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PREDICTING CRYPTOCURRENCY MOVEMENT USING ARIMA MODELLING

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ABSTRACT

The growth and development of crypto currencies has gained notable significance. Global trading in crypto currencies has resulted in highly speculative and bubble like price movements. The global crypto currency market size is expected to grow from USD1.6 Billion in 2021 to USD 2.2 Billion by 2026. India has emerged as one of the biggest hubs for crypto currency adoption in the world with the total value of crypto currency owned by Indians at over $6.5 billion as of May 2021. The ownership of crypto assets in India has increased to 400 per cent over the past 17 months.

KEYWORDS: *Cryptocurrency, Bitcoin, Ethereum, Portfolio, and Cryptography*.

INTRODUCTION

According to a survey by Finder, almost 30 per cent of the respondents in India said that they owned private cryptocurrencies in their investment portfolio making it the third-highest among Asian countries. Recent media reports have suggested that the government may look at designating cryptocurrency as a commodity, which will allow them to function as an asset class like equity, bonds and gold. Viewed in this background, with cryptocurrency becoming as a notable speculative investment media, in this article an attempt has been made to predict the cryptocurrency movement using ARIMA modelling.

A cryptocurrency is a digital or virtual currency that is secured by cryptography. These currencies are decentralized, and no authority regulates them. They are built on the block chain network technology, which ensures transparency and helps track every transaction. The digital structure facilitates free portability across geographical borders, divisibility and transparency ([1. article about cryptocurrency], n.d.).

The growth and development of cryptocurrencies has gained notable significance. Global trading in cryptocurrencies has resulted in highly speculative and bubble like price movements. The global cryptocurrency market capitalization is USD1.85 trillion (Business World, 2-16 August, 2021). The global cryptocurrency market size is expected to grow from USD 1.6 Billion in 2021 to USD 2.2 Billion by 2026 ([article about cryptocurrency], 2021.). India has emerged as one of the biggest hubs for cryptocurrency adoption in the world with the total value of cryptocurrency owned by Indians at over $6.5 billion as of May 2021. The ownership of crypto assets in India has increased to 400 per cent over the past 17 months (EconomicTimes, sept 9,2021).

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designating cryptocurrency as a commodity, which will allow them to function as an asset class like equity, bonds and gold (Economic Times, sept 9,2021).

A look into cryptocurrency scenario in India reveals that cryptocurrency, Bitcoin was accessible to Indians through Unocoin which was launched in 2013. During the year of introduction bitcoin witnessed a rise in the price of bitcoin from USD100 to USD 1000. During 2018 RBI banned cryptocurrency and later in 2020 RBI reversed the ban as per Supreme Court order. The Government is expected to work on cryptocurrency bill and RBI is also planning to introduce Central Bank Digital Currency in phased manner. The cryptocurrency space in India is witnessing revolution, despite of ambiguity in regulations and volatility. Millions of Indians prefer investing in cryptocurrencies instead of gold. (Business World, 2-16 August, 2021).

Investors in cryptocurrency have seen rapid growth in cryptocurrency returns in 2020 and 2021. But this greater return is with greater risk. Cryptocurrencies carry higher risk as their value is intangible, subject to extreme price volatility, lacking government support and not backed by underlying assets. The investment could easily become worthless overnight. If investor wanted to invest in cryptocurrency, they would need to establish a digital wallet and an account on online exchange (like Coinbase, Cash app, Binance US, Bisq) there are many exchanges of various nature. Cryptocurrencies can be divided down into eight decimals, so that it can even be purchased less than a whole coin (William M. Vandeburgh, 2019).

Viewed in this background, with cryptocurrency becoming as a notable speculative investment media, in this article an attempt has been made to predict the cryptocurrency movement using ARIMA modelling.

I- REVIEW OF LITERATURE

Wenjun Feng et.al. (2018) in their study titled" Can cryptocurrencies be a safe haven: a tail risk perspective analysis concluded that cryptocurrencies are very good diversification assets for stocks, as their left tails are uncorrelated with the left tails of indices selected for the study such as S&P 500, Euro Stoxx 50, Nikkei 225 and CSI 300 Index..J.D.Agarwarl et. al. (2018) in their research paper propose setting up of "M5" as money supply measure with cryptocurrency also in the lines of inclusion of other currency products developed in the last 50 years in order to promote efficiency in the money markets. The paper also insists on government intervention to generate cryptocurrency as it is critical for tomorrow's normal economy and business conditions in a globalized economy.

Varma (2019) in his article block chain in finance explains the application of block chain in cryptocurrencies.William M. Vandenburgh et. al. (2019) explored the pragmatic realities of bitcoin and crypto investing expressed that though cryptocurrencies like Bitcoin have witnessed great gain, values have also fluctuated dramatically in short order. The article also conveys that the certified public accountant may face complex questions from investors, and they should advice caution and be wary of providing investment advice in this risky field.

Javier Gutierrez Castro et.al. (2020) analysed about crypto assets portfolio optimization under omega measure. The results of the study indicate that in a portfolio of traditional and crypto assets, higher proportion of traditional assets will maximize the return and minimize the risk. If the portfolio is formed only by crypto assets, the results suggest that crypto assets with better Sharpe-Omega ratio will give better return. Adrian (wai-kong) Cheung et.al. (2013) investigated cryptocurrency bubbles (market price which exceeds or undershoots an asset fundamental values) using Phillips-Shi-Yu methodology. The investigation was done for the period from 2010-2014 on the bitcoin price. The study detected a no of short lived bubbles and three huge bubbles in the later part of the period from 2011-2013 lasting from 66 to 106 days. This may have been responsible for the demise of bitcoins biggest exchange Mt Gox.

Rama K. Malladi et.al. (2020) analyzed the linkages between the returns and volatility of S&P 500 index, global stock market indices (MSCI world Index), volatility index, gold and US economic policy uncertainty index. The findings of the study revealed that returns of global stock markets and gold do not have a causal effect on bitcoin returns. But the smaller cryptocurrencies are more sensitive to gold prices and stock market volatility. Primary factors influencing Bitcoin prices are VIX, US economic policy and other cryptocurrency returns like Ripple.

The review of literature reveals the fact that cryptocurrencies are largely seen as an investment avenue, hence predicting the price movements will help the investors in buy and sell decision.

II- METHODOLOGY

To predict cryptocurrency movement Bitcoin was taken as a representative currency. The opening price of one bitcoin in INR for the period of 1 year from 13 September 2020 to 13 September 2021 was taken for the study. The recent one-year period was particularly selected as the total value of cryptocurrency owned by Indians crossed over $6.5billion as of May 2021. The ownership of crypto assets in India has increased to 400 percent over the past 17 months (Economic Times, September 9, 2021). The data required for the study was taken from https://in.investing.com/crypto/bitcoin/btc-inr-historical-data. The ARIMA modelling introduced by Box-Jenkins in 1976 was used to predict cryptocurrency price movement. E-views software has been used for data analysis.

IV – ARIMA MODELLING

The Auto Regressive Integrated Moving Average (ARIMA) model uses time series data to interpret the data and make future forecast. In this study the most popular ARIMA model introduced by Box – Jenkins, 1976 has been used. This model is popular because it adjusts for seasonal and trend factors. ARMA model has two components (1) Autoregressive model (AR) and (2) Moving Averaged (MA).

AR denotes number of past values of the variable included for the forecast and is usually denoted by AR(p). The generalized AR(p) model is:

$Yt = a0 + b1\ Yt\text{-}1 + \ldots\ldots + bp\ Yt\text{-}p + et \ldots\ldots$ AR (p)

Note: 1) $b<1$

Null Hypothesis: D(CLOSE) has a unit root

Exogenous: None

Lag Length: 0 (Automatic - based on SIC, maxlag=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-20.31078	0.0000
Test critical values:	1% level	-2.571383	
	5% level	-1.941704	
	10% level	-1.616111	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CLOSE,2)
Method: Least Squares

MA denotes present and terms that to make is usually MA(q). The MA(q)
Yt = a0 + δ1 δq et-q + et
MA(q)
The form of model is

Date: 09/15/21 Time: 11:17
Sample (adjusted): 9/15/2020 9/13/2021
Included observations: 361 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CLOSE(-1))	-1.068836	0.052624	-20.31078	0.0000

R-squared	0.533996	Mean dependent var	-341.5346
Adjusted R-squared	0.533996	S.D. dependent var	177596.4
S.E. of regression	121235.3	Akaike info criterion	26.25162
Sum squared resid	5.29E+12	Schwarz criterion	26.26239
Log likelihood	-4737.418	Hannan-Quinn criter.	26.25590
Durbin-Watson stat	1.990372		

number of past error are included forecast and denoted by generalized model is:
et-1 +……+ ……
generalized ARMA(p,q)

Yt = a0 + b1 Yt-1 + δ1 et -1+ ……+ bp Yt-p + δq et -q + et …ARMA (p,q)

Difference between ARMA and ARIMA integration component. Integration means the level at which data series is stationary and it is denoted by 'I' or 'd'. If the data is stationary at first difference then it is denoted as I(1) or d(1). ARIMA model is generally denoted by ARIMA (p,d,q).

'p' denotes number of lags of past values of the variable

'q' denotes number of times the variable is differenced to become stationary

'q' denotes number of lags of past error term of the variable.

Box-Jenkins ARIMA modeling has four steps: 1. Identify the model 2. Estimate Parameters 3. Diagnostic checking 4. Forecasting. (svetlozar T. Rachev, 2007, pp 242-271)

V-RESULTS AND DISCUSSION

5.1 Tests for Stationarity

As a first step to predict cryptocurrency price movements, the data was tested for stationarity using Augmented Dickey Fuller (ADF) test. The data was stationary at first difference as p-value is less than 0.05. Table-1 shows the result of ADF test.

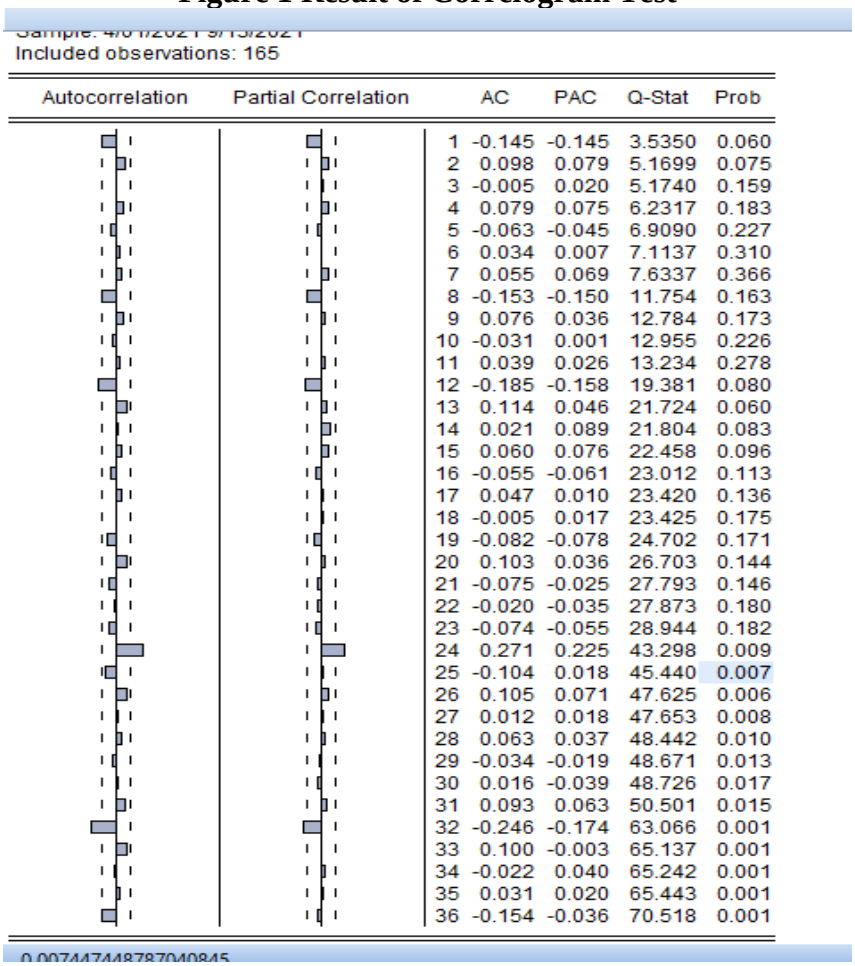
Table-1 ADF Test at First Difference

Source: E-Views output

5.2 Identification of Model

To identify the model generate differenced series and the same was subjected to correlogram test. Based on the output result the tentative ARIMA model considered for further analysis are ARIMA (8,1,8), ARIMA (12,1,12), ARIMA (8,1,12) and ARIMA (12,1,8) as the autocorrelation and partial correlation spikes of lag 8 and 12 exceeds standard error.

Figure 1 Result of Correlogram Test



	AC	PAC	Q-Stat	Prob
1	-0.145	-0.145	3.5350	0.060
2	0.098	0.079	5.1699	0.075
3	-0.005	0.020	5.1740	0.159
4	0.079	0.075	6.2317	0.183
5	-0.063	-0.045	6.9090	0.227
6	0.034	0.007	7.1137	0.310
7	0.055	0.069	7.6337	0.366
8	-0.153	-0.150	11.754	0.163
9	0.076	0.036	12.784	0.173
10	-0.031	0.001	12.955	0.226
11	0.039	0.026	13.234	0.278
12	-0.185	-0.158	19.381	0.080
13	0.114	0.046	21.724	0.060
14	0.021	0.089	21.804	0.083
15	0.060	0.076	22.458	0.096
16	-0.055	-0.061	23.012	0.113
17	0.047	0.010	23.420	0.136
18	-0.005	0.017	23.425	0.175
19	-0.082	-0.078	24.702	0.171
20	0.103	0.036	26.703	0.144
21	-0.075	-0.025	27.793	0.146
22	-0.020	-0.035	27.873	0.180
23	-0.074	-0.055	28.944	0.182
24	0.271	0.225	43.298	0.009
25	-0.104	0.018	45.440	0.007
26	0.105	0.071	47.625	0.006
27	0.012	0.018	47.653	0.008
28	0.063	0.037	48.442	0.010
29	-0.034	-0.019	48.671	0.013
30	0.016	-0.039	48.726	0.017
31	0.093	0.063	50.501	0.015
32	-0.246	-0.174	63.066	0.001
33	0.100	-0.003	65.137	0.001
34	-0.022	0.040	65.242	0.001
35	0.031	0.020	65.443	0.001
36	-0.154	-0.036	70.518	0.001

Source: E-Views output

5.3 Parameters Estimation and Diagnostic Check

For the selected ARIMA models parameters such as significance levels for AR and MR variable, adjusted R2, Akaike Info Criterion (AIC) and Schwarz Criterion (SIC) were estimated. The results of the same were tabulated as shown in Table- 2

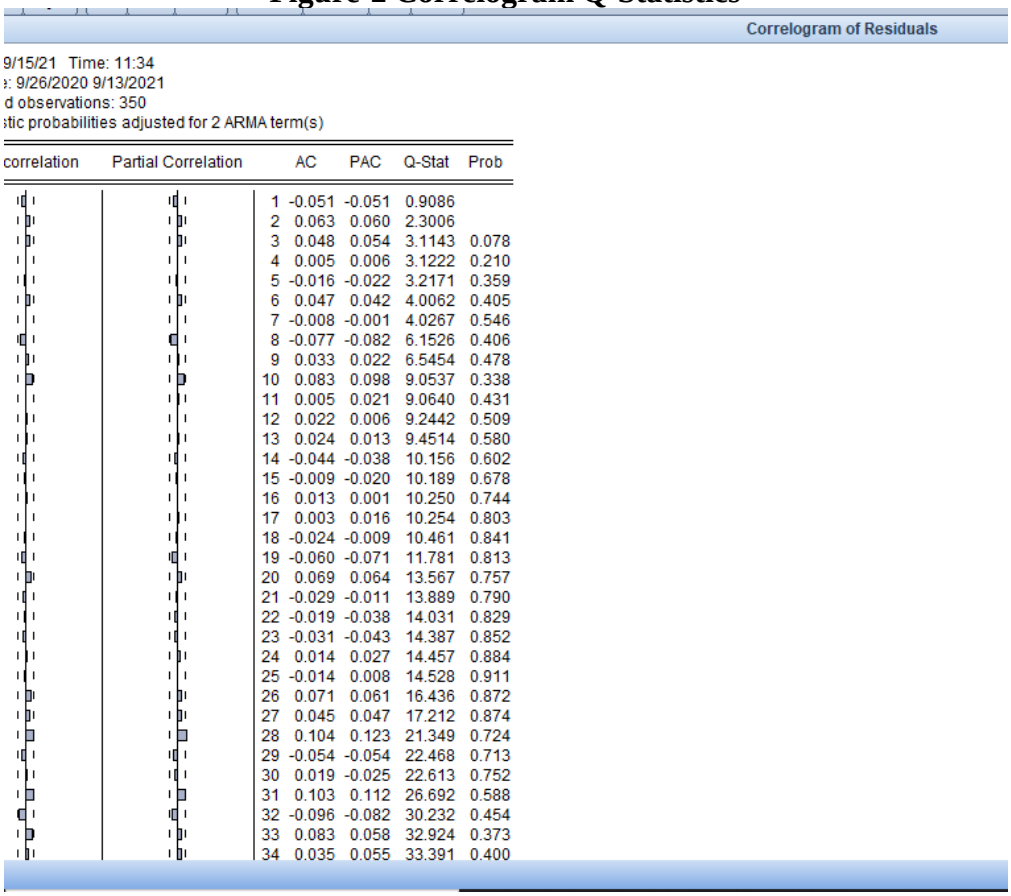
TABLE-2 PARAMETERS ESTIMATION

Model	Significance	Adjusted R2	AIC	SIC
ARIMA (8,1,8)	0	0.004	26.273	26.306
ARIMA (12,1,12)	2	0.019	26.269	26.302
ARIMA (8,1,12)	0	0.013	26.264	26.297
ARIMA (12,1,8)	0	0.014	26.274	26.307

Source: Compiled from E-Views output

The ARIMA (12,1,12) model showed maximum significance, highest R2 value, Lowest AIC and SIC value. This model was selected for the further analysis. For selected model lag significance diagnostic check was performed by using correlogram Q-Statistics. The result of the same is show in Figure- 2.

Figure-2 Correlogram Q-Statistics



correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.051	-0.051	0.9086	
		2	0.063	0.060	2.3006	
		3	0.048	0.054	3.1143	0.078
		4	0.005	0.006	3.1222	0.210
		5	-0.016	-0.022	3.2171	0.359
		6	0.047	0.042	4.0062	0.405
		7	-0.008	-0.001	4.0267	0.546
		8	-0.077	-0.082	6.1526	0.406
		9	0.033	0.022	6.5454	0.478
		10	0.083	0.098	9.0537	0.338
		11	0.005	0.021	9.0640	0.431
		12	0.022	0.006	9.2442	0.509
		13	0.024	0.013	9.4514	0.580
		14	-0.044	-0.038	10.156	0.602
		15	-0.009	-0.020	10.189	0.678
		16	0.013	0.001	10.250	0.744
		17	0.003	0.016	10.254	0.803
		18	-0.024	-0.009	10.461	0.841
		19	-0.060	-0.071	11.781	0.813
		20	0.069	0.064	13.567	0.757
		21	-0.029	-0.011	13.889	0.790
		22	-0.019	-0.038	14.031	0.829
		23	-0.031	-0.043	14.387	0.852
		24	0.014	0.027	14.457	0.884
		25	-0.014	0.008	14.528	0.911
		26	0.071	0.061	16.436	0.872
		27	0.045	0.047	17.212	0.874
		28	0.104	0.123	21.349	0.724
		29	-0.054	-0.054	22.468	0.713
		30	0.019	-0.025	22.613	0.752
		31	0.103	0.112	26.692	0.588
		32	-0.096	-0.082	30.232	0.454
		33	0.083	0.058	32.924	0.373
		34	0.035	0.055	33.391	0.400

Source: E-Views output

Figure-2 results reveal that at lag 10, autocorrelation and partial correlation spikes exceeds standard error. Therefore, further two adjusted ARIMA models were identified i.e. AR(12) AR(10) MA(12) and AR(12) MA(10) MA(10). The parameters were estimated for the adjusted ARIMA and the results are shown in Table-3.

Model	**Significance**	**Adjusted R2**	**AIC**	**SIC**
ARIMA (12,1,12)	2	0.019	26.269	26.302
AR(12)AR(10)MA(12)	2	0.024	26.267	26.311
AR(12)MA(10)MA(10)	2	0.023	26.268	26.312

Source: Compiled from E-Views output

The model AR (12) AR (10) MA (12) which has maximum significance, highest adjusted R2 lowest AIC and SIC values was selected for further diagnostic check. The diagnostic check showed the result that no lags are significant, no autocorrelation and series is homoscedasticity. Therefore, the best model for forecasting AR (12) AR (10) MA (12) which can be written as follows:

$Yt = a0+b12Yt-12+ \delta 10et-10 + \delta 12et-12 +et$

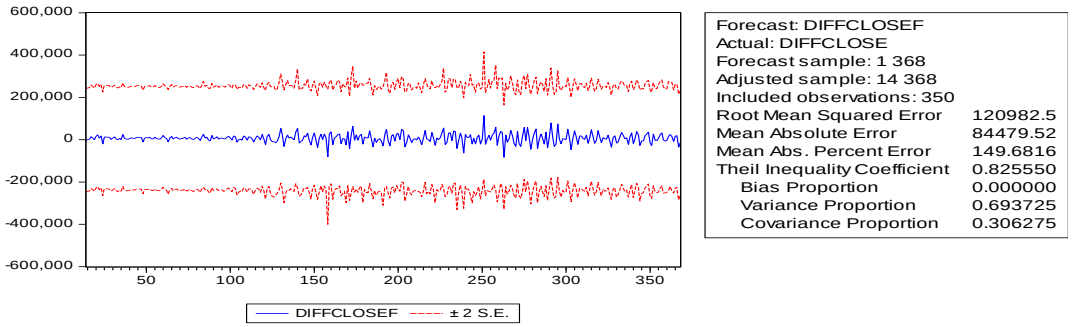
$Yt = 7134.399+0.675316\ Yt—12 + 0.0615462\ et-10 + 0.550352\ et-12 + et$

5.4 Forecasting

Figure 3 and 4 shows the graphical representation of forecasted value of the series taken for the study. It could be observed from the Figure 3 that the forecasted line which is in center lies within the standard error lines. This proves that model has provided a good forecast. Figure 4 shows the

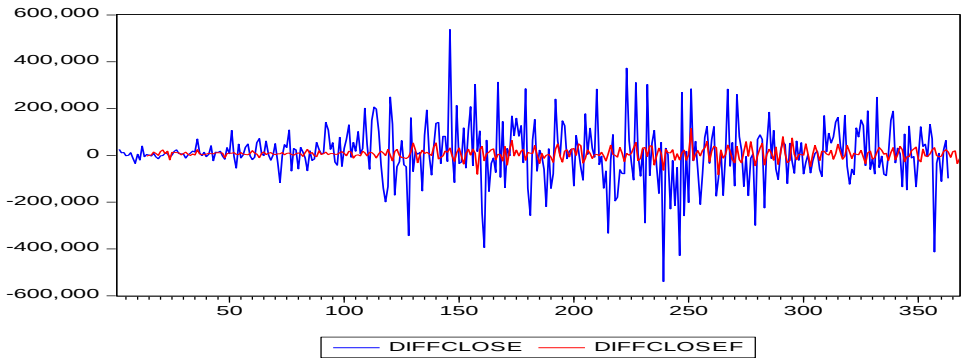
forecasted value for the series.

Figure 3 Forecasted Series with Standard Error



Source: E-Views output

Figure 4 Forecasted Series



Source: E-Views output

Using the differenced value obtained by using e-views software the series taken for the study is forecasted for further 5 days by using the equation Y^t+1 = ΔY^t + Yt-1 + et and shown in Table-4 .

TABLE-4 FORECASTED VALUE OF BITCOIN

Day	ΔY^t	Yt-1	Forecasted Value (Y^t+i)	Actual Bitcoin Value
14 Sept 2021	-8258.97	3288879	3280620	3,305,373
15 Sept 2021	15892.19	3280620	3296512	3,467,143
16 Sept 2021	19321.43	3296512	3315834	3,534,530
17 Sept 2021	-35177.6	3315834	3280656	3,514,291
18 Sept 2021	-12303.3	3280656	3268353	3,481,783

Source: Compiled using E-Views output

It could be observed from Table-4 that the forecasted value and actual Bitcoin value is almost similar and the difference is due to error term. Therefore AR(12) AR(10) MA(12) provides good forecast.

VI CONCLUSION

During recent years' volume of cryptocurrency trading and price as well is increasing. Many studies have been done to explore the various facets of cryptocurrency such as: cryptocurrency for asset diversification (Wenjun Feng et. al., 2018), including cryptocurrency in a money supply measure (J.D.Agarwal et.al., 2018) crypto assets are also used as on investment alternative in portfolio optimization measure (Javier Gutierrez Castero et.al., 2020), impact of return and

volatility of S&P 500 index, global stock market indices, volatility index, gold and US economic policy uncertainity index on crypto currencies (Rama K. Malladi et.al., 2020). In line with these earlier studies in this article an attempt has been made to forecast the cryptocurrency movement using ARIMA modelling. The modelling result showed that AR (12) AR (10) MA(12) provides good forecast. Thus it can be concluded that ARIMA model could be used to predict the future price movements of cryptocurrencies. As a scope of future study, the ARIMA modelling could also be applied on other types of cryptocurrencies like Ethereum, Binancecoin, Cardano etc.

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