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POST-COVID-19 VOLATILITY OF EXCHANGE RATE RETURNS A CASE STUDY OF PAKISTAN

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ABSTRACT

The purpose of the study is to forecast the volatility for returns of the exchange rate of Pakistan concerning US dollars along with the impact of covid-19 so that we can find out the feasibility of holding this asset along with the risk and returns associated with it. For this purpose daily data has been taken from the State bank of Pakistan on a period from February 01, 2001, to June 30, 2021, where covid-19 is used as a dummy variable. Furthermore, in methodology, we applied GARCH models after finding the presence of the ARCH effect which is at ARCH (6) in the series. It is found in all GARCH models that the past volatility of the exchange rate returns has a statistically significant influence on the current volatility of the exchange rate means there is time-varying and time-correlated volatility associated with exchange rate returns. According to GARCH-M, GARCH-M (variance) (1,1) and GARCH-M (SD) (1,1) results it is concluded that average returns of exchange rate are small but significant and there is no risk factor associated with exchange rate returns but the past square residual terms have a significant impact on risk volatility. Furthermore, Both T-GARCH and E- GARCH depicts that the impact of covid-19, which is bad news, although has a significant impact but its magnitude has a lesser influence on exchange rate volatility than the good news.

Keywords: Exchange rate, covid-19, GARCH model, volatility, Pakistan
JEL classification codes: F31, O16

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INTRODUCTION:

Traditionally, Volatility models are used to determine the economic health of any country for portfolio allocation and risk management. In the case of risk management analysis exchange rate volatility (ERV) is the major determinant, which is noticeable for the investors, as it impacts local and foreign investment, while

policymakers monitor ERV to formulate appropriate fiscal and monetary policies. Volatility in ER is equally important for both exporting and importing nations, as it catalyses trade in both directions (positive and negative). According to Taylor (2005), it is observed that ERV is sometimes better for the financial market if it deals with hedging, risk management, etc. Sometimes, it affects the long-term policies of the state. It is also evident that investors' confidence to invest in the market in some countries is negatively related to ERV, which is the main reason behind the use of the volatility model. This paper is an attempt to examine the volatile behaviour of ER before and during the pandemic of COVID-19 which originates from China but jolt the global financial market. It is an already known fact that the pandemic leaves its harmful effects on every facet of life including ER market and being the worldwide accepted currency ERV of Rupee versus Dollar always leaves strong footprints on Pakistan's economy. This paper attempts to evaluate the unprecedented effects of ERV in Pakistan. The study hypothesized that the Pandemic has a strong impact on the performance of the stock exchange and is one of the major causes of ERV during the COVID. This paper evaluated the performance and volatility of ER by using the high-frequency daily data and forecasted by GARCH family model including M-GARCH, T-GARCH, and E-GARCH.

LITERATURE REVIEW:

Accuracy in high-frequency data is required for future values and improved forecasting results. Therefore it is of utmost importance to analyse the volatility of the exchange rate as it affects the macroeconomic variables of a country like international trade flows, the flow of capital, etc. Due to these reasons researchers, governments and policymakers are keen to analyse and inspect the volatile behaviour to control and manage the exchange rate risks involved in the growth of the economy.

Different researchers have examined the volatility on different exchange rates. Jarque-Bera test rejects the null hypothesis proving normality does not exist, the curve was found to be leptokurtic and therefore different Arch-Garch type models are applied (Ravanoglu 2020, (Mohsin et al., 2019).,(Hung, 2018). Most Recently (Ravanoglu, 2020) investigated the model for the nominal exchange rate of Turkey by the ARCH and GARCH methodology. The data has been collected from 2002-2017. The Garch (1,2) model is most appropriate. Although the effects of variance are symmetric in exchange rate data volatility clusters can be found.

(Mohsin et al., 2019), Showed the exchange rate uncertainty against U.S. dollar in Pakistan. The daily data from January 2005 to December 2018 of volatility exchange rate was taken for using GARCH family models. The symmetric and asymmetric effects were checked in exchange rate of Pakistan against dollar. The uncertain and high volatility conditions of exchange rate were observed in this research. It is also observed that, volatile behaviour of

dollar against Pakistani Rupee is the main reason behind high risk factor of erosion in capital market of Pakistan. (Sharma & Pal, 2019), in their study, took 73 Commodities from 2013 to 2016 in India for testing the relationship between exchange rate and imports of these commodities. The heteroscedasticity and time series model were used for testing this relationship. All the imports of the commodities declined in long run by 12%.In short run the agriculture sector was more sensitive than manufacturers sector.

((Abdullah et al., 2017) and (Dung, 2018)) analysed the volatility of exchange rates by assuming student's- terror assumptions and found to have better results compared to normal or Gaussian method as student's t test captures the non-normality of the series involved. Further the researchers' results depict a general view where the curve had leptokurtic curve. AR, ARMA, GARCH (1, 1) and GARCH (1, 2) models are used. Trade in both cases was found to be significant and therefore the impact of these rates had serious impacts on growth.
Additionally (Epaphra, 2017) explored the exchange rate of Tanzania on daily basis from 2009-2015.Volatility clustering, non-normality, non-stationarity and serial correlations are all found in the series therefore ARCH, GARCH and EGARCH models were used. It was also found that exchange rate volatility is dependent on the volatility on its lag. Since asymmetric volatility is estimated it can be concluded that compared to negative shocks the positive shocks suggested next period conditional variance.

(Olowe, 2009) investigated Nairo's exchange rate on fixed and floating regimes both before and after deregulation of currency. He found to have the same results for both regimes. Results of the asymmetric models were found to reject any leverage effects. The persistent high volatility that was found in the fixed exchange rate was considered due to import dependence on Nigerian economy.

Both symmetric and asymmetric models are considered by (Abdalla, 2012) of volatility clustering and leverage effects for nineteen Arab countries. The empirical results show that the volatility is explosive for seven while persistent for ten countries. Leverage effects were found in all of them except for Jordanian dinar. In conclusion it was found that the Garch model is appropriate for exchange rate models for the nineteen Arab countries.

(Thorlie et al., 2012) explore the volatility model including ARMA, GARCH and asymmetric GARCH in Sierra Leone. The parameters of the model were found to be statistically significant. It was further found that no serial correlation exists in the series of exchange rate return. Furthermore Arch effect does not have a significant appearance in the return series neither is the variance equation correctly specified.

The US exchange rate volatility due to the impact of Covid-19 cases and related deaths is investigated using a GARCH (1, 1) model in this paper. According to the findings, a boost in

the number of cases and deaths in the United States has a positive impact on the USD/EUR, USD/Yuan, and USD/LivreSterling. While In another paper by (Omari et al., 2017), both symmetric and asymmetric GARCH models are used. The paper finds strong evidence that the aforementioned models can characterize daily returns. In the residuals series, the USD/KES data showed a significant departure from normality and the presence of conditional heteroscedasticity.

METHODOLOGY:

Daily data for variable exchange rate has been taken from State bank of Pakistan which spans from Tue, Jan 02, 2001, to Wed, Jun 30, 2021. Here covid-19 is used as a dummy variable. Therefore, in this research paper our data set consists of total 5535 observations.

In this research study we tried to find out the risk factor and time varying volatility associated with exchange rate returns with respect to US dollars. For this purpose, we used GARCH model (Bollerslev, 1986) by using following steps:

Step 1: Generation of exchange rate returns series.

Step 2: Identification of volatility clustering by using conditional variance graph or simple graph of the series.

Step 3: ARCH effect has been checked by applying hetroscedasticity test ARCH of OLS method. The lag of ARCH effect helps in opting between ARCH and GARCH method.

Step 4: Estimation of GARCH method to find out the risk factor and time varying volatility associated with exchange rate returns.

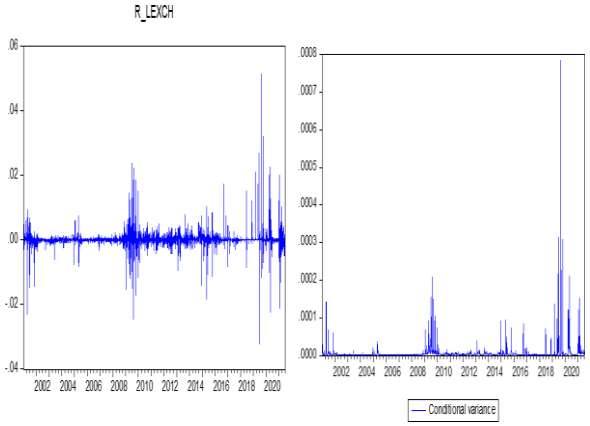
Step 5: Forecasting of the series has been done by using both dynamic and static method.

Step 6: Finally, we have applied normality test by using histogram.

Table 1: Descriptive Statistics	
Mean	86.08
Median	84.10
Maximum	168.20
Minimum	57.19
Std. Dev.	28.29
Skewness	1.04
Kurtosis	3.58
Jarque-Bera	1037.64
Probability	0.000
Observations	5347

The **table 1** above summarizes the descriptive information of returns on exchange rate volatility for 20 years on daily basis. The mean of log is 86.082. Standard deviation shows returns of exchange rate deviation by 1.04 from its mean. Since the skewness is a little greater than 1 the distribution can be concluded as skewed. Kurtosis is greater than 3 this means the series is leptokurtic depicting that the curve has flatter tails and is wider therefore it is portrayed that impact of Covid-19 is extensive on exchange rate returns. The Probability of Jarque-Bera test <0.05 which means the distribution is normal.

Volatility Clustering:.



Identification of the ARCH effect in the above graph takes place by recognizing the clusters. It is the time when large changes are assisted with additional larger change and smaller changes are assisted with additional smaller changes. While conditional Variance acts in different phases of time series model and corresponds with actual plot of the given series.

Here it is observed from 2000-2002; 2008-2010 and 2019-2020 clusters are present. These are the time periods where exchange rate volatility is very frequent.

Table 2: ADF Unit Root Test for Exchange Rate Returns		
	T-STATS	PROBABLITY
Augmented Dickey-Fuller test statistic	-45.875	0.0001
Test critical values:		
1% level	-3.431	
5% level	-2.862	
10% level	-2.567	
H0: there is a unit root / the series is non-stationary		
At Confidence interval: 5%		

Table 2 shows results of ADF unit root test for stationarity according to which p-value of ADF test is less than 0.05 that means null hypothesis mentioned in table 3 should be rejected indicating exchange rate returns are stationary at 5% level of confidence interval.

Table 3: ARCH Effect			
Heteroskedasticity Test: ARCH	lag 1	lag 3	lag 6
F-statistic	84.48	45.9	23.23
Obs*R-squared	83.23	134.45	136.17
Prob. F(1,5530)	0.000	0.000	0.000
Prob. Chi-Square(1)	0.000	0.000	0.000
HO: No heteroscedasticity			
Confidence interval: at 5%			

The ARCH test of heteroscedasticity results shown in table 3 stated that p-value of observed R-squared is statistically significant so, the null hypothesis mentioned in table 2 has been rejected indicating that there is ARCH effect at lag 1,3 and 6 which means there is a significance heteroscedasticity at 5% confidence level, so if we apply ARCH model at lag six it will increase coefficients and model will no longer be parsimonious that is why GARCH (1,1) model has been chosen because it is parsimonious model as compare to ARCH (6) model.

General equation of GARCH model:

This model can be generalized to a GARCH (p, q) model in which there are p lagged terms of the conditional variance and q lagged terms of squared error term:

$$GARCH\ (p,q)\colon h_{t=}\ \vartheta + \sum_{i=1}^{p} \theta_i h_{t-i} + \sum_{j=1}^{q} b_j u_{t-j}^2$$

$$GARCH - M\ (1,1)\colon h_{t=}\ \vartheta + \sum_{i=1}^{p} \theta_1 h_{t-1} + \sum_{j=1}^{q} b_1 u_{t-1}^2$$

$$T - GARCH\ (1,1)\colon h_{t=}\ \vartheta + \theta_1 h_{t-1} + b_1 u_{t-1}^2 + \gamma_1 u_{t-1}^2 D_{t-1}$$

$$E - GARCH\ log(h_t)$$

$$= \Phi + \sum_{j=1}^{q} n_j \left| \frac{u_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{j=1}^{q} \lambda_j \frac{u_{t-j}}{\sqrt{h_{t-j}}} + \sum_{i=1}^{p} \theta_i \log(h_{t-i})$$

Table 4: Results of GARCH-M (1,1)		
	COEFFICIENT	**PROBABLITY**
GARCH	-0.962	0.900
C	0.000	0.005
R_LEXCH(-1)	0.287	0.000
COVID_19	0.001	0.000
VARIANCE EQUATION		
C	8.03E-07	0.000
RESID(-1)^2	0.298	0.000
GARCH(-1)	0.611	0.000
At Confidence interval: 5%		

The risk behaviour of the exchange rate return and volatility is estimated using the GARCH-M model, in which the conditional mean depends on its own conditional because of variance if the risk is captured by the volatility or by the conditional variance, and then the conditional variance may enter the conditional mean function of series (Engle, 1993). In **Table 4** results of GARCH –M model depicts that there are two equations first, the mean equation which explains the average returns associated with exchange rate returns which is exhibits by coefficient of constant term C and in this model average returns of exchange rate are small but significant, whereas the R-LEXCH (-1) term exhibits how previous exchange rates influence the current exchange rate. While the impact of covid-19 is statistically significant at 5% confidence level. Second the variance equation demonstrates impact of past square residual term on risk volatility therefore according to the results both the past square residual term (RESID (-1) ^2) term and past conditional variance term (GARCH (-1)) are statistically significant at 5 %, indicating that past square residual terms have a significant impact on risk volatility. However, the GARCH (-1) signifying that past volatility of the exchange rate returns has a statistically significant influence on current volatility of exchange rate. Hence its is concluded that there is no risk factor associated with exchange rate returns but there is time varying and time correlated volatility.

Table 5: Results of GARCH-M (Variance) (1,1)		
	COEFFICIENT	**PROBABLITY**
GARCH	-0.963	0.9
C	0.000	0.005
R_LEXCH(-1)	0.287	0.000
COVID_19	0.001	0.000
VARIANCE EQUATION		
C	8.03E-07	0.000
RESID(-1)^2	0.298	0.000
GARCH(-1)	0.611	0.000
At Confidence interval: 5%		

The results of GARCH-M (variance) model in **Table 5** describe that the risk factor/conditional variance (GARCH) associated with Pakistan exchange rate with respect to US is not statistically significant implying that the previous day's exchange rate does not influence the current day's exchange rate or the mean exchange rate returns are not affected by the risk factor. However average returns of exchange rate are small but statistically significant. Second the variance equation demonstrates impact of past square residual term on risk volatility therefore according to the results both the past square residual term and past conditional variance term are statistically significant at 5 %, indicating that past square residual terms have a significant impact on risk volatility. However, the GARCH (-1) signifying that past volatility of the exchange

rate returns has a statistically significant influence on current volatility of exchange rate. Hence its is concluded that there is no risk factor associated with exchange rate returns but there is time varying and time correlated volatility.

Table 6: Results of GARCH-M (1, 1) (Standard Deviation)		
	COEFFICIENT	**PROBABLITY**
At SQRT(GARCH)	0.014	0.812
C	9.54E-05	0.346
R_LEXCH(-1)	0.289	0.000
COVID_19	0.001	0.000
VARIANCE EQUATION		
C	8.14E-07	0.000
RESID(-1)^2	0.297	0.000
GARCH(-1)	0.611	0.000
At Confidence intervel : 5%		

The risk behaviour of the exchange rate return and volatility is estimated using the GARCH-M model with standard deviation, this model used to capture the risk by with standard deviation of the series instead of variance. The results of GARCH-M (Standard Deviation) model in **Table 6** describe that GARCH M (SD) depicts same results as of GARCH M model but more significantly as significance of its variance term of mean equation is improved. Therefore, according to GARCH M (SD) there is no risk factor associated with exchange rate returns but there is time varying and time correlated volatility.

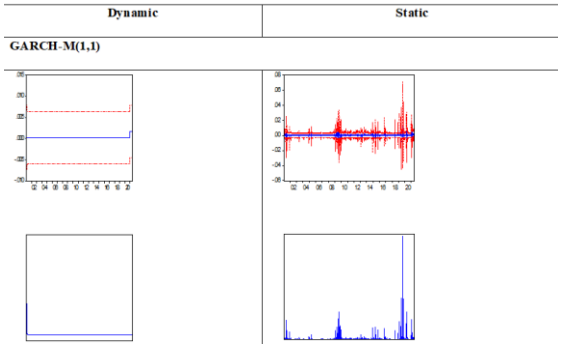
Table 7: Results of T-GARCH (1,1)		
	COEFFICIENT	**PROBABLITY**
C	0.0001	0.0001
R_LEXCH(-1)	0.297	0.000
COVID_19	-0.0004	0.000
VARIANCE EQUATION		
C	7.37E-07	0.000
RESID(-1)^2	0.35	0.000
RESID(-1)^2*(RESID(-1)<0)	-0.186	0.000
GARCH(-1)	0.637	0.000
At Confidence intervel : 5%		

Furthermore the risk behaviour of the exchange rate return and volatility is estimated using the T-GARCH model, to check the impact of covid-19 since these types of news or shocks has significant impact on assets and decisions of assets holders. The main target of the TGARCH model is to capture asymmetries in term of negative (bad news) and positive shocks (good news) (R. Rabemananjara, 1993). This model also includes two equations. The results of mean equation T-GARCH model in **Table 7** describe that the risk factor/conditional variance (GARCH) associated with Pakistan exchange rate with respect to US is statistically significant implying that the previous day's exchange rate does influence the current day's exchange rate or the mean exchange rate returns are affected by the risk factor. The sign for the coefficient of covid-19 is negative which means it is bad news for investors. According to the results of variance equation both the past square residual term (RESID (-1) ^2) term and past conditional variance term are statistically significant at 5 %, indicating that past square residual terms have a significant impact on risk volatility. However, the GARCH (-1) signifying that past volatility of the exchange rate returns has a statistically significant influence on current volatility of exchange rate. While the coefficient of the asymmetric term (RESID (-1) ^2*(RESID(-1)<0) is negative and statistically significant at 5% level of significance which signify that for the exchange rate there are symmetries in the news. Moreover, due to the negative asymmetric term ($b1+\gamma 1$=0.164) < ($b1$=0.350) therefore for this asset bad news has lesser effect on the volatility than good news.

Table 8: Results of E-GARCH (1,1)		
	COEFFICIENT	PROBABLITY
C	0.0002	0.000
R_LEXCH(-1)	0.279	0.000
COVID_19	0.0007	0.000
VARIANCE EQUATION		
C(4)	-2.871	0.000
C(5)	0.445	0.000
C(6)	0.019	0.0134
C(7)	0.787	0.000
At Confidence intervel : 5%		

The E-GARCH model is an asymmetric GARCH model used to record the leverage effects of disturbing events. E-GARCH model directs conditional hetroscedasticity. The E-GARCH variables displayed in the **Table 8** exhibit that variable are significant at 5% level in the variance equation. The constant c is significant at 5%. C (5) the ARCH term has a p-value of 0.000 therefore the magnitude of covid-19 has a significant impact on the volatility of exchange rate. C (5) also shows the larger the magnitude of covid-19 to the variance larger the volatility. C (6) is also significant as p value is 0.013 at 5% level so an agreement can be devised that the sign of covid-19 influences the volatility of exchange rate. The positive sign of C (6) also specify that bad news will lower the volatility higher than good news of the same size. C (7) is also significant as its probability is 0.000.

Table 9: Stability Test



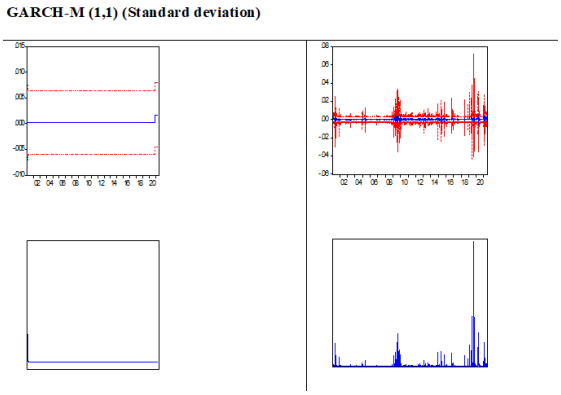


Table 9 depicts dynamic and static forecasting and stability of volatility for GARCH models. According to dynamic forecasting volatility is steady, as it is evident that volatility lies between the standard error bands, the dynamic approach assesses forecasting for periods after the initial sample period, using the past fitted values from the lags of the variable that is dependent. While the static analysis uses the true values of regress and variable. Therefore, it is safe for investors and asset holder to hold this asset (exchange rate).

Table 10: Results Normality test : Histogram		
MODELS	JARQUE-BERA	PROBABLITY
GARCH M (1,1)	34825386	0.000
GARCH M (1,1) (Standard Deviation)	32477848	0.000
T-GARCH (1,1)	35240246	0.000
E-GARCH (1,1)	33412654	0.000
At Confidence intervel : 5%		

The above **Table 10** depicted the result of histogram normality test of the GARCH models indicates that the null hypothesis of Jarque-bera is rejected and shows that there is no normality as p-value is less than 0.05. So, it can be concluded that exchange rate of dollar is volatile.

CONCLUSION:

In this research study GARCH symmetric and asymmetric models GARCH-M (1,1),

GARCH-M (SD) (1,1), T-GARCH and E-GARCH have been used to analyse the volatility and risk associated with daily exchange rate returns of Pakistani rupees against US dollars. According to GARCH-M (1,1) and GARCH-M (SD) (1,1) results it is concluded that GARCH term of mean equation is statistically insignificant which means there is no risk factor associated with exchange rate returns but the variance equation states that the past square residual term (RESID (-1) ^2) term and past conditional variance term are statistically significant at 5 %, indicating that past square residual terms have a significant impact on risk volatility. However, the GARCH (-1) signifying that past volatility of the exchange rate returns has a statistically significant influence on current volatility of exchange rate means there is time varying and time correlated volatility.

While asymmetric model T-GARCH shows that all coefficients of the model are statistically significant at 5% level of confidence which describe that the risk factor/conditional variance (GARCH) is statistically significant implying that the previous day's exchange rate does influence the current day's exchange rate. The sign for the coefficient of covid-19 is negative which means it is the bad news for investors. According to the results of variance equation indicate that past square residual terms have a significant impact on risk volatility. However, the GARCH (-1) signifying that past volatility of the exchange rate returns has a statistically significant influence on current volatility of exchange rate. While the coefficient of the asymmetric term (RESID (-1) ^2*(RESID (-1)<0) is negative which signify that for the exchange rate there are symmetries in the news. Moreover, due to the negative asymmetric term ($b1+\gamma 1$=0.164) < ($b1$=0.350) therefore for this asset bad news has lesser effect on the volatility than good news. However another asymmetric model E-GARCH shows c (4) is ω which is the constant, c(5) is the arch term is positive and significant, It depicts the magnitude of covid-19 has on exchange rate returns. In our case it shows that α is positive and significant which depicts that larger the magnitude of Covid -19 larger will be the volatility. The coefficient of leverage term is also positive and significant representing that since Covid -19 is considered a negative shock it will affect the future volatility of exchange rate returns less than a positive shock. Therefore covid-19 is statistically significant which is depicted by probability which is less than 5% but all models indicate that the magnitude of covid-19 has an insignificant impact on the volatility of exchange rate.

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