Identification of Technical Analysis Patterns with Smoothing Splines for Bitcoin Prices

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Part 1: Introduction

The Basics

- Bitcoin is a decentralized digital currency that can be transferred on the peer-to-peer bitcoin network. Bitcoin transactions are verified by network nodes through cryptography and recorded in a public distributed ledger called a blockchain.
- A blockchain is a distributed database that maintains a continuously growing list of ordered records, called blocks. These blocks are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data.
- Decentralized Finance refers to a wide range of software protocols and tools that give people the power to perform financial transactions—trading, borrowing, lending, and more—without third parties like banks, exchanges, or brokerages.
    - Open
    - Pseudonymous
    - Flexible
    - Fast
    - Transparent

The Basics Part 2

- Technical analysis is a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume.
- Fundamental analysis, which attempts to evaluate a security's value based on business results such as sales and earnings, technical analysis focuses on the study of price and volume.
- Technical Analysis has been studied within academia on U.S. Equity market, UK Stock Market, and Chinese Stock Market. This paper focuses on cryptocurrency market specifically Bitcoin.

Part 2: Background

Section 1: Smoothing Splines

We consider a general non parametric model :

$$y_i = \mu(t_i) + \varepsilon_i, \quad i = 1, 2, \ldots, n,$$

We consider a natural cubic Spline:

$$\frac{1}{n}\sum_{i=1}^{n}(y_i - f(t_i))^2 + \lambda \int_0^1 (f''(t))^2 \, \mathrm{d}t$$

We consider the the Smoothing spline estimator:

$$\hat{\boldsymbol{\mu}}_\lambda = (\hat{\mu}_\lambda(t_1), \ldots, \hat{\mu}_\lambda(t_n))^{\mathrm{T}} = \mathbf{S}_\lambda \mathbf{y},$$

Section 2: Selection of λ

The article determines lambda based on GCV which we observe the criterion below:

$$GCV(\lambda) = \frac{\frac{1}{n}\sum_{i=1}^{n}(y_i - \mu_\lambda(t_i))^2}{\left(\frac{1}{n}\mathrm{tr}(I - S_\lambda)\right)^2},$$

Part 3: Dataset & Methodology

Section 1: Dataset

- The Papers Data:
  - Produced by Python from Global Digital Assets Exchange, installed with SQL and read into R
  - Data based on 1 minute Open, High, Low, Close Prices as well as Volume
- My Data:
  - Obtained by cryptodatadownload.com, downloaded and read into R
  - Provides Data up to the previous day (I used until November 29th 2022
  - Provides Hourly and Daily Open, High, Low, Close Prices as well as Volume

Section 2: Pattern Rules

Consider:

T as trading time points

P as closing Price

V as trading Volume

E as local Extrema corresponding to t occurrences of trading time

Head and Shoulders

E1 is a maximum, E3 > E1, E3 > E5, E1 and E5 are within 1.5% of their average, E2 and E4 are within 1.5% of their average. Pattern gives sell signal, and trades are short.

Inverted Head and Shoulders

E1 is a minimum, E3 < E1, E3 < E5, E1 and E5 are within 1.5% of their average, E2 and E4 are within 1.5% of their average. Pattern gives buy signal, and trades are long.

Broadening Tops & Broadening Bottoms

E1 is a maximum, E1 < E3 < E5, E2 > E4. Pattern gives sell signal, and trades are short.

E1 is a minimum, E1 > E3 > E5, E2 < E4. Pattern gives buy signal, and trades are long.

Triangle Tops & Triangle Bottoms

E1 is a maximum, E1 > E3 > E5, E2 < E4. Pattern gives sell signal, and trades are short.

E1 is a minimum, E1 < E3 < E5, E2 > E4. Pattern gives buy signal, and trades are long

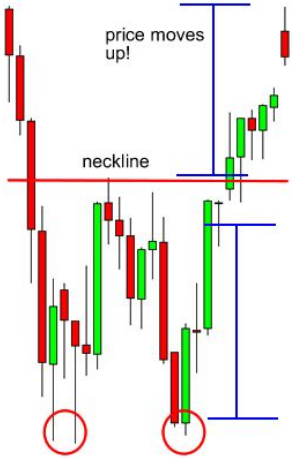
Rectangle Tops & Rectangle Bottoms

E1 is a maximum, tops are within 0.75% of their average, bottoms are within 0.75% of their average, lowest top > highest bottom. Pattern gives buy signal, and trades are long

E1 is a minimum, tops are within 0.75% of their average, bottoms are within 0.75% of their average, lowest top > highest bottom. Pattern gives sell signal, and trades are short.

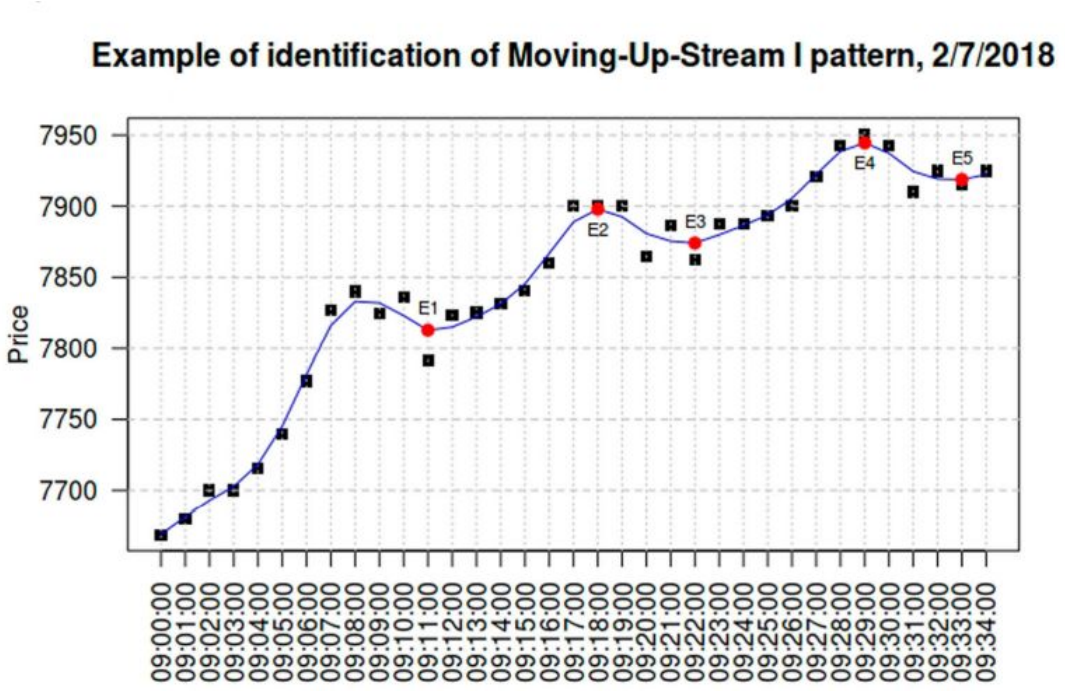
Double Tops & Double Bottoms

E1 is an initial local maximum with index 1 counting from the start of the time subinterval,
Ea = sup[Pt ∗ k : t ∗ k > t ∗ 1 , k = 2, … , n], t ∗ a – t ∗ 1 > 22,
E1 and Ea are within 1.5% of their average.
Pattern gives sell signal, and trades are short.



E1 is an initial local minimum with index 1 counting from the start of the time subinterval,
Eb = inf[Pt ∗ k : t ∗ k > t ∗ 1 , k = 2, … , n], t ∗ b – t ∗ 1 > 22,
E1 and Eb are within 1.5% of their average.
Pattern gives buy signal, and trades are long

Section 3: Procedures & Methodology



- An example of Moving-Up-Stream 1 pattern for technical analysis.
- Moving-Up-Stream charting type I
  - E1 is the minimum
  - E1 < E3 < E5
  - E2 < E4
  - V1 > V3
  - V2 < V4.
  - Pattern gives buy signal
  - Trades are long

Simulation

- Simulation:
  - 1 minute data fit into 35 minute windows
  - If pattern is identified the trade would be entered and simulated in multiple different windows
  - It would include returns held in 1, 2, 3, 4, 5, 10, 15, 20, 25, 30 minute windows

- Goal: Identify the best holding period for the particular pattern
  - If pattern is not identified, simulation would move to another window fitting
  - Each pattern identified with different holding period, mean return and standard deviation would be recorded for both random and specified trading strategies.
  - Create proportion of random mean returns and strategy based mean returns (baseline)
  - The lower the proportion the higher confidence we have that the particular pattern and holding period form a good basis for a profitable trading strategy.

Part 4: Analysis & Results

Cubic Spline Fit to Data

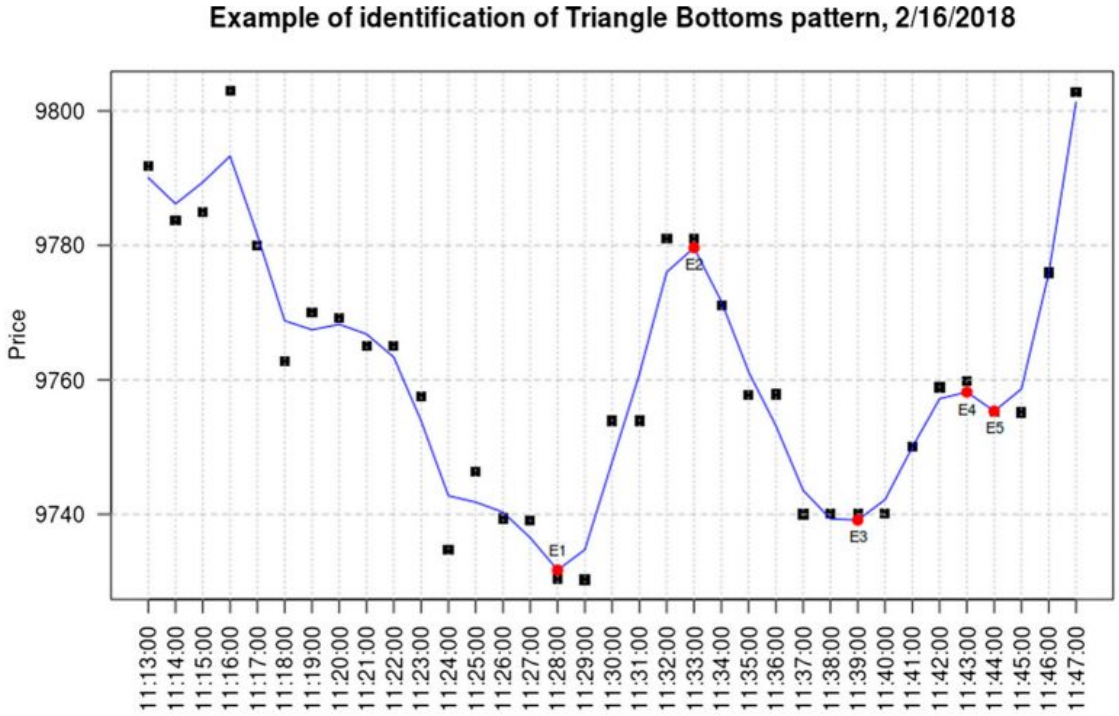


Figure 2. Price pattern: Triangle Bottom.

Results of Simulations

- Promising Strategies:
  - Head and Shoulders for 1-5 Min hold
  - Inverted Head and Shoulders for 1-5 Min hold
  - Triangle Bottoms 1-5 Min hold
  - Double Bottoms for 10, 20 25, and 30 min hold

Table 1. Proportions of returns for baseline (random/unconditional trading strategy) that are above the given technical analysis pattern and holding periods, number of trades and average bitcoin (BTC) volume per minute when trade is taken. The lower the proportion, the higher confidence we have that the strategy has higher returns than the unconditional trading strategy.

	HS	IHS	BT	BB	TT	TB	RT	RB	DT	DB	MUS I	MUS II
1 min	0.0000	0.0000	0.8450	0.8722	0.1845	0.0000	0.9998	1.0000	0.9112	0.6233	0.2414	0.5847
2 min	0.0000	0.0000	0.8474	0.9017	0.3289	0.0000	0.9997	0.9999	0.9859	0.3232	0.2610	0.5071
3 min	0.0000	0.0000	0.7655	0.9399	0.4626	0.0001	0.9999	0.9999	0.7547	0.3475	0.2578	0.2820
4 min	0.0002	0.0000	0.8503	0.8984	0.4083	0.0001	1.0000	1.0000	0.7478	0.2534	0.4778	0.3681
5 min	0.0048	0.0000	0.8527	0.8941	0.4822	0.0000	0.9998	0.9999	0.8446	0.1562	0.7320	0.5186
10 min	0.4920	0.1117	0.5594	0.7252	0.9597	0.0153	0.9626	0.9925	0.8555	0.0390	0.9938	0.8872
15 min	0.9897	0.6407	0.5657	0.9570	0.9817	0.1791	0.7911	0.7681	0.9528	0.1649	0.9927	0.9948
20 min	0.9651	0.9404	0.7719	0.9667	0.9061	0.1371	0.8592	0.5083	0.6803	0.1267	0.9053	0.9964
25 min	0.9336	0.8195	0.7259	0.9498	0.8912	0.2465	0.7403	0.3377	0.7234	0.0524	0.5373	0.9875
30 min	0.7370	0.4468	0.7984	0.9914	0.7711	0.2417	0.9080	0.5674	0.5222	0.0375	0.2692	0.9211
# of trades	3269	3629	218	211	927	1085	5685	6097	13683	14481	1490	528
Mean BTC volume	17.087	16.779	18.663	19.560	19.450	18.265	17.296	15.716	19.266	18.221	20.364	16.383

Further Investigation of Results

Table 2. Mean returns, standard deviations, and cumulative/combined returns of strategies based on patterns Head-And-Shoulders, Inverted Head-And-Shoulders and Triangle Bottoms for holding periods from 1 to 5 min.

	HS			IHS			TB		
	Mean	Combined	SD	Mean	Combined	SD	Mean	Combined	SD
1 min	0.0001451	0.4742002	0.0019285	0.0001536	0.5575000	0.0019500	0.0002733	0.2965000	0.0019100
2 min	0.0002148	0.7022002	0.0026354	0.0003059	1.1100001	0.0027028	0.0003236	0.3511000	0.0027792
3 min	0.0002168	0.7087999	0.0032918	0.0003490	1.2665000	0.0033401	0.0003945	0.4280000	0.0033825
4 min	0.0001759	0.5750001	0.0038088	0.0003726	1.3519999	0.0037867	0.0004628	0.5021000	0.0038196
5 min	0.0001455	0.4755999	0.0042598	0.0003436	1.2467999	0.0042912	0.0005088	0.5521000	0.0042520

Part 5: Conclusion & Discussion

Conclusions

- The article proposed method to evaluate the effectiveness of the technical analysis by market returns
- Identified 3 strategies: Head and Shoulders, Inverted Head and Shoulders, and Triangle Bottoms
    - Head and Shoulders and Triangle Bottoms did not perform well in U.S. Stock market
- Liquidy (the access and availability of funds/asset) may hinder the ability of technical analysis strategy

Part 6: My R-Code

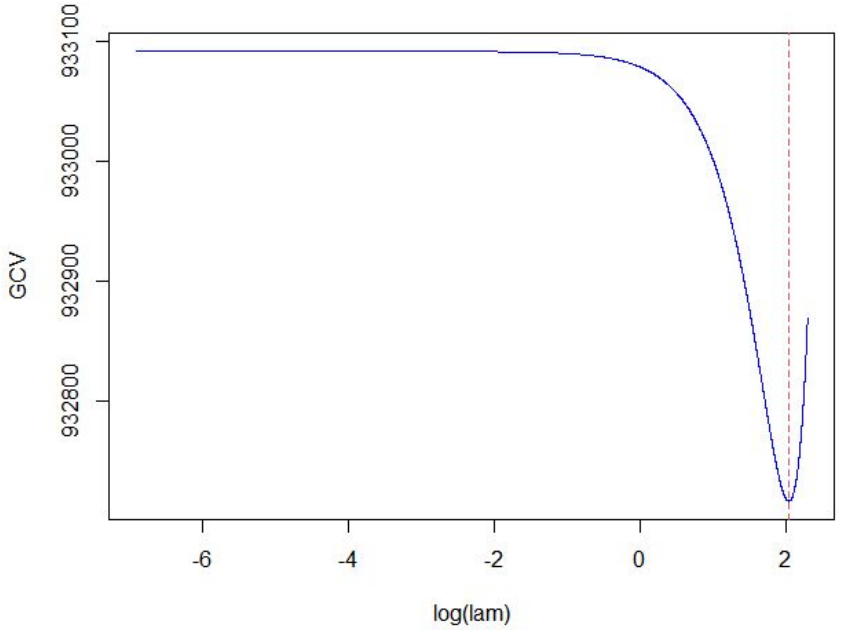
Part 7: My Results

Data 1

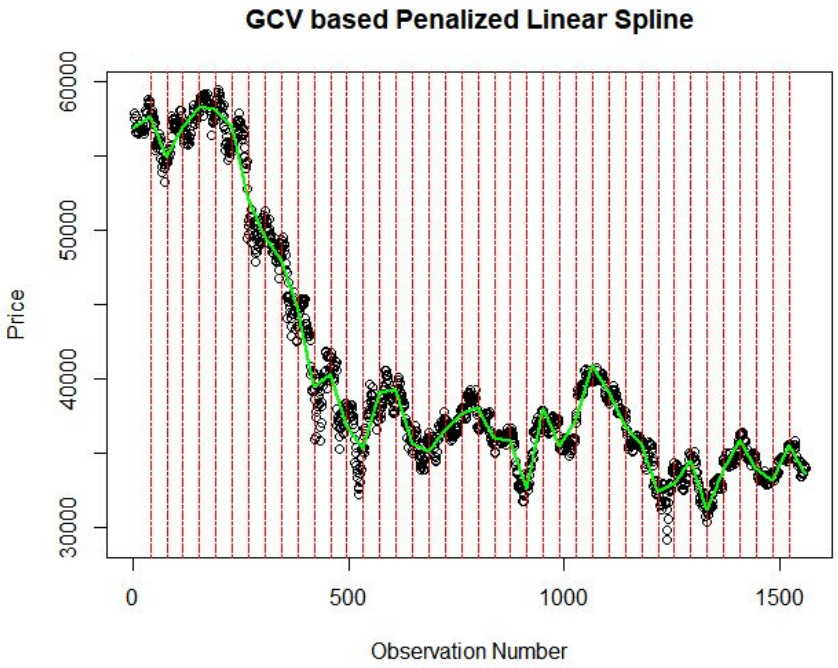
- Modeling Data from May 2, 2021 to July 5, 2021
- 1560 1 hour observations
- Will Find the minimum Lambda with GCV
- Will fit and compare different models for our data
    - Penalized Linear Spline based on GCV
    - Linear Spline Regression Estimate
    - Cubic Spline Estimate
    - B-Spline Corresponding to Cubic Spline
    - Natural Cubic Spline
- Analyze Technical Analysis
- Calculate Mean Return and Standard Deviation on Investment

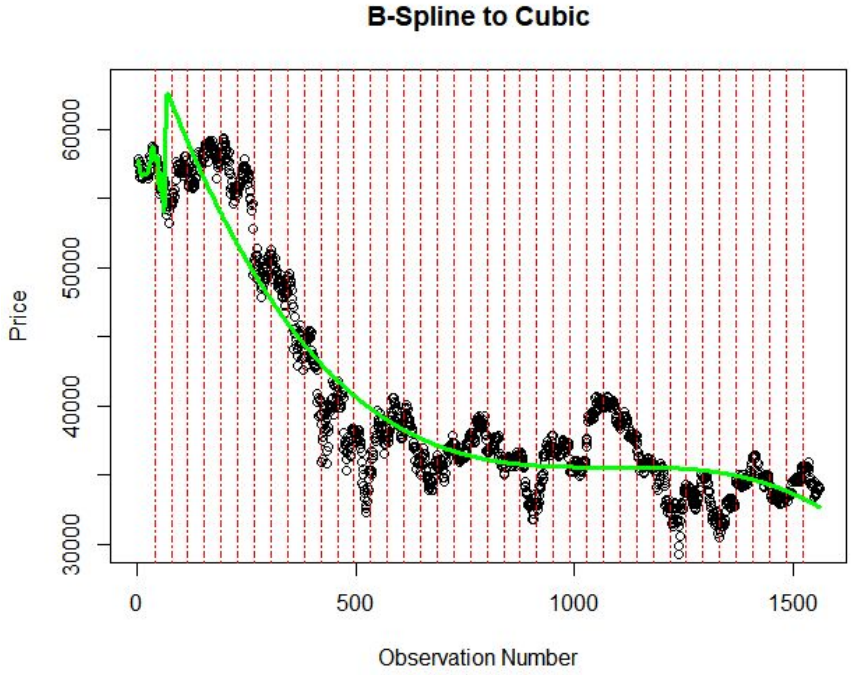
Finding Lambda with GCV

- Using R we plot our GCV curve and observe a minimum value of log(lambda)=2.044591 with the min() function
- Converting this to lambda we obtain a lambda=7.72599
- We will use this as lambda for modeling



Our Models Part 2





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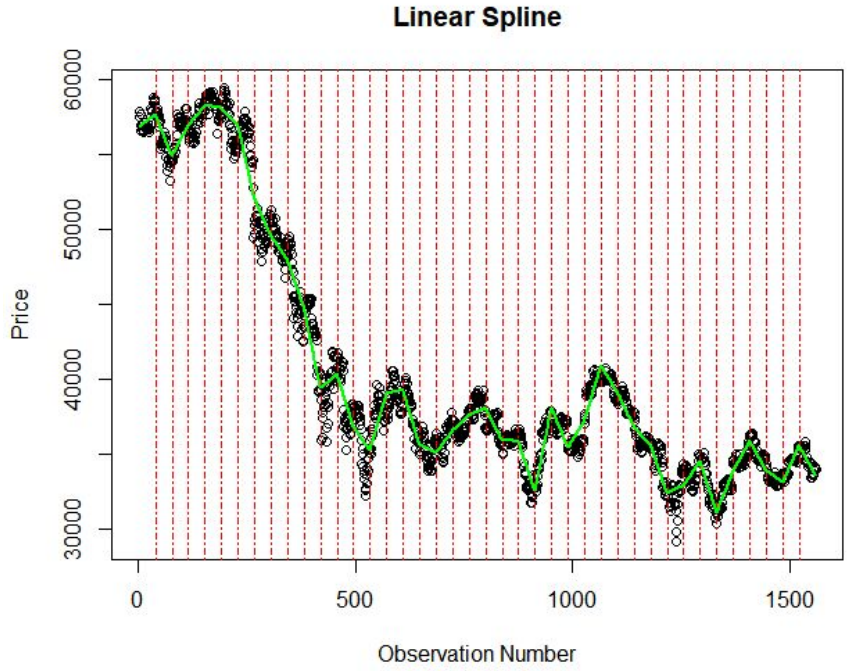
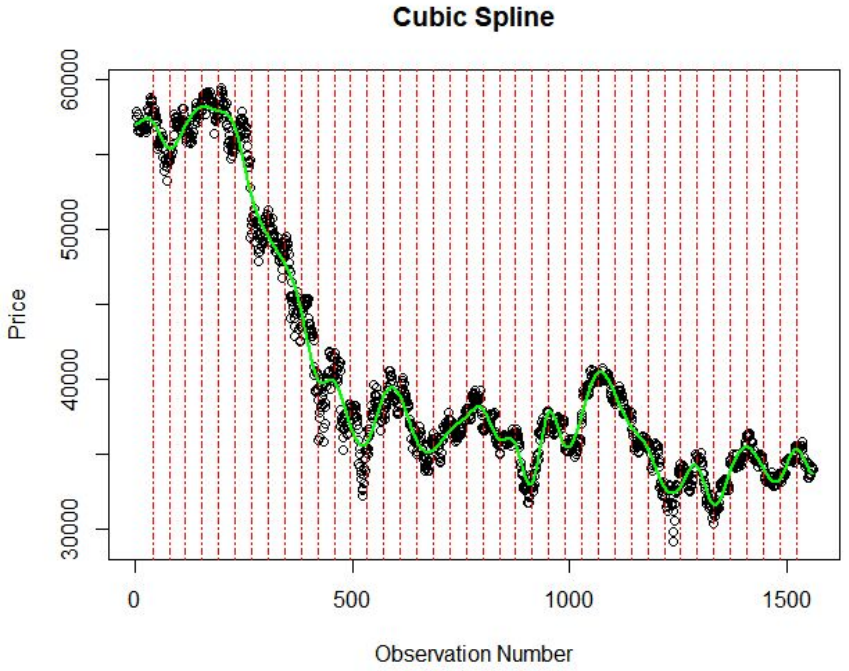
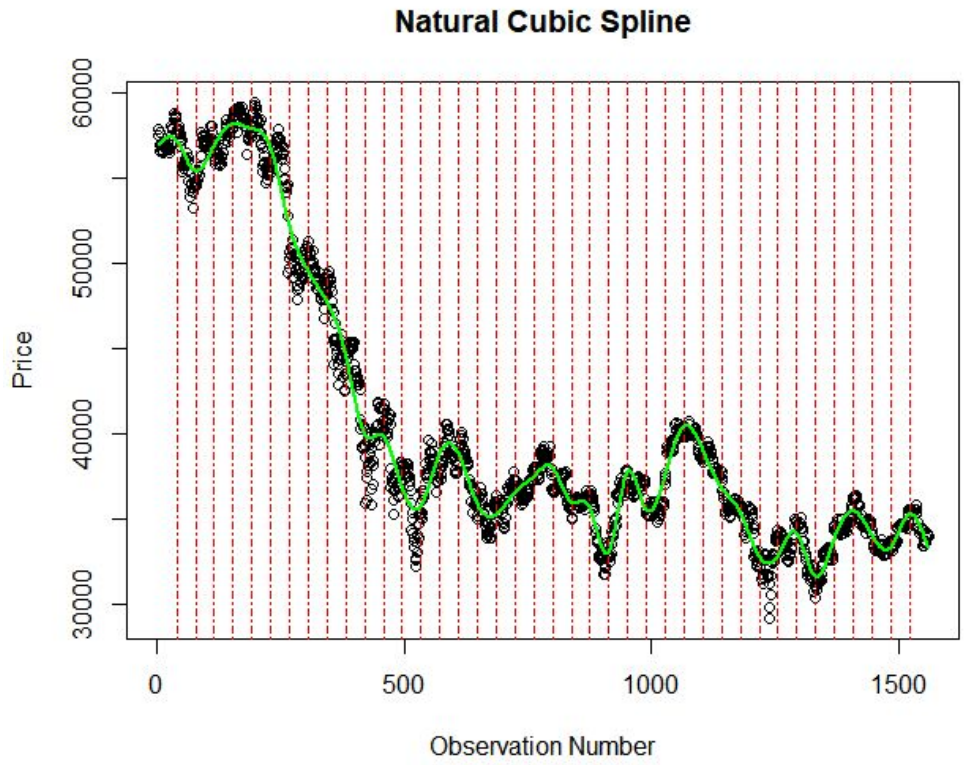
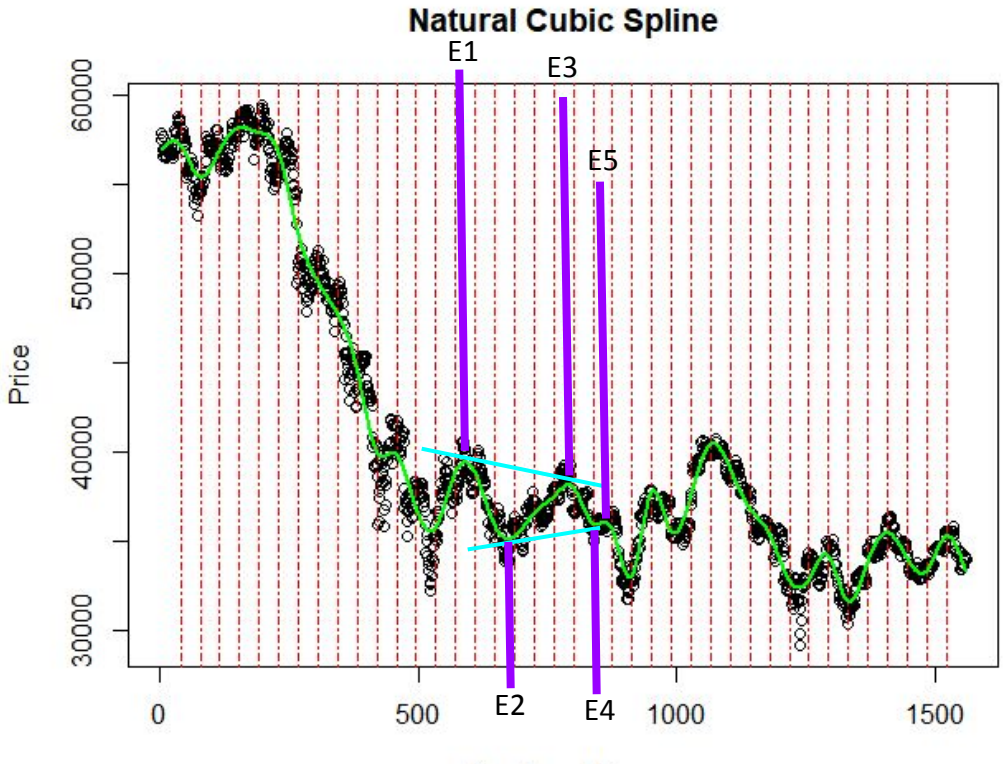




Natural Cubic Spline Model



Technical Analysis



Triangle Top

E1 is a maximum

E1 > E3 > E5

E2 < E4

Pattern gives sell signal

Trades are short.

Mean Return and Standard Deviation

- Enter Trade at the 23rd knot (Observation 876) or June 7, 2021 at 10:00 am at a closing price of $36,531
- Exit Trade at the 24th knot (Observation 915) or June 9, 2021 at 1:00am at a closing price of 32,526

$$\left| \frac{Current\ Value - Initial\ Cost}{Initial\ Cost} \right|$$

- We observe a 10% return utilizing the Triangle Top in this one occurrence.

Technical Analysis Result