Relative Efficiency of DCC Estimates via Different Algorithms

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Abstract - Volatility plays an important role in capturing the variability in any series, hence multivariate volatility models help us in figuring out the spillovers across variables. The observation of such spillovers plays a very crucial role in financial decision making. Starting from the pioneering works of [1] and [2] ARCH/ GARCH type models and their multivariate extensions are widely used for capturing volatility spillovers. Dynamic Conditional Correlation (DCC) model proposed by [3] is one of the most widely used multivariate GARCH model. As GARCH type models are non-linear in nature, hence their solutions vary across the algorithms used for their computation. Different algorithms are used in different software and thus give varying results. In this study, we are going to compute and compare DCC model estimates through different software. In our study SAS results would be considered as baseline estimates and the competing results would be obtained from Stata and R. We will model the DCC estimates between returns on NYSE and PSX indices data for the time period of September 2001 to August 2016. This study would help us to determine the relative efficiency and accuracy of algorithms used for estimating the DCC model.

Keywords: GARCH, DCC, SAS, STATA, R-Console.

I. INTRODUCTION

Over the years, ARCH/ GARCH type volatility models have emerged as a prominent tool in capturing the dispersion prevailing in any time series. Starting from [1] Autoregressive conditional heteroscedasticity (ARCH) models and its extension to GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model by [2] becomes very well-known approach to capture volatility in time series analysis. These ARCH/ GARCH models are frequently applied on financial time series where these models yield us the risk factor for any financial asset or phenomenon. Risk factor, from the standpoint of economics gives us the opportunity cost for obtaining the returns. Whereas for investors, it is the degree of uncertainty that must be accounted before making wealth allocation decisions so that they may be aware of potential losses which can occurred at any point in time.

Despite the utility of volatility models, accuracy of ARCH/GARCH is always considered as a serious issue which arises due to the non-linearity of these models. Different packages produce different estimates for the same series or series’ owing to different numerical algorithms which are used in different software. One of the reasons for divergence in results. One of the reasons for the divergence in results is that at the time of development standardization of the resulting estimates are

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not been stressed instead notable advancement is considered with respect to the computational speed, and power. This is very important for practitioners to inquire that do estimates obtained through different software packages yield the similar estimates. Are those approximations are accurate? Many software packages enable users to estimate the conventional time series models such as Autoregressive Moving Average ARIMA type and Autoregressive Conditional Heteroscedasticity ARCH/GARCH type models.

The GARCH type model further extended to Multivariate GARCH (MGARCH). MGARCH type models dealt with studying inter-relationship between volatilities & co – volatilities of several variables, i.e. via multivariate GARCH one can have the insight of volatility spillover among the variables. So far, the availability of multivariate GARCH models in software packages is limited despite its usefulness for various applications. However it is possible to get multivariate estimates by only using univariate GARCH estimates [4]. The most leading tool to this model is DCC (Dynamic Conditional Correlation) by researchers in [3] and [5]. How much a shock in one market can generate the volatility on the other market/(s)? Answers to the research questions depends upon the accuracy of the estimated results. Different algorithm yield different approximation and estimates which differentiate each algorithm’s accuracy to different level of significance.

Therefore the practitioner in order to maintain accuracy cannot rely on a single estimation. One should have answers to these questions that which software package is the most accurate? Which package should be considered as the base line for the estimated results in comparisons with other? How much one package estimates differ from the other?

The objective of this paper is to evaluate most widely used software packages to estimate results with emphasis on their estimation accuracy. Here we are extending the prior work of researchers in [6] by modeling DCC using different statistical packages on the logarithmic index return of KSE100 and S&P 500 index estimating the coefficients and standard errors for the determination of most accurate package. It will also help determine the volatility spillover among the countries, the impact of past shock, shock impact’s nature etc.

Packages considered are SAS (Statistical Analysis Software), R – 3.3.1 and Stata 12. It is also necessary to state that issues regarding calculation speed, power of the software packages are those issues which we are not considered here.
II. LITERATURE REVIEW

Authors in [7] reviewed eminent developments pertaining MGARCH modeling. They analyzed the competing MGARCH models for the same problem and data. They argued that in MGARCH modeling the most crucial issue is provision of realistic and parsimonious specification of the covariance matrix while ensuring its positive definiteness. BEKK models require large number of parameters for estimations as compared to Diagonal VEC and BEKK models. Factor GARCH models also belongs to the category of MGARCH models where conditional variances and covariances can depend on past variances and covariances. Similarly, DCC model allow for varied degree of persistence between variances and correlations.

Authors in [6] stated that two different packages can produce two different solutions to the same estimation problem. They attempted to benchmark GARCH procedures in several software packages. They discussed the issues encountered while fitting default GARCH model in different packages. They estimated the GARCH model on the daily data of percentage nominal returns for the Great Britain Pound to US Dollar exchange rate. They concluded that large variations in results observed are not possible to draw general inferences when different software packages are used.

Authors in [8] reviewed a number of widely used statistical software packages, with respect to the accuracy of their estimates against a benchmark. They considered numerical consistency of GARCH and EGARCH estimation forecasting in their study. Using the same dataset they found that result obtained via default applications of widely used packages significantly vary from one another.

Researchers in [9] based their research objective to estimate conditional covariance matrices. They analyzed the consistency of most widely used GARCH (1, 1) model. They used weekly market indices of seven developed countries starting from January 1975 to December 2000. They avoid fitting additional restrictions, which led them to the advantage of less computation resulting to go for large sample sizes. They applied their procedure to 25 years of weekly data of the considered stock markets and compared the accuracy of CCC (Constant Conditional Correlation), Diagonal BEKK model, rolling window estimator and exponential smoothing estimator. Direct applications of the method further lead to the portfolio selection.

Researchers in [10] analyzed the statistical adequacy of GARCH models for eight Asian Stock Markets using Hinich portmanteau bi-correlation test as a diagnostic tool to determine the suitability of GARCH models in characterizing the behavior of the stock markets of Thailand, Hong Kong, Indonesia, South Korea, Malaysia, Japan, Philippines & Singapore. Data consist of daily basis stock
indices for the above stock markets starting from January 2, 1990 to December 31, 2003. The result of the study indicated that there exist some statistical structures in the data of all considered Asian markets which cannot be captured by GARCH model. They attribute this inadequacy of GARCH procedures to the non-stationary structure of covariance.

III. DATA AND METHODOLOGY

We have selected the data of the daily market indices of Pakistan Stock Exchange (PSX) and New York Stock Exchange (NYSE) from January 2000 to September 2016. The performance of PSX here is measured by KSE 100 index whereas S &P 500 index returns are used for the NYSE. All the market indices are taken at log level in order to ensure that series’ would remain I(0), which would facilitate the volatility analysis carried out here.

Multivariate GARCH modeling generally involves two steps. The estimation for univariate volatility functions are made through the class of ARCH/GARCH type models proposed by [1] and extended by [2] is carried out in first step using GARCH (1,1) model for figuring out univariate volatility prevailing in each series.

In the second step, the obtained volatility series’ are interlinked through multivariate volatility models such as Vector error correction (VECH) of [11], Constant conditional correlation (CCC) of [12], BEKK model of [13], Dynamic conditional correlation (DCC) model of [3] and Orthogonal GARCH model of [4] etc. This inter-linkage actually gives us spillovers existing between/ among two or more series’ present in any model.

In this study we are going to deploy the DCC model on our considered series. The model can be shown through the following equations.

\[ H_t = D_tD_tD_t \]  \hspace{1cm} (1)

Where

\[ D_t = \begin{bmatrix} \sqrt{h_{1t}} & 0 & \cdots & 0 \\ 0 & \sqrt{h_{2t}} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sqrt{h_{nt}} \end{bmatrix} \]  \hspace{1cm} (2)

\[ R_t = Q_{t}^{*-1}Q_{t}Q_{t}^{*-1} \]  \hspace{1cm} (3)

And
\[
Q_t^{-1} = \begin{bmatrix}
\frac{1}{\sqrt{q_{11t}}} & 0 & \cdots & 0 \\
0 & \frac{1}{\sqrt{q_{22t}}} & \ddots & \vdots \\
\vdots & \ddots & \ddots & 0 \\
0 & \cdots & 0 & \frac{1}{\sqrt{q_{ntn}}} \\
\end{bmatrix}
\] (4)

In this study, we have computed the above mentioned DCC model through three different software; SAS, R and Stata. Due to nonlinear nature of the DCC model we are aiming to find out the relative efficiency of the given software for computing it. As SAS results are considered most reliable as compared to other software, therefore values obtained through SAS are considered here as true values. By comparing the results of R and Stata results from SAS, we are deriving the relative efficiency of the said software.

IV. EMPIRICAL RESULTS

Table I presents the descriptive statistics of PSX and NYSE stock indices returns over the considered time period. As mentioned earlier the stock returns of PSX and NYSE are modeled through KSE 100 index and S&P 500 index respectively.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSX</td>
<td>0.000804</td>
<td>0.001044</td>
<td>0.085071</td>
<td>-0.07741</td>
<td>0.013624</td>
<td>-0.27</td>
<td>6.594204</td>
</tr>
<tr>
<td>NYSE</td>
<td>9.42E-05</td>
<td>0.000195</td>
<td>0.109572</td>
<td>-0.09856</td>
<td>0.012684</td>
<td>-0.23741</td>
<td>11.91298</td>
</tr>
</tbody>
</table>

The descriptive statistics depicts comparable market conditions in the above markets. It can be seen the coefficient of skewness is negative for the returns of both markets in a time invariant perspective which implies that the leverage effect is prevalent in both markets and both markets can be influenced more rapidly due to negative developments as compare to the positive developments. Thus, it is found logical to compare both markets.

The first step in the application of multivariate GARCH is to observe volatility values for individual time series. Table II below presents the volatility values through the GARCH (1,1) model.
The above results depict that PSX is more exposed to the shocks as compared to the NYSE as the value of $\alpha$ is found higher as compared to the NYSE. Up to this point, all analysis has been carried out through SAS. Now we will move on to more important component of our analysis that is the spillover analysis. This analysis has been carried out using DCC model through three different software SAS, R and Stata. Its results are depicted below.

Table III represents atypical example of nonlinear models where we find huge disparities across software. The results found indicates that shock, or theoretically the development or news component has a spillover impact across US and Pakistani stock market, but the variance spillover component is only found significant through SAS. As the results of SAS are conceived as most reliable hence we may treat the estimates obtained through as the true values of the parameters. In Table IV below presents the relative error found in the DCC estimates of STATA and R.

As the values of DCC $\alpha$ and DCC $\beta$ were found insignificant through STATA and R, hence there values while calculating the relative error are kept as 0. The results of relative error indicate that the techniques used by STATA and R for the estimation of DCC model almost yield the same results. Thus, we can say that both software are subjected to similar degree of error.
V. CONCLUSION

The study investigates the relative accuracy of STATA and R over the SAS for the estimation of volatility spillovers obtained through DCC. Among all the three software; SAS is considered as most reliable hence its values are treated as true values. The study found that there does not exist a tangible difference among the estimates calculated through R and STATA. Hence based on the findings of this study we may conclude that none of the software has an edge on the other in terms of accuracy. In future, the study can be extended by the estimation of DCC model through other software. Nevertheless, the estimation of volatility spillovers through other multivariate volatility models by the usage of different statistical software would be treated as a logical extension of this work.

REFERENCES


