Modeling the behavior of Bitcoin price for December 2022

(GEOMETRIC BROWNIAN MOTION)

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Submitted to

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I. Introduction

As a fellow Cryptocurrency holder, I do see cryptocurrencies as an alternative to current fiat currency in the future. When I heard that Brownian motion is used to predict the stock market. I knew I would want to see how Brownian motion was used to predict Bitcoin Price.

II. Background

Bitcoin is a virtual currency designed to act as money and a form of payment. Bitcoin was introduced to the public in 2009 by an anonymous developer or group of developers using the name Satoshi Nakamoto. At the current moment, one Bitcoin is worth $16,537.30 USD. Bitcoin is valuable because of its scarcity, decentralization, auditability, portability, and divisibility. As nydig article mentions Bitcoins' valuability is because:

Scarcity. Bitcoin's creator Satoshi Nakamoto intentionally limited the lifetime supply of Bitcoin to 21 million coins (More Bitcoins can't be made), which contributed to the high price of the coins. (gold)

Decentralization. After creating Bitcoin, creator Satoshi Nakamoto stepped away from the entire project, Bitcoin was placed into the hands of its users as a decentralized alternative to government currency. So i.o.w any movement of Bitcoin is made by a distributed network. Blockchain helps Bitcoin by allowing all the history

of bitcoin transactions to be stored and run by a database spread out among several networks at various locations, all while keeping its users anonymous.

Auditability:The Bitcoin blockchain ledger provides a permanent record of all transactions, and the open-source accessibility of the ledger allows anyone to view and verify previous or ongoing transactions and addresses.

Portability: Since it is digital it can be stored on any personal device or flash drive.

Divisibility:A single bitcoin can be broken down into one hundred-millionth of a bitcoin (1 satoshi = 0.00000001 BTC). Therefore, you can buy a small fraction of a Bitcoin to get started.

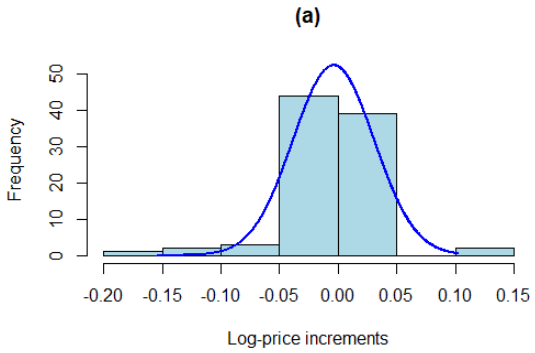
Bitcoin has become popular over the years and become valuable to many, but at the same time, Bitcoin has been viewed as negative by individuals. Making Countries prohibit the use of Bitcoin because of its negative impact on countries' economies. As said in the article Money, Since November 2021, nine countries have banned cryptocurrency completely. These countries are Algeria, Bangladesh, China, Egypt, Iraq, Morocco, Nepal, Qatar, and Tunisia. Meanwhile, 42 other countries have an implicit ban (prohibits banks and financial institutions managing Bitcoin). Some reason why countries have banned this virtual currency is the possibility of Black Markets use and Money Laundering. Since Bitcoin transactions can't be tracked by governments(because of its decentralization) they fear that it will be used illegally.

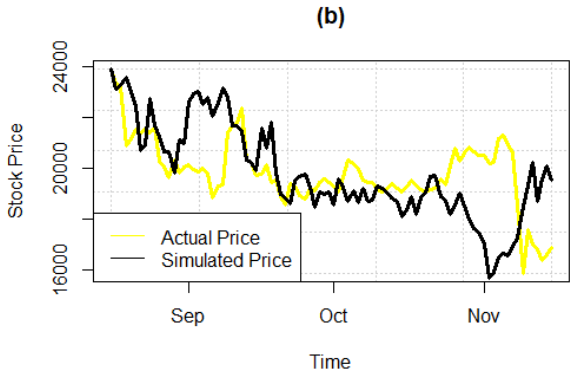
III. Data Description

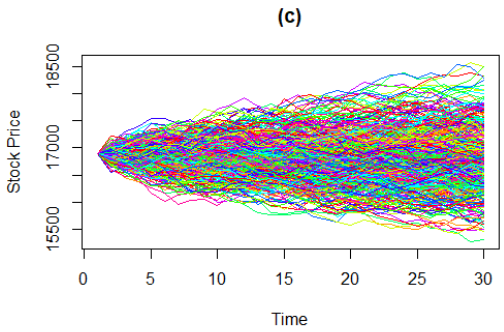
According to Investopedia, “The SEC(Securities and Exchange Commission) is a government agency responsible for protecting investors, maintaining fair and orderly functioning of the securities markets, and facilitating capital formation.”. In 2017, the SEC announced digital currencies would be regarded as securities. Bitcoin’s price surged more than 1,000 percent. On December 17th, 2017, bitcoin hit its all-time high of $20,000. Since then, the price has been volatile. Ranging over the years from dropping to $6,635.84 to an all-time high of $63,558 on April 12, 2021.

I took the liberty to get data from 8/16/2022 to 11/15/2022 to see how we can use that data to predict the price for the next month. I got the dataset from Yahoo Finance. Yahoo finance keeps track of Bitcoin’s price around the clock (24/7). The time that the data started being recorded starts at 9:30 am and ends at 4:00 pm every day. The variables that were used for this project were date and closing price.

IV. Results







A geometric Brownian motion is often used to model the behavior of a stock price over time. To find the drift coefficient which is represented by mu(μ) and the

standard deviation (σ) we have to estimate them based on our dataset. We do that by getting the log price increments of both the mean and standard deviation and from that, we get the estimated mean and standard deviation (the estimated mean is -.0038 and the standard deviation is .03).

In plot (a), the x-axis represents the Log-price increments, and the y-axis represents the Frequency. The histogram on (a) comes from the plotted estimated mean and estimated standard deviation. Here we conclude that the distribution can be assumed normal since a bell curve is formed to describe the density of the log price.

In plot (b) the x-axis was made to represent the time (from August 16th 2022 to November 15th 2022, each tick represents a month) and the y-axis as the Stock Price. The yellow-colored line-plot represents the actual price and the black colored line-plot represents the simulated price (which is a trajectory of a Geometric Brownian Motion simulation). We can see from the simulated price of Bitcoin that it captures most of the major increases and decreases in the actual price. Having a maximum peak between September and October. While also having a major drop in the month of November. While still, both have an average slope decline.

In plot (c) the x-axis was made to represent the time (November 15th 2022 till December 15th 2022, each tick represents days passed starting on November 15th) and the y-axis is the Stock Price. Plot (b) represents 500 simulations of Geometric Brownian motion to predict what will happen to the price in a month. From the plot, we can see that the best case scenario is that Bitcoin price reaches a price of $18,750 USD and the worst case scenario is that the price decreases to $15,250 USD.

V. Conclusion

The Bitcoin dataset was downloaded from Yahoo Finance from 8/16/2022 to 11/15/2022. From the histogram of the log-price increments, we see a bell-shaped curve. We conclude that the distribution can be assumed normal, and we calculate the estimated mean and variance to use as the drift and volatility coefficient for our Geometric Brownian Motion model. We see that our Geometric Brownian Motion model follows through the pattern of the actual dataset by putting both plots in the same graph. Which we finally created a Monte Carlo Simulation to model 500 Geometric Brownian motion trajectories to see what the price of Bitcoin will be in the next month. We seem to find that the maximum price Bitcoin can reach within a month is $18,750 USD and the lowest it can reach in the next month is approximately $15,250 USD.

VI. Appendix

```r
#Read data and Store in data variable
data<- read.csv(file="./BTC-USD.csv", header=TRUE, sep=",")
date<- as.POSIXct(data$Date)

price<- data$Close
data <- na.omit(data) # Remove NA if needed
data = subset(data, select = -c(2,3,4,6,7) )
```

Figure 1(a): R-code for reading the dataset BTC-USD and storing it in “data” variable.

```r
#calculating increments of log-price
log.inc<- c()
price1<- price[-1]
price1.lag<- head(price, -1)
log.ratio<- log(price1/price1.lag)
#plotting histogram
library(rcompanion)
plotNormalHistogram(log.ratio,main="(a)", xlab="Log-price increments",
                    col="light blue")
```

Figure 2(a): R-code for plotting a histogram of log-price increments.

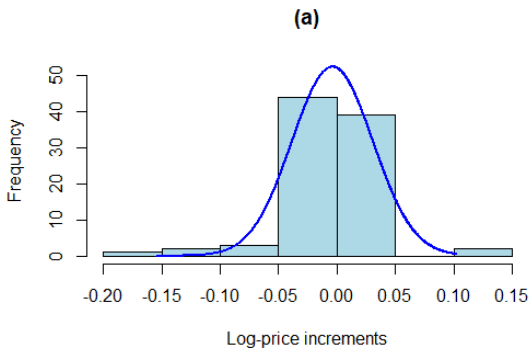


Figure 2(b): Output of Figure 2(a)

```r
#estimating parameters
print(mu.hat<- mean(log.ratio))
print(sigma.hat<- sd(log.ratio))
```

Figure 3a: Printing the estimated parameters (μ, σ) from "log.ratio"

```
> #estimating parameters
> print(mu.hat<- mean(log.ratio))
[1] -0.003810729
> print(sigma.hat<- sd(log.ratio))
[1] 0.03467786
```

Figure 3(b): Output of Figure 3(a)

```r
#Geometric Brownian Motion Simulation:

#specifying Brownian motion as vector
BM<- c()
#specifying initial value
BM[1]<- 0
#specifying seed
set.seed(1234321457)
#simulating Brownian motion with drift and volatility
for (i in 2:92)
  BM[i]<- mu.hat+BM[i-1] + sigma.hat*rnorm(1)
#computing values for geometric Brownian motion
GBM<-price[1]*exp(BM)
#plotting actual and simulated trajectories
plot(date, price, type="l", lty=1, lwd=3.5, col="yellow",
     xlab="Time", ylab="Stock Price",main="(b)" ,first.panel=grid())
lines(date, GBM, lwd=3, col="black")
legend("bottomleft", c("Actual Price", "Simulated Price"),
       lty=1, col=c("yellow", "black"))
```

Figure 4(a): Plotting Geometric Brownian Motion based on the estimated parameters(μ,σ).

```r
#Monte Carlo Simulation for Geometric Brownian Motion SDE:
set.seed(231431)
nsim <- 500
S0 <- price[92]
mu <- mu.hat
sigma <- sigma.hat
t = 30
gbm <- matrix(ncol = nsim, nrow = t)
for (simu in 1:nsim) {
  for (day in 2:t) {
    epsilon <- rnorm(t)
    dt = 1 / t
    gbm[1, simu] <- S0
    gbm[day, simu] <- exp((mu - sigma * sigma / 2) * dt
                          + sigma * epsilon[day] * sqrt(dt))
  }
}
gbm <- apply(gbm, 2, cumprod)
ts.plot(gbm,main = "(c)" ,ylab = "Stock Price",gpars = list(col=rainbow(10)))
```

Figure 5(a): Plotting 500 trajectories of Geometric Brownian Motion.

VII. References

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- Finance, Yahoo. “Bitcoin USD (BTC-USD) Price History & Historical Data.” Yahoo! Finance, Yahoo!, 20 Nov. 2022, https://finance.yahoo.com/quote/BTC-USD/history?period1=1513468800.