# Day of the Week Effect in Cryptocurrencies' Returns and Volatility

**Vandana Dangi***

**Abstract**

Calendar anomalies as the seasonal tendencies in stock returns are the signal of irregular behaviour of stock markets. These anomalies have been comprehensively studied in many matured as well as emerging stock markets. But there is lack of exploration of calendar anomalies in the cryptocurrency market. So, the present treatise is an attempt to fill this lacuna by studying day of the week effect on cryptocurrencies' returns and volatility. This study is based on the prices of eight cryptocurrencies (viz. Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar) for a period starting from July 2017 and up to March 2020. The series of daily and day-wise returns were initially studied for stationarity using Ng-Perron tests and augmented Dickey–Fuller test. The results from these tests confirmed that the cryptocurrencies' return series are stationary. The day of the week effect on cryptocurrencies returns was studied by introducing the dummies for each day of the week in the ordinary least square regression equation. The residuals from the ordinary least square regression equation were tested for ARCH effect using Engle's ARCH test. The results from the test confirmed the presence of ARCH effect in all series. The GARCH (1,1) model and PARCH model were further applied to account for ARCH effect and these models confirmed the presence of the day of the week effect in all the cryptocurrencies' returns and volatility except for day of week effect in Bitcoin and Tether returns. So, the significant day of the week effect was present in all cryptocurrencies' returns and volatility but the significant day of the week effect was absent in Bitcoin's returns and Tether's returns. These findings of significant day effect may help the existing and potential investors in taking investment decision in contemporary scenario of no ban in cryptocurrency market in India.

**Keywords:** ARCH Effect, Calendar Anomalies, Cryptocurrency, Day of the Week Effect, Dummies and Stationarity.

## INTRODUCTION

The journey of invention, initiation and evolution of cryptocurrencies during past twelve years signifies the appropriate utilisation of advanced technological development in block chain technology. This technology claims to offer transparent, decentralised, quick, flexible and reliable transactions. These benefits have surged the usage of cryptocurrencies around the world as virtual medium of exchange among disintermediate market participants. The popularity of cryptocurrencies as a strong competitor to fiat currencies has aroused the interest of market players. Market Research Report (2020) highlighted key insights regarding the projection of global cryptocurrency market to reach USD 1758 million by 2027 from USD 754 million in 2019 exhibiting compound annual growth of 11.2%. This emerging sector has on one hand gained the acceptance of investors as a reliable investment alternative and on

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other hand raised the suspicion from regulators and governments. A peculiar point to note here is that cryptocurrencies are not considered as legal tender in most of the countries including India. However, the cryptocurrencies exchanges are legal and need registration as per the laws and regulations of respective countries. There is wide range of regulations governing the cryptocurrencies sector around the world ranging between lenient regulatory approach and complete/or effective ban on cryptocurrency dealing. Global Legal Research Directorate Staff (2018) in their report highlighted that the countries like Germany, Japan and The Netherlands had adopted lenient regulatory approach as the government and regulators of these countries have given these currencies the status of asset, commodity or security. However, countries like China has completely banned the cryptocurrency dealing. As far as India is concerned, there is dicey regulatory environment surrounding the cryptocurrencies sector. The Reserve Bank of India had banned the dealing in virtual currencies in 2018 by terminating the relationship of all entities (regulated by RBI) with individuals or firms dealing in cryptocurrencies. But in March 2020, the ban was uplifted by the Supreme Court in Internet and Mobile Association of India vs. RBI. It declared the prohibition imposed in 2018 by RBI as disproportionate ban that ultra vires the Constitution. This decision authored by Justice V Ramasubramanian was a big boost to this sector. The contemporary scenario of no ban in cryptocurrency sector in India has aroused the need of reframing investment strategy by market players. Investors are again analysing this sector in terms of risk and return in context of present scenario. There is a vast literature analysing risk, return and efficiency of financial and commodity markets. Researchers have developed pertinent approaches to capture the vital attributes of financial data. In earlier studies volatility was considered as a constant and unconditional statistics. However, Engle (1982) and Bollerslev (1986) introduced the concept of conditional volatility that had really improved the way of capturing the properties of financial data. Many researchers like Crouhy et al. (1997), Kaur (2004), Robert et al. (2005), Pati Pratap (2006), Sarangi et al. (2006), Daal et al. (2007), Hourvouliades (2007), Ninga et al. (2009), Mahmud et al. (2011), Sinha (2012), Xue et al. (2012), Lin et al. (2013), Dangi (2014, 2015, 2017), Bouoiyour et al. (2015, 2016), Katsiampa (2017), Siwen (2018), Caporale et al. (2019) had discarded the volatility in returns as a constant and unconditional statistics. These researchers used various models of GARCH family to study the risk-return trade-off, volatility behaviour and leverage effect in financial markets. Gronwald (2014), Cheah et al. (2015), Bouoiyour et al. (2015, 2016), Letra (2016), Katsiampa (2017), Siwen (2018) and Dangi (2020) had studied the volatility dynamics of Bitcoins with help of various models of GARCH family and found optimal fit model. They found that the cryptocurrency market was immature and their prices were marked by extreme price movements. They proved the presence of highly persistent volatility and asymmetry in the cryptocurrencies' returns. There also exists a vast literature encompassing the analysis of calendar anomalies. The literature encompasses various studies on day of the week effect, turn of the month effect, holiday effect and many more in the financial and commodity market. Fields (1931), Rozeff et al. (1976), French (1980), Gibbons et al. (1981), Brown et al. (1983), Smirlock et al. (1986), Cadsby et al. (1992), Mills et al. (1995), Berument et al. (2001), Fountas et al. (2002), Kiymaz et al. (2003), Joshi et al. (2005), Marrett et al. (2008), Parikh (2009), Silva (2010), Dash et al. (2011), Swinkels et al. (2012) reported the presence of calendar anomalies in several developed and emerging stock markets. Arora et al. (2013), Singal et al. (2014), Dangi (2014) analysed the calendar anomalies in commodity markets and they found the presence of anomalies. Kurihara et al. (2017) studied the calendar anomalies in Bitcoin returns. They examined the existence of weekly price anomalies by analysing the market efficiency of Bitcoin. They used standard ordinary least squares and robust least squares estimation and found that the Bitcoin market was not efficient. Caporale et al. (2019) studied the day of the week effect in the returns of Bitcoin, Litecoin, Ripple and Dash. They used average analysis, simulation analysis, the Kruskal–Wallis test and ordinary least squares estimation. They found the absence of anomaly in Litecoin, Ripple and Dash. Whereas, this anomaly was present in the returns of Bitcoin. However, the ordinary least square estimation is not appropriate in the light of well proven concept of conditional volatility. So, the present treatise is an attempt to fill this lacuna by using GARCH family models to examine the day of week effect in the cryptocurrency market. The present treatise will provide extensive evidence of the presence or absence of the day of week effect anomaly in the returns and volatility of eight cryptocurrencies (viz. Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar).

## OBJECTIVE OF THE STUDY

The objective of the present treatise is to study the day of the week effect in cryptocurrencies' returns and volatility.

## RESEARCH METHODOLOGY

### DATABASE

The daily closing prices of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar for the period of July 2017 to March 2020 are taken for the study. The data is taken from online database maintained by the Coinall exchange. It is a worldwide community-driven exchange.

## ECONOMETRIC METHODOLOGY

The present study uses rate of return to study the day of the week effect in Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar. So, the price series of these eight cryptocurrencies have been converted into return series using the following equation:

$$R_t = (\ln P_t - \ln P_{t-1}) \times 100 \quad (1)$$

where $R_t$ is the return of cryptocurrency for day t

$P_t$ is cryptocurrency's closing prices for day t

$P_{t-1}$ is the cryptocurrency's closing prices of previous trading day

In is natural log

The Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series are initially studied for stationarity using modern Ng-Perron tests. A peculiar point to note here is that the augmented Dickey–Fuller test is also employed in order to corroborate the results of the Ng-Perron tests. The day of the week effect on cryptocurrencies' returns is initially studied with the help of introducing dummies for each day of the week in the ordinary least square regression equation. Note that it has an assumption of constant variance. The equation of ordinary least square regression is:

$$\text{Cryptocurrency's Return} = b_1DM + b_2DT + b_3DW + b_4DTH + b_5DF + b_6DS + b_7DSu + e_t \quad (2)$$

where $e_t$ is the error term.

$b_1$; $b_2$;$b_3$;$b_4$;$b_5$;$b_6$ and $b_7$ are the coefficients.

*DM, DT, DW, DTH, DF, DS and DSu* are dummies for week days returns i.e. returns of Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday respectively. Note that DM is taken as one in case the

particular day is Monday and zero otherwise; DT is taken as one in case the particular day is Tuesday and zero otherwise; and the same pattern follows for other days of the week. Also note that there is no intercept in the above ordinary least square regression equation. It is not included in order to avoid the dummy variable trap. But as the literature highlights that the ordinary least square equation may mislead due to the presence of time varying variance. So, the residuals from the above ordinary least square regression equation are tested for autoregressive conditional heteroscedasticity effect with the help of Engle's ARCH test. The ARCH effect, if present in the residuals, can accounted by GARCH (1,1) model. So, the Bollerslev's GARCH model is further estimated to study the day of week effect in the returns and volatility of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series. The variance equation in the GARCH (1.1) model is:

$$h_t = c + e^2_{t-1} + h_{t-1} \quad (3)$$

Where $e^2_{t-1}$ is previous period error (ARCH) term

$h_{t-1}$ is previous period variance (GARCH) term

Ding et al. (1993) PARCH model generalized the above GARCH model with the Power ARCH specification. In this model, power parameter of the standard deviation is not imposed. It is estimated in the model. The equation of PARCH model is as follows:

$$\sigma^{\delta}{}_t = w + \sum_{j=1}^{q} \beta_j \sigma^{\delta}{}_t \sigma^{\delta}{}_{t-j} + \sum_{i=1}^{p} \propto_i (|\varepsilon_{t-i}| - \gamma \varepsilon_{t-1})^{\delta} \quad (4)$$

where d is equal to 2

($s^d_t$) is conditional variance in the return series of cryptocurrency

w, $b_j$, $\mu_i$ $\gamma$ and $\delta$ are parameters

## BASIC CHARACTERISTICS OF BITCOIN, EOS, ETHEREUM, BITCOIN CASH, LITECOIN, TETHER, XRP AND STELLAR RETURN SERIES

The daily and day-wise prices of cryptocurrencies are taken for the purpose of examining the day of the week effect. The series of cryptocurrencies' prices are initially converted to return series. The basic statistics of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series are portrayed in the table 1:

**Table 1: Basic Statistics of Cryptocurrencies' Return Series**

| **Bitcoin Returns** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Descriptive Statistics** | **Monday Returns** | **Tuesday Returns** | **Wednesday Returns** | **Thursday Returns** | **Friday Returns** | **Saturday Returns** | **Sunday Returns** | **Overall Returns** |
| Mean | 0.006928 | 0.006312 | 0.006558 | 0.006601 | 0.006901 | 0.006268 | 0.006288 | 0.000902 |
| Median | 0.005155 | 0.001652 | 0.007052 | 0.000292 | 0.007729 | 0.006812 | 0.008682 | 0.000524 |
| Maximum | 0.364290 | 0.381364 | 0.339034 | 0.527118 | 0.390335 | 0.361952 | 0.364750 | 0.227602 |
| Minimum | -0.482820 | -0.420161 | -0.418408 | -0.357236 | -0.536611 | -0.513927 | -0.476738 | -0.234065 |
| Std. Dev. | 0.125063 | 0.118329 | 0.119128 | 0.117489 | 0.121406 | 0.132743 | 0.130893 | 0.042867 |
| Skewness | -0.560079 | -0.001697 | -0.117315 | 0.375399 | -0.490425 | -0.296952 | -0.403448 | -0.024443 |
| Kurtosis | 5.442581 | 4.611280 | 4.419224 | 5.413319 | 5.478905 | 4.454923 | 4.384862 | 7.253636 |
| Jarque-Bera | 42.72398 | 15.46924 | 12.24305 | 37.79453 | 42.04996 | 14.61135 | 15.19946 | 754.7460 |
| Probability | 0.000000 | 0.000437 | 0.002195 | 0.000000 | 0.000000 | 0.000672 | 0.000501 | 0.000000 |
| **EOS Returns** | | | | | | | | |
| Mean | 0.001578 | 0.001283 | 0.001933 | 0.001814 | 0.001508 | 0.001308 | 0.001178 | 0.000183 |
| Median | 0.000471 | -0.007023 | -0.005314 | 0.001986 | 0.004196 | 0.006267 | 0.001542 | -0.001227 |
| Maximum | 0.833368 | 0.733470 | 0.767352 | 0.713626 | 0.812237 | 0.721626 | 0.779834 | 0.355890 |
| Minimum | -0.508922 | -0.477157 | -0.567939 | -0.648943 | -0.674339 | -0.610208 | -0.538475 | -0.356675 |
| Std. Dev. | 0.200193 | 0.205835 | 0.205397 | 0.189416 | 0.199807 | 0.193383 | 0.207157 | 0.070117 |
| Skewness | 0.765191 | 0.860545 | 0.550092 | 0.214413 | 0.445307 | 0.396489 | 0.474987 | 0.454589 |
| Kurtosis | 5.310872 | 5.174385 | 4.865615 | 4.635943 | 5.269677 | 4.458582 | 4.963625 | 8.463167 |
| Jarque-Bera | 16.92287 | 35.17238 | 16.30795 | 28.15312 | 16.92287 | 35.17238 | 16.30795 | 1279.311 |
| Probability | 0.000211 | 0.000000 | 0.000288 | 0.000001 | 0.000211 | 0.000000 | 0.000288 | 0.000000 |
| **Ethereum Returns** | | | | | | | | |
| Mean | -0.003044 | -0.004868 | -0.004620 | -0.004704 | -0.003886 | -0.004510 | -0.004227 | -0.000695 |
| Median | 0.006820 | -0.000241 | 0.005034 | 0.002419 | -0.003540 | 0.007542 | 0.008391 | -0.000995 |
| Maximum | 0.419744 | 0.401989 | 0.512526 | 0.503294 | 0.427835 | 0.393636 | 0.501529 | 0.208768 |
| Minimum | -0.564932 | -0.559014 | -0.551969 | -0.406513 | -0.632845 | -0.627294 | -0.586023 | -0.229832 |
| Std. Dev. | 0.154417 | 0.149355 | 0.149808 | 0.146452 | 0.148503 | 0.153901 | 0.162673 | 0.052957 |
| Skewness | -0.516151 | -0.555960 | -0.148122 | 0.100701 | -0.196787 | -0.411282 | -0.226280 | -0.315511 |
| Kurtosis | 4.921078 | 4.680353 | 4.449191 | 4.141771 | 4.954637 | 4.821742 | 4.789989 | 5.976749 |
| Jarque-Bera | 28.14077 | 24.19056 | 12.94517 | 7.953207 | 23.52174 | 23.63917 | 20.16916 | 386.1867 |
| Probability | 0.000001 | 0.000006 | 0.001545 | 0.018749 | 0.000008 | 0.000007 | 0.000042 | 0.000000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Bitcoin Cash Returns** | | | | | | | | |
| Mean | 0.002396 | 0.008022 | 0.007786 | 0.002483 | 0.002369 | 0.003746 | 0.003692 | 0.000049 |
| Median | -0.010687 | -0.016511 | -0.007000 | -0.025638 | -0.018184 | -0.006705 | 0.001763 | -0.003238 |
| Maximum | 0.864198 | 0.911608 | 0.883578 | 0.832925 | 0.837287 | 0.852615 | 0.725634 | 0.435461 |
| Minimum | -0.741814 | -0.732334 | -0.616941 | -0.628570 | -0.653466 | -0.718794 | -0.764236 | -0.500632 |
| Std. Dev. | 0.243456 | 0.255308 | 0.246375 | 0.242495 | 0.228032 | 0.236000 | 0.233684 | 0.077552 |
| Skewness | 0.508832 | 0.752931 | 1.058953 | 0.755248 | 0.827134 | 0.764666 | 0.224678 | 0.459256 |
| Kurtosis | 5.411113 | 5.837585 | 5.893823 | 5.198607 | 5.369872 | 5.792036 | 4.602893 | 11.82087 |
| Jarque-Bera | 55.18969 | 30.53723 | 35.84784 | 43.49314 | 11.89301 | 55.18969 | 30.53723 | 3280.419 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.002615 | 0.000000 | 0.000000 | 0.000000 |
| **Litecoin Returns** | | | | | | | | |
| Mean | -0.001397 | -0.001137 | -0.000964 | -0.001109 | -0.001445 | -0.001604 | -0.001489 | -0.000162 |
| Median | 0.000574 | -0.004527 | -0.002920 | -0.010582 | -0.007065 | -0.000249 | 0.004048 | -0.002813 |
| Maximum | 0.856757 | 0.645298 | 0.765811 | 0.740164 | 1.248639 | 1.140582 | 1.063711 | 0.476615 |
| Minimum | -0.404112 | -0.388886 | -0.388169 | -0.460526 | -0.603397 | -0.553863 | -0.568945 | -0.307951 |
| Std. Dev. | 0.167925 | 0.160978 | 0.165020 | 0.160553 | 0.177526 | 0.168777 | 0.170643 | 0.058563 |
| Skewness | 1.000095 | 0.646303 | 0.810132 | 0.742043 | 2.171717 | 2.023206 | 1.377562 | 1.016714 |
| Kurtosis | 7.755400 | 5.008066 | 5.664014 | 5.959271 | 19.54473 | 16.94064 | 13.43343 | 11.94510 |
| Jarque-Bera | 157.4696 | 33.98134 | 57.52319 | 64.84547 | 1731.178 | 1246.730 | 688.9794 | 3509.739 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Tether Returns** | | | | | | | | |
| Mean | 0.000016 | 0.000020 | -0.000003 | 0.000006 | 0.000030 | -0.000006 | 0.000004 | 0.000003 |
| Median | -0.000116 | -0.000059 | 0.000000 | 0.000000 | -0.000084 | 0.000000 | 0.000000 | 0.000000 |
| Maximum | 0.024815 | 0.029559 | 0.022273 | 0.024298 | 0.039221 | 0.024307 | 0.048901 | 0.034571 |
| Minimum | -0.025620 | -0.019803 | -0.027490 | -0.034945 | -0.036149 | -0.041631 | -0.038336 | -0.038336 |
| Std. Dev. | 0.006698 | 0.006632 | 0.006870 | 0.006981 | 0.009000 | 0.008407 | 0.008989 | 0.005124 |
| Skewness | -0.009373 | 0.835380 | -0.321398 | -0.459441 | 0.012161 | -0.957850 | 0.568239 | 0.131392 |
| Kurtosis | 6.896816 | 7.396238 | 6.266971 | 9.684536 | 8.397577 | 8.415045 | 10.94402 | 12.69890 |
| Jarque-Bera | 89.84768 | 131.7885 | 65.59388 | 269.3702 | 172.3787 | 195.2063 | 381.0278 | 3926.331 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

| **XRP Returns** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mean | -0.000256 | -0.000433 | -0.000784 | -0.000634 | -0.000781 | -0.000500 | -0.000377 | -0.000061 |
| Median | -0.014122 | -0.006211 | -0.007592 | -0.004543 | -0.021948 | -0.010957 | -0.011138 | -0.001061 |
| Maximum | 1.149499 | 1.145383 | 1.141844 | 1.126111 | 0.725529 | 0.813681 | 1.430394 | 0.618317 |
| Minimum | -0.361084 | -0.368963 | -0.510789 | -0.623527 | -0.571275 | -0.461973 | -0.391830 | -0.354034 |
| Std. Dev. | 0.179551 | 0.178901 | 0.194150 | 0.186475 | 0.174622 | 0.177475 | 0.193942 | 0.061671 |
| Skewness | 2.556996 | 2.458552 | 1.917497 | 1.936276 | 1.004846 | 1.398051 | 3.286612 | 2.081912 |
| Kurtosis | 16.01849 | 15.80400 | 12.50099 | 13.89017 | 7.271965 | 8.231405 | 23.98630 | 21.65924 |
| Jarque-Bera | 1157.502 | 1120.884 | 621.1078 | 790.4222 | 131.8739 | 208.1826 | 2861.489 | 15244.59 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Stellar Returns** | | | | | | | | |
| Mean | 0.004271 | 0.003699 | 0.003950 | 0.004211 | 0.004011 | 0.003824 | 0.004074 | 0.000528 |
| Median | -0.003803 | -0.014032 | -0.017876 | -0.024563 | -0.013748 | -0.010444 | -0.014504 | -0.002781 |
| Maximum | 0.781531 | 0.816211 | 0.837855 | 0.790109 | 0.919438 | 1.361767 | 1.161885 | 0.640660 |
| Minimum | -0.412707 | -0.434524 | -0.507998 | -0.582200 | -0.493106 | -0.474129 | -0.584441 | -0.324944 |
| Std. Dev. | 0.186682 | 0.195039 | 0.200120 | 0.194961 | 0.201658 | 0.219964 | 0.204344 | 0.070576 |
| Skewness | 0.944343 | 1.353486 | 0.984368 | 1.085631 | 1.704473 | 2.175742 | 1.659667 | 1.331377 |
| Kurtosis | 5.610525 | 7.107886 | 5.704568 | 6.215337 | 8.745371 | 13.34308 | 10.18899 | 14.44671 |
| Jarque-Bera | 61.42670 | 144.2061 | 66.21111 | 89.06221 | 264.0620 | 744.9948 | 370.9726 | 5760.651 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

Source: Author's Calculations

The calculated basic statistics in table 1 reveal the basic characteristics of the data from July 2017 to March 2020 of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar returns. The basic statistics indicate highest average overall returns of Bitcoin followed by Stellar, EOS, Bitcoin Cash and Tether respectively. These cryptocurrencies have positive overall average returns that indicate the increase in returns over the sample period. Whereas, negative overall average returns of Ethereum, Litecoin and XRP reveal decrease in returns over the sample period. The highest average returns are on Monday followed by Friday, Thursday, Wednesday, Tuesday, Sunday and Saturday respectively in case of Bitcoin. The average returns of EOS are highest on Wednesday followed by Thursday, Monday, Friday, Saturday, Tuesday and Sunday respectively. The highest average returns are on Tuesday followed by Wednesday, Saturday, Sunday, Thursday, Monday and Friday respectively in case of Bitcoin Cash. The day-wise average returns of all days of week are positive in case of Tether except on Wednesday and Saturday. The average returns of Tether are highest on Friday followed by Tuesday, Monday, Thursday, Sunday, Wednesday and Saturday respectively. However, the day-wise average returns of all days of week are negative in case of Ethereum, Litecoin and XRP. The average returns are least negative on Monday followed by Friday, Sunday, Saturday, Wednesday, Thursday and Tuesday respectively in case of Ethereum. The lowest negative average returns are on Wednesday followed by Thursday, Tuesday, Monday, Friday, Sunday and

Saturday respectively in case of Litecoin. The average returns are least negative on Monday followed by Sunday, Tuesday, Saturday, Thursday, Friday and Wednesday respectively in case of XRP. The positive skewness values indicate high probability of earning positive returns in EOS, Bitcoin Cash, Litecoin, XRP and Stellar. But there is negative skewness value in Bitcoin and Ethereum that indicates high probability of earning negative returns. Although the overall skewness is positive in case of Tether but it is negative on Monday, Wednesday, Thursday and Saturday. All return series are leptokurtic as the kurtosis statistics is above three in all series. It indicates more peaked data in comparison of normal curve. The null hypothesis of normal distribution of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series cannot be accepted as the value of probability of Jarque-Bera test in case of all return series is zero. The returns series of all cryptocurrencies are tested for stationarity initially by graphical method. Exhibits 1 to 9 display the graphs of daily and day-wise returns of all cryptocurrencies.

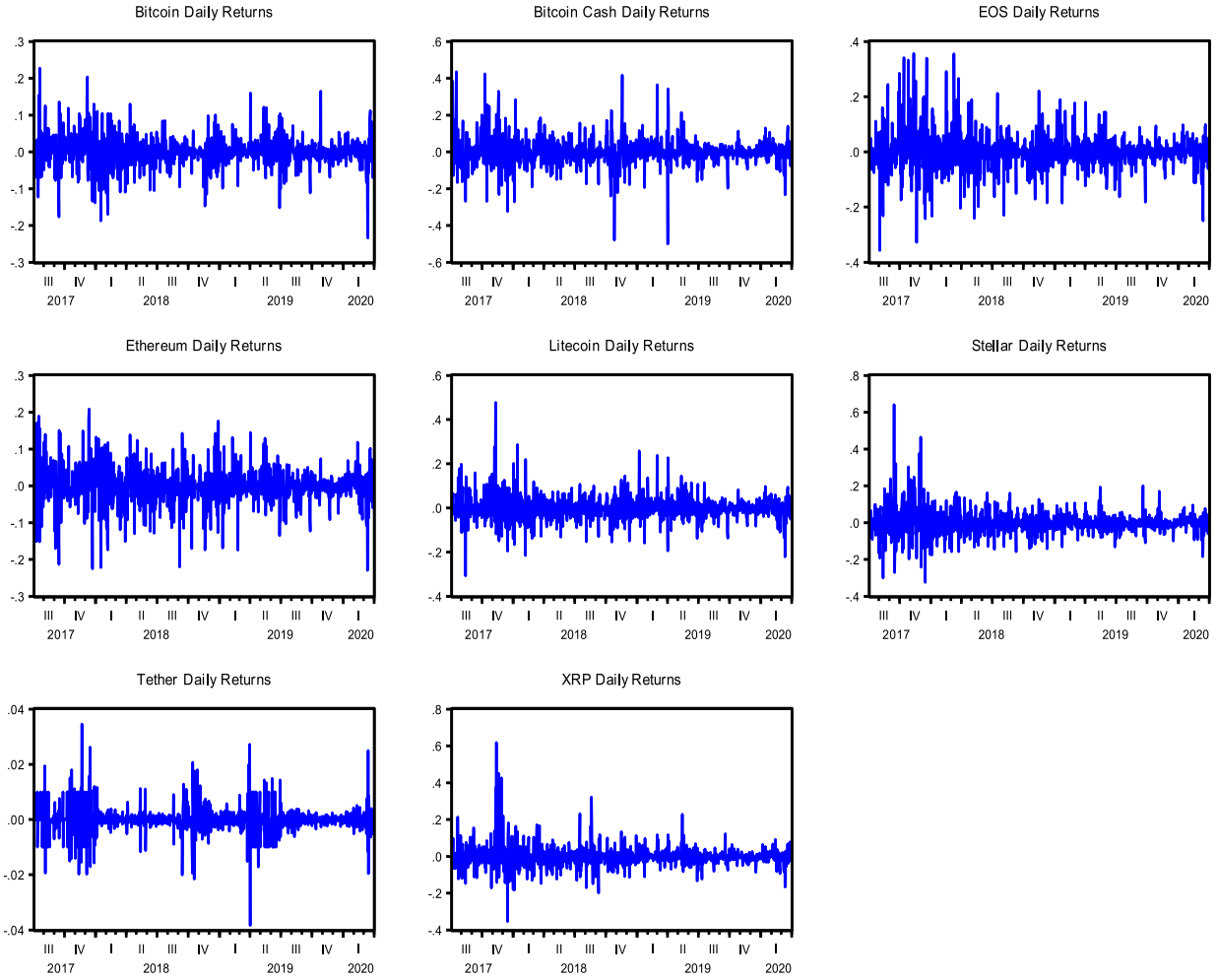


**Exhibit 1: Plot of Daily Cryptocurrencies' Returns**

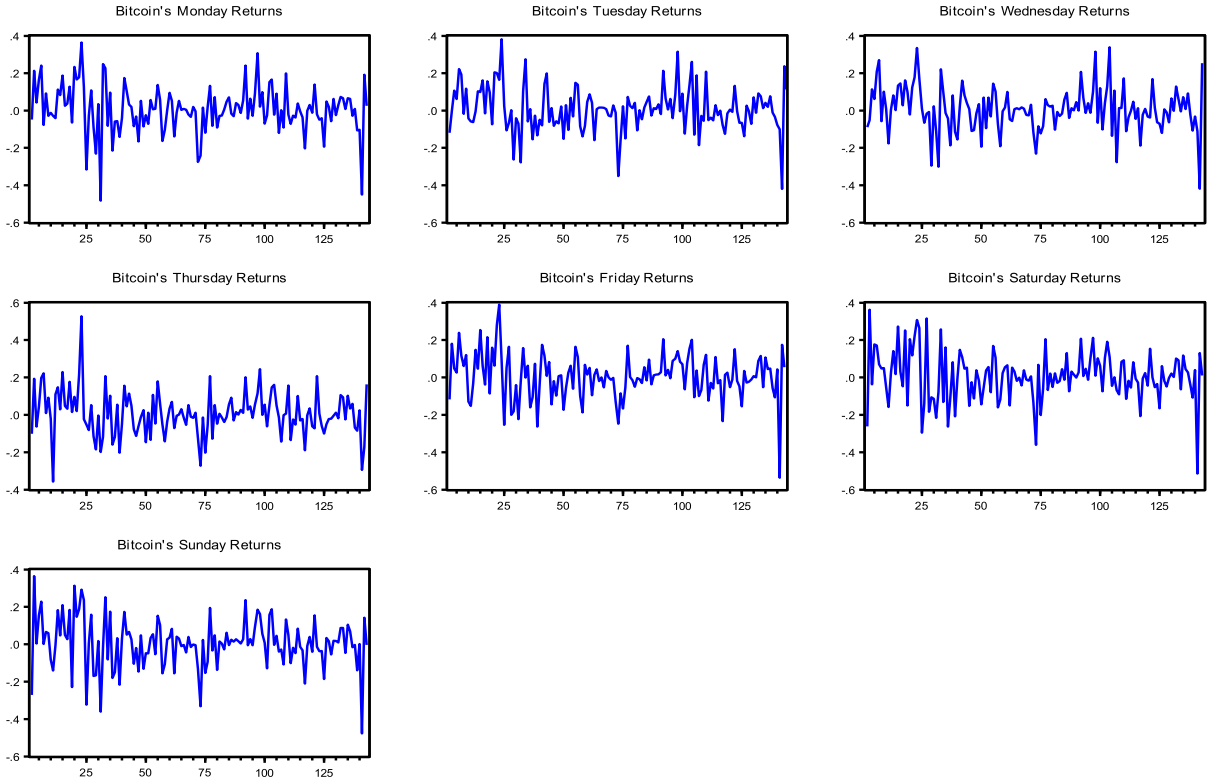


**Exhibit 2: Plot of Day-wise Bitcoin's Returns**

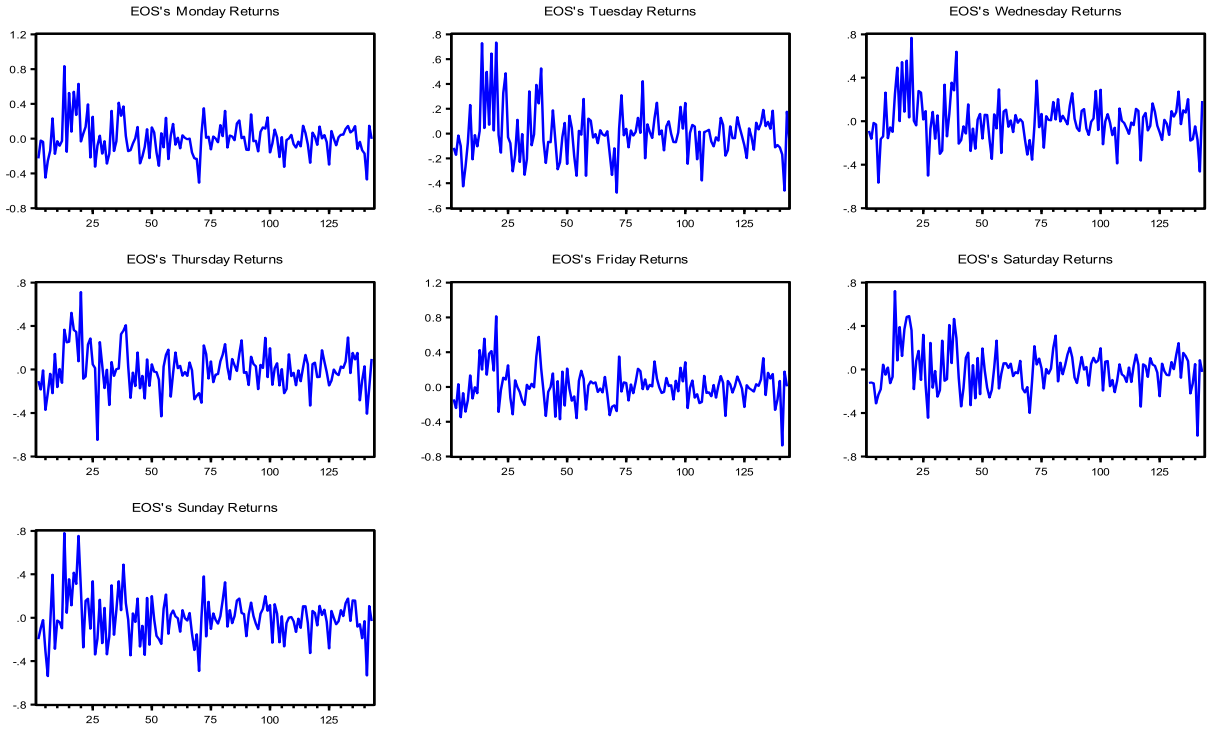


**Exhibit 3: Plot of Day-wise EOS's Returns**

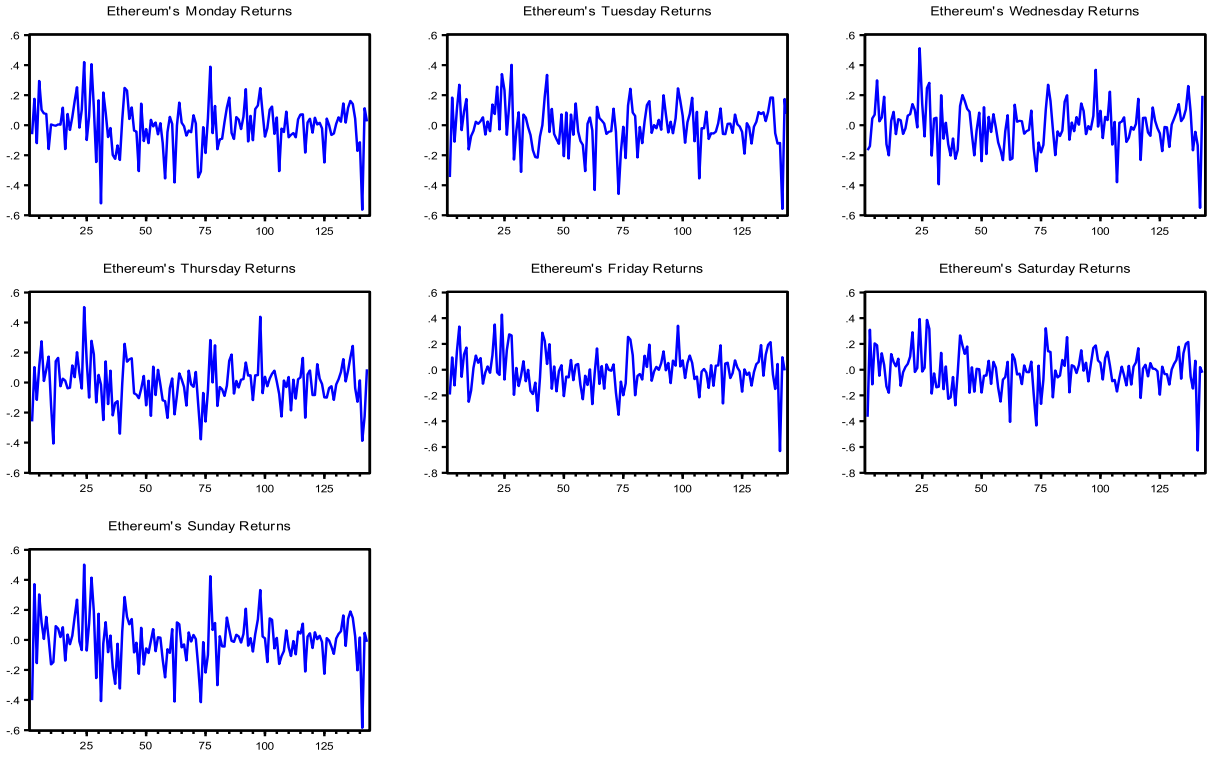


**Exhibit 4: Plot of Day-wise Ethereum's Returns**

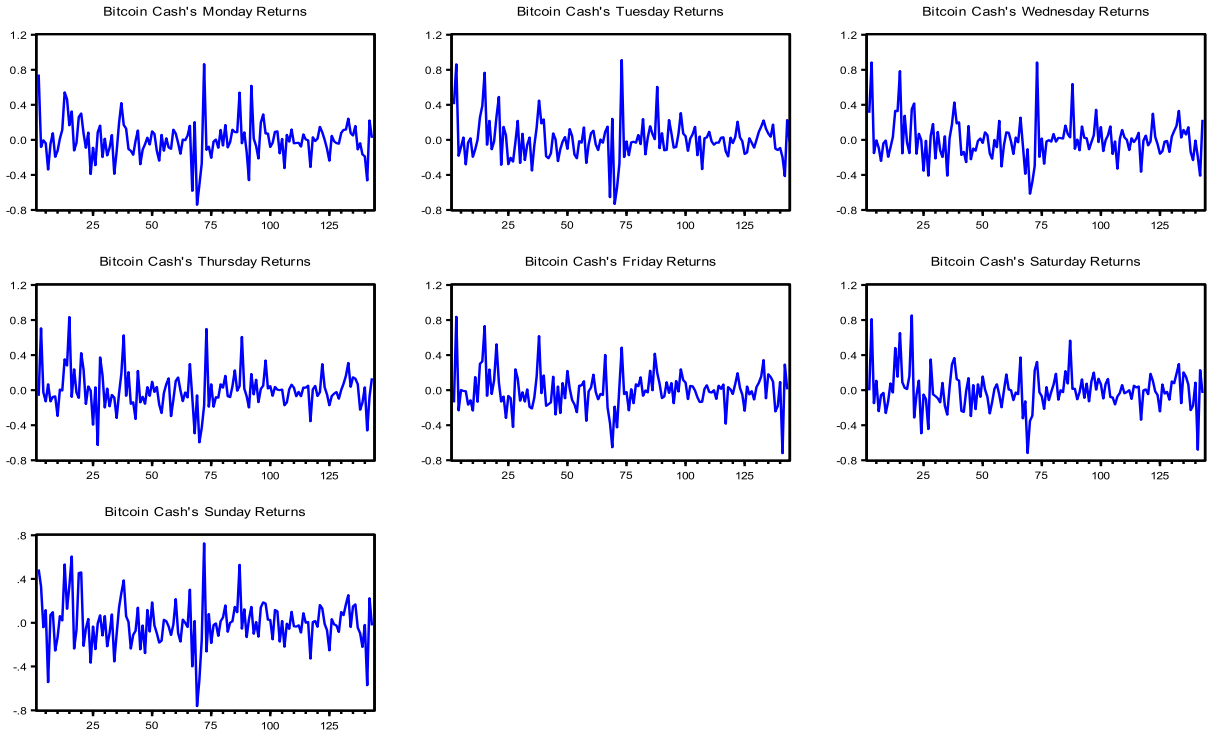


**Exhibit 5: Plot of Day-wise Bitcoin Cash's Returns**

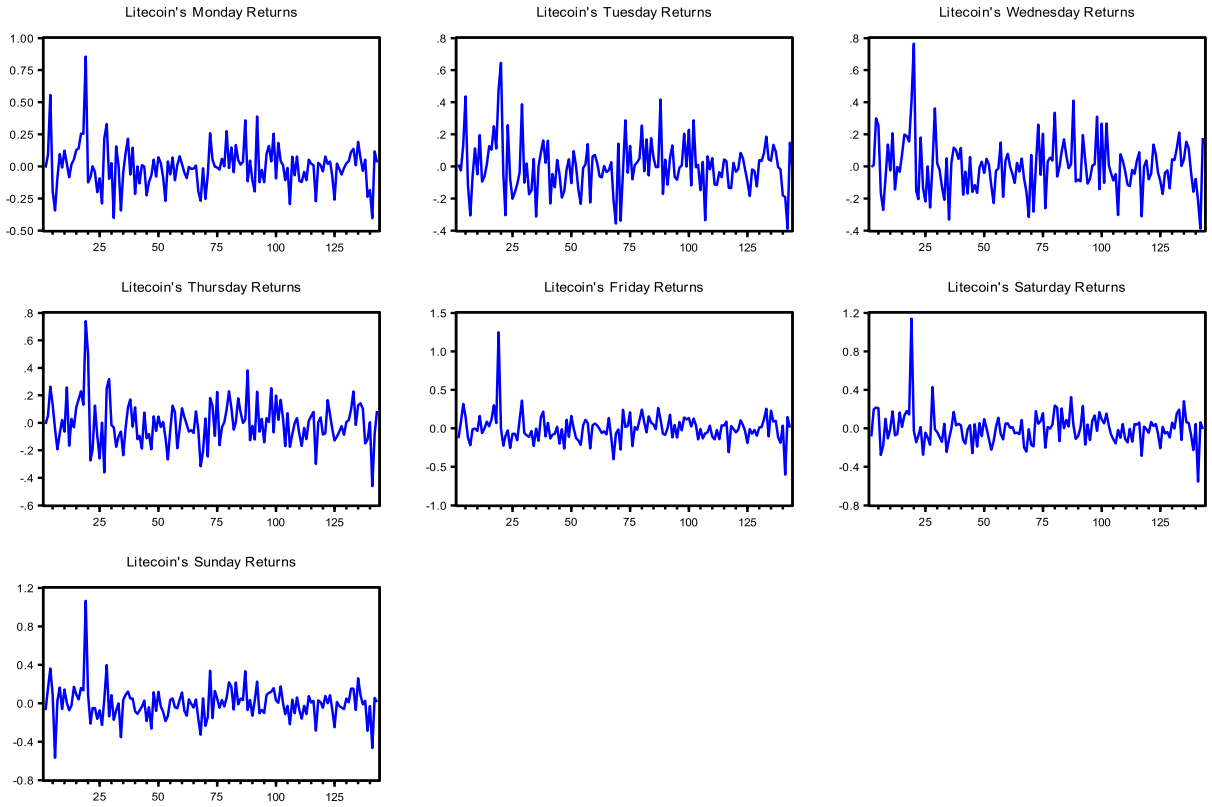


**Exhibit 6: Plot of Day-wise Litecoin's Returns**

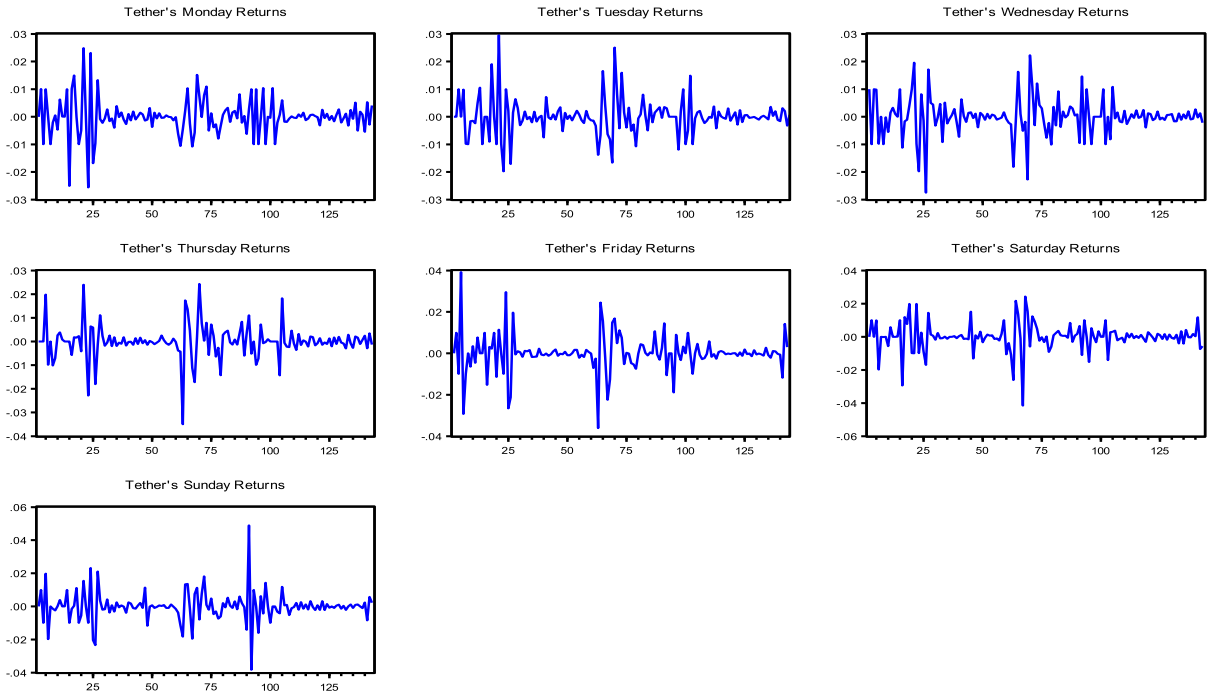


**Exhibit 7: Plot of Day-wise Tether's Returns**

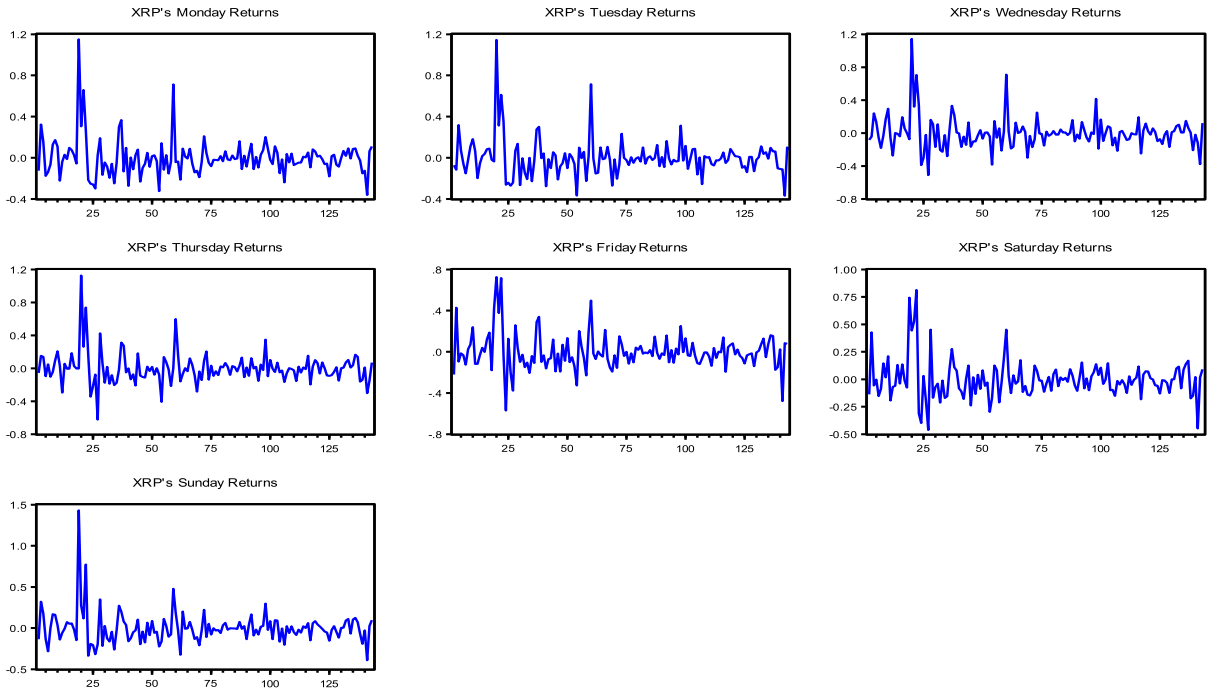


**Exhibit 8: Plot of Day-wise XRP's Returns**

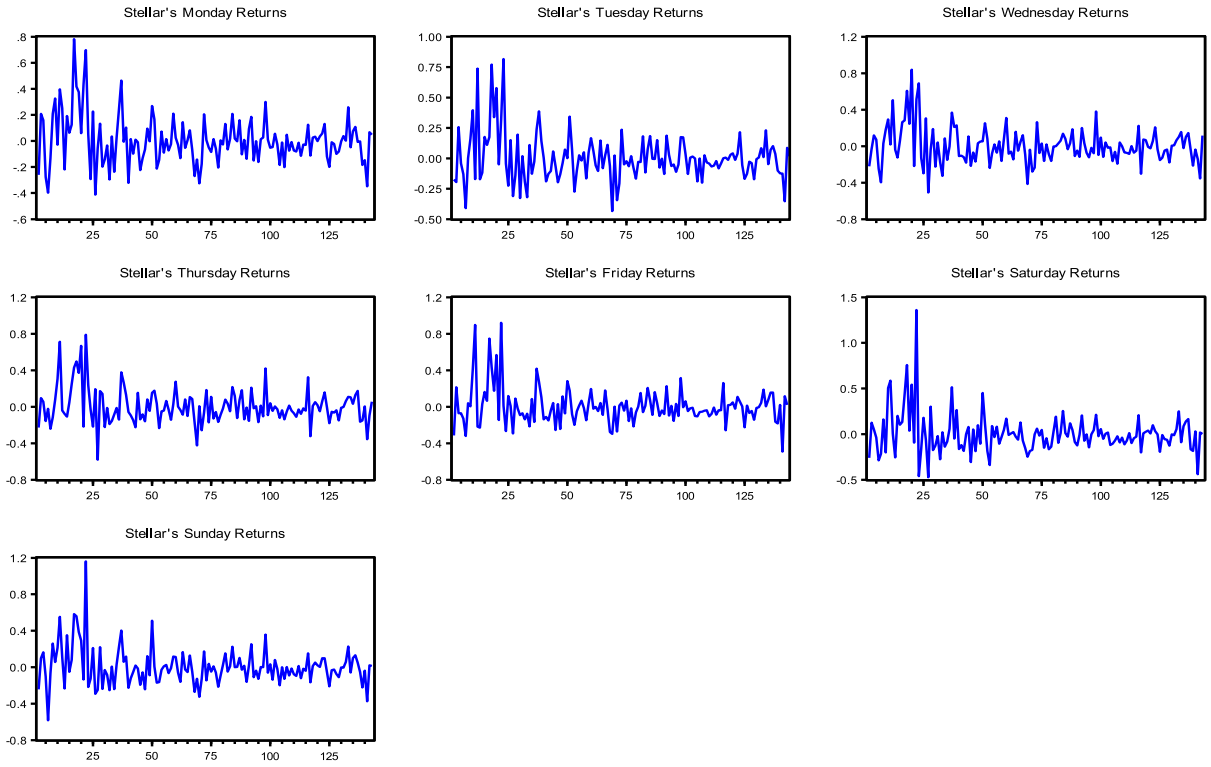


**Exhibit 9: Plot of Day-wise Stellar's Returns**

The graphical presentations in exhibits 1 to 9 for daily and day-wise returns of cryptocurrencies indicate the stationarity of all the returns series. Ng-Perron tests and augmented Dickey–Fuller test are further applied to Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series to examine stationarity. The table 2 indicates the results of these unit root tests for Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series.

**Table 2: Results of Unit Root Tests on Cryptocurrencies' Return Series**

| **Cryptocurrency's Returns** | **Ng-Perron Tests** | | | | **Augmented Dickey–Fuller Test** | |
|---|---|---|---|---|---|---|
| **Bitcoin Returns** | **MZa** | **MZt** | **MSB** | **MPT** | **t-Statistic** | **Prob.*** |
| Monday Returns | -69.08 | -5.87 | 0.09 | 0.36 | -11.12 | 0.00 |
| Tuesday Returns | -30.45 | -3.90 | 0.13 | 0.82 | -10.62 | 0.00 |
| Wednesday Returns | -39.28 | -4.28 | 0.11 | 1.04 | -10.61 | 0.00 |
| Thursday Returns | -61.33 | -5.48 | 0.09 | 0.55 | -10.40 | 0.00 |
| Friday Returns | -19.29 | -3.07 | 0.16 | 1.39 | -10.78 | 0.00 |
| Saturday Returns | -1.52 | -0.78 | 0.52 | 14.41 | -12.77 | 0.00 |
| Sunday Returns | -1.62 | -0.82 | 0.51 | 13.82 | -12.36 | 0.00 |
| Overall Returns | -499.32 | -15.80 | 0.03 | 0.05 | -30.60 | 0.00 |
| **EOS Returns** | | | | | | |
| Monday Returns | -22.92 | -3.37 | 0.15 | 1.12 | -10.98 | 0.00 |
| Tuesday Returns | -39.77 | -4.46 | 0.11 | 0.62 | -6.66 | 0.00 |
| Wednesday Returns | -40.92 | -4.49 | 0.11 | 0.70 | -6.52 | 0.00 |
| Thursday Returns | -41.06 | -4.51 | 0.11 | 0.65 | -9.83 | 0.00 |
| Friday Returns | -32.21 | -4.01 | 0.12 | 0.78 | -10.63 | 0.00 |
| Saturday Returns | -40.03 | -4.47 | 0.11 | 0.62 | -9.93 | 0.00 |
| Sunday Returns | -17.67 | -2.96 | 0.17 | 1.42 | -11.01 | 0.00 |
| Overall Returns | -27.38 | -3.68 | 0.13 | 0.95 | -31.49 | 0.00 |
| **Ethereum Returns** | | | | | | |
| Monday Returns | -69.73 | -5.90 | 0.08 | 0.36 | -11.28 | 0.00 |
| Tuesday Returns | -1.60 | -0.83 | 0.51 | 14.02 | -11.38 | 0.00 |
| Wednesday Returns | -17.64 | -2.86 | 0.16 | 1.80 | -10.60 | 0.00 |
| Thursday Returns | -9.08 | -2.05 | 0.23 | 3.00 | -10.83 | 0.00 |
| Friday Returns | -15.19 | -2.74 | 0.18 | 1.69 | -10.96 | 0.00 |
| Saturday Returns | -5.21 | -1.57 | 0.30 | 4.83 | -11.61 | 0.00 |
| Sunday Returns | -5.03 | -1.53 | 0.30 | 5.01 | -12.41 | 0.00 |
| Overall Returns | -499.89 | -15.81 | 0.03 | 0.05 | -31.53 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Bitcoin Cash Returns** | | | | | | |
| Monday Returns | -5.31 | -1.62 | 0.31 | 4.63 | -9.90 | 0.00 |
| Tuesday Returns | -2.21 | -0.98 | 0.44 | 10.51 | -9.62 | 0.00 |
| Wednesday Returns | -4.16 | -1.44 | 0.35 | 5.89 | -9.34 | 0.00 |
| Thursday Returns | -69.99 | -5.90 | 0.08 | 0.38 | -9.72 | 0.00 |
| Friday Returns | -69.99 | -5.90 | 0.08 | 0.38 | -9.12 | 0.00 |
| Saturday Returns | -70.39 | -5.93 | 0.08 | 0.35 | -9.28 | 0.00 |
| Sunday Returns | -1.63 | -0.81 | 0.50 | 13.41 | -9.35 | 0.00 |
| Overall Returns | -46.78 | -4.84 | 0.10 | 0.53 | -28.65 | 0.00 |
| **Litecoin Returns** | | | | | | |
| Monday Returns | -70.29 | -5.93 | 0.08 | 0.35 | -11.17 | 0.00 |
| Tuesday Returns | -70.59 | -5.94 | 0.08 | 0.35 | -10.99 | 0.00 |
| Wednesday Returns | -69.95 | -5.89 | 0.08 | 0.40 | -10.76 | 0.00 |
| Thursday Returns | -68.81 | -5.86 | 0.09 | 0.37 | -10.08 | 0.00 |
| Friday Returns | -43.37 | -4.65 | 0.11 | 0.58 | -11.37 | 0.00 |
| Saturday Returns | -68.84 | -5.86 | 0.09 | 0.36 | -11.25 | 0.00 |
| Sunday Returns | -69.29 | -5.88 | 0.08 | 0.36 | -11.16 | 0.00 |
| Overall Returns | -498.66 | -15.79 | 0.03 | 0.05 | -30.94 | 0.00 |
| **Tether Returns** | | | | | | |
| Monday Returns | -139.74 | -8.35 | 0.06 | 0.18 | -14.28 | 0.00 |
| Tuesday Returns | -199.80 | -99.91 | 0.01 | 0.00 | -8.15 | 0.00 |
| Wednesday Returns | -1.11 | -0.63 | 0.57 | 17.73 | -11.07 | 0.00 |
| Thursday Returns | -131.58 | -8.11 | 0.06 | 0.19 | -11.86 | 0.00 |
| Friday Returns | -109.47 | -7.40 | 0.07 | 0.23 | -11.97 | 0.00 |
| Saturday Returns | -118.49 | -7.69 | 0.06 | 0.22 | -10.45 | 0.00 |
| Sunday Returns | -113.12 | -7.52 | 0.07 | 0.22 | -13.91 | 0.00 |
| Overall Returns | -303.00 | -389.6 | 0.00 | 0.00 | -22.47 | 0.00 |
| **XRP Returns** | | | | | | |
| Monday Returns | -42.14 | -4.56 | 0.11 | 0.65 | -9.73 | 0.00 |
| Tuesday Returns | -66.27 | -5.75 | 0.09 | 0.39 | -9.66 | 0.00 |
| Wednesday Returns | -67.95 | -5.81 | 0.09 | 0.40 | -10.39 | 0.00 |
| Thursday Returns | -68.77 | -5.86 | 0.09 | 0.37 | -10.43 | 0.00 |
| Friday Returns | -16.23 | -2.81 | 0.17 | 1.67 | -10.35 | 0.00 |
| Saturday Returns | -61.96 | -5.55 | 0.09 | 0.44 | -10.05 | 0.00 |
| Sunday Returns | -26.24 | -3.60 | 0.14 | 1.02 | -11.10 | 0.00 |
| Overall Returns | -45.94 | -4.78 | 0.10 | 0.56 | -29.83 | 0.00 |

| **Stellar Returns** | | | | | | |
|---|---|---|---|---|---|---|
| Monday Returns | -12.93 | -2.51 | 0.19 | 2.04 | -9.24 | 0.00 |
| Tuesday Returns | -17.02 | -2.90 | 0.17 | 1.50 | -10.26 | 0.00 |
| Wednesday Returns | -12.66 | -2.46 | 0.19 | 2.15 | -4.86 | 0.00 |
| Thursday Returns | -15.82 | -2.78 | 0.18 | 1.67 | -6.43 | 0.00 |
| Friday Returns | -10.83 | -2.29 | 0.21 | 2.40 | -6.95 | 0.00 |
| Saturday Returns | -6.88 | -1.83 | 0.27 | 3.66 | -7.26 | 0.00 |
| Sunday Returns | -12.43 | -2.47 | 0.20 | 2.06 | -10.92 | 0.00 |
| Overall Returns | -14.84 | -2.70 | 0.18 | 1.74 | -30.51 | 0.00 |
| **Asymptotic critical values at 0.05*** | -8.10 | -1.98 | 0.23 | 3.17 | - | - |

Source: Author's Calculations *MacKinnon (1996) one-sided p-values

The results of the Ng-Perron tests in table 2 clearly indicate that, for the Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar return series, the null hypothesis of non-stationary cannot be accepted. The results of augmented Dickey–Fuller test complement the results of Ng-Perron tests. The null hypothesis that returns of Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar have unit root is rejected as the probability value of augmented Dickey–Fuller test for returns of all cryptocurrencies is equal to zero.

## DAY OF THE WEEK EFFECT ON CRYPTOCURRENCIES' RETURNS AND VOLATILITY

The day of the week effect on cryptocurrencies' returns is studied by introducing the dummies for each day of the week in the ordinary least square regression equation. Table 3 displays the results of the ordinary least square regression with dummies.

**Table 3: Estimates of the Ordinary Least Square Regression with Dummies**

| Dependent Variable: **Bitcoin Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.002351 | 0.003589 | 0.655148 | 0.5125 |
| DT | 0.001305 | 0.003589 | 0.363604 | 0.7162 |
| DW | -0.000692 | 0.003589 | -0.192814 | 0.8471 |
| DTH | -0.002577 | 0.003589 | -0.718087 | 0.4729 |
| DF | 0.002536 | 0.003589 | 0.706585 | 0.4800 |
| DS | 0.005192 | 0.003589 | 1.446496 | 0.1484 |
| DSU | -0.001803 | 0.003589 | -0.502331 | 0.6155 |

| Dependent Variable: **EOS Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | -0.000818 | 0.005840 | -0.140016 | 0.8887 |
| DT | 0.006768 | 0.005840 | 1.159046 | 0.2467 |
| DW | -0.009459 | 0.005840 | -1.619870 | 0.1056 |
| DTH | -0.010862 | 0.005840 | -1.860137 | 0.0632 |
| DF | 0.010092 | 0.005840 | 1.728119 | 0.0843 |
| DS | 0.010278 | 0.005840 | 1.760050 | 0.0787 |
| DSU | -0.004716 | 0.005840 | -0.807519 | 0.4196 |
| Dependent Variable: **Ethereum Returns** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | -0.002958 | 0.004419 | -0.669331 | 0.5034 |
| DT | 0.002950 | 0.004419 | 0.667652 | 0.5045 |
| DW | -0.004688 | 0.004419 | -1.060877 | 0.2890 |
| DTH | -0.009575 | 0.004419 | -2.166723 | 0.0305 |
| DF | 0.003913 | 0.004419 | 0.885536 | 0.3761 |
| DS | 0.007368 | 0.004419 | 1.667411 | 0.0957 |
| DSU | -0.001879 | 0.004419 | -0.425320 | 0.6707 |
| Dependent Variable: **Bitcoin Cash Returns** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.007617 | 0.006468 | 1.177555 | 0.2393 |
| DT | 0.010151 | 0.006468 | 1.569355 | 0.1169 |
| DW | -0.000446 | 0.006468 | -0.068901 | 0.9451 |
| DTH | -0.013757 | 0.006468 | -2.126819 | 0.0337 |
| DF | 0.002237 | 0.006468 | 0.345871 | 0.7295 |
| DS | 0.004400 | 0.006468 | 0.680255 | 0.4965 |
| DSU | -0.009858 | 0.006468 | -1.524098 | 0.1278 |
| Dependent Variable: **Litecoin Returns** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.003213 | 0.004879 | 0.658558 | 0.5103 |
| DT | 0.009837 | 0.004879 | 2.016385 | 0.0440 |
| DW | -0.003034 | 0.004879 | -0.621932 | 0.5341 |
| DTH | -0.008999 | 0.004879 | -1.844448 | 0.0654 |
| DF | 0.007573 | 0.004879 | 1.552199 | 0.1209 |
| DS | -0.001499 | 0.004879 | -0.307260 | 0.7587 |
| DSU | -0.008228 | 0.004879 | -1.686579 | 0.0920 |

| Dependent Variable: **Tether Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.000128 | 0.000426 | 0.301357 | 0.7632 |
| DT | 0.000946 | 0.000426 | 2.220157 | 0.0266 |
| DW | -0.000650 | 0.000426 | -1.525202 | 0.1275 |
| DTH | -0.000957 | 0.000426 | -2.245496 | 0.0250 |
| DF | 0.000837 | 0.000426 | 1.964437 | 0.0498 |
| DS | -0.000119 | 0.000426 | -0.278169 | 0.7809 |
| DSU | -0.000166 | 0.000426 | -0.388766 | 0.6975 |
| Dependent Variable: **XRP Returns** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.003420 | 0.005161 | 0.662600 | 0.5077 |
| DT | 0.001728 | 0.005161 | 0.334845 | 0.7378 |
| DW | -0.002897 | 0.005161 | -0.561404 | 0.5746 |
| DTH | -0.009055 | 0.005161 | -1.754640 | 0.0796 |
| DF | 0.003005 | 0.005161 | 0.582329 | 0.5605 |
| DS | 0.000774 | 0.005161 | 0.149930 | 0.8809 |
| DSU | 0.002593 | 0.005161 | 0.502517 | 0.6154 |
| Dependent Variable: **Stellar Returns** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| DM | 0.003092 | 0.005903 | 0.523773 | 0.6006 |
| DT | 0.005720 | 0.005903 | 0.969024 | 0.3328 |
| DW | -0.003652 | 0.005903 | -0.618730 | 0.5362 |
| DTH | 0.002425 | 0.005903 | 0.410758 | 0.6813 |
| DF | 0.004625 | 0.005903 | 0.783572 | 0.4335 |
| DS | 0.002032 | 0.005903 | 0.344233 | 0.7307 |
| DSU | -0.010542 | 0.005903 | -1.785938 | 0.0744 |

Source: Author's Calculations

The coefficients for Wednesday, Thursday and Sunday are negative for all cryptocurrencies except XRP in which the coefficient is positive for Sunday and Stellar in which the coefficient is positive for Thursday. The coefficients for all other days are positive except Monday for EOS and Ethereum; Saturday for Litecoin and Tether additionally. The coefficients for all days of week in case of Bitcoin, EOS, XRP and Stellar are not statistically different from zero as the probability values of the estimated t values are higher than 0.05. However, the coefficients for Thursday are statistically different from zero as the probability values of the estimated t values in case of Ethereum, Bitcoin Cash and Tether are less than 0.05. Additionally, the coefficient for Tuesday are also statistically different from zero in case of Litecoin and Tether as the probability values of the estimated t values are less than 0.05. The residuals obtained from the ordinary least square regression equation are tested for ARCH effect. The results of Engle's ARCH are portrayed in table 4.

**Table 4: Results of Engle's ARCH Test**

| | | | | |
|---|---|---|---|---|
| **Bitcoin Returns** | F-statistic | 36.56424 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 35.34264 | Prob. Chi-Square(1) | 0.0000 |
| **EOS Returns** | F-statistic | 7.575753 | Prob. F(1,998) | 0.0060 |
| | Obs*R-squared | 7.533747 | Prob. Chi-Square(1) | 0.0061 |
| **Ethereum Returns** | F-statistic | 50.94110 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 48.56431 | Prob. Chi-Square(1) | 0.0000 |
| **Bitcoin Cash Returns** | F-statistic | 66.91476 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 62.83579 | Prob. Chi-Square(1) | 0.0000 |
| **Litecoin Returns** | F-statistic | 138.4463 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 121.8239 | Prob. Chi-Square(1) | 0.0000 |
| **Tether Returns** | F-statistic | 120.4855 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 107.7220 | Prob. Chi-Square(1) | 0.0000 |
| **XRP Returns** | F-statistic | 32.66909 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 31.69697 | Prob. Chi-Square(1) | 0.0000 |
| **Stellar Returns** | F-statistic | 38.59606 | Prob. F(1,998) | 0.0000 |
| | Obs*R-squared | 37.23346 | Prob. Chi-Square(1) | 0.0000 |

Source: Author's Calculations

The resultant value of Obs*R-squared from Engle's ARCH are significant as the probability values are less than 0.05 in all cryptocurrencies' return series. The results of this test confirm the presence of heteroskedasticity in cryptocurrencies' returns. So, the GARCH (1,1) model is applied to account for the ARCH effect. The results of GARCH (1,1) model on all cryptocurrencies returns are portrayed in table 5.

**Table 5: Estimation of GARCH Model on Cryptocurrencies' Returns Series**

| Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)<br>GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1) | | | | |
|---|---|---|---|---|
| Dependent Variable: **Bitcoin Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | -0.000370 | 0.002683 | -0.137983 | 0.8903 |
| DT | 0.003206 | 0.002747 | 1.166977 | 0.2432 |
| DW | -0.004085 | 0.002666 | -1.532368 | 0.1254 |
| DTH | -0.001819 | 0.002516 | -0.722827 | 0.4698 |
| DF | 0.002062 | 0.002958 | 0.696981 | 0.4858 |
| DS | 0.004458 | 0.003564 | 1.250882 | 0.2110 |
| DSU | -0.001377 | 0.003439 | -0.400307 | 0.6889 |
| Variance Equation | | | | |
| C | 0.000113 | 0.000015 | 7.526421 | 0.0000 |
| RESID(-1)^2 | 0.158277 | 0.017533 | 9.027182 | 0.0000 |
| GARCH(-1) | 0.790124 | 0.020144 | 39.22364 | 0.0000 |

| Dependent Variable: **EOS Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.002359 | 0.004861 | 0.485257 | 0.6275 |
| DT | 0.003506 | 0.004623 | 0.758286 | 0.4483 |
| DW | -0.008194 | 0.005037 | -1.626875 | 0.1038 |
| DTH | -0.015221 | 0.003789 | -4.017469 | 0.0001 |
| DF | 0.007062 | 0.005084 | 1.389050 | 0.1648 |
| DS | 0.008426 | 0.004354 | 1.935019 | 0.0530 |
| DSU | -0.004717 | 0.004640 | -1.016717 | 0.3093 |
| Variance Equation | | | | |
| C | 0.000032 | 0.000007 | 4.366056 | 0.0000 |
| RESID(-1)^2 | 0.045573 | 0.005050 | 9.024968 | 0.0000 |
| GARCH(-1) | 0.949763 | 0.004500 | 211.0747 | 0.0000 |
| Dependent Variable: **Ethereum Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | -0.000692 | 0.003671 | -0.188508 | 0.8505 |
| DT | 0.001905 | 0.003423 | 0.556466 | 0.5779 |
| DW | -0.007030 | 0.003463 | -2.030306 | 0.0423 |
| DTH | -0.012394 | 0.003336 | -3.715557 | 0.0002 |
| DF | 0.004938 | 0.003720 | 1.327413 | 0.1844 |
| DS | 0.006111 | 0.004889 | 1.250016 | 0.2113 |
| DSU | -0.000160 | 0.004228 | -0.037776 | 0.9699 |
| Variance Equation | | | | |
| C | 0.000109 | 0.000021 | 5.136355 | 0.0000 |
| RESID(-1)^2 | 0.093904 | 0.011521 | 8.150303 | 0.0000 |
| GARCH(-1) | 0.867703 | 0.015098 | 57.47183 | 0.0000 |
| Dependent Variable: **Bitcoin Cash Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.007617 | 0.011593 | 0.657033 | 0.5112 |
| DT | 0.010151 | 0.019061 | 0.532545 | 0.5943 |
| DW | -0.000446 | 0.017157 | -0.025976 | 0.9793 |
| DTH | -0.013757 | 0.014046 | -0.979378 | 0.3274 |
| DF | 0.002237 | 0.012195 | 0.183443 | 0.8545 |
| DS | 0.004400 | 0.013752 | 0.319958 | 0.7490 |
| DSU | -0.009858 | 0.011271 | -0.874644 | 0.3818 |
| Variance Equation | | | | |
| C | 0.003862 | 0.001252 | 3.083601 | 0.0020 |
| RESID(-1)^2 | 0.150000 | 0.047980 | 3.126302 | 0.0018 |
| GARCH(-1) | 0.600000 | 0.114884 | 5.222644 | 0.0000 |

| Dependent Variable: **Litecoin Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.002266 | 0.003794 | 0.597455 | 0.5502 |
| DT | 0.004779 | 0.004666 | 1.024275 | 0.3057 |
| DW | -0.003844 | 0.004911 | -0.782728 | 0.4338 |
| DTH | -0.013255 | 0.004209 | -3.149270 | 0.0016 |
| DF | 0.006687 | 0.003753 | 1.781653 | 0.0748 |
| DS | 0.002022 | 0.004286 | 0.471876 | 0.6370 |
| DSU | -0.002952 | 0.004038 | -0.731001 | 0.4648 |
| Variance Equation | | | | |
| C | 0.000258 | 0.000037 | 6.884545 | 0.0000 |
| RESID(-1)^2 | 0.109784 | 0.015306 | 7.172500 | 0.0000 |
| GARCH(-1) | 0.813350 | 0.021870 | 37.19080 | 0.0000 |
| Dependent Variable: **Tether Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 7.91E-05 | 0.000291 | 0.272064 | 0.7856 |
| DT | 0.000345 | 0.000234 | 1.472302 | 0.1409 |
| DW | -0.000182 | 0.000175 | -1.035811 | 0.3003 |
| DTH | -0.000201 | 0.000231 | -0.869880 | 0.3844 |
| DF | 0.000388 | 0.000212 | 1.828791 | 0.0674 |
| DS | 0.000187 | 0.000204 | 0.916918 | 0.3592 |
| DSU | -0.000216 | 0.000228 | -0.945111 | 0.3446 |
| Variance Equation | | | | |
| C | 4.22E-07 | 0.00000005 | 8.472523 | 0.0000 |
| RESID(-1)^2 | 0.200627 | 0.013952 | 14.37999 | 0.0000 |
| GARCH(-1) | 0.804459 | 0.010165 | 79.13721 | 0.0000 |
| Dependent Variable: **XRP Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.001743 | 0.003621 | 0.481487 | 0.6302 |
| DT | 0.001659 | 0.003603 | 0.460290 | 0.6453 |
| DW | -0.005599 | 0.003511 | -1.594912 | 0.1107 |
| DTH | -0.007410 | 0.002979 | -2.487655 | 0.0129 |
| DF | 0.003073 | 0.003093 | 0.993581 | 0.3204 |
| DS | -0.000216 | 0.003321 | -0.065072 | 0.9481 |
| DSU | -0.005333 | 0.003777 | -1.411861 | 0.1580 |
| Variance Equation | | | | |
| C | 8.40E-05 | 0.000010 | 8.101962 | 0.0000 |
| RESID(-1)^2 | 0.135047 | 0.010841 | 12.45688 | 0.0000 |
| GARCH(-1) | 0.851206 | 0.009615 | 88.52745 | 0.0000 |

| Dependent Variable: **Stellar Returns** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.002820 | 0.004910 | 0.574327 | 0.5657 |
| DT | -0.003722 | 0.004147 | -0.897585 | 0.3694 |
| DW | -0.000851 | 0.003896 | -0.218468 | 0.8271 |
| DTH | -0.008826 | 0.003893 | -2.267259 | 0.0234 |
| DF | 0.002495 | 0.004414 | 0.565279 | 0.5719 |
| DS | -0.000205 | 0.004628 | -0.044299 | 0.9647 |
| DSU | -0.009417 | 0.004291 | -2.194481 | 0.0282 |
| Variance Equation | | | | |
| C | 0.000062 | 0.000011 | 5.451494 | 0.0000 |
| RESID(-1)^2 | 0.075810 | 0.011177 | 6.782549 | 0.0000 |
| GARCH(-1) | 0.911761 | 0.011303 | 80.66761 | 0.0000 |

Source: Author's Calculations

The probability values are zero for both GARCH term and ARCH term in all cryptocurrencies return series except for Bitcoin Cash. However, the probability value is less than 0.05 in the case of Bitcoin Cash. So, the GARCH term as well as ARCH term are significant in all cryptocurrencies return series. This proven significance of ARCH and GARCH terms clearly indicates the time varying and persistent volatility in case of all cryptocurrencies' returns. It also indicates that recent past information and future estimation have been creating a positive and significant impact on the cryptocurrencies' volatility. The day-wise returns for some week days are positive and for others are negative. The coefficients for Wednesday, Thursday and Sunday are negative for all cryptocurrencies. The coefficients for all other days are positive except Monday for Bitcoin and Ethereum; Saturday for Stellar and XRP; Tuesday for Stellar additionally. The coefficients for all days of week in case of Bitcoin, Bitcoin Cash and Tether are not statistically different from zero as the probability values of the estimated z values are higher than 0.05. However, the coefficients for Thursday are statistically different from zero as the probability values of the estimated z values in case of EOS, Ethereum, Litecoin, XRP and Stellar are less than 0.05. Additionally, the coefficients for Wednesday in case of Ethereum and Sunday in case of Stellar are also statistically different from zero as the probability values of the estimated z values are less than 0.05. So, the estimation of GARCH model confirms the absence of the day of week effect in the returns of Bitcoin, Bitcoin Cash and Tether. The estimation further highlights the presence of the Thursday effect in the returns of EOS, Ethereum, Litecoin, XRP and Stellar. The Wednesday effect is also present in case of Ethereum returns and the Sunday effect in Stellar returns. Note that the day of week effect is present in the volatility of all cryptocurrencies. The PARCH model is further applied to account for ARCH effect. The results of PARCH model are portrayed in table 6.

**Table 6: Estimation of PARCH Model on Cryptocurrencies' Returns Series**

| Equation: @SQRT(GARCH) = C(8) + C(9)*(ABS(RESID(-1)) - C(10)*RESID(-1)) + C(11)*@SQRT(GARCH(-1)) | | | | |
|---|---|---|---|---|
| Dependent Variable: **Bitcoin Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | -0.003182 | 0.002398 | -1.326975 | 0.1845 |
| DT | 0.000616 | 0.002648 | 0.232687 | 0.8160 |
| DW | -0.003812 | 0.002484 | -1.534623 | 0.1249 |
| DTH | -0.000958 | 0.002406 | -0.398377 | 0.6904 |
| DF | 0.001388 | 0.002956 | 0.469472 | 0.6387 |
| DS | 0.006405 | 0.003361 | 1.905642 | 0.0567 |
| DSU | -0.001194 | 0.002352 | -0.507588 | 0.6117 |
| Variance Equation | | | | |
| C(8) | 0.003437 | 0.000460 | 7.477713 | 0.0000 |
| C(9) | 0.170175 | 0.015706 | 10.83492 | 0.0000 |
| C(10) | 0.095166 | 0.045128 | 2.108831 | 0.0350 |
| C(11) | 0.798642 | 0.019422 | 41.11950 | 0.0000 |
| Dependent Variable: **EOS Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.002918 | 0.004695 | 0.621608 | 0.5342 |
| DT | 0.002383 | 0.004118 | 0.578646 | 0.5628 |
| DW | -0.006071 | 0.004489 | -1.352387 | 0.1763 |
| DTH | -0.013174 | 0.003856 | -3.416240 | 0.0006 |
| DF | 0.006642 | 0.004716 | 1.408239 | 0.1591 |
| DS | 0.008892 | 0.004130 | 2.152798 | 0.0313 |
| DSU | -0.003254 | 0.004655 | -0.699178 | 0.4844 |
| Variance Equation | | | | |
| C(8) | 0.000607 | 0.000146 | 4.141789 | 0.0000 |
| C(9) | 0.062820 | 0.005993 | 10.48241 | 0.0000 |
| C(10) | 0.038356 | 0.062505 | 0.613641 | 0.5395 |
| C(11) | 0.948602 | 0.004626 | 205.0539 | 0.0000 |
| Dependent Variable: **Ethereum Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.001126 | 0.003649 | 0.308473 | 0.7577 |
| DT | 0.003175 | 0.003292 | 0.964379 | 0.3349 |
| DW | -0.006726 | 0.003374 | -1.993195 | 0.0462 |
| DTH | -0.012896 | 0.003395 | -3.799083 | 0.0001 |
| DF | 0.002617 | 0.003572 | 0.732434 | 0.4639 |
| DS | 0.004884 | 0.004782 | 1.021329 | 0.3071 |
| DSU | -0.002281 | 0.003648 | -0.625347 | 0.5317 |

| Variance Equation | | | | |
|---|---|---|---|---|
| C(8) | 0.002478 | 0.000421 | 5.879581 | 0.0000 |
| C(9) | 0.103481 | 0.011584 | 8.932809 | 0.0000 |
| C(10) | 0.077431 | 0.062758 | 1.233801 | 0.2173 |
| C(11) | 0.877884 | 0.013682 | 64.16254 | 0.0000 |
| Dependent Variable: **Bitcoin Cash Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.005883 | 0.005141 | 1.144434 | 0.2524 |
| DT | 0.010465 | 0.005553 | 1.884654 | 0.0595 |
| DW | -0.006004 | 0.005180 | -1.159064 | 0.2464 |
| DTH | -0.011700 | 0.004462 | -2.622262 | 0.0087 |
| DF | 0.003458 | 0.004265 | 0.810920 | 0.4174 |
| DS | -0.001627 | 0.004979 | -0.326883 | 0.7438 |
| DSU | -0.006095 | 0.004854 | -1.255713 | 0.2092 |
| Variance Equation | | | | |
| C(8) | 0.003503 | 0.000457 | 7.673098 | 0.0000 |
| C(9) | 0.112619 | 0.011029 | 10.21070 | 0.0000 |
| C(10) | -0.150291 | 0.055216 | -2.721868 | 0.0065 |
| C(11) | 0.876467 | 0.011554 | 75.86027 | 0.0000 |
| Dependent Variable: **Litecoin Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.001139 | 0.003585 | 0.317696 | 0.7507 |
| DT | 0.004308 | 0.004196 | 1.026498 | 0.3047 |
| DW | -0.006362 | 0.004252 | -1.496180 | 0.1346 |
| DTH | -0.017214 | 0.003672 | -4.687538 | 0.0000 |
| DF | 0.007990 | 0.003542 | 2.255800 | 0.0241 |
| DS | 0.003407 | 0.003975 | 0.857221 | 0.3913 |
| DSU | -0.001602 | 0.003675 | -0.436067 | 0.6628 |
| Variance Equation | | | | |
| C(8) | 0.005282 | 0.000802 | 6.586818 | 0.0000 |
| C(9) | 0.153350 | 0.015744 | 9.740125 | 0.0000 |
| C(10) | 0.081241 | 0.058724 | 1.383442 | 0.1665 |
| C(11) | 0.797755 | 0.022737 | 35.08556 | 0.0000 |
| Dependent Variable: **Tether Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.000441 | 0.000245 | 1.802368 | 0.0715 |
| DT | 0.000895 | 0.000209 | 4.277202 | 0.0000 |
| DW | -0.000574 | 0.000213 | -2.700716 | 0.0069 |
| DTH | -0.000196 | 0.000172 | -1.139146 | 0.2546 |
| DF | 0.000533 | 0.000174 | 3.069373 | 0.0021 |
| DS | 0.000534 | 0.000217 | 2.458153 | 0.0140 |
| DSU | -0.000522 | 0.000207 | -2.517731 | 0.0118 |

| Variance Equation | | | | |
|---|---|---|---|---|
| C(8) | 0.000174 | 0.000024 | 7.104144 | 0.0000 |
| C(9) | 0.231504 | 0.013896 | 16.65957 | 0.0000 |
| C(10) | 0.118835 | 0.052446 | 2.265852 | 0.0235 |
| C(11) | 0.805452 | 0.010579 | 76.14014 | 0.0000 |
| Dependent Variable: **XRP Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.003400 | 0.003160 | 1.075846 | 0.2820 |
| DT | 0.002222 | 0.003051 | 0.728482 | 0.4663 |
| DW | -0.006335 | 0.002946 | -2.150614 | 0.0315 |
| DTH | -0.006450 | 0.002770 | -2.328733 | 0.0199 |
| DF | 0.005174 | 0.002808 | 1.842579 | 0.0654 |
| DS | 0.001788 | 0.003025 | 0.591123 | 0.5544 |
| DSU | -0.002491 | 0.003148 | -0.791269 | 0.4288 |
| Variance Equation | | | | |
| C(8) | 0.002651 | 0.000270 | 9.816776 | 0.0000 |
| C(9) | 0.195436 | 0.013483 | 14.49530 | 0.0000 |
| C(10) | -0.232443 | 0.048458 | -4.796792 | 0.0000 |
| C(11) | 0.820641 | 0.011004 | 74.57576 | 0.0000 |
| Dependent Variable: **Stellar Returns** | | | | |
| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
| DM | 0.006991 | 0.004470 | 1.563980 | 0.1178 |
| DT | -0.004544 | 0.003965 | -1.146171 | 0.2517 |
| DW | -0.000724 | 0.003799 | -0.190591 | 0.8488 |
| DTH | -0.004262 | 0.003534 | -1.205892 | 0.2279 |
| DF | 0.003870 | 0.004247 | 0.911294 | 0.3621 |
| DS | -0.000793 | 0.004457 | -0.178025 | 0.8587 |
| DSU | -0.008985 | 0.003925 | -2.289499 | 0.0221 |
| Variance Equation | | | | |
| C(8) | 0.001282 | 0.000221 | 5.792488 | 0.0000 |
| C(9) | 0.088270 | 0.010557 | 8.361639 | 0.0000 |
| C(10) | -0.356145 | 0.077310 | -4.606749 | 0.0000 |
| C(11) | 0.915581 | 0.009536 | 96.00830 | 0.0000 |

Source: Author's Calculations

The squared GARCH term is significant in all cryptocurrencies return series as the probability value is zero for GARCH coefficient (11) in all cryptocurrencies return series. These results complement the results of GARCH model. The day-wise returns for some week days are positive and for others are negative. The coefficients for Wednesday, Thursday and Sunday are negative for all cryptocurrencies. The coefficients for all other days are positive except Monday for Bitcoin; Saturday for Bitcoin Cash and Stellar; Tuesday for Stellar additionally. The coefficients for all days of week in case of Bitcoin only are not statistically different from zero as the probability

| | | | |
|---|---|---|---|
| Schwarz criterion | -7.678774 | -8.379737 | -8.317082 |
| Hannan-Quinn criterion | -7.700055 | -8.410138 | -8.350523 |
| **XRP Returns** | | | |
| Akaike info criterion | -2.725603 | -3.142979 | -3.146205 |
| Schwarz criterion | -2.691276 | -3.093941 | -3.092262 |
| Hannan-Quinn criterion | -2.712557 | -3.124342 | -3.125704 |
| **Stellar Returns** | | | |
| Akaike info criterion | -2.456929 | -2.842959 | -2.856996 |
| Schwarz criterion | -2.422602 | -2.793920 | -2.803053 |
| Hannan-Quinn criterion | -2.443883 | -2.824322 | -2.836495 |

Source: Author's Calculations

A peculiar point to here is that the Akaike info criterion, Schwarz criterion and Hannan-Quinn criterion are lower in PARCH model estimation as compared to ordinary least squares estimation and GARCH model in case of EOS, Bitcoin Cash, XRP and Stellar return series. So, PARCH model fits better in EOS, Bitcoin Cash, XRP and Stellar return series. On the other hand, these values are lower in GARCH model estimation in case of Bitcoin, Ethereum, Litecoin and Tether return series. That is why, GARCH model fits better in Bitcoin, Ethereum, Litecoin and Tether return series.

## DISCUSSION

The calendar anomalies in terms of weekend effect, January effect, half of the month effect, turn of the month effect and holiday effect have been comprehensively studied in many matured as well as emerging stock markets. But there is lack of exploration of calendar anomalies in cryptocurrency sector. The present treatise is an attempt to study the day of the week effect in the crypto sector that will benefit the existing and potential investors in timing their transactions for hedging purpose. The results of the present study discard the volatility in returns as a constant and unconditional statistics. This result totally asserts to the findings of all previous studies by Crouhy et al. (1997), Kaur (2004), Robert et al. (2005), Pati Pratap (2006), Sarangi et al. (2006), Daal et al. (2007), Hourvouliades (2007), Ninga et al. (2009), Mahmud et al. (2011), Sinha (2012), Xue et al. (2012), Lin et al. (2013), Dangi (2014, 2015, 2017), Bouoiyour et al. (2015, 2016), Katsiampa (2017), Siwen (2018), Caporale et al. (2019). The results of the present treatise also affirm to the results of Gronwald (2014), Cheah et al. (2015), Bouoiyour et al. (2015, 2016), Letra (2016), Katsiampa (2017), Siwen (2018) and Dangi (2020) in terms of finding GARCH family as optimal fit model. The results of the present treatise also assert to the results of Fields (1931), Rozeff et al. (1976), French (1980), Gibbons et al. (1981), Brown et al. (1983), Smirlock et al. (1986), Cadsby et al. (1992), Mills et al. (1995), Berument et al. (2001), Fountas et al. (2002), Kiymaz et al. (2003), Joshi et al. (2005), Marrett et al. (2008), Parikh (2009), Silva (2010), Dash et al. (2011), Swinkels et al. (2012), Arora et al. (2013), Singal et al. (2014), Dangi (2014), Kurihara et al. (2017) in terms of the presence of calendar anomalies in several developed and emerging markets. However, the results of the present treatise are contrary to the results of Caporale et al. (2019) in terms of presence of anomaly in the returns of Bitcoin. The results of the present study are based on the daily return series of eight cryptocurrencies only and these results can be further upgraded by extending the methodology on more cryptocurrencies using high frequency data.

values of the estimated z values are higher than 0.05. However, the coefficients for Thursday are statistically different from zero as the probability values of the estimated z values in case of EOS, Ethereum, Bitcoin Cash, Litecoin and XRP are less than 0.05. Additionally, the coefficients for Wednesday in case of Ethereum, Tether and XRP; Friday in case of Litecoin and Tether; Saturday in case of EOS and Tether; Tuesday in case of Tether; and Sunday in case of Tether and Stellar are also statistically different from zero as the probability values of the estimated z values are less than 0.05. So, the estimation of PARCH model confirms the absence of the day of week effect in the returns of Bitcoin only. The estimation further highlights the presence of the Thursday effect in the returns of EOS, Ethereum, Bitcoin Cash, Litecoin and XRP. The Wednesday effect is present in case of Ethereum, Tether and XRP returns. The Sunday effect is present in Tether and Stellar returns; the Saturday effect is present in EOS and Tether; the Friday effect is present in Litecoin and Tether; and the Tuesday effect is present in Tether. In nutshell, the Bitcoin has no day of the week effect; EOS has the Thursday and the Saturday effect; Ethereum has the Wednesday and Thursday effect; Bitcoin Cash has the Thursday effect; Litecoin has the Thursday and Friday effect; Tether has Tuesday, Wednesday, Friday, Saturday and Sunday effect; XRP has the Wednesday and Thursday effect; Stellar has the Sunday effect. Note that the day of week effect is present in the volatility of all cryptocurrencies. Table 7 portrays the values of Akaike info criterion, Schwarz criterion and Hannan-Quinn criterion for estimation of ordinary least squares, GARCH and PARCH model to find the best fitted model.

**Table 7: Criteria of Ordinary Least Squares, GARCH Model and PARCH Model**

| Cryptocurrency Returns | Ordinary Least Squares | GARCH | PARCH |
|---|---|---|---|
| **Bitcoin Returns** | | | |
| Akaike info criterion | -3.451969 | -3.637286 | -3.636436 |
| Schwarz criterion | -3.417643 | -3.588248 | -3.582494 |
| Hannan-Quinn criterion | -3.438923 | -3.618649 | -3.615936 |
| **EOS Returns** | | | |
| Akaike info criterion | -2.478488 | -2.676971 | -2.683963 |
| Schwarz criterion | -2.444161 | -2.627932 | -2.630020 |
| Hannan-Quinn criterion | -2.465442 | -2.658333 | -2.663462 |
| **Ethereum Returns** | | | |
| Akaike info criterion | -3.035982 | -3.174669 | -3.170150 |
| Schwarz criterion | -3.001655 | -3.125630 | -3.116207 |
| Hannan-Quinn criterion | -3.022936 | -3.156032 | -3.149649 |
| **Bitcoin Cash Returns** | | | |
| Akaike info criterion | -2.274026 | -2.150496 | -2.485294 |
| Schwarz criterion | -2.239699 | -2.101457 | -2.431352 |
| Hannan-Quinn criterion | -2.260980 | -2.131859 | -2.464793 |
| **Litecoin Returns** | | | |
| Akaike info criterion | -2.838056 | -2.999525 | -2.996072 |
| Schwarz criterion | -2.803729 | -2.950486 | -2.942130 |
| Hannan-Quinn criterion | -2.825010 | -2.980888 | -2.975572 |
| **Tether Returns** | | | |
| Akaike info criterion | -7.713101 | -8.428775 | -8.371024 |

## CONCLUSION

The day of the week effect in returns and volatility of eight cryptocurrencies (viz. Bitcoin, EOS, Ethereum, Bitcoin Cash, Litecoin, Tether, XRP and Stellar) was studied by introducing the dummies for each day of the week in the ordinary least square regression equation. The residuals from the ordinary least square regression equation were then tested for ARCH effect using Engle's ARCH test. The results from the test confirmed the presence of ARCH effect in all series. So, the GARCH model and PARCH model were further applied to account for ARCH effect and the estimates from these models confirmed the presence of the day of the week effect in the returns of EOS, Ethereum, Bitcoin Cash, Litecoin, XRP and Stellar. However, there was no evidence of the day of week effect in the Bitcoin's and Tether's returns. The estimations of GARCH and PARCH model also affirmed the presence of the day of week effect in the volatility of all cryptocurrencies. The diagnostic checking confirmed that PARCH model is best fitted model in EOS, Bitcoin Cash, XRP and Stellar return series. And, GARCH model is best fitted in Bitcoin, Ethereum, Litecoin and Tether return series. The estimates from best fitted model confirmed that there is no day of week effect in Bitcoin's and Tether's returns. These results further confirmed the presence of the Thursday and Saturday effect in EOS's returns; the Wednesday and Thursday effect in the returns of Ethereum and XRP; the Thursday effect in returns of Bitcoin Cash and Litecoin; the Sunday effect in Stellar. In nutshell, the significant day of the week effect was present in all cryptocurrencies' returns and volatility but the significant day of the week effect was absent in Bitcoin and Tether returns. This presence of day of week effect indicates inefficiency in cryptocurrency markets. A peculiar point to note here is that the inefficiency of markets necessitates the use of technical and fundamental analysis by investors to beat the market as all information is not already reflected in their prices. The results of present treatise deny the efficient market hypothesis in cryptocurrency sector. The denial of efficient market hypothesis makes their prices predictable. So, investors should use technical and fundamental analysis to predict prices and utilise this inefficiency of cryptocurrency market by trading on it timely. These analyses may help the existing and potential investors in generating abnormal returns consistently by timing their transactions for hedging purpose. So, investors should opt for passive strategies rather than active strategies in case of these cryptocurrencies. These findings of significant day effect may help the existing and potential investors in taking investment decision in cryptocurrency sector in present scenario of uplift of ban in India. The results of the present treatise may also help the regulators in their decision regarding the intervention in the cryptocurrencies' market in order to avoid the build-up of bubbles.

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