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Stochastic Impact Analysis of COVID-19 on Karachi Stock Exchange

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***Abstract*—**The stock market of any country acts as a predictor of the economy. The spread of the COVID-19 pandemic has severely impacted the global financial markets. Besides, it has also critically affected the economy of Pakistan. In this study, we consider the role of the Karachi Stock Exchange (KSE) with regard to the Pakistan Stock Exchange and quantify the impact on macroeconomic variables in presence of COVID-19. The suitable macroeconomic variables are used to quantify the impact of COVID-19 by developing the stochastic model. The sufficiency of the computed model is attained by means of available techniques in the literature. The estimated equations are used to forecast the impact of pandemic on macroeconomic variables. The constructed model can help the policymakers take counteractive measures for restricting the influence of viruses on the Karachi Stock Market.

***Keywords*—**COVID-19, Karachi Stock Market, macroeconomic variables, stochastic model, forecasting.

I. Introduction

COVID ailment has shocked the worldwide economy and monetary business sectors. The preventive measures like social distancing, lockdowns etc. have counterbalanced some of the pandemic's influence but it has caused a deeper recession in the global economy. Likewise, volatility in the Karachi Stock Market has also been noticed because it is fragile and sensitive to surprises and tittle-tattle (sudden ups and downs). These variations in Stock Market Index are owing to the disturbances in macroeconomic variables such as money supply, interest rate, inflation rate and exchange rate etc. [1].

The monetary development of stock market advances through liquidity and risks involvement. The rise and fall in growth of stock price is a coherent occurrence of economies among the stockholders, organization, strategy makers and investigators. A market-based mechanism, such as demand and supply, stabilizes stock prices [2]. Investigators have tried to find out the dynamics, which influence stock prices. The vital macroeconomic volatility has causation with the cost-of-living index. The preliminary studies determined that changes in macroeconomic parameters generate the variation in the anatomy of the stock exchange index [3]. In these scenarios, government strategies play leading role for the monetary activities and stock prices of a country

In this study, models have been constructed for assessing the effects of COVID-19 on macroeconomic parameters during the pre and post period of the pandemic. The stability of the constructed models is achieved by utilizing an available technique in the literature. Besides, developed models are utilized to forecast and for observing the upcoming behavior of Karachi Stock Index during and after pandemic regime. This study has been organized along these lines. In next section related review of literature is considered whereas Section III describes the material and method for measuring the impact of the pandemic. Section IV represents a stochastic estimation of the developed models; Section V deliberates on the constancy of built equations; Section VI signifies finding and analysis, whereas the last section communicates conclusion and recommendations.

II. Literature Review

The eruption of the Corona pandemic was generated in December 2019 in Wuhan city in Hubei province of China. Primarily, it was considered as severe acute respiratory syndrome corona virus 2 i.e. (SARS COV-2) by World Health Organization (WHO). The symptoms of this pandemic were observed either in China or through migrants from China. This contagion afterward was affirmed as a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO). Subsequently, this ailment was titled the as Corona virus disease 2019 (COVID-19) and was declared as global pandemic [1]-[4]. This contagious syndrome rigorously impacted the economy. But by developing & implementing various policies, effect of economic activities caused by pandemic on macroeconomic variables can be reduced. To develop these strategies trends of macroeconomics parameters were observed. Investigators considered different parameters for developing connotation between macro-economic and stock exchange variables. Some of the researchers considered exchange rate, inflation rate, interest rate; foreign exchange reserves, money supply and industrial production index as key factors that can disturb the stock market prices and develop relation [5]. However, some of them considered inflation, money supply, government bonds and call money rates to determine the association between stock market and macro-economic constraints [6]. The outcome of analysis performed on data obtained from more than six thousand companies chosen from 56 countries described that companies with stable and stronger finances

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before pandemic encountered an insignificant pandemic impact on stock price. Furthermore, the outcomes also communicate that the businesses having higher commercial proprietorship performed fine and companies having more partnership of investment fund performed adversely [7]. The real-time investigation was performed on about 4070 companies of US during the infection growth period for observing variation in firm-level stock and cumulative returns. The analysis specifies that US Stock Market estimated constraints during doubled probable cases reduced time cumulative US market revenues and vice-versa. The investigation also recommended that during the rising of pandemic market damages increases with impact and capital strength. Furthermore, the businesses which are extremely vulnerable for transmission of viruses observed high losses [8]. Researchers conducted the study to notice people ownership during the pandemic. They examined that by what means the presence of peoples in authority and proprietorship interrupts the monetary performance of the enterprises. The data considered for this analysis have been taken from Italian firms during the spread of COVID-19. The outcome proposes that the companies having supervisory shareholders on their panels accomplished improvement during the pandemic as compared to the others [9]. The study for measuring COVID-19 effects on Chinese Stock Market reflects that during that massive monetary disaster correlation between Bitcoin and Chinese Stock Markets have changed [10]. The analysis conducted to quantify risk factors of financial market by virtue of pandemic observes the decline in the worth of firms in this regard [11].

III. Material & Method

In this research influence of coronavirus on KSE is considered. Therefore, following macroeconomics variables i.e. KSE-100 index (y_t), money supply (M_t), interest rate (I_t), inflation rate (x_t) and exchange rate (z_t) were considered for construction of model. The data utilized for construction of the model are obtained from the websites of KSE and State Bank of Pakistan. The sample period consists of monthly data for the period of 2019-2020. Subsequently, Stochastic Models were developed by regressing KSE-100 index on the remaining macroeconomic variables to forecast before and after COVID-19 pandemic fluctuation in the responding variable.

IV. Stochastic Estimation

The association in the macroeconomic variables before and after corona pandemic is depicted in Tables I A & B.

Tables I A & B show variations in the strength of the macroeconomics variables caused by the spread of COVID-19 concerning the KSE. Analysis of correlation matrix indicates that parameters are correlated positively and negatively which can cause the problem of multi-collinearity in the construction of the models. Fig. 1 also confirms unpredictability in the trend of macroeconomic variants w.r.t. pandemic waves.

TABLE I
ASSOCIATION IN MACROECONOMIC PARAMETERS
A BEFORE COVID

	y_t	z_t	I_t	M_t	x_t
y_t	1				
z_t	-0.36	1			
I_t	-0.29	0.49	1		
M_t	0.15	0.13	0.75	1	
x_t	0.05	0.24	0.84	0.96	1

B AFTER COVID

y_t	z_t	I_t	M_t	x_t	
1	-0.39	0.66	-0.63	0.74	y_t
	1	-0.86	0.86	-0.77	z_t
		1	-0.99	0.89	I_t
			1	-0.90	M_t
				1	x_t

Stochastic models were constructed by considering (y_t) as a predicted and M_t, I_t, x_t and z_t as predictor parameters. By employing these variables stochastics parameters prior to and following COVID regime were assessed. The estimated models for these regimes that sampled data set into a smooth continuous function are given below:

a) Macroeconomic model equation before COVID-19 period

$$\Delta y_t = 1769.7 - 379.4\Delta z_{t-1} + 136.5\Delta x_t - 40.29\Delta^2 M_t - 5974 I_{t-1} + \varepsilon_t \quad (1)$$

with $R^2 = 0.94$

b) Macroeconomic model equation after COVID-19 period

$$\Delta y_t = 2706.02 + 505.05\Delta z_t - 2327.37\Delta x_{t-1} - 3.02\Delta^2 M_t + 7027.24 I_t + MA(2) = -18.98 + \varepsilon_t \quad (2)$$

with $R^2 = 0.95$. Here ε_t denotes error term with i.i.d $\sim(0, \sigma_\varepsilon^2)$.

Regime statistics of the probable models (1) & (2) are given in Table II.

TABLE II
ASSOCIATION IN MACROECONOMIC PARAMETERS

Estimated Stat	Before COVID	After COVID
R-squared	0.94	0.95
DW – stat	1.61	1.68
AIC	17.32	13.91
BIC	17.14	13.97
Log likelihood	-46.96	-49.64
F-statistic	334.71	345.07
Prob (F-statistic)	0.033	0.002

V. Stability of the Model

The adequacy of the model is pursued by utilizing available tests in the literature. All the tests were performed on error term attained through estimation of parameters. The entire results of accomplished examination confirm the stability of the computed equation. The accompanying detailS of these are given below:

(i) The coefficients of determination for both regimes presented in Table II authenticate that macroeconomic predictor parameter explains responding parameters.

(ii) In Table II, DW statistics validates that there is no undeviating connotation among adjacent error terms of stochastic model. Besides AIC and BIC criteria also suggest parsimony of the model.

(iii) Fig. 2 presents the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots for COVID-19 and Non-COVID-19 regime which endorse the white noise certainty on residuals.

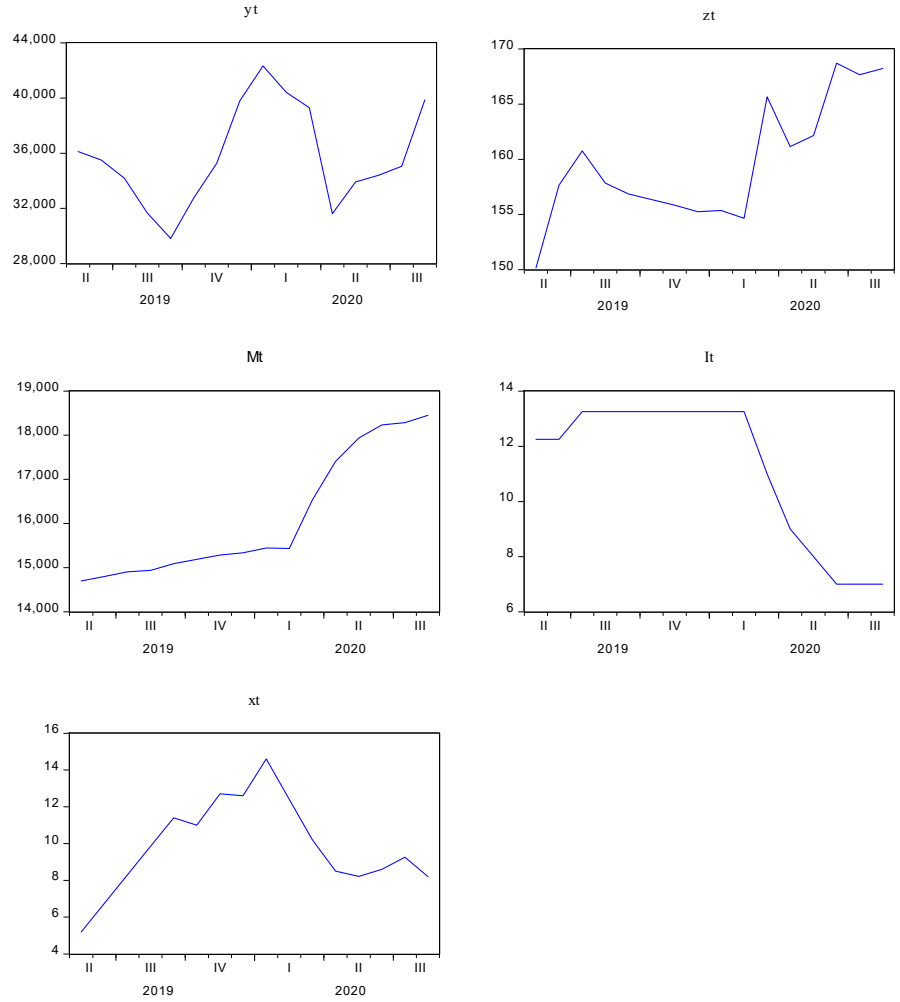

Fig. 1 Trend inconsistency in parameters attributable to COVID-19

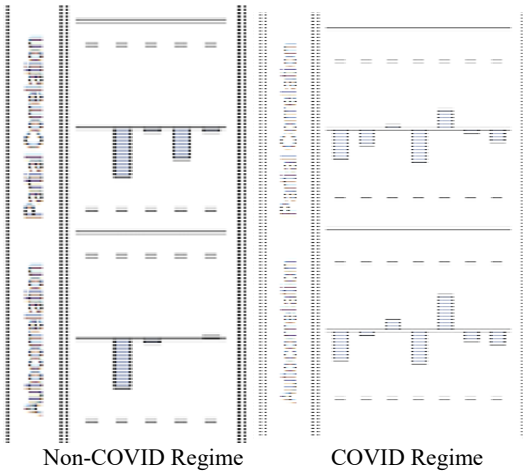

Fig. 2 ACF and PACF for COVID & Non-COVID regimes

(iv) Actual & simulated graphs for the regimes are demonstrated in Fig. 3 which ratifies the genuineness of the evaluated equations (1) and (2).

VI. Findings & Analysis

In this study stochastic affiliation of macroeconomic parameters for COVID-19 and Non-COVID-19 period have been attained separately. It has been noticed that macroeconomic parameters for KSE have mixture of indication with and without COVID-19 period as exposed in Fig. 1. This graph also displays that fluctuation in macroeconomic parameters starts in Pakistan in first quarter of the current year during pandemic. Additionally, predicted parameter declines to the lowest point of the previous years due to no trading and pulling out of foreign investments because of the rise of corona cases. At the end of the first quarter, progress in stock market is observed because of

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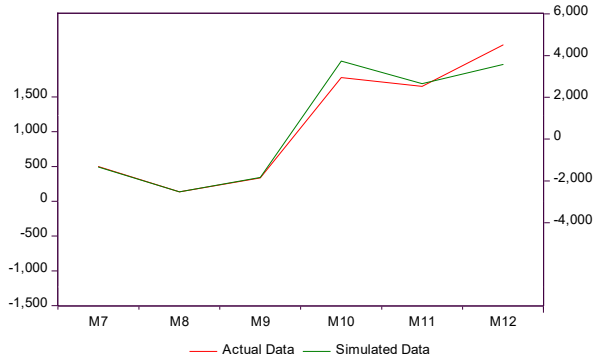
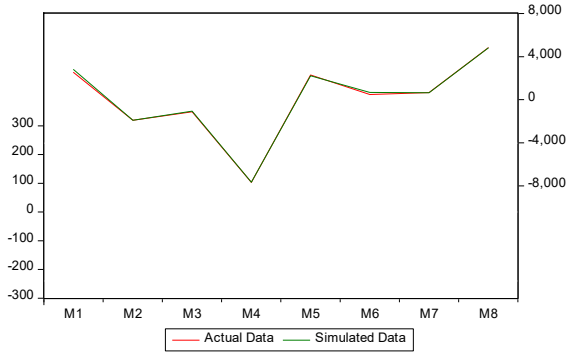
lowest interest rate and relief package of $5.66 billion from the Government of Pakistan to assist the community and trivial business activities. This package includes Rs.100 billion for exporters for improving the trades and monetary endeavors in Pakistan which help to stable and improve stock market.



(a) Actual & Simulated graph for Non-COVID regime



(b) Actual & Simulated graph for COVID-19 regime

Fig. 3 Observed & simulated traces for different regimes

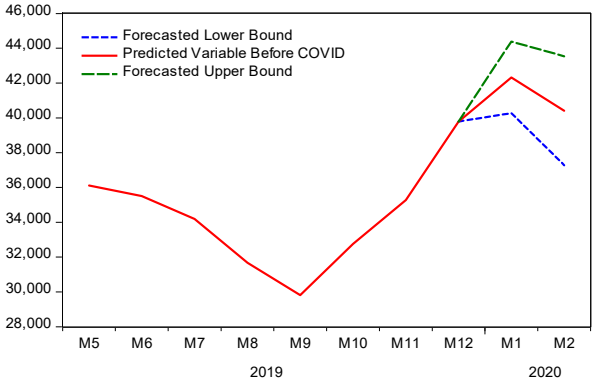
The model equations (1) and (2) show that change of variation of conditional mean of difference of y_t with respect to difference of z_t has negative impact of 379.4 for first lag during Non-COVID period whereas positive influence of 505.05 for COVID-19 period keeping the other variables immovable. Similarly, difference of x_t has negative impact of 136.5 for Non-COVID period and increases to damaging value of 2327.37 of first lag for COVID interval in the constant behavior of other parameters. The quantity of M_t advocates that each unit of twofold modified measurements of M_t abate 40.29 in non-pandemic which reduces to 3.02 in pandemic regime by fixing other macroeconomic variables. Besides, the one lag I_t quantity has adverse impact before the spread of disease start, enhancing during the disease.

The forecasting estimation portrayed in Table III authenticates the forecasted power of model.

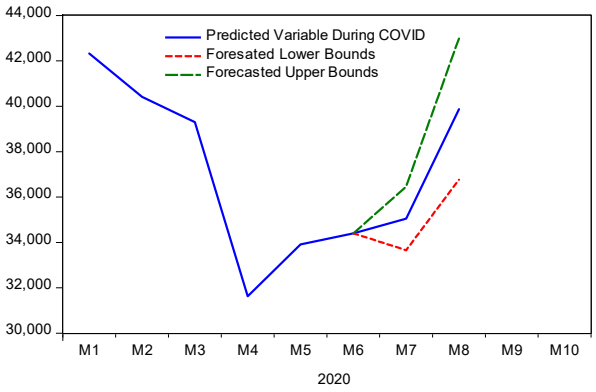
The forecasting graphs with its upper and lower bounds exposed in Figs. 3 (a) and (b) endorse that the predicted variables which start declining in the first regime now coming to the normal due to government policy and hence Stock Market Index is showing considerable flow in index point.

TABLE III
FORECAST STATISTICS FOR COVID & NON-COVID REGIMES

Forecasted Statistics	Non-COVID Regime	COVID Regime
RMS	21862.78	3520.38
MAE	13411.60	2269.62
MAPE	987.53	129.801
Theil Inequality Coefficients	0.89	0.60



(a) Non-COVID Regime



(b) During COVID Regime

Fig. 3 Time plot of predicted variable with forecast and 95% confidence limit

VII. CONCLUSION

In this study an impact of COVID-19 on macroeconomic parameters with regards to KSE is carried. This study is divided into two regimes i.e. pre and post period of pandemic. In the beginning of pandemic regime Pakistan Stock Exchange like other countries also had adverse impact which is obvious from modeled equations (1) & (2). Subsequently, Government of Pakistan has taken appropriate preventive measures like relief package for community, small entrepreneur and reducing of profit margin which proves to have constructive influence on the KSE. The projected value estimated by utilizing these constructed models for COVID-19 and Non-COVID scenario shows that preventive measure taken by the government clarifies that it helps the stock market to become stable and maintain the required growth which has been obstructed by Corona pandemic.

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