

Seasonality, Trend-following, and Mean reversion in Bitcoin

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Abstract

The cryptocurrency market is not negligible nor minor anymore. With the continuous development of the crypto market, researchers aimed to analyze novel cryptocurrencies thoroughly. An excellent starting point might be in other recognized effects from the developed asset classes. This research examines seasonality effects such as when the major NYSE opened or closed and their intraday, overnight, or daily components. Furthermore, we also examine the distribution of the daily returns and the returns that are significant. The results point to a simple seasonality strategy that is based on holding BTC only for two hours per day. The second aim is to examine trend-following and mean reversion strategies. The data suggests that BTC tends to trend when it is at its maximum and bounce back when at the minimum. These findings support the empirical observations that BTC tends to trend strongly and revert after drawdowns.

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1. Introduction

As we observe markets, we tend to identify various patterns that continuously repeat. As one of the most followed markets, the stock market is probably connected with most of the sayings, empirical observations, seasonality research, or even some legends like "sell in May and go away." Although some proposed seasonalities might be far-fetched, there are plenty of sound and research-backed seasonality effects. In the stock market, there is sound evidence of many seasonality anomalies, e.g., the Turn of the Month effect (Xu and McConnell, 2006), Option-Expiration Week (Stivers and Sun, 2013), or Payday Anomaly (Ma and Pratt, 2018). However, the seasonality is not stock market exclusive. There is seasonality in Treasury bonds connected with auctions (Lou et al., 2013), annual rebalancing of the S&P GSCI index in commodities (Yan et al., 2019), or FOMC meetings and US dollar (Mueller et al., 2014). Overall, plenty of seasonality effects can be connected with a specific hour, day in the week/month, or even a more extended period. Regardless of the period, all effects have one common matter: abnormal performance during the timeframe. For example, there might be a large amount of capital that investors seek to allocate that creates upward pressure and stocks rise.

All the aforementioned effects are present in the developed markets that offer a long history either for empirical observations or thorough systematic analysis. Are there any seasonality effects in Bitcoin's market? Indisputably, the BTC has attracted many, but there is high volatility, and the market is truly dynamic. This research aims to examine some possible seasonality effects in BTC using the hourly data from the Gemini exchange during 9.10.2015 – 3.2.2022.

One of the most recognized effects relates to the part of the day – the opening of the market, closing auction, overnight anomaly, intraday reversal, and many more daily effects were suggested by academics. However, the cryptocurrency markets are unique, and these crypto-assets are traded 24/7. Therefore, there is no "open" or "close" time. Although we can map the hours to when traditional markets are open, cryptos can still be traded outside these hours. We further review the seasonality effects in the section Seasonality analysis.

The second part of the study examines two key concepts in quantitative investing or technical analysis: trend following and mean reversion. The trend-following proponents suggest a performance continuation and that assets that have performed well will continue to do so. In other words, the trend-following strategies are characterized primarily as buying high and

selling even higher. Conversely, the mean-reversion theory suggests that assets tend to revert to their long-term mean after all. Therefore, the mean reversion strategies are commonly described as buy low and sell high. Naturally, both approaches can also have short legs: short losers for trend-following and short winners for mean-reversion.

At first sight, the coexistence of these two effects might be confusing. One might think that either there is a continuation or reversion. However, the devil is in the details. For example, in the stocks, the past one month's return is not connected with continuation (past winners will outperform and losers will underperform), but rather with mean reversion. This effect is commonly known as the short-term reversal. If we move a few months back, the trend-following idea becomes dominant. The effect is most widely recognized as the twelve months stock momentum. The continuation tends to disappear if we move even further back (e.g., in stocks or commodities). There is also a long-term reversal effect that suggests that past losers would outperform and vice versa for winners. Still, it is crucial to bear in mind that the trending or reverting might not be connected only with a specific time frame but also with specific situations such as liquidity provision during crises, buying the dips, short-squeezes, earnings announcements, and many more. Moreover, there are numerous ways to identify over/undervalued securities – some prefer to use the return-based metrics (e.g., momentum), others prefer moving averages, distances to x-weeks highs (lows), or even their combination.

What about the Bitcoin? Are there trend-following or mean-reversion patterns? Or are both effects present and co-exist? In this short research, we examine how Bitcoin's price is affected by its maximal or minimal price over the previous 10 to 50 days. Consistent with the popularity of these price-based strategies, several variants of these strategies are already well-documented. Rohrbach et al. (2017) examined exponential moving averages in fiat and cryptocurrencies. Hubrich (2017) examined the time-series momentum factor in cryptocurrencies. Detzel et al. (2020) provided Bitcoin-centered results, which used several simple moving averages to form the trading strategy. Cong et al. (2021) examined several cryptocurrency factors, and among them also the momentum factor, which seems to be present cross-sectionally in the largest cryptos, and reversal which tend to be present in the smallest cryptos. While our research is related to the existing literature, we are not aware of any analysis that examines Bitcoin's behavior connected with nearness to maximal/minimal price of the previous days.

The data includes Bitcoin prices from the Gemini exchange, and the sample spans from 26.11.2015 to 3.2.2022. Since Bitcoin is traded continuously, the sample also includes weekends or holidays.

The remainder of the paper is structured as follows. Section 2 examines seasonality effects in BTC, Section 3 presents the analysis of the trend-following and mean reversion in BTC, and Section 4 concludes the paper.

2. Seasonality analysis

In our first examination, we map the Gemini hours to NYSE hours, and we examine the period when the NYSE is open (9:30-16:00). For BTC, we define the NYSE hours as 10:00-16:00 of NY local time (we miss half an hour to ensure that the NYSE is already open given our hourly granularity) to 15:00-21:00 UTC +0. Therefore, we define the intraday return as the return during 10:00-16:00, the overnight as return from 16:00 to 10:00 on the following day, and daily return as the return during 16:00 to 16:00 of the following day. Additionally, we define the days when the NYSE is closed (weekends and holidays) and the days when the NYSE is opened. To examine Bitcoin's behavior, one can evaluate statistical properties, e.g., by plotting a boxplot.

Secondly, by dividing returns into intraday, overnight, and daily components for days when NYSE is open or closed, one can examine the cumulative returns and empirically judge the properties during these distinct periods. Even though the crypto markets never close, defining the "intraday" and "overnight" components can be interesting since we can examine the performance when the main market is open. Additionally, it can represent the "core" daily hours when people (traders and investors) tend to be most active, at least on the traditional markets.

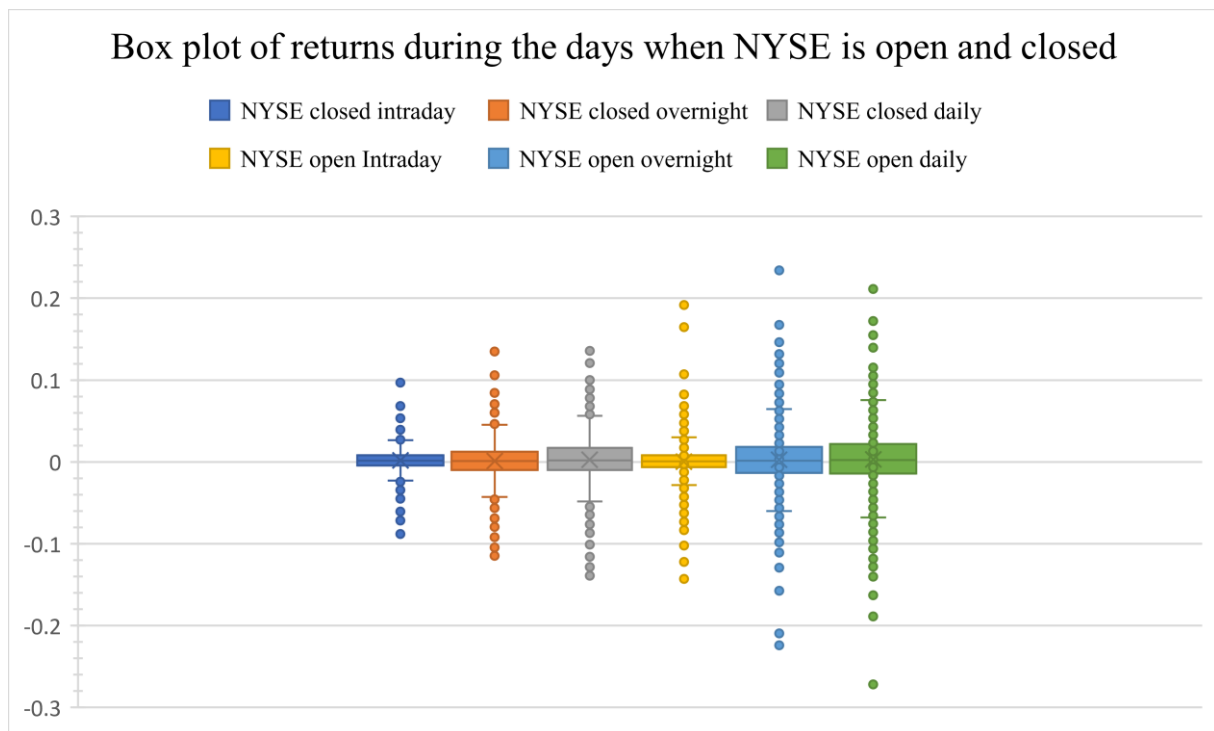


Figure 1 Box plot of returns mapped to days when NYSE is either opened or closed. Sample is based on the hourly data from the Gemini exchange during 9.10.2015 – 3.2.2022.



Figure 2 Theoretical development of the Bitcoin's intraday, overnight and daily returns when NYSE is closed.

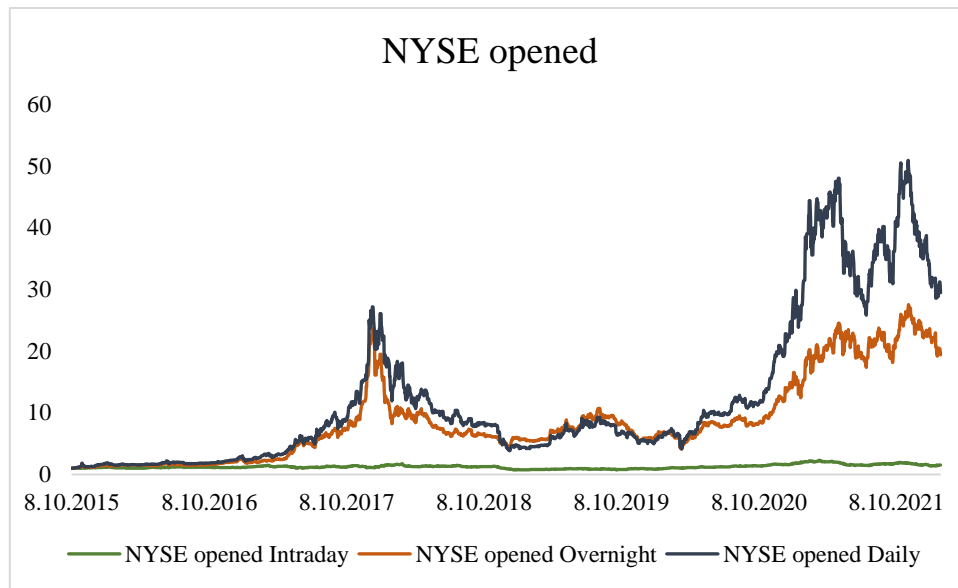


Figure 3 Theoretical development of the Bitcoin's intraday, overnight and daily returns when NYSE is opened.

As expected, the most significant proportion of the overall return relates to the days when NYSE is open (there are more days like that). Several interesting properties can be observed during weekends and holidays. The intraday return is stronger and more stable than the overnight return. Conversely, this does not hold for the days when NYSE is opened. In this case, the overnight's return dominates, and the intraday's return is small and volatile.



Figure 4 Theoretical development of the Bitcoin's intraday returns when NYSE is opened.

So, what about the main takeaways? The weekends/holidays performance is driven mainly by the intraday's component, and the overnight's return is more volatile, at least from the US investor's perspective. The opposite holds for the "normal" days when the NYSE is opened. The intraday return is relatively small and volatile, and the performance is driven mostly by the overnight component.

With the availability of the hourly data, we can also examine the hourly patterns in BTC. Are there significant differences during the day? Is there any period when it is best to hold the BTC? These are the questions we aim to answer in the following section.

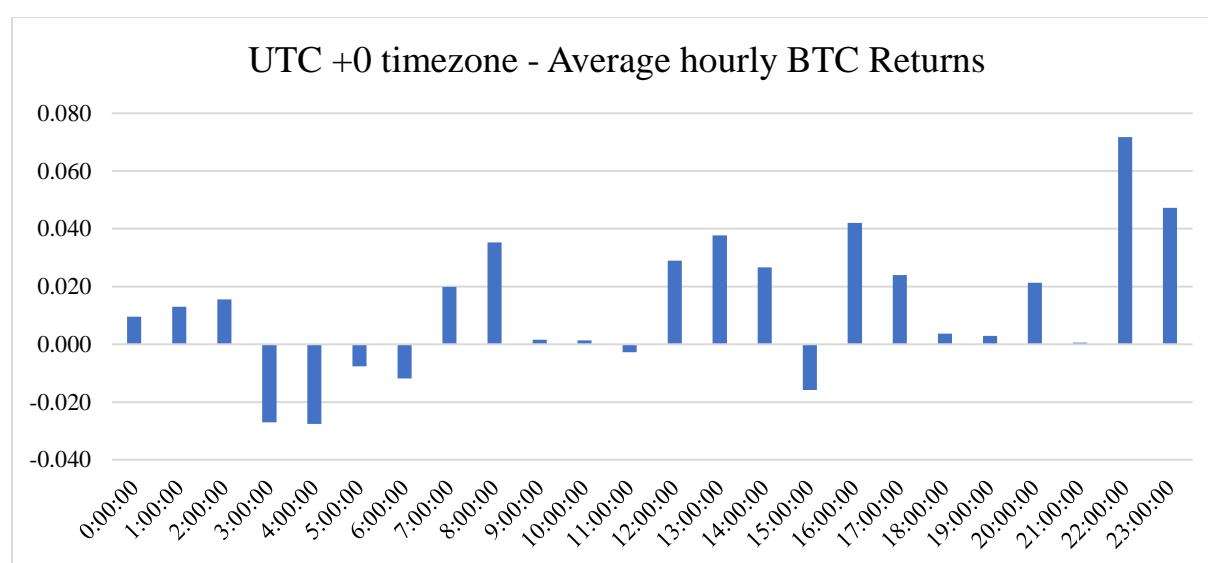


Figure 5 Average hourly returns for BTC.

The hourly distribution of the daily returns is not uniform. There are several periods when the return is relatively small and economically insignificant. Furthermore, there are several hours when the BTC returns are above the average. In particular, the returns for 22:00 and 23:00 seem to be the most economically significant. On the other hand, the sample's returns for 3:00 and 4:00 are the worst.

Nonetheless, the negative returns are insignificant, while several positive returns are statistically significant on the 5% level. From both statistical and economic points of view, the returns 22:00 and 23:00 dominate. Interestingly, all major markets are closed during this period. For UTC +0, the NYSE is open during 14:30 and 21:00, Tokyo Stock Exchange is also closed (it is opened from 00:00 to 06:00 of UTC +0 time), Hong Kong is also closed (it is opened from 01:30 to 08:00 of UTC +0 time), same as India (2:30 to 10:00 of UTC +0 time), and Australia

is closed too (23:00 to 05:00 of UTC +0 time). Both London and continental Europe are closed during these significant hours since it is night there. Therefore, it seems that the best time to trade (and hold) BTC is when every other major exchange is closed.

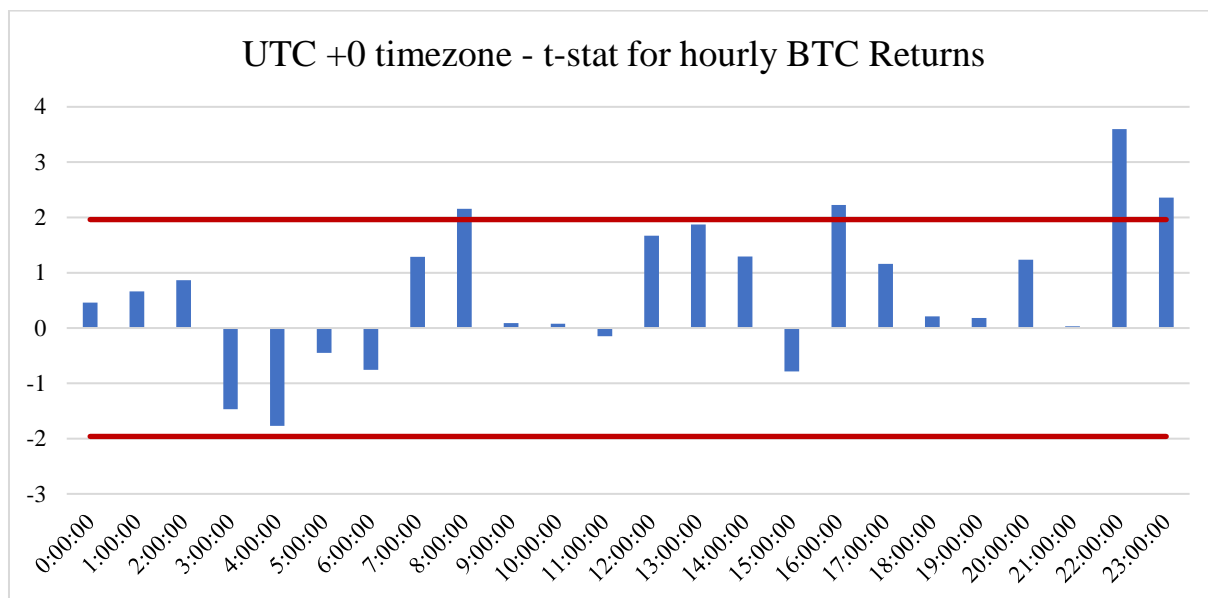


Figure 6 T-stats for average hourly returns for BTC. The red line denotes the 5% significance level.

Based on the previous results, we propose a simple seasonality strategy with a simple rule: buy Bitcoin at 21:00 (UTC +0) and sell it at 23:00 (UTC +0).

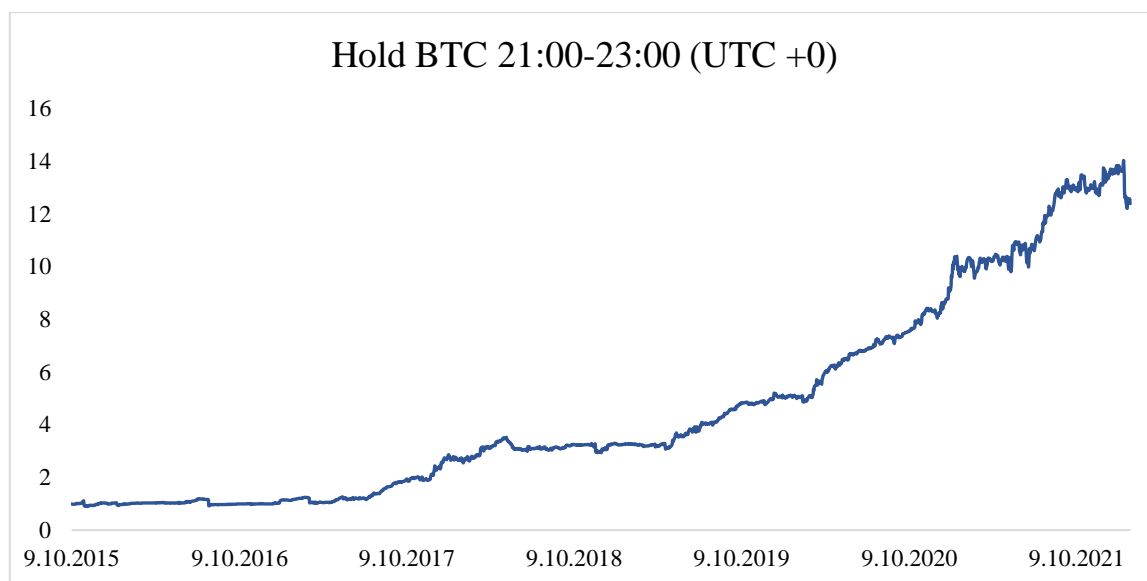


Figure 7 Development of the simple BTC seasonality strategy.

Compared to the BTC, the performance of the seasonality strategy is much more stable – the annualized volatility is 20.93%, and the maximum drawdown is only -22.45%. The annualized return is 33%.

3. Trend-following and mean reversion analysis

The first step consists of the calculation of the MAX or MIN at day t over the previous 10, 20, 30, 40 and 50 days:

$$\text{MAX}_{x,t} = \max(\text{BTC}_t, \dots, \text{BTC}_{t-x+1})$$

$$\text{MIN}_{x,t} = \min(\text{BTC}_t, \dots, \text{BTC}_{t-x+1})$$

Where BTC_t is the price at day t and x is the lookback period.

Subsequently, we can examine how does the Bitcoin behave when it is at its maximum, below its maximum, over its minimum or right at the minimum. The corresponding strategies can be formulated as follows:

$$r_{t,x,\text{at MAX}} = \begin{cases} r_{t,BTC} & \text{BTC}_{t-1} = \text{MAX}_{x,t-1} \\ 0 & \text{BTC}_{t-1} < \text{MAX}_{x,t-1} \end{cases}$$

$$r_{t,x,\text{below MAX}} = \begin{cases} r_{t,BTC} & \text{BTC}_{t-1} < \text{MAX}_{x,t-1} \\ 0 & \text{BTC}_{t-1} = \text{MAX}_{x,t-1} \end{cases}$$

$$r_{t,x,\text{at MIN}} = \begin{cases} r_{t,BTC} & \text{BTC}_{t-1} = \text{MIN}_{x,t-1} \\ 0 & \text{BTC}_{t-1} > \text{MIN}_{x,t-1} \end{cases}$$

$$r_{t,x,\text{over MIN}} = \begin{cases} r_{t,BTC} & \text{BTC}_{t-1} > \text{MIN}_{x,t-1} \\ 0 & \text{BTC}_{t-1} = \text{MIN}_{x,t-1} \end{cases}$$

Panel A					
Below MAX	10	20	30	40	50
Return	32.07	38.64	44.08	46.59	55.17
Volatility	65.49	66.46	67.08	68.06	68.58
MDD	-86.47	-84.36	-83.17	-84.68	-84.2
Ret/Vol	0.49	0.58	0.66	0.68	0.8
Panel B					
At MAX	10	20	30	40	50
Return	60.47	52.86	47.09	44.58	36.58
Volatility	35.44	33.59	32.33	30.2	29
MDD	-26.54	-26.32	-26.32	-23.49	-24.89
Ret/Vol	1.71	1.57	1.46	1.48	1.26

Panel C					
Over MIN	10	20	30	40	50
Return	71.35	96.22	87.29	84.88	94.51
Volatility	67.17	68.87	70.08	70.58	71.19
MDD	-83.75	-86.12	-83.71	-84.72	-80.88
Ret/Vol	1.06	1.4	1.25	1.2	1.33

Panel D					
At MIN	10	20	30	40	50
Return	23.68	8.01	13.15	14.63	8.96
Volatility	32.1	28.18	25.04	23.59	21.62
MDD	-36.05	-29.33	-26.62	-26.62	-26.62
Ret/Vol	0.74	0.28	0.53	0.62	0.41

Table 1 Basic performance characteristics of strategies that trade below or at MAX and over or at MIN. Return is the annualized return, Volatility is annualized volatility, MDD is the maximum drawdown, and Ret/Vol is the annualized return divided by the annualized volatility.

Based on Table 1, there are two striking observations. First, Bitcoin seems to be the riskiest when it is below the maximum or over the minimum. It is easy to argue that the strategies that follow these two events are more frequently invested, but the pattern also holds for maximum drawdowns.

For the MAX, the Bitcoin returns are better after at MAX days, and the strategy has higher returns and lower risk compared to a strategy that buys BTC below the MAX. The observation suggests that there is a strong momentum after local x-days maximums.

For the MIN, the Bitcoin returns are more substantial when the Bitcoin price is over the local x-days minima, but the strategies are hazardous with drawdowns over 80%. On the contrary, strategies that buy BTC at the minimum are less profitable and significantly less risky.

Therefore, we believe there might be a mean-reversion effect in the BTC.

For both at MAX and at MIN strategies, the shorter the lookback period is a better option, which is in line with the widely recognized dynamic behavior of the BTC. Both strategies have lower drawdowns or volatilities than the BTC (annualized volatility: 74.35% and MDD: -83.65%), but there might be a catch. The BTC trading at the MAX is a clear trend-following strategy that bets on the continuation of the good performance, and the risk lies in the negative return the following day. Betting on the mean-reversion at the bottom (at MIN) seems to be profitable and not that risky, but it is necessary to consider that BTC appears to be in favor of investors. Even though the BTC has already had several crushing drawdowns, it has always

bounced back. However, there is no guarantee that when the music stops the next time, it will play it again. For now, the data suggests that the BTC tends to revert to the mean, but a black swan event can be truly costly. Therefore, money and risk management might be necessary for such a strategy.

We further examine the strategies by plotting their equity curves.

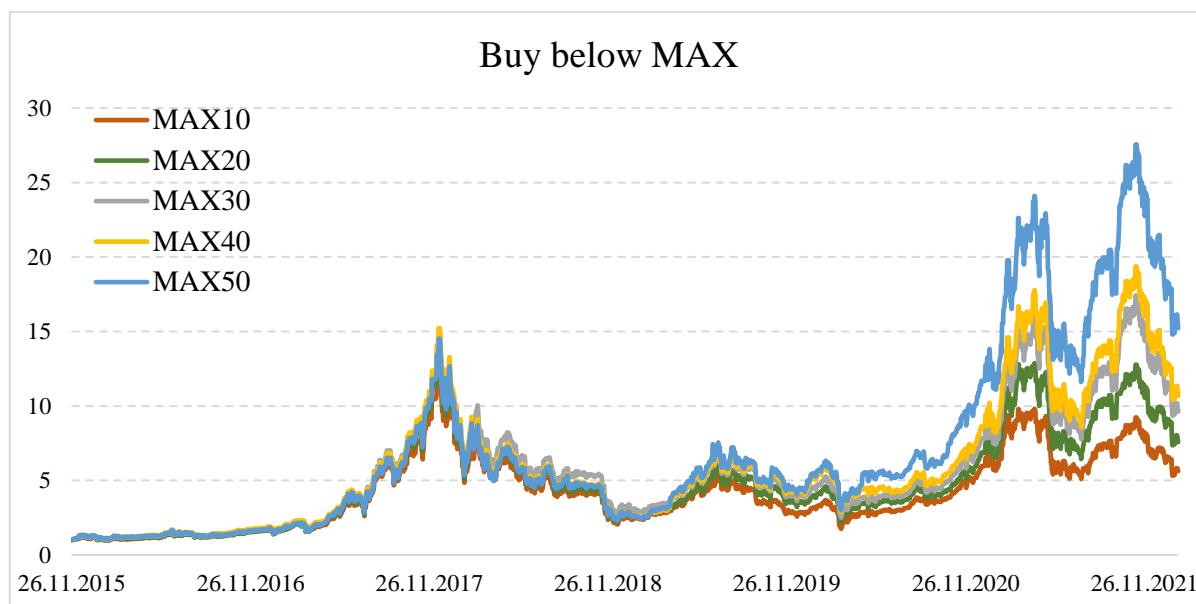


Figure 8 Visualization of simple strategies that buy BTC below the x-days maximum.

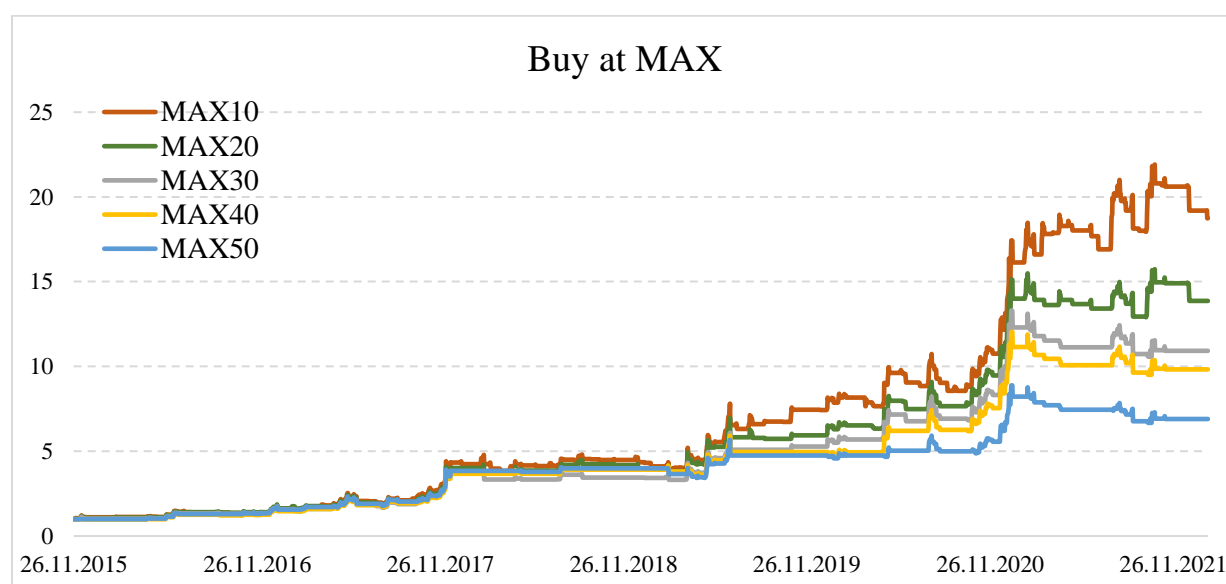


Figure 9 Visualization of simple strategies that buy BTC right at the x-days maximum.

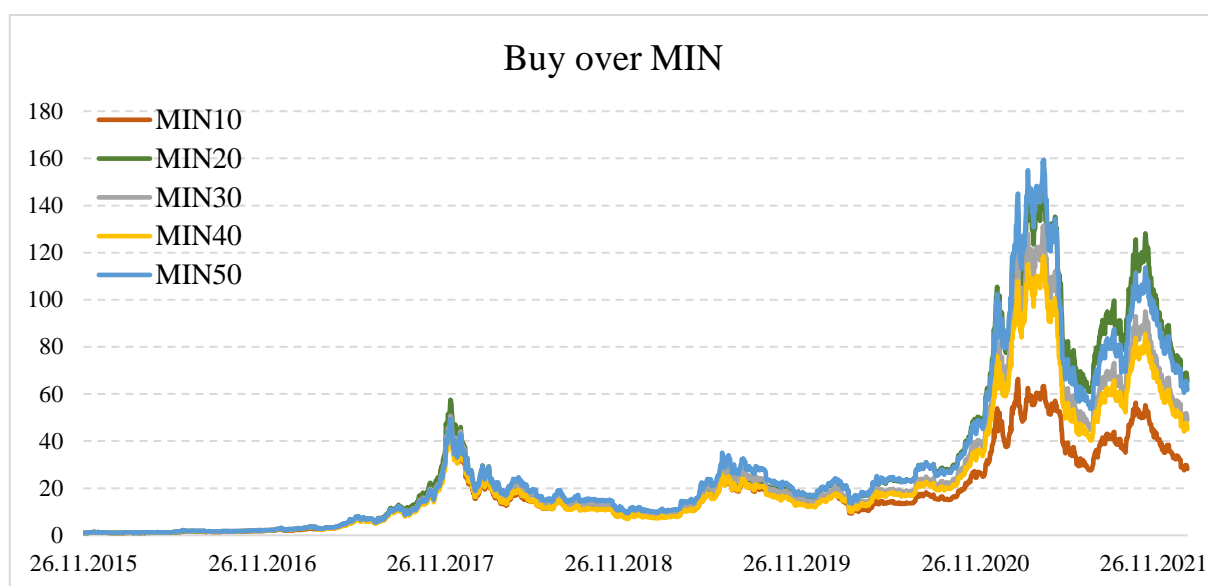


Figure 10 Visualization of simple strategies that buy BTC if it is higher than the x-days minimum.

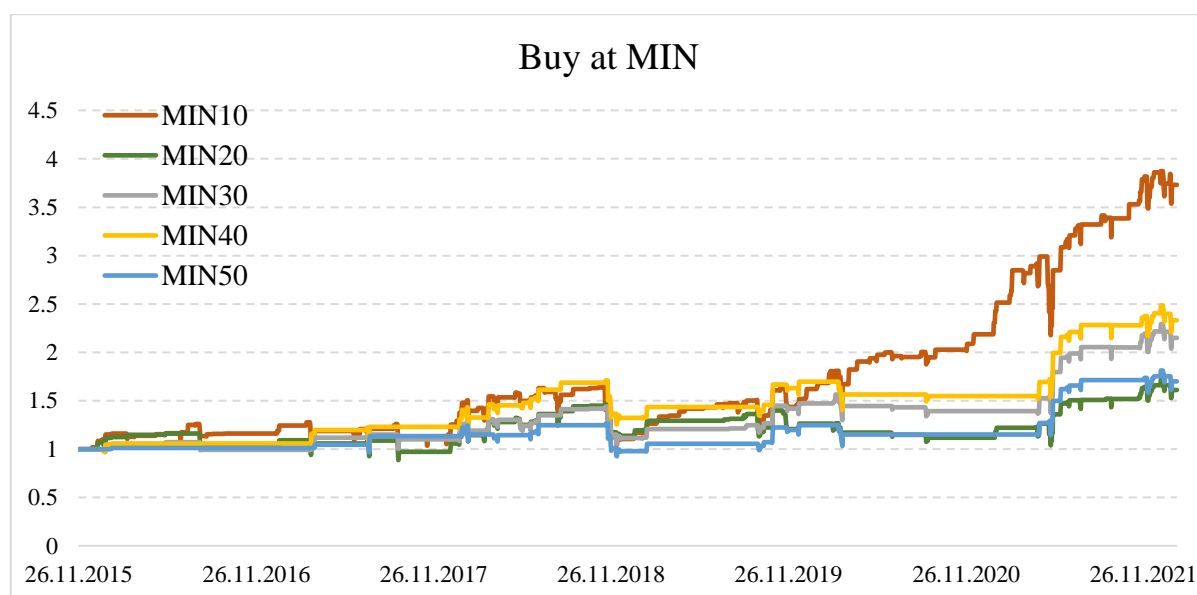


Figure 11 Visualization of simple strategies that buy BTC if it is right at the x-days minimum.

Buying BTC at the bottom or top (defined by the MAX or MIN) leads to more appealing equity curves. Although the strategies are frequently flat, the data support the hypothesis that the Bitcoin trends at the max and bounce back at the min.

Furthermore, since both strategies are mutually exclusive – you cannot be at the MIN and MAX simultaneously, it opens an obvious possibility to combine these two strategies. For that reason, we examine the combined strategy that buys the BTC if we are at the max or at the min and stays flat otherwise.



Figure 12 Composite MIN10 and MAX10 strategy.

So far, the strategy would have been excellent with an annualized return of 98.43%, 47.75% volatility, -37.67% MDD, and Ret/Vol 2.06.

4. Conclusion

In the first part of the study, we identified a major discrepancy among the intraday and overnight returns during the days when the NYSE is opened or closed (weekends and holidays). When the traditional market is closed, BTC has a strong intraday component and weak overnight component, and vice versa for the days when the NYSE is opened.

We have also examined the hourly patterns in Bitcoin's return. Results also point to a systematic difference. There is no statistically negative hour, but the performance is worst during 03:00 and 04:00 (UTC +0). On the other hand, there are several hours when the BTC returns are statistically significant. The most sizeable and significant returns relate to the 22:00 and 23:00. We also show that based on this finding, it is possible to construct a simple

seasonality-based strategy that is invested only during the two hours of the day and can deliver sizeable annualized returns of 33% with much smaller risk than the passive BTC holding, either measured by the volatility or maximum drawdown.

The second part examines technical strategies: the trend-following and mean-reversion. Both styles have been found quite effective across perhaps every asset class. Bitcoin and other cryptos are no exception. Several variations of trend-following strategies such as moving averages, time-series, cross-sectional momentum, and mean-reversion strategies such as reversal were identified in cryptos.

In our short study, we examined Bitcoin as the premier cryptocurrency. The main idea was to investigate whether there are trends and reversals. Or in other words, whether the trend-following and mean-reversion principles are effective while trading BTC.

Our finding shows that when the BTC is at the local maxima, it tends to continue trending upwards. Furthermore, the local minima are also connected with abnormal price action. As a result, the BTC tends to mean-revert and bounce back. In line with other literature, shorter lookback periods work better, and we have found that after exploring 10-, 20-, 30-, 40- and 50-days periods, the shortest tend to work the best.

The final finding is that since buying BTC at the local minima and maxima are mutually exclusive; these two strategies can be combined to exploit both effects. So far, building on the trending and back-bouncing behavior of the BTC would equate to the return to the volatility ratio over 2.

Related Literature

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