

Time Series Analysis and Forecasting of Bitcoin Price

An in-depth look at the price action of bitcoin

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Introduction [^]_—

What is money?

That is a question that most individuals will brush off, as they feel that the answer is too obvious. When in reality, most do not truly know how to answer the question.

Money is whatever is used as a medium of exchange and a store of value. Throughout history, many different objects have been used as money, such as: seashells, salt, grains, glass beads, and precious metals (silver, gold, etc), and many more.

Money also need to have 5 important properties for it to be effective. They are: divisibility, durability, recognizability, portability, and scarcity.

Throughout history, the objects that best satisfied these 5 properties seems to have risen to the top as the main currency of exchange and store of value, ie. money.

For the majority of history, this was gold. However, gold had mediocre portability (ie. cumbersome to carry around), and thus, a promissory system emerged on top of gold to make it more portable. This system is paper currencies, which at their conception were just promissory notes that stated that the holder of the paper currency could take it to the bank in order to redeem it for gold at any time. This was a good system while it lasted.

The Problem

In 1971, the president of the United States, Richard Nixon, took the country off the gold standard, which meant that paper currency could no longer be redeemed for gold. And as a result, with the United States dollar being the reserve currency of most countries in the world, most countries also came off the gold standard. And thus began the era of FIAT currencies, which only have value since the government decrees so and is able to enforce said decree.

Since then, without having to be accountable to the gold standard, countries "printed" money as they pleased. Due to this, inflation has been steadily rising as there is more liquid money in the system. Most ordinary individuals suffer the consequence of their paychecks not stretching as far as they used to, or the money they saved up is worth a lot less as time passes.

The Solution

The most obvious solution would be to just cease "printing" money. However, doing so will result in many governments not having the necessary funds to carry out the tasks they initiated. And so, this is unlikely to happen.

When all hope seemed lost, someone by the name of Satoshi Nakamoto (most likely a pseudonym), released the initial whitepaper outlining a new technology called Bitcoin. It outlined how Bitcoin uses blockchain technology to make peer-to-peer transactions possible, without having to rely on an intermediary. Bitcoin seemed to have all the important properties of money, without anyone being able to

control it. And in 2009, Bitcoin was released into the world. Starting out at extremely small price of close to zero, the value has sky-rocketed throughout the years to as high as \$67,000.

Many users of the technology expect it to continue growing, even all the way up to a million dollars and beyond.

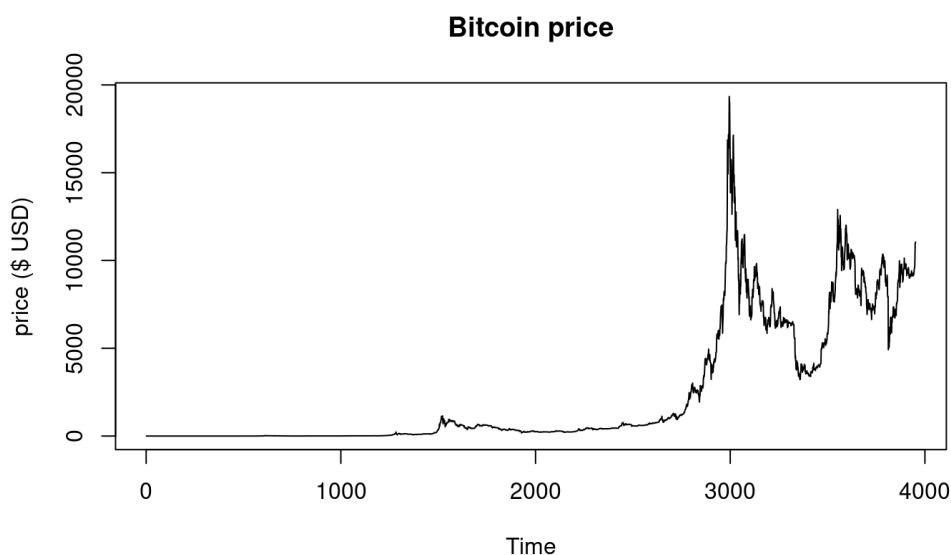
Goal: The goal of this project is to examine the history of the price of Bitcoin throughout the years and identify some trends, and attempt to create a model to predict the future value of Bitcoin.

1. Data Collection & Cleaning [^]

The data for this project was scraped from [this](#) website. It consists of the daily average price of Bitcoin and was one of the few sources that went back as far as 2009.

Since the scraped data was already fairly clean, only minor formatting was required.

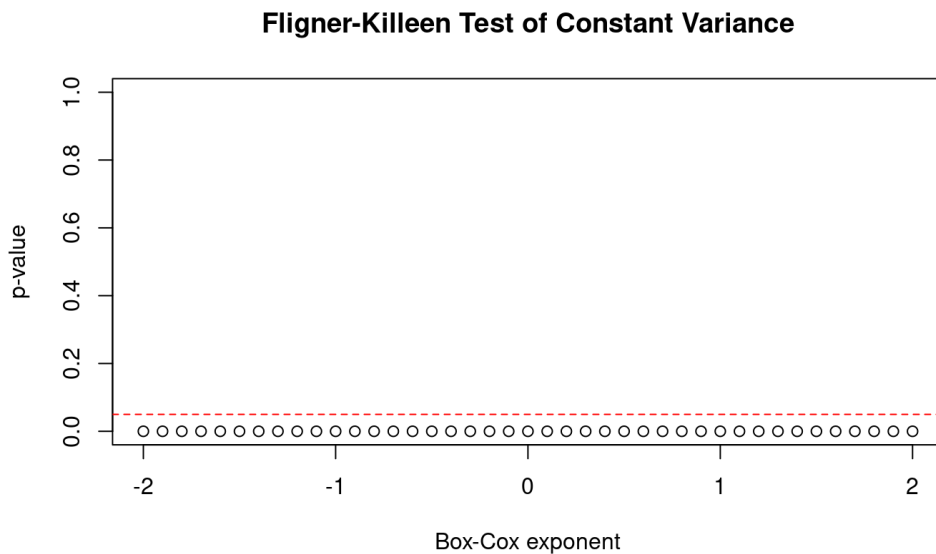
2. Exploratory Analysis [^]



The data is not stationary because an upward trend, seasonality, and non-constant variance are present.

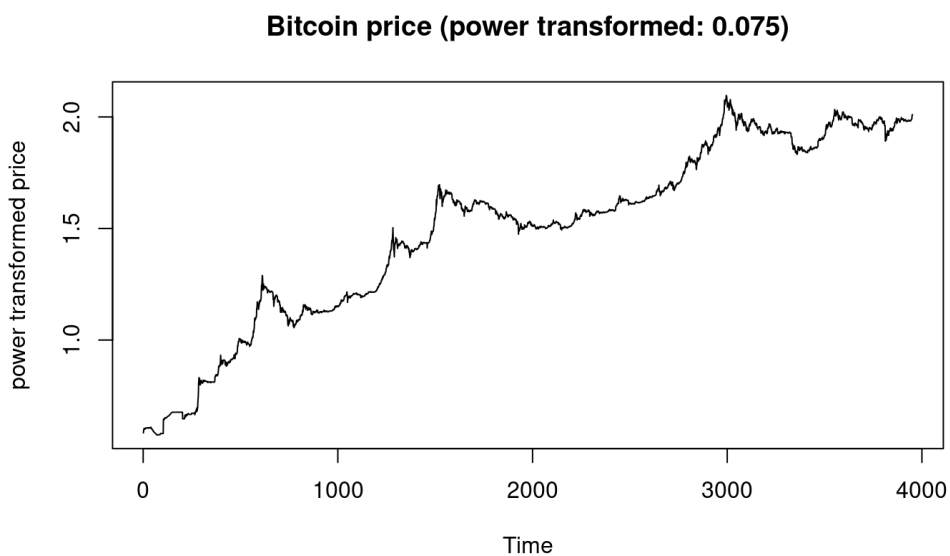
Stablilizing Variance

To stablize the variance, we can attempt to apply Box-Cox power transformations.



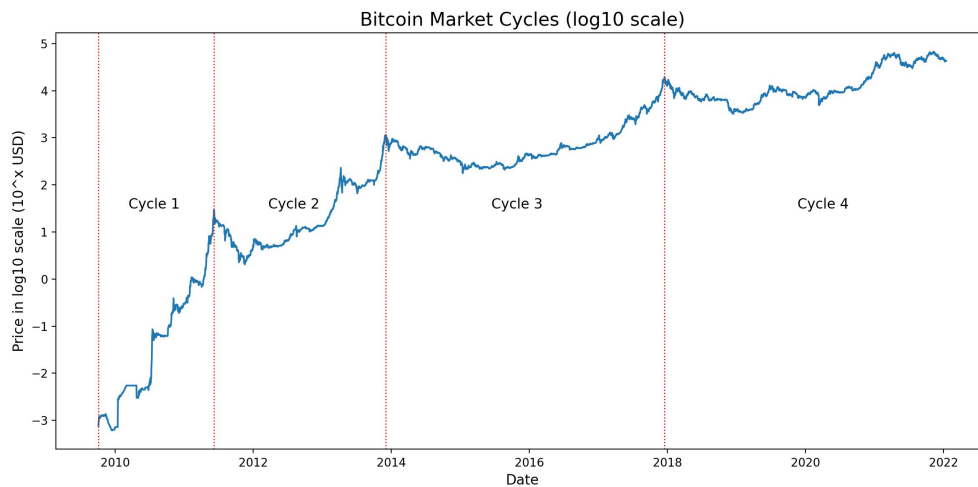
However, none of the applied power transformations seem to cause a significant result of constant variance with the Fligner-Killeen test.

After examining the plots of a number of power transformations, visually, the transformation $Y^{0.075}$ seems to result in the most stable variance, and thus, will be used to transformation the data and the transformed data will be used for further analyses and modelling.



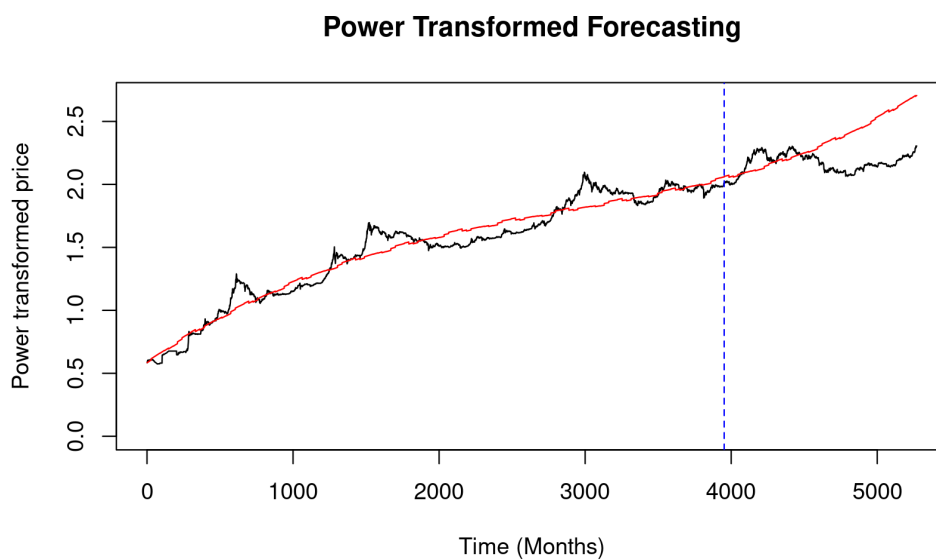
Examining Seasonality

This power transformed plot make it clear that there exists seasonality in the data. However, the over-arching seasonality is difficult to capture as the seasons seem to be lengthening as time progresses, as shows in the externally referenced plot below:

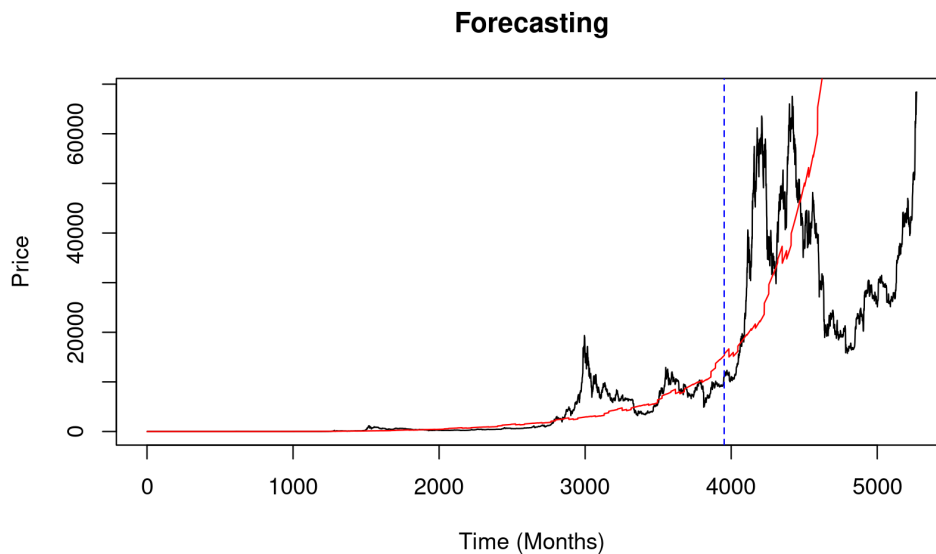


3. Regression Modelling ^

A number of classical linear regression, ridge, lasso, and elastic net models were tested with polynomial degrees up to 15, and the best performing model on the forecast was the Elastic Net model with up to degree 4 polynomials, with the plot of the prediction pictured below:



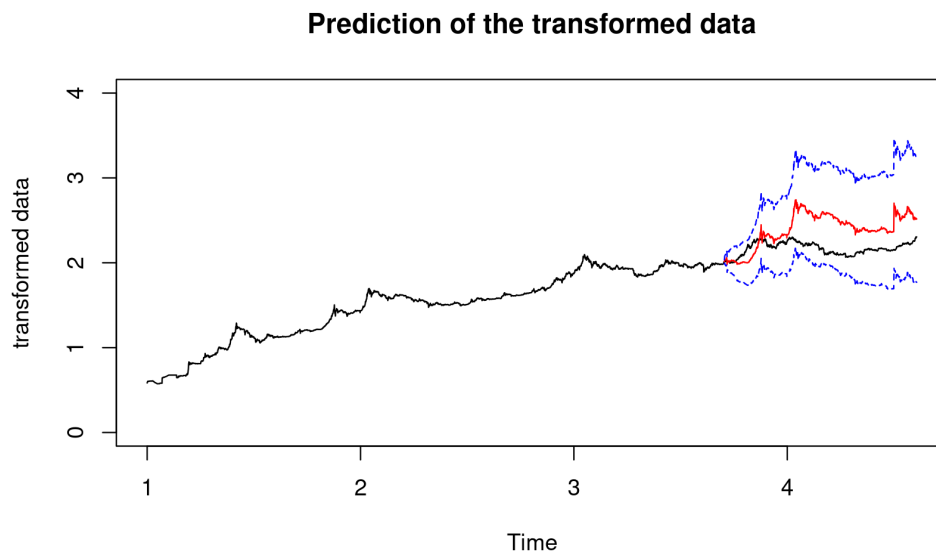
And once the data and predictions were transformed back into the original scale:



4. Smoothing Methods ^

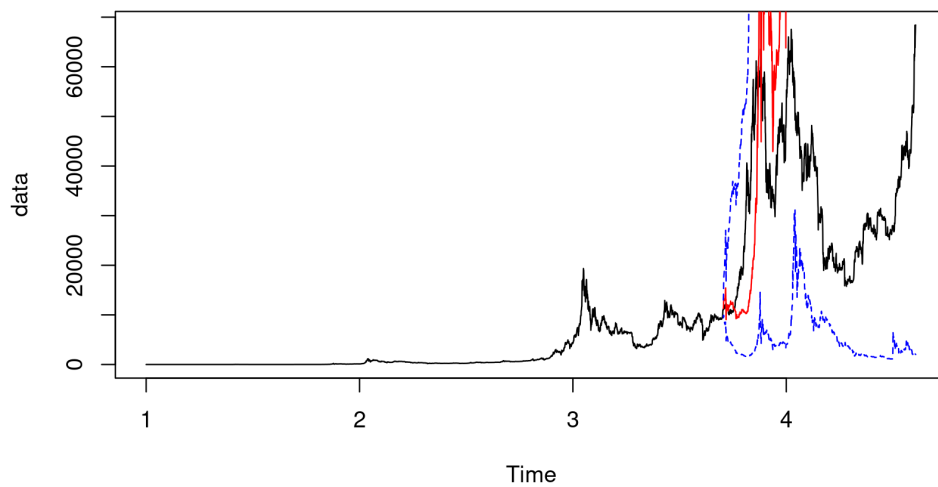
Holt-Winters Smoothing

After applying a number of exponential smoothing and Holt-Winters smoothing methods, the model that exhibited the best APSE score was an exponential smoothing model, but in terms of shorter term prediction, the model with the predictive performance was the Holt-Winters multiplicative model as shows below on the transformed data:



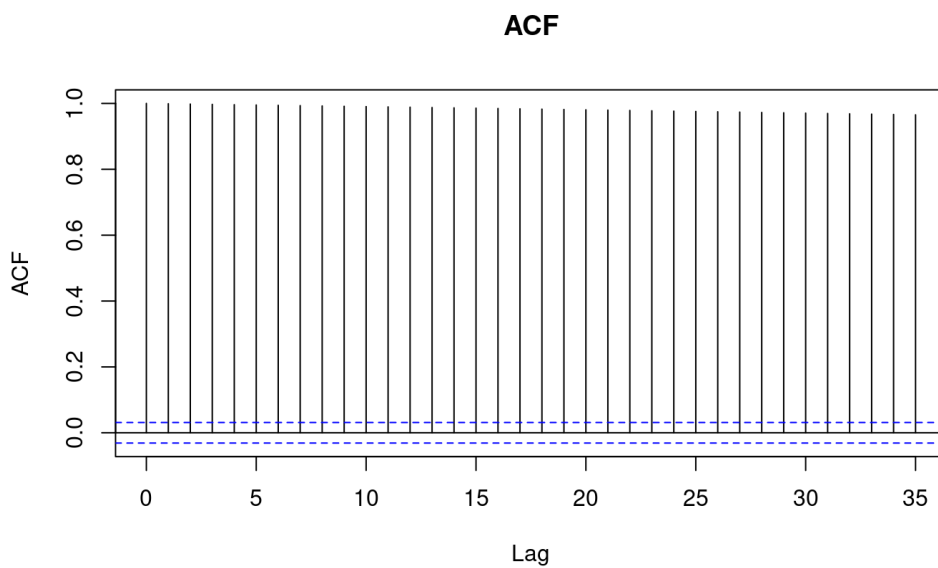
When the data is transformed back to it's original scale, it looks like:

Prediction of the data



Detrendize

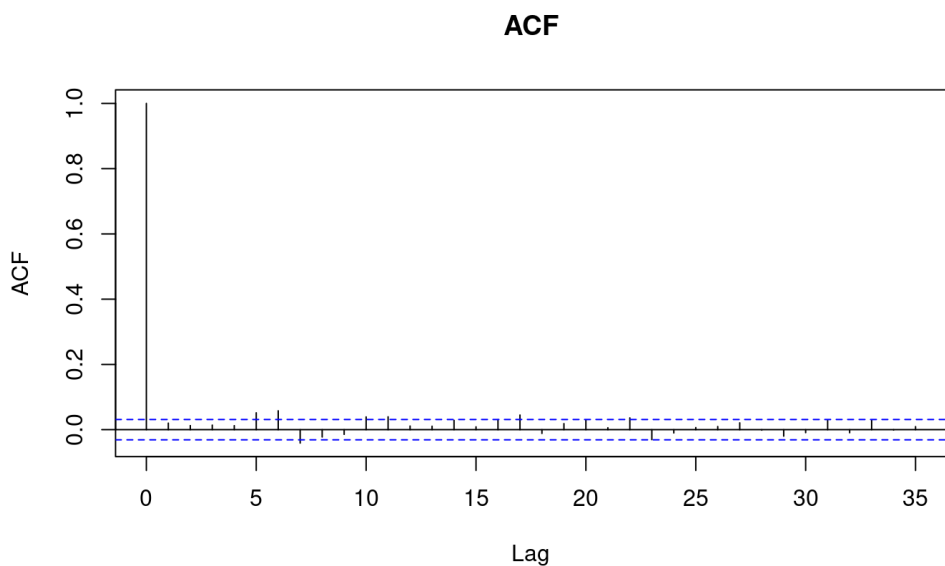
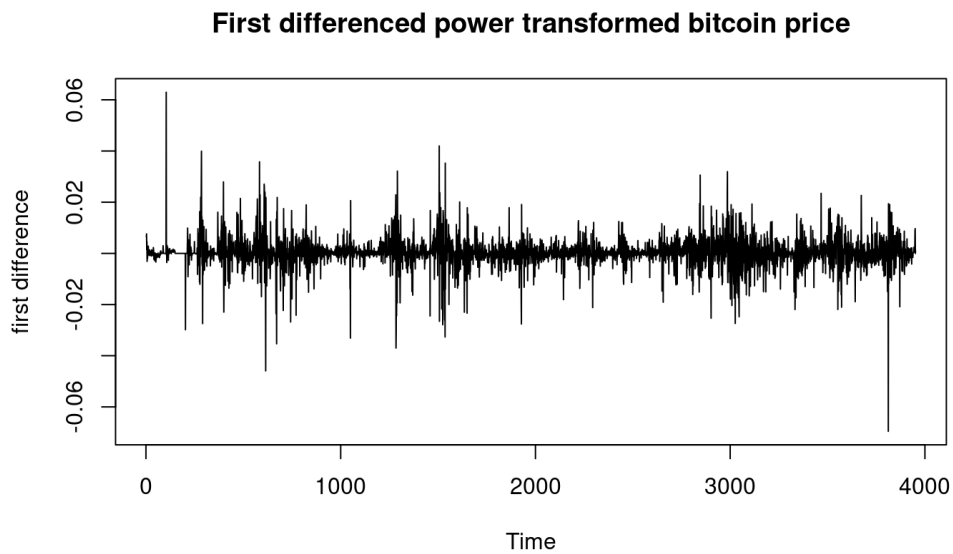
Here is the ACF of the power transformed data:



There is a clear linear decay, representing the presence of trend/seasonality.

To remove the trend/seasonality, we will be using differencing.

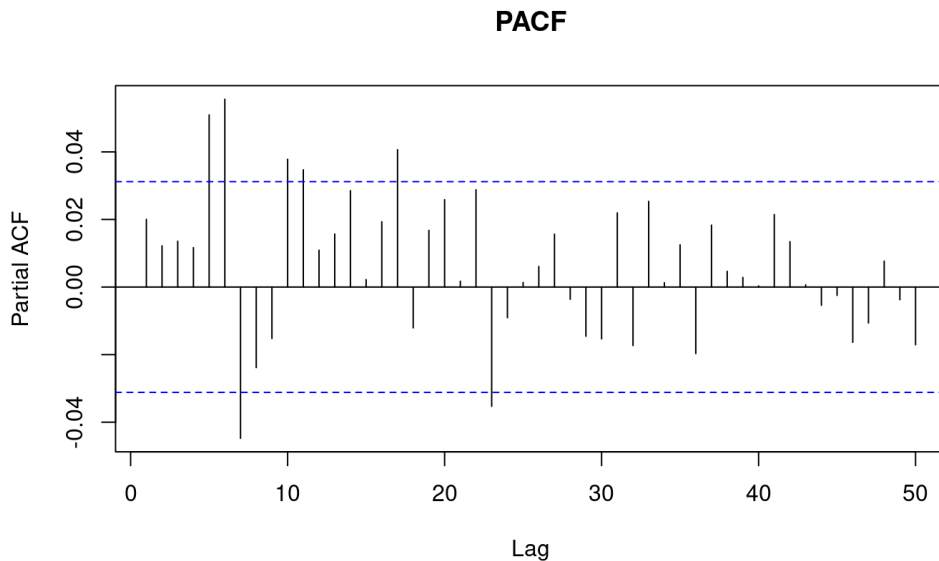
Differencing



No patterns in the plot or ACF, so the data seems to have been made stationary after a single differencing.

5. ARIMA/SARIMA [^]

After differencing, we saw that there was no patterns in the ACF, and here is the PACF:

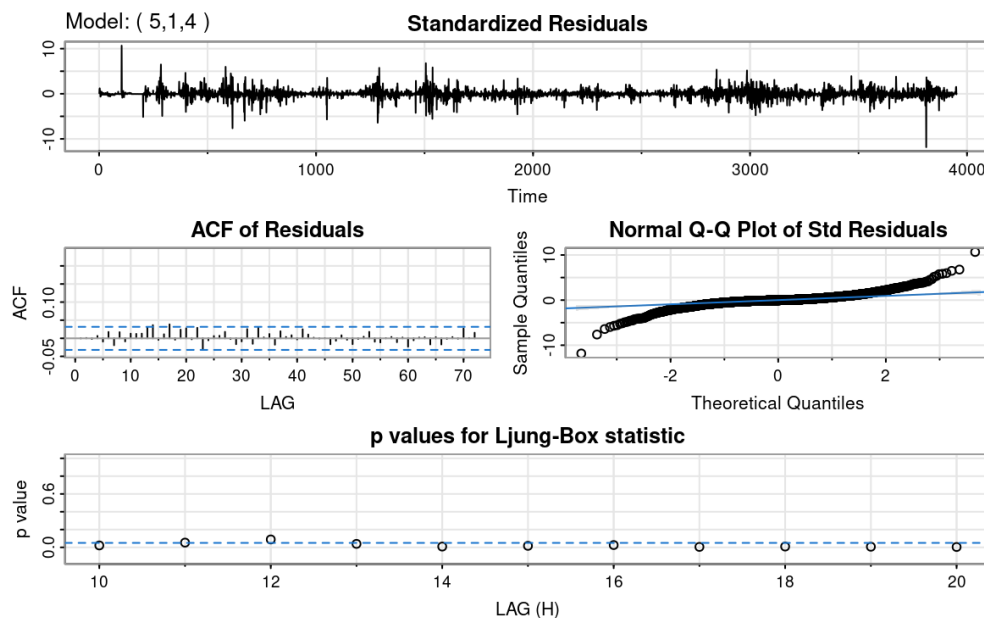


We see that there is no clear indication of exponential decay or lag cut-off in either the ACF or PACF, so the best strategy would be to just try a number of ARIMA models.

So the following ARIMA models are proposed for the power transformed data:

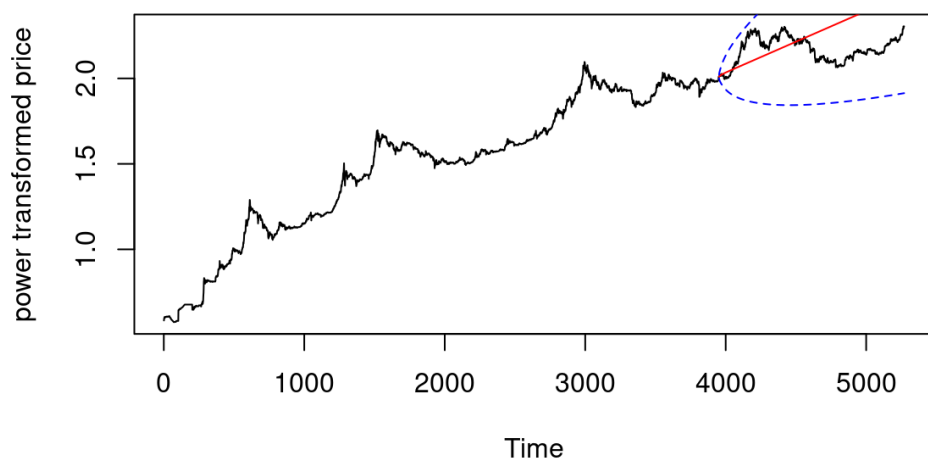
- $p = 0-6$
- $d = 1$
- $q = 0-6$

After performing training and testing, the model that performed best was ARIMA(5, 1, 4):

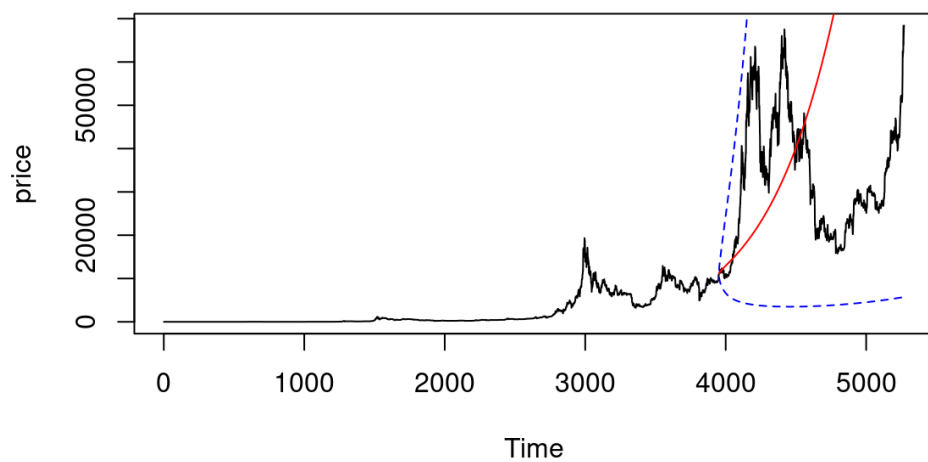


Using this model to perform prediction results in:

Forecasting

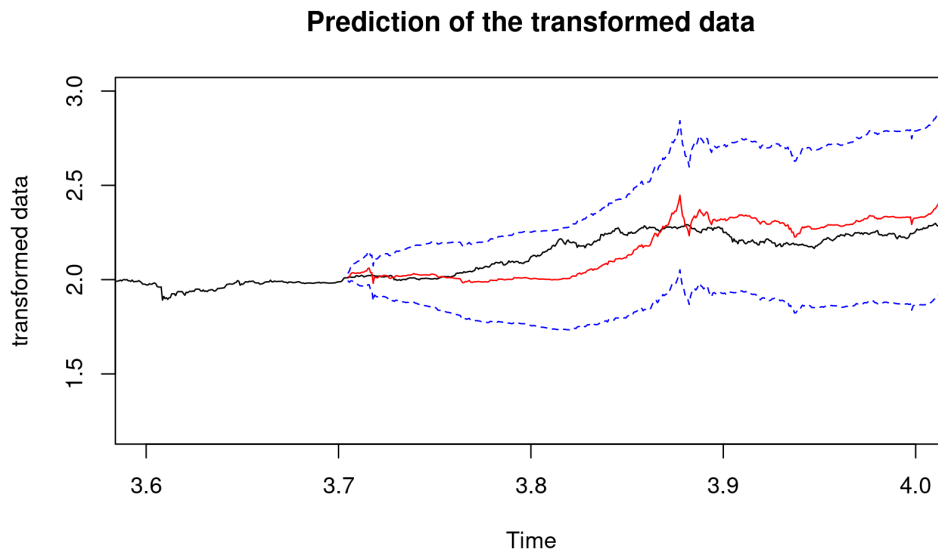


Forecasting

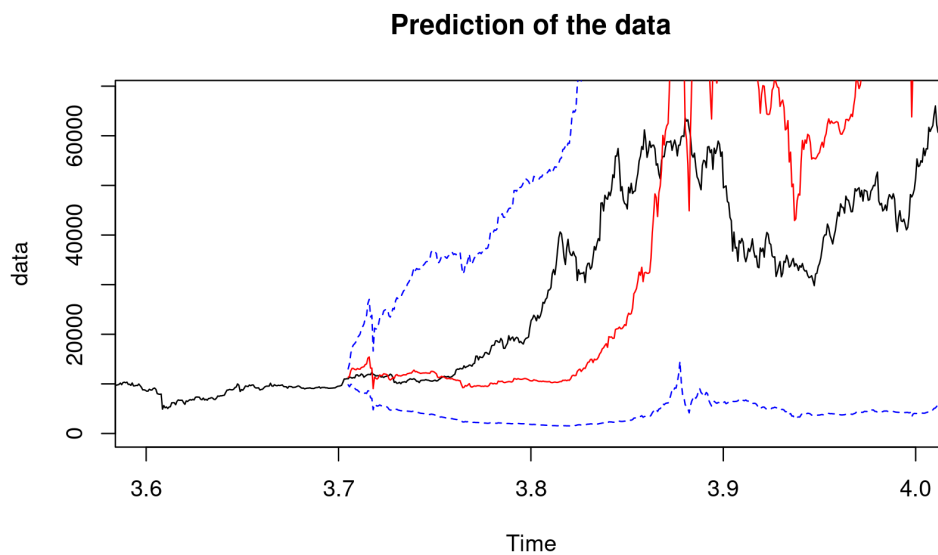


Final Model Selection [^]_^

After trying a vast number of model and testing their performance on the testing set, the model that performed the best (short-term) forecasting ability was the Holt-Winters multiplicative model, as picture below:



When the data is transformed back to it's original scale, it looks like:



With data as volatile and with high variance as Bitcoin price, forecasting for the longer term in made exponentially more difficult as the errors compound as the forecast extends more and more into the future.

Therefore, the Holt-Winters multiplicative model shows above was chosen as the best model for forecasting.

Conclusion [^]

Being able to forecast the price of bitcoin has proven to be a challenging endeavour as it is a highly volatile asset with large price fluctuations. To make the problem more difficult, the data does not seem to have a set period for seasonality, instead, seasons seems to be getting longer as time progresses. However, we attempted to use all the tools at our disposal from regression techniques such as classical, ridge, lasso, elastic net; smoothing techniques: exponential, Holt-Winters, differencing; and ARIMA models to attempt to model and forecast the price of Bitcoin. While we were able to make good forecast into the short-term future, predictions diverged from actual as we got into the long-term. However, this was a great learning opportunity as we got the chance to put into practice all the techniques we had learned over the term.

Regardless of whether we are able to predict the price of Bitcoin with any level of accuracy, it is clear that it is an appreciating asset with an upward trend, and thus, it is recommended for everyone to have at least a small position in the asset.

With a track record of more than a decade, Bitcoin seems to be evolving into a viable medium of exchange and store of value, and possibly even the future currency of the internet and the world.