance, enhancing food production, providing raw material to industrial sectors and earning of foreign exchange. Furthermore, agriculture and industry are like two hands of Indian economy, without which the economy neither can function nor can be survived [10].

**Volatility in Growth of Industrial Sector:** The volatility in industrial sector also positively influences the GDP growth rate in Indian economy. It explained that industry and agriculture had significant positive impact on both economic growth of Indian economy [10].

**Volatility in Growth of Services Sector:** The role of labor force services in economic growth of the economies has been empirically evidenced by a number of studies like Linden and Mahmood [18] along with theoretical support from Kuznet [21]. Our results have shown that in India volatility of GDP growth rate is positively influenced by volatility in services sector. The results show that volatility shocks in services sector have much more effect on volatility in growth of national output. The explanation may be that services sector played a key role in national income particularly the exports of software. The results further revealed that volatility shocks in services sector contributes highest in volatility of growth of output as compared to other sectors.

**Volatility in Growth of Exports:** The literature generally agreed that exports benefit economic growth. Our results have shown that volatility in export sector negatively impact the volatility in national output. The result is supported by Rashid, et al. for Pakistan, India, Sri-Lanka and Nepal [22].

**CONCLUSION AND POLICY RECOMMENDATION**

The main objective of the study was to see the contribution of volatility in economic sectors to fluctuations in national output. The study has findings regarding the volatility in sectors. It is found that agriculture, export and import sector have higher volatility shocks.

Similarly the volatility in agricultural, industrial, services and export sector contributes in fluctuations of GDP growth rate while imports sector shows insignificant impact on volatility in growth rate of output. It is also found that fluctuations in growth rate of services sector contributes more to volatility in growth rate of output as compared to other sectors. However volatility in growth of exports negatively affects the fluctuations in GDP growth rate.

Services sector highly contributes in fluctuations of national output and there are empirical evidences showing that share of services sector increases as the economy passes through the stages of development that is from underdevelopment to development. So there is a need to stabilize the services sector, which will contribute to stabilize economic growth rate. It may be recommend equipping labor force with education, advance technical skills particularly the software skills which will reduce the probability of labor force to be out of employment along with increase in productivity of labor force. It is also needed to improve research and development, technology and human resources.

The volatility in agriculture sector in India is causing high volatility in GDP growth rate. So agricultural sector of the economy should attain the stability. One of the way may be linkage between agriculture and industrial sector. The process may have spillover effects on stabilization of growth rate of national output. For agriculture sector, the most important recommendation may be the provision of inputs like quality seeds, fertilizers, pesticides, etc. at proper time along with credit facilities to the farmers.

One of the unique results is that the fluctuations in export sector create smoothness in growth rate of GDP. From this result a notion emerged that there should be no regulations on exports but it should be market oriented. The supply and demand forces for the exports should work freely. Possibly in the case of India the exports are comprised of the items which are needed in the domestic production. So when they are exported there may be a shortfall in the raw material and national output is affected. The market mechanism may solve the problem. It is recommended to leave the export market of the economy on market mechanism.

Whenever there is high surplus of exportable commodities, they are exported and they contribute to GDP growth but whenever there is comparatively less volume of exportable are available in the economy, there should be lower exports. In this case, if it is attempted to
increase the exports the GDP growth rate may suffer because these commodities are used as raw material within the economy.

**REFERENCES**