Master in Finance

Dissertation

Bitcoin cyclicality and investment strategy

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Abstract

Bitcoin, una fuerza pionera en el mundo de las finanzas digitales desde su creación en 2009, ha redefinido cómo percibimos el dinero. Esta disertación, "Ciclicidad de Bitcoin y estrategia de inversión", explora su papel como punto de referencia y sus eventos periódicos de reducción de la recompensa a los mineros, conocidos como “halvenings”. Estos eventos, que ocurren aproximadamente cada cuatro años, tienen el potencial de alterar las estrategias de inversión.

El objetivo principal es investigar el carácter cíclico de Bitcoin dentro de la dinámica de precios, proponer una estrategia de inversión basada en herramientas de análisis técnico y evaluar rigurosamente su desempeño frente a un enfoque de tenencia pasiva de Bitcoin.

La historia de Bitcoin, marcada por una extrema volatilidad de precios, ha pasado de la oscuridad a los titulares mundiales. Su escasez, estatus de “oro digital”, y los eventos de reducción a la mitad, que comenzaron en noviembre de 2012 y se repitieron en julio de 2016 y mayo de 2020, han dejado una huella notoria en la trayectoria de sus precios.

Esta disertación busca determinar si estos eventos y ciclos de precios recurrentes significan tendencias fundamentales. ¿Pueden ofrecer a los inversores oportunidades para optimizar la rentabilidad? El presente trabajo de investigación emplea análisis de datos históricos, indicadores técnicos y evaluaciones estadísticas para descubrir patrones y comportamientos del mercado.

Los siguientes capítulos han sido escritos inglés, con la intención de llegar a un publico internacional.

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1. Introduction

In the ever-evolving landscape of digital finance, Bitcoin (BTC) has emerged as the benchmark of the crypto space, reshaping the way we perceive and engage with the world of money. Since its inception in 2009, it has transcended traditional financial paradigms, offering both promise and perplexity to investors and enthusiasts alike. Central to this intrigue is BTC unique mechanism of "halvening," an event that occurs approximately every four years and has the potential to disrupt prevailing investment strategies.

This dissertation, titled "Bitcoin Cyclicality and Investment Strategy," explores the cyclical nature that underscores its price dynamics, intricately intertwined with the periodic halvening events. The objective of the current dissertation is to study BTC's price movements, formulate a well-considered investment strategy, grounded in the principles of technical analysis; and evaluate with statistical techniques whether this strategy can yield superior returns when compare against the passive approach of holding BTC as a long-term asset.

BTC's remarkable journey from its nascent stages to world headlines in 2017, is well known for its price volatility, ranging from mere cents to reaching meteoric heights. What distinguishes it from traditional assets is its programmed scarcity, in some remarks, making it comparable to gold. Hence the comparison of BTC being considered as digital gold. Every four years, BTC experiences a reduction in the rate at which new coins are created – a halvening. The first occurred in November 2012, followed by subsequent halvenings in July 2016 and May 2020, each leaving an indelible mark on the cryptocurrency's price trajectory.

This dissertation intends to explore whether these halvening events and the ensuing price cycles hold more than mere coincidence. Could these recurring patterns be indicative of fundamental trends that, when deciphered, offer investors an opportunity to optimize their returns? This research aims to provide answers to these critical questions.

The methodology comprises a multi-pronged approach, combining meticulous historical data analysis, advanced technical indicators, and rigorous financial assessment criteria. By deconstructing BTC's past price performances in relation to the halvening events, the aim is to discern patterns, correlations, and market behavior that may serve as guideposts for prospective investors.

2. Conceptual framework

This dissertation employs different theoretical tools widely used in the financial world to support or reject the idea behind the investment strategy.

2.1 Jensen's Alpha

Jensen's alpha is based on systematic risk. Any given portfolio's systematic risk can be measured by estimating the market model, which is done by regressing the portfolio's daily return on the market's daily return. The coefficient on the market return is an estimate of the beta risk of the portfolio. To calculate the risk-adjusted return of the portfolio, it is necessary to use the beta of the portfolio and the CAPM. The difference between the actual portfolio return and the calculated risk-adjusted return is a measure of the portfolio's performance relative to the market portfolio and is called Jensen's alpha. By definition, α of the market is zero. Jensen's alpha is also the vertical distance from the Security Market Line (SML) measuring the excess return for the same risk as that of the market and is given by:

$$\alpha_p = R_p - \{R_f + \beta_p[E(R_m) - R_f]\}$$

Where:
$R_{p=}$ the realized return of the investment
$R_{f=}$ the risk-free rate of return for the time period
$R_{m=}$ the realized return of the market index
β_p= the beta of the portfolio of investment with respect to the chosen market index

If the period is long, it may contain different risk-free rates, in which case R_f represents the average risk-free rate. Furthermore, the returns in the equation are all realized, actual returns. The sign of α_p indicates whether the portfolio has outperformed the market. If α_p is positive, then the portfolio has outperformed the market; if α_p is negative, the portfolio has underperformed the market. Jensen's alpha is commonly used for evaluating most institutional managers, pension funds, and mutual funds. Values of alpha can be used to rank different managers and the performance of their portfolios, as well as the magnitude of underperformance or overperformance.

2.2 Regression Analysis

Regression analysis, both the simple and multiple forms, are used by financial analysts and portfolio managers to examine whether a variable is useful for explaining another variable. It also allows for the use of hypotheses testing to examine the strength of the relationship between the variables. The variable whose variation is being explained is referred to as the dependent variable or explained variable, typically denoted by Y. Whereas, the variable used to explain the variation of the dependent variable is known as the independent variable, denoted by X. In the

current dissertation the dependent variable Y is the investment strategy, and the dependent variable X is the benchmark, BTC. Given that there is only one independent variable, the regression analysis used is a Simple Linear Regression (SLR) and it takes the following form:

$$Y = \alpha + \beta_0 X + \varepsilon$$

Where:
$Y =$ the dependent variable
$X =$ the independent variable
$\alpha =$ Intercept
$\beta_0 =$ Slope coefficient
$\varepsilon =$ residual error

In the context of SLR, there are some concepts that play an important role in understanding and interpreting the relationship between the independent and dependent variables. These concepts are the Mean, Variance and Standard deviation.

The mean is used to calculate the average return of a financial asset or investment over a specific period. It provides a measure of the central tendency of the data. Investors and analysts use the mean return to assess the historical performance of an investment or portfolio. It helps in understanding the average gain or loss over a given time frame.

In SLR, the mean is often used to calculate the average values of the variables involved. For instance, the mean of the independent variable X and the mean of the dependent variable Y are crucial in determining the coefficients of the regression equation.

$$Mean(\bar{X}) = \frac{\sum_{i=1}^{n} x}{n}$$

Where:
$X =$ the variable value
$n =$ number of periods

Variance measures the dispersion or spread of a set of financial returns around the mean. In finance, variance is used to assess the volatility or risk associated with an investment. A higher variance indicates greater price volatility, which is often associated with riskier investments. Investors and portfolio managers use variance to understand the potential fluctuations in the value of an asset. In SLR, it helps assess how much individual data points deviate from the mean of the dependent variable.

$$Variance(X) = \frac{\sum_{i=1}^{n}(X_i - \bar{X})}{n-1}$$

Where:
$\bar{X} =$ the variable mean
$X_i =$ the variable value
$n =$ number of periods

Standard deviation is closely related to variance and is another measure of the risk or volatility of a financial asset. It is often preferred over variance because it is expressed in the same units as the original data. Investors and analysts use standard deviation to quantify the degree of uncertainty or risk associated with an investment. A higher standard deviation implies higher risk.

$$Standard\ Deviation\ (X) = \sqrt{Var(X)}$$

Where:
$Var(X) =$ the variance

2.3 Hypothesis testing

In regression analysis, statistical hypothesis testing is often used to assess the significance of the regression coefficients, including the intercept α and the slope β_0. The significance of these coefficients is tested using the t-statistic and associated p-value. The null hypothesis H_0 typically states that the coefficient is equal to zero, implying no effect, while the alternative hypothesis H_a suggests that the coefficient is different from zero. The procedure for hypothesis testing is as follows:

The first step is defining the hypotheses.

The null hypothesis, the value assumed to be true and tested for validity. The assumption being that the strategy returns are similar to the benchmark, $H_0 = 0$. Whereas, the Alternative hypothesis, is everything else that isn't the Null hypothesis. Case at hand, that the strategy returns are different than the benchmark's, $H_a \neq 0$.

The second step is calculating the statistics for the Z and p-value.

$$Z = \frac{\bar{X} - \mu}{\sigma / \sqrt{n}}$$

Where:
$\bar{X}$ = the sample mean
μ = the population mean
σ = standard deviation
n = number of samples

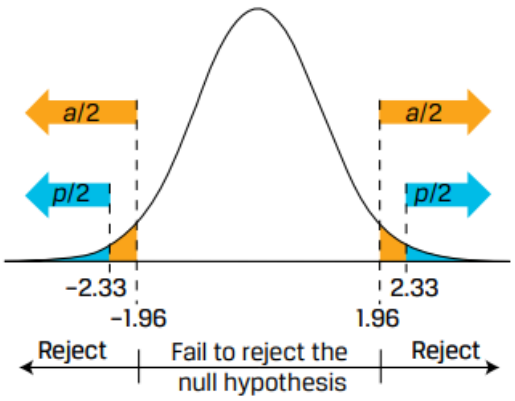
The p-value associated with the t-statistic is used to assess the statistical significance of the coefficient. A low p-value, of less than the chosen significance level of α=2.5% for a two tail test, indicates that the coefficient is statistically significant.

$$Z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$$

Where:
$\hat{p}$ = sample proportion
p_0 = assumed population proportion in the null hypothesis

Third step is establishing the critical values and rejection zones of H_0, taking in consideration the Type I & II errors. Where Type I is the incorrect rejection of an accurate H_0 and Type II is the probability of incorrectly retaining H_0, when it is not applicable to the entire population. In the current case, the significance level α has been set at 5%, and since it is a two tailed test, the critical region is α/2 = 2.5%

Figure 1: Null Hypothesis rejection



Source: CFA 2023, Level 1, Volume 1 Quantitative methods

The fourth and final step is taking a decision with the results.

The critical value for rejecting the H_0 will be all those observations of the intercept that are in excess of 2 standard deviations. The p-value will be used as an extra means of confirmation, but not a decisive factor in the rejection of H_0.

3. Investment strategy

3.1 Active vs passive approach

There are basically two ways of approaching investments in risky assets, an active pursuit in which the investor seeks to be compensated by his exposure to risk by maximizing his return, called alpha. Under this strategy the investor will have an active role in choosing the entry and exit points of his investment, believing it is possible to outperform the benchmark. And there is a passive strategy in which the investor believes that the performance of the benchmark cannot be beaten and therefore the strategy is simple. Invest in the benchmark and do not try to generate an excess return by taking opportunities during the market cycle.

The strategy outlined hereafter seeks to take advantage of the key events that characterize the BTC market cycle and outperform the returns of a passive investment strategy.

3.2 The asset and platform

The chosen asset for this strategy is BTC paired against the US Dollar (BTC/USD). BTC is a decentralized digital currency and a pioneer in the world of cryptocurrencies. It was created in 2009 by an anonymous individual or group of individuals using the pseudonym Satoshi Nakamoto. BTC operates on a technology called blockchain, which is a distributed ledger that records all transactions across a network of computers.

BTC was created to address various shortcomings in traditional financial systems, including centralization, lack of transparency, and issues related to trust and security. It aimed to provide an open, decentralized, and secure means of transferring value and conducting transactions in a digital world. Its impact has extended beyond its initial goals, influencing not only the broader cryptocurrency and blockchain ecosystem but also financial institutions. Currently the European region has a spot BTC ETF listed on Euronext Amsterdam and BlackRock is in process to achieve the same in US territory.

The chosen platform was Bitstamp, for being one of the earliest and most well-established cryptocurrency exchanges in the world. But also, for having one of the most complete data sets for the BTC pair. Founded in 2011, Bitstamp has earned a reputation for reliability and security in the cryptocurrency industry. Overall, the platform has played a pivotal role in the development and maturation of the cryptocurrency market. Its commitment to security, compliance, and user experience has made it a trusted platform for buying, selling, and trading cryptocurrencies for both individual and institutional investors.

3.3 Indicators and concepts

Simple moving average (SMA)

Is a commonly used technical indicator in financial analysis that smoot price data over specific periods to identify trends. Its calculation is quite straight forward and can be calculated over different time frames. The formula is as follows:

$$SMA = \frac{\sum_{i=1}^{n} P}{n}$$

Where:
P is the price value.
n = the number of periods.

Exponential moving average (EMA)

Is another commonly used technical indicators in financial analysis, similar to the SMA. However, the key difference with the EMA, is that it gives more weight to recent price data, making it more responsive to recent price changes. The formula is as follows:

$$EMA = (P * \alpha) + (Previous\ EMA * (1 - \alpha))$$

Where:
P = current price
α = smoothing factor = $\frac{2}{1+n}$
n= number of periods

Bull market support band (BMSB)

The bull market support band is an indicator that combines a 20 week SMA and a 21 week EMA. These two together create a band that has historically acted as support for the price during bull markets and as resistance during bear market.

Figure 2: BMSB

Source: Own (tradingview.com platform)

Pi cycle top indicator

This indicator has gained notoriety for indicating with days difference the highs of previous market cycles. It combines both a daily 111 SMA and a 350 SMA x2. When the 111 SMA approaches the 350 SMAx2 from below and crosses over, this signal indicates a market top.

Figure 3: Pi cycle indicator

Source: Own (tradingview.com platform)

RSI

The Relative Strength Index (RSI) is a popular technical indicator used in traditional assets and also in cryptocurrencies. It is a momentum oscillator that measures the speed and change of price movements. The main feature of the RSI is that it can help investors identify overbought

and oversold conditions in an asset, together with potential trend reversals. The formula is as follows:

$$RSI = 100 - \frac{100}{1 + RS}$$

Where:
Relative Strength (RS) = $\frac{Avg\ Gain}{Avg\ Loss}$

Both Average Gain and Loss are calculated over a period of 14 consecutive days. Positive and negative results are summed separately and divided by 14 to obtain the RS.

The results are going to range between 0 and 100 and the way to interpret them is the following:

- Overbought: If the RSI is above 70 it is in the overbought region. This suggests that the asset might be overvalued and that a correction or reversal might be close.
- Oversold: If the RSI is below 30, it is in the oversold region. It suggests that the asset might be oversold and a reversal might be possible.
- Trend reversal: Besides the oversold or overbought regions, RSI can be used in conjunction with price. If divergences are forming between the price and the indicator, this might signal a bullish or bearish reversal.

Figure 4: RSI Indicator

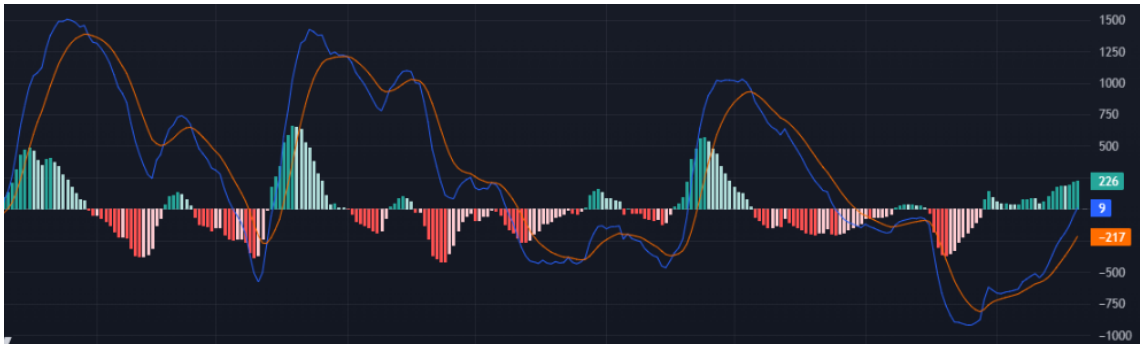
Source: Own (tradingview.com platform)

MACD

The Moving Average Convergence Divergence (MACD) is used in financial analysis, including stock, cryptocurrency, and other asset trading. The MACD is used to analyze the strength and direction of a price trend and to identify potential trend reversals. It consists of three main components:

- MACD Line (Blue Line): The MACD line is calculated by subtracting the 26-period EMA from the 12-period EMA. The result is plotted as a continuous line on a chart.
- Signal Line (Orange Line): The Signal line, also known as the 9-period EMA of the MACD line, is plotted on the same chart. It helps smooth out the MACD line and provides signals for potential buy or sell opportunities.
- Histogram (Bar Graph): The Histogram is the visual representation of the difference between the MACD line and the Signal line. It is plotted as vertical bars on a chart. The height of each bar represents the divergence between the two lines.

Figure 5: MACD Indicator



Source: Own (tradingview.com platform)

The common ways to interpret the MACD are the following:

- Crossovers: When the MACD line crosses above the Signal line, it generates a bullish signal, suggesting it may be a good time to buy. Conversely, when the MACD line crosses below the Signal line, it generates a bearish signal, suggesting it may be a good time to sell.
- Histogram: The Histogram is used to visualize the momentum of a trend. When it moves above the zero line, it indicates increasing bullish momentum. When it moves below the zero line, it indicates increasing bearish momentum.
- Divergence: Traders also look for divergences between the MACD and the price. For example, if the price is making lower lows while the MACD is making higher lows, it may signal a potential bullish reversal, and vice versa.

Divergences

Divergences in the context of cryptocurrency trading refer to a situation where the price of a cryptocurrency and a technical indicator (RSI, MACD or other oscillators) move in opposite directions or show a disparity. These divergences can provide traders with important signals about potential trend reversals or shifts in market sentiment. There are two main types of divergences in cryptocurrency trading: bullish and bearish divergences.

- Bullish Divergence: occurs when the price of an asset is making lower lows, but the technical indicator is making higher lows. This can be an early indication of a potential upward price reversal. It suggests that while the price is still in a downtrend, the momentum or strength of the downtrend is weakening, and a bullish reversal may be imminent. Bullish divergences are often seen as a buying signal.
- Bearish Divergence: occurs when the price of a cryptocurrency is making higher highs, but the technical indicator is making lower highs. This can be a warning sign of a potential downward price reversal. It suggests that although the price is still in an uptrend, the momentum or strength of the uptrend is waning, and a bearish reversal may be approaching. Bearish divergences are often seen as a selling signal.

BTC Halvening event

This is not an indicator, as the previously described, but rather an event that is programmed into the BTC protocol and occurs approximately every 4 years. Every 210,000 blocks mined, the reward that miners receive is halved, making the asset scarcer. The first halving occurred in 2012 when the reward went from 50 to 25 BTCs per block. The second halving occurred in 2016, reducing the reward to 12.5 BTCs. The third halving occurred in 2020, bringing the reward down to 6.25 BTCs. The last BTC halving is due to occur around the year 2140.

This event is of importance because it is designed to mimic the scarcity of precious metals like gold. By reducing the rate at which new BTCs are created, the total supply is capped at 21 million, creating a deflationary model.

Figure 6: Halvenings

Source: Own (tradingview.com platform)

3.4 Strategy and objectives

The aim of the strategy outline here is to outperform the benchmark in the long term by utilizing a mix of signals from the indicators and concepts mentioned previously; and avoid the periods of drawdown that BTC has become famous for.

This strategy enters a long position – non-leveraged- and exits into cash according to the signals given by the indicators mentioned previously.

The Pi cycle top indicator, on a daily frequency, identifies with great accuracy the current market cycle top price, thus acting as a sell signal.

The BMSB, on a weekly frequency, acts as the trigger for entering or exiting a long position.

The market cycle bottom range is identified by a combination of signals from different indicators, that as a standalone, don't tell much. But used together give a strong signal, this is known as a confluence[1].

Long buy criteria

- Enter long position when price opens for two consecutive weekly candles on top of bull market support band.
- Exception to rule, open long position close to market cycle bottom given by the confluence of the following indicators:
    - Halvening event must have occurred (1 every 4 years).
    - Pi cycle signal must have occurred (Daily signal)
    - Price must be below BMSB (Weekly frequency)
    - There must be over 105 weekly candles since the latest halvening.
    - Divergence in MACD histogram and BTC price (Weekly frequency)
    - Weekly RSI must have bottomed out in the oversold region of 30 and higher low structure confirmed on RSI. When all previous signals are confirmed, higher low RSI executes Long Buy.

[1] Confluence is the combination of multiple strategies and ideas into a complete strategy. Convergence occurs when two or more different ideas or strategies are used together to form a comprehensive investment strategy that fits the investor's risk profile and goals.

Sell Criteria

- When weekly candle price opens below BMSB.
- Pi cycle top signal has been confirmed after daily candle close.
- Exception to rule:
    - Long position has been opened closed to mkt cycle bottom, do not sell till Pi cycle top signal.

4. Strategy testing and conclusions

4.1 From scratch to results

Although there are several sites that have BTCUSD data set not all sites have a lengthy history and there are discrepancies between exchanges. The first step was identifying an exchange with a reliable data set and writing a python script to fetch the data. The chosen exchange is www.bitstamp.net, the written script to fetch the data set can be found in the subsequent annex section.

Once obtained the daily ohlcv for BTC (Open, High, Low, Close, Volume) data set in a .csv file, this was imported and formatted in an excel file. Within this excel file, in a new separate sheet were consolidated the date range, close and open prices, all related to the benchmark, BTC. An additional column was added to calculate the percentual gain or loss compared to the same day opening price. Immediately, next to these, three columns were added and are related to the strategy per se. The first column defines the condition "Long" vs "sold". Where the value 1 represents taking a long position in the asset and 0 represents selling into cash. The second column is the result of multiplying the daily returns by either the long or sold condition; returning the exact same daily return percent as the benchmark, in the case of "Long" condition and 0 for "Sold". The last column provides the name of the key event triggering the Long or Sold. In brief, the two most important columns of this table are: the benchmark's daily returns and the strategy returns. The starting point in time for both the passive and active strategies is the 11th of June 2012 when the long signal is confirmed, and the last day of the dataset is 4th of September 2023.

Having obtained the returns for the benchmark and the strategy, the next step was performing the linear regression using the strategy daily returns as the dependent variable Y and the benchmark daily returns as the independent variable X. For this, in a separate excel sheet were added the results of the regression analysis. The first examined period was from 11th June 2012 up till 4th September 2023. After these results, subsequent regression results were added to the same excel sheet but moving the entry point to approximately 1 year after, taking the starting point as 1st of June. The second regressed period was 1st June 2013 up till dataset end. Next period was 1st June 2014 and repeating this process up till the last examined period of 1st June 2022 till 4th September 2023. The idea behind performing several regression analysis with different entry points in time, was to have an additional valuation measure as to if the results are statistical significant or not.

To obtain the accumulated results of the strategy in time - and to keep things structured - an additional sheet containing the same data as the second sheet, was created. In this sheet, the

cumulative returns were calculated for both the passive approach and the active strategy. To obtain a better means of comparison the returns were calculated on a yearly basis.

Lastly, on a separate excel sheet, utilizing the open & close prices in conjunction with the key events triggering the long or sell signals, equity curves were created for the different long/sell signals. The equity curves simulate the growth of the trading account, assuming 1000 US$ were invested in each the passive and active strategy, with no other additional injection of capital. Thus, the passive strategy remains with a constant amount of BTC, determined at the moment the long is triggered; whereas the active strategy experiences a compounding effect with the different long and sell signals. In order to have a point of comparison with the active strategy, in terms of account value expressed in US$, the value of the passive account was also calculated at the date of long and sell signals.

4.2 Strategy Conclusions

The aim of this dissertation was to explore and analyze with statistical tools if the proposed active strategy could beat the performance of the benchmark, BTC. The short answer is that the strategy is successful.

Based on the regression results, it is clearly evidenced that the null hypothesis $H_0 = 0$ stating that the returns of the strategy are no different than the benchmark's, is rejected in favor of the alternative hypothesis $H_a \neq 0$. The results of the strategy are statistically significant in 9 out of the 11 periods examined. For those 9 periods, the t Stat value is in excess of the 1,96 mark defining the rejection area of the Null Hypothesis (when using a two tailed test with a 95% confidence interval). Furthermore, in 8 out of the 11 periods, the P-value is lower than 2,5%, supporting the rejection of the Null Hypothesis.

Figure 7: regression results

Period	*Coefficient α*	*Standard Error*	*t Stat >2*	*P-value < 2,5%*
6/2012 -9/2023	0.00191	0.00034	5.69609	1.31179E-08
6/2013 -9/2023	0.00162	0.00033	4.94859	7.80415E-07
6/2014 - 9/2023	0.00140	0.00031	4.52465	6.25762E-06
6/2015 - 9/2023	0.00138	0.00032	4.31433	1.65227E-05
6/2016 - 9/2023	0.00150	0.00036	4.20039	2.75256E-05
6/2017 - 9/2023	0.00155	0.00040	3.84010	0.000126327
6/2018 - 9/2023	0.00110	0.00039	2.80415	0.00509575
6/2019 - 9/2023	0.00087	0.00042	2.08565	0.037172588
6/2020 - 9/2023	0.00126	0.00049	2.56881	0.0103261
6/2021 - 9/2023	0.00048	0.00055	0.87163	0.383662797
6/2022 - 9/2023	0.00089	0.00062	1.44579	0.148918959

Source: Own (MS Excel)

When examining the yearly cumulative returns of Benchmark versus the strategy several things can be noticed. The first one, that when BTC rallies, the strategy outperforms the returns of a passive approach, as seen from years 2013, 2017 and 2021. The second notorious is that the strategy is also effective in limiting the negative results, as observed from the results for years 2014, 2018 and 2022. The third thing that can be appreciated from the returns of the benchmark, is a cyclical pattern recurring every four years. This pattern begins with the halvening event (years 2012, 2016 and 2020), continues with a bull market phase (years 2013, 2017 and 2021) and ensues with a bear market period (years 2014, 2018 and 2022).

Figure 8: cumulative returns

Year	Cum. ret BM	Cum. ret Strategy
2012	144.28%	144.28%
2013	5428.70%	8292.48%
2014	-56.15%	-24.49%
2015	34.23%	92.46%
2016	124.26%	124.26%
2017	1336.41%	1885.70%
2018	-73.39%	-3.71%
2019	94.09%	94.09%
2020	304.45%	304.45%
2021	59.40%	117.05%
2022	-64.24%	-23.26%
2023	56.21%	56.21%

Source: Own (MS Excel)

The results for the equity curve, that is, the growth for a hypothetical trading account, also yield significant results in favor of the strategy compared to the passive approach. The below table illustrates what would have been the end result of a trading account worth 1.000US$ if invested in the benchmark at the beginning of each of the periods. Note that the first date of the period is due to a “buy” signal. Followed by the value of the trading account at the end of the period, expressed as “End capital”. ROI is the return on the investment and the last column is the excess return generated by the strategy on top of the benchmark. As evidenced from the results of the equity curves, the strategy outperformed the benchmark in all of the selected periods.

Figure 9: equity curve comparison

Period	*End capital*	*ROI*	*Excess return on BM*
11/6/2012 - 4/9/2023	$ 4,711,496	471050%	5379%
2/9/2013 - 4/9/2023	$ 197,620	19662%	4948%
6/6/2014 - 4/9/2023	$ 39,239	3824%	3144%
9/2/2015 - 4/9/2023	$ 115,305	11430%	1362%
31/12/2018 - 4/9/2023	$ 6,739	574%	192%
16/8/2021 - 4/9/2023	$ 549	-45%	129%
4/4/2022 - 4/9/2023	$ 556	-44%	115%

Source: Own (MS Excel)

In summary, the regression analysis dismisses the null hypothesis, firmly demonstrating that the strategy's returns diverge significantly from the benchmark across the examined periods. The statistical significance, underscored by consistently surpassing the critical t-Stat value and yielding consistently low P-values, leaves no room for doubt in rejecting the Null Hypothesis.

Furthermore, a close examination of yearly cumulative returns highlights the strategy's adeptness in capitalizing on BTC rallies and mitigating losses during the bear cycles. This dynamic performance aligns with the cyclical nature of cryptocurrency markets.

The results from the equity curves bolster the case for the strategy's efficacy, showcasing its consistent outperformance of the benchmark in hypothetical trading scenarios.

It's noteworthy that the strategy demonstrates its effectiveness in navigating both bullish and bearish market conditions, consistently outpacing benchmark returns in upswings and mitigating losses in downturns. It is unclear whether the BTC price dynamics will continue to behave as they have so far, and similar results as the ones obtained may not be replicable. Nonetheless, the comprehensive evaluation across regression results, cumulative returns and equity curves, confirm its merit for serious consideration in investment decisions.

4.3 Afterthoughts on BTC's growth

As demonstrated by the statistical analysis, applying the active strategy during the selected period would have outperformed BTC with statistical significance. Although not related to the strategy, there is one question that deserves some consideration. Why has BTC experienced such incredible returns? While not exclusive, some of the arguments as to why BTC could have experienced such phenomenal periods of growth, are the following ones.

Market capitalization (mkt cap)

In July 2010 BTC had a mkt cap of slightly under 250,000 USD, by July 2013 it grew to 1.5 B and by the time of its first massive bull run mkt cap ascend to 13.6 B. Four years later, by the time of the second massive bull run on Dec 2017 mkt cap ascended to 320 B, only to drop to 56.4 B one

year later during the bear mkt cycle. At the height of its latest bull run on Nov 2021, mkt cap reached 1.3 T USD for BTC, whereas for the remaining crypto space it amounted to 1.7 T. Current BTC mkt cap, as per the time of writing, is around 738 B and remaining crypto assets mkt cap amounts to 661 B, 1.4T combined. Whereas just to give a means of comparison, the mkt cap of Apple, currently the highest company by mkt cap, is of 2.95 T. Silver stands at 1.3T and Gold at 13.2 T. The market cap of the S&P 500 currently stands at about 38 T, the global equity market is roughly 109 T and global bond markets, as of 2022, was 133 T.

Figure 10: market capitalization by market

Markets by mkt cap (in Trillion USD) Nov 2023	
Global Bond (as of 2022)	133
Global Equity	109
S&P 500	38
Gold	13.2
Apple	2.95
Global crypto	1.4
Silver	1.3
BTC	0.66

Source: Own (MS Excel)

It is important to remember that BTC is, after all, a new asset that has been in existence for only 15 years, compared to more mature markets mentioned previously. Given that BTC is an asset that is traded 24/7 and with global exposure it is essential to try to understand how global liquidity could affect the BTC price dynamics. Particularly when given its relatively small mkt cap, it can be easily pumped by the inflow of institutional investors or private companies that decide to buy and hold BTC as part of the assets within their balance sheet. This scenario occurred during the last cycle that saw BTC price propelled to 67,000 USD per BTC. Also equally important, is the fact that some governments hold BTC in their balance sheet and some countries, such as El Salvador and Central African Republic, have adopted BTC as legal tender currency. All of the aforementioned have a direct impact in the demand for BTC and thus have an impact in the price dynamics.

Inflation and interest rates

BTC is a consequence of the financial crisis of 2008, one of its purposes is to be a store of value and a hedge against inflation. Maybe it is a mere coincidence, but it is interesting to observe that the three bull rallies occur while inflation numbers (in the US) were on the rise and that the respective bear cycles take place while inflation numbers decrease. Another possible factor that could have contributed to BTC's growth and the bull periods, are the US Fed's interest rates during these periods. The growth cycles occur while interest rates are at their lowest value in

decades, sub 0.5 points. Rates started going up since Nov 2016 till they plateaued at 2.5 on Dec 2018, also marking the bottom for the 2018 bear cycle. Then on Feb 2020, the Covid-19 black swan event triggered the return of low interest rates of 0.25 points. Which could have benefited institutional investors by having access to cheap money for investment purposes.

The figure below illustrates in a graphical sense what was happening and when.

Figure 11: BTC's timeline along FED's interest rate & US inflation rate

Source: Own (tradingview.com platform)

Inverse relation with the DXY U.S. Dollar Index (USDX)

Curiously enough, throughout BTC's history there has been an inverse relationship with the DXY. Whilst also occurring in other periods, this inverse relationship is not as significant as in the months following the halvening event. This could well be a mere coincidence, or it could be an indicative of global economic factors. Under this premise, it is of interest studying the relationship between BTC and the DXY, given that the later factors in 7 major currencies: the US dollar, Euro, Japanese Yen, British Pound Sterling, Canadian Dollar, Swedish Krona and Swiss Franc.

At its core the index reflects the appreciation or depreciation of the US dollar versus the other major currencies in the basket, therefore its use as an economic indicator. Under this light, an inverse relation between BTC and the DXY could be explained by some of the objectives of BTC:

- Acting as a safe haven: BTC was conceived as a store of value and a form of digital gold. Inspired by the 2008 financial crisis, it was designed to act as a safe heaven during times of uncertainty when there is a lack of confidence in traditional financial markets.

- Inflation Hedge: Under an inflationary context, when there are doubts about currency devaluation and rising inflation, investors might take shelter in an asset like BTC, that has a capped supply and is not subject to central bank policies.

Figure 12: BTC-DXY inverse relation

Source: Own (tradingview.com platform)

Figure 12 illustrates the inverse relationship that has been observed between BTC and the DXY after the halvening event or shortly before. The figure plots in yellow the halvening event, color green and red are used to show the percentual increases or decreases for the same time window in BTC and DXY.

Halvenings effect

The halvening might mistakenly be overlooked as a simple event thar reoccurs every four years and that just halves BTC's miners reward in half. In fact, the BTC halvening is one of, if not, the most important characteristic of the asset, with profound implications for its economic model. The price fluctuations of the asset in the weeks prior and after the halvening can be explained by the following:

Supply Reduction: the reward that miners receive for validating and adding new blocks to the blockchain is reduced by half. Initially, when BTC was launched in 2009, miners received 50 BTCs per block. The first halving occurred in 2012, reducing the reward to 25 BTCs. The second halving occurred in 2016, reducing it further to 12.5 BTCs. The third halving occurred in 2020, reducing the reward to 6.25 BTCs. This reduction in the rate of new BTC creation is designed to control its overall supply.

Scarcity and Deflationary Nature: BTC's total supply is capped at 21 million coins. By halving the reward every four years, the rate at which new BTCs are created slows down over time. This controlled issuance creates a sense of scarcity, similar to precious metals like gold. The idea is that as the supply becomes more limited, and if demand remains constant or increases, the value of each BTC could rise.

Market Perception and Speculation: Traders, investors, and the broader market pay close attention to the halving events. The anticipation of reduced new supply often leads to increased speculation about potential price increases. This heightened interest can lead to increased demand in the period leading up to and following a halving, affecting the market dynamics.

In the figure below, the yellow lines mark when the halvening occurred and the consecutive growth in BTC's price after the event.

Figure 13: BTC's halvenings

Source: Own (tradingview.com platform)

In summary, the previously mentioned are some ideas that required further study and examination. But could provide a valid explanation as to why BTC grew the way it did.

In the first place, there is valid questioning regarding how easy it could have been to manipulate its value, given the low mkt cap of the asset. Further on this topic, throughout its history, BTC hasn't been a regulated asset and still isn't. It is not ruled out and requires further study, but pump and dump schemes could have taken place during the early years of the asset. At the same time, the influence that big institutional players have should not be overlooked nor the global exposure if the asset.

Second, as described above, macroeconomic forces and investors sentiment could have a strong impact on the price of BTC, as seen from price behavior during inflationary times and during times where interest rates are changing.

Lastly, is the halvening effect that as previously described, could have longer lasting effects on the value perception of the asset.

5. Annexes

Figure 14: Python script

```
pip install requests
import json
import requests
import pandas as pd
import datetime

currency_pair = "btcusd"
url = f"https://www.bitstamp.net/api/v2/ohlc/{currency_pair}/"

start = "2012-01-01"
end = "2023-09-05"

dates = pd.date_range(start, end, freq = "1D")
dates  = [ int(x.value/10**9) for x in list(dates)]

master_data = []

for first, last in zip(dates, dates[1:]):
    #print(first,last)

    params = {
            "step":86400,
            "limit":1000,
            "start":first,
            "end":last,
            }

    data = requests.get(url, params = params)
    data = data.json()["data"]["ohlc"]

    master_data += data

df = pd.DataFrame(master_data)
df = df.drop_duplicates()

df["timestamp"] = df["timestamp"].astype(int)
df = df.sort_values(by="timestamp")

df = df[ df["timestamp"] >= dates[0] ]
df = df[ df["timestamp"] < dates[-1] ]
# Montar el drive y descargar csv al drive
from google.colab import drive
drive.mount('/content/drive')
df.to_csv('/content/drive/MyDrive/Data/BTCUSDohlcv.csv', index=False)
```

Source: Own (google colabs)

Figure 15 below shows all the buy and sell signals, defined by the strategy. Note that on the sell signals, the Long/Sold is also 1, that is due to the signal confirming on the trading day end, executing the sell signal on the following day open.

Figure 15: Buy and sell signals

Benchmark + strategy returns						
Benchmark (BTC)				Strategy		
Date	close	open	BM %	Long/Sold	Strategy %	Key event
11/6/2012	5.5	5.5	0.73%	1	0.73%	Bull mkt crossover
5/4/2013	141.8	134.7	5.29%	1	5.29%	Pi Cycle Top
2/9/2013	130.2	130.7	-0.38%	1	-0.38%	Bull mkt crossover
5/12/2013	1,023.9	1,135.0	-9.79%	1	-9.79%	Pi Cycle Top
9/6/2014	648.8	658.0	-1.39%	1	-1.39%	Bull mkt crossover
17/8/2014	496.9	523.5	-5.08%	1	-5.08%	Bull mkt crossunder
9/2/2015	220.9	223.9	-1.35%	1	-1.35%	RSI bottom
16/12/2017	19,187.8	17,478.0	9.78%	1	9.78%	Pi Cycle Top
31/12/2018	3,693.3	3,831.0	-3.60%	1	-3.60%	RSI Bottom
12/4/2021	59,831.7	59,972.3	-0.23%	1	-0.23%	Pi Cycle Top
16/8/2021	45,930.5	47,025.0	-2.33%	1	-2.33%	Bull mkt crossover
5/12/2021	49,463.2	49,240.8	0.45%	1	0.45%	Bull mkt crossunder
4/4/2022	46,598.2	46,414.9	0.39%	1	0.39%	Bull mkt crossover
10/4/2022	42,133.9	42,774.9	-1.50%	1	-1.50%	Bull mkt crossunder
29/8/2022	20,302.0	19,571.0	3.74%	1	3.74%	RSI Bottom
4/9/2023	25,819.0	25,972.0	-0.59%	1	-0.59%	dataset end

Source: Own (MS Excel)

Figure 16: Regression results for the period June 2012 – September 2023

Regression Statistics	
Multiple R	0.736832059
R Square	0.542921483
Adjusted R Square	0.542810028
Standard Error	0.021452838
Observations	4103

ANOVA 6/2012 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.241844586	2.241844586	4871.200289	0
Residual	4101	1.887379722	0.000460224		
Total	4102	4.129224307			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001912339	0.000335729	5.696086283	1.31179E-08	0.001254129	0.002570549	0.001254129	0.002570549
X Variable 1	0.541903132	0.007764324	69.79398462	0	0.526680843	0.557125421	0.526680843	0.557125421

Source: Own (MS Excel)

Figure 17: Regression results for the period June 2013 – September 2023

Regression Statistics	
Multiple R	0.764598691
R Square	0.584611158
Adjusted R Square	0.58450027
Standard Error	0.02002793
Observations	3748

ANOVA 1/6/2013 - 4/9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.114716556	2.114716556	5272.056396	0
Residual	3746	1.502587913	0.000401118		
Total	3747	3.617304469			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001621352	0.000327639	4.948591096	7.80415E-07	0.000978984	0.00226372	0.000978984	0.00226372
X Variable 1	0.58339584	0.008034767	72.6089278	0	0.567642896	0.599148784	0.567642896	0.599148784

Source: Own (MS Excel)

Figure 18: Regression results for the period June 2014 – September 2023

Regression Statistics	
Multiple R	0.801665338
R Square	0.642667314
Adjusted R Square	0.642561626
Standard Error	0.018030477
Observations	3383

ANOVA 6/2014 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.976846985	1.976846985	6080.770879	0
Residual	3381	1.099156634	0.000325098		
Total	3382	3.076003619			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.00140421	0.000310346	4.524653556	6.25762E-06	0.000795724	0.002012696	0.000795724	0.002012696
X Variable 1	0.641296261	0.00822393	77.97929776	0	0.625171883	0.657420639	0.625171883	0.657420639

Source: Own (MS Excel)

Figure 19: Regression results for the period June 2015 – September 2023

Regression Statistics	
Multiple R	0.827404482
R Square	0.684598177
Adjusted R Square	0.6844936
Standard Error	0.01753562
Observations	3018

ANOVA 6/2015 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.013006273	2.013006273	6546.405088	0
Residual	3016	0.927413876	0.000307498		
Total	3017	2.940420149			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001379695	0.000319793	4.314334451	1.65227E-05	0.00075266	0.00200673	0.00075266	0.00200673
X Variable 1	0.683253104	0.008444621	80.90985779	0	0.666695306	0.699810903	0.666695306	0.699810903

Source: Own (MS Excel)

Figure 20: Regression results for the period June 2016 – September 2023

Regression Statistics	
Multiple R	0.813924384
R Square	0.662472902
Adjusted R Square	0.662345533
Standard Error	0.018397075
Observations	2652

ANOVA 6/2016 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.760365672	1.760365672	5201.221478	0
Residual	2650	0.896898748	0.000338452		
Total	2651	2.657264421			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001503065	0.000357839	4.200389218	2.75256E-05	0.000801392	0.002204738	0.000801392	0.002204738
X Variable 1	0.661014456	0.009165545	72.11949444	0	0.64304211	0.678986803	0.64304211	0.678986803

Source: Own (MS Excel)

Figure 21: Regression results for the period June 2017 – September 2023

Regression Statistics	
Multiple R	0.793125941
R Square	0.629048758
Adjusted R Square	0.628886416
Standard Error	0.019301856
Observations	2287

ANOVA 6/2017 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.443616496	1.443616496	3874.8392	0
Residual	2285	0.851303377	0.000372562		
Total	2286	2.294919873			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001551604	0.000404053	3.840104248	0.000126327	0.000759256	0.002343953	0.000759256	0.002343953
X Variable 1	0.627590385	0.010082064	62.2482064	0	0.607819431	0.64736134	0.607819431	0.64736134

Source: Own (MS Excel)

Figure 22: Regression results for the period June 2018 – September 2023

Regression Statistics	
Multiple R	0.814801741
R Square	0.663901876
Adjusted R Square	0.663726825
Standard Error	0.017223493
Observations	1922

ANOVA 6/2018 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.125075084	1.125075084	3792.617434	0
Residual	1920	0.56956553	0.000296649		
Total	1921	1.694640614			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.00110236	0.000393118	2.804147102	0.00509575	0.000331377	0.001873343	0.000331377	0.001873343
X Variable 1	0.662922233	0.01076448	61.5842304	0	0.641810931	0.684033535	0.641810931	0.684033535

Source: Own (MS Excel)

Figure 23: Regression results for the period June 2019 – September 2023

Regression Statistics	
Multiple R	0.848495599
R Square	0.719944782
Adjusted R Square	0.719764682
Standard Error	0.016528042
Observations	1557

ANOVA 6/2019 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.092015255	1.092015255	3997.476443	0
Residual	1555	0.424788925	0.000273176		
Total	1556	1.516804179			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.000874218	0.000419158	2.085654839	0.037172588	5.20443E-05	0.001696392	5.20443E-05	0.001696392
X Variable 1	0.719272455	0.011376285	63.22559959	0	0.696957977	0.741586933	0.696957977	0.741586933

Source: Own (MS Excel)

Figure 24: Regression results for the period June 2020 – September 2023

Regression Statistics	
Multiple R	0.757264733
R Square	0.573449875
Adjusted R Square	0.573091128
Standard Error	0.016849533
Observations	1191

ANOVA 6/2020 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.45381931	0.45381931	1598.480137	3.1765E-222
Residual	1189	0.337565133	0.000283907		
Total	1190	0.791384443			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.001255304	0.000488672	2.568806102	0.0103261	0.000296548	0.00221406	0.000296548	0.00221406
X Variable 1	0.572303773	0.014314395	39.9809972	3.1765E-222	0.544219487	0.600388059	0.544219487	0.600388059

Source: Own (MS Excel)

Figure 25: Regression results for the period June 2021 – September 2023

Regression Statistics	
Multiple R	0.681337777
R Square	0.464221166
Adjusted R Square	0.463570949
Standard Error	0.015938483
Observations	826

ANOVA 6/2021 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.18136796	0.18136796	713.9480249	8.9521E-114
Residual	824	0.20932504	0.000254035		
Total	825	0.390693			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.000483384	0.000554573	0.871632471	0.383662797	-0.000605158	0.001571925	-0.000605158	0.001571925
X Variable 1	0.463996675	0.017365271	26.71980585	8.9521E-114	0.429911303	0.498082048	0.429911303	0.498082048

Source: Own (MS Excel)

Figure 26: Regression results for the period June 2022 – September 2023

Regression Statistics	
Multiple R	0.818354957
R Square	0.669704836
Adjusted R Square	0.668985239
Standard Error	0.013247581
Observations	461

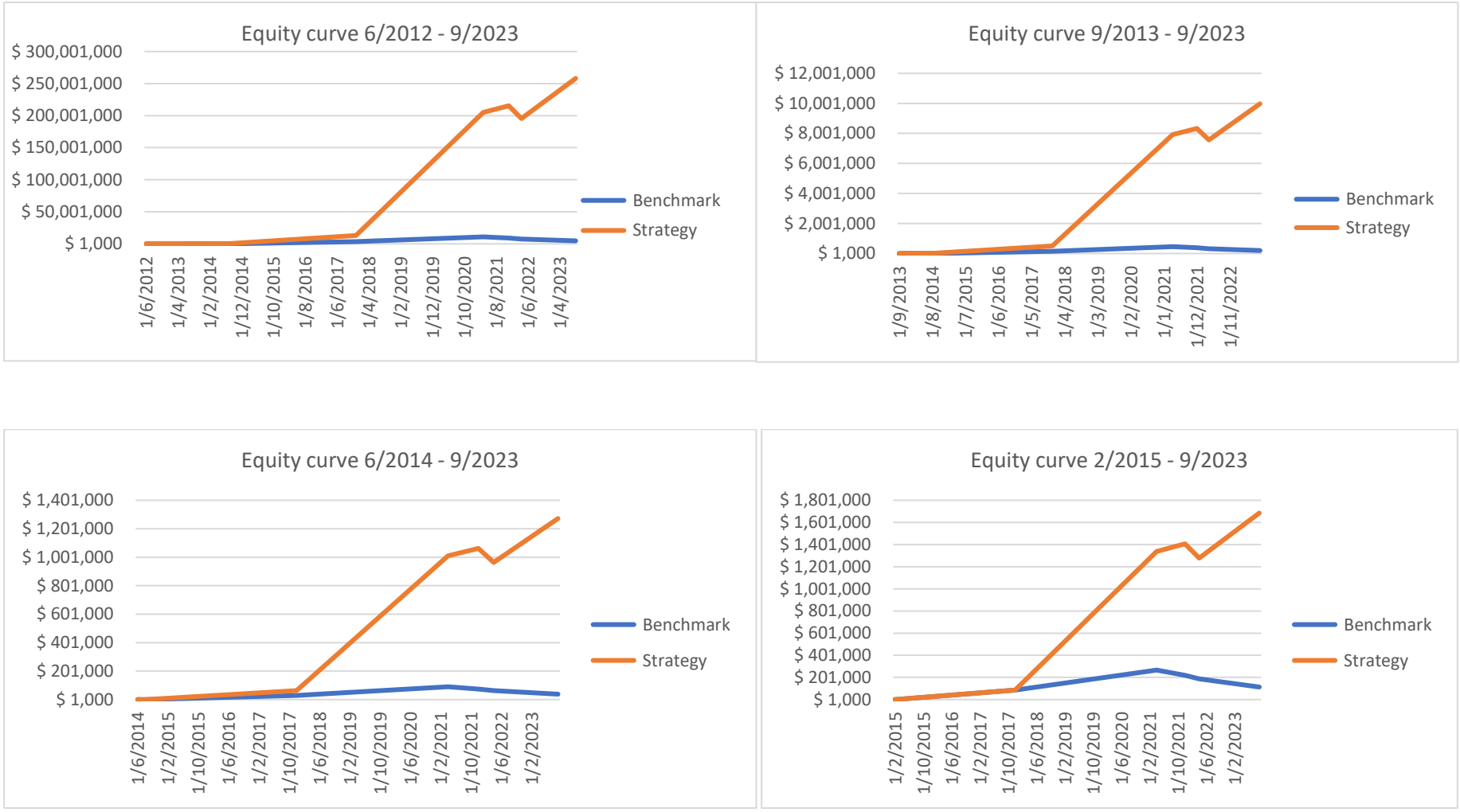
ANOVA 6/2022 - 9/2023

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.163330422	0.163330422	930.6661242	1.7597E-112
Residual	459	0.080553769	0.000175498		
Total	460	0.243884191			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.000892055	0.000617002	1.445788505	0.148918959	-0.000320445	0.002104555	-0.000320445	0.002104555
X Variable 1	0.668719954	0.021920342	30.50682095	1.7597E-112	0.625643287	0.711796622	0.625643287	0.711796622

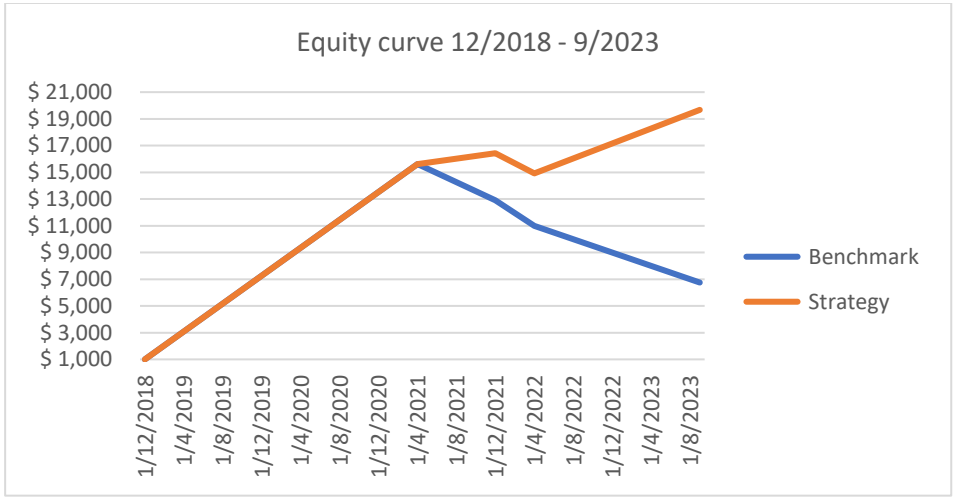
Source: Own (MS Excel)

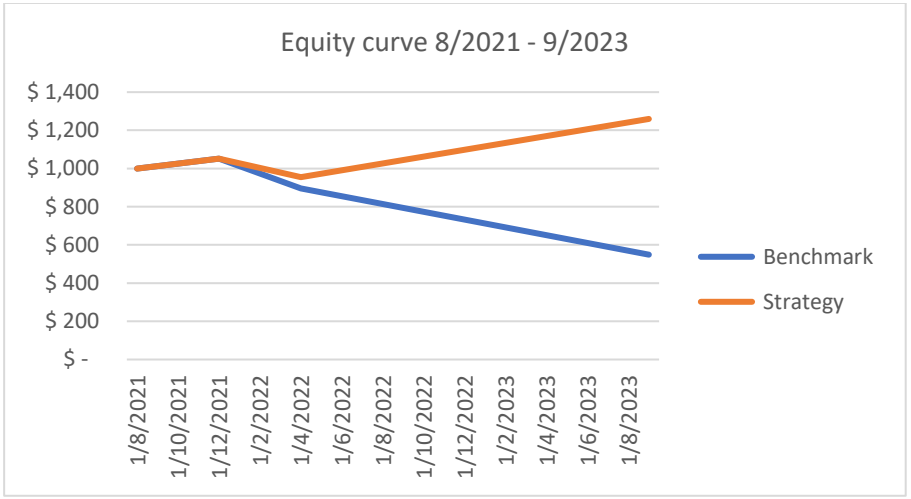
Figure 27: Equity curves pt 1

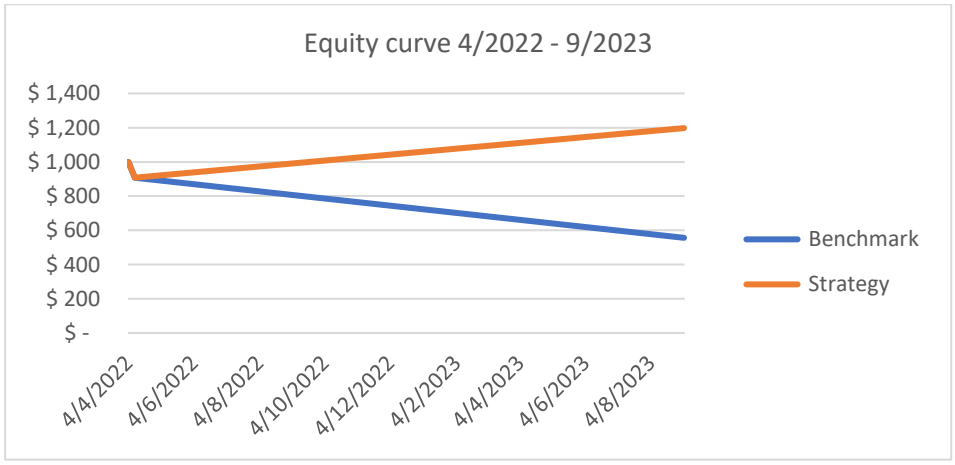


Source: Own (MS Excel)

Figure 28: Equity curves pt 2







Source: Own (MS Excel)

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