# Hedge Funds

Final project: Bitcoin, the Canary in the Coalmine

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## *Introduction & Trading Hypothesis*

Our systematic trading strategy builds on the hypothesis that Bitcoin's price movements over the weekend may provide predictive signals for early-week price action in other assets (Equities, Bonds, Gold and Bitcoin related assets). This aligns with research on market inefficiencies and cross-asset spillovers, suggesting that liquidity constraints, trader composition, and institutional market participation drive delayed price reactions in correlated assets (Fidelity Digital Assets, 2021). We identify, test, and assess these inefficiencies for profitable early-week trades. This report details the data, methodology, backtesting results of our four strategies, respective sensitivity analyses and overall conclusion.

## *Data Description*

The dataset includes daily open/close prices across asset classes. The data spans January 1, 2021, to March 13, 2025. Solely for the purpose to ensure a functioning strategy at the beginning of 2021, we extended the data set for the calculation rolling windows of the volatilities and means, starting September 30, 2020. The dataset encompasses a total of 13 distinct instruments, categorized as follows:

- Equities: S&P 500 Futures (ES1), DAX Futures (DAX)

- Bonds: US 2-Year Generic Bond (TU1), US 10-Year Generic Bond (TY1)

- Currencies: US Dollar to Euro (USDEUR, EC1), US Dollar to Japanese Yen (USDJPY, JY1)

- Bitcoin-Related Equities & ETFs: MicroStrategy (MSTR US), HUT 8 Corp (HUT CN), XTRA Bitcoin Inc (CBTC US), CoinShares Valkyrie Bitcoin Miners ETF (WGMI US), Bitwise Crypto Industry Innovators ETF (BITQ US)

- Commodities & Cryptocurrencies: Gold (XAU), Bitcoin (XBT)

For each asset, daily logarithmic returns were calculated based on open and close prices to ensure consistency. The dataset was partitioned into an in-sample period, spanning from January 1, 2021, to December 31, 2023, and an out-of-sample period, covering January 1, 2024, to March 13, 2025.

## *Methodology*

Our investment strategy employs a systematic and quantitative approach to generating investment signals and determining position sizing. The primary signal is derived from the mean daily logarithmic return of the Bitcoin spot price. A directional signal $S_t$ $(-1,1)$ is set each Monday from Bitcoin's average weekend log return. The signal is defined as follows:

$$S_t = \begin{cases} 1, & \text{if } \bar{r}_{BTC} > 0 \\ -1, & \text{if } \bar{r}_{BTC} \leq 0 \end{cases}$$

Once the binary signal is generated, we assess the correlation between Bitcoin and each asset over the preceding two weeks (10 trading days, excluding weekends) $\rho_{BTC,Asset} = \text{Corr}(r_{BTC}, r_{Asset})$. If the correlation exceeds the predefined correlation threshold, we proceed with trading based on the signal. In our hyperparameters, we additionally specify our trading behaviour based on the binary signal being positive or negative:

- If Positive = 1, we take a long position when $S_t = 1$ and vice versa

- If Negative = -1, we take a short position when $S_t = -1$ and vice versa

To account for trading costs, we apply a fee of 2 bps per trade, which is incorporated by multiplying the number of trades and deducting them from the return. To further leverage information potentially

embedded within weekend price movements, we incorporate four distinct sub-strategies. A binary strategy that does not size positions and three strategies that dynamically adjust position size: a Z-Score adjustment based on weekend returns, a volatility-based adjustment, and a volatility-of-volatility-based adjustment. Positions initiated based on these signals are held intraday, from market opening to closing.

### *Strategies*

We tested Long-Short, Long-only, and Short-only strategies, optimizing the correlation filter for maximum Info-Sharpe across the 13 assets. These were then validated out-of-sample

### *Binary*

Using a common binary signal, without employing sophisticated position sizing or overly engineered signals, we achieve Information Sharpe ratios as high as 1.28 (including fees). This performance is observed in the Bitwise Crypto Industry Innovators ETF (BITQ) when setting the correlation threshold to 0.05 and taking a long position when Bitcoin's weekend return is negative (i.e., Negative = 1).

### *Return Z-Score*

To incorporate potential signals embedded within the weekend price dynamics of Bitcoin and to transition from a binary signal to a continuous measure, we employ a Z-score for the transformation.

The Z-Score given as: $Z_t = \frac{(r_t - \mu)}{\sigma}$

Where $\mu$ is the mean of a given time window and $\sigma$ the variance. While the Z-Score has theoretically no boundaries, it ranges in our sample between 5 and -5 with the expected zero mean. As we take the absolute value of the Z-Score as the position size, this does imply that we have at most a positioning that is 5 times the book value. This is reasonable as we only hold the position for one day, therefore it does not result in exuberated fees. In this case the metric is constructed by calculating the Z-score of the two-day mean Bitcoin returns ($r_t$), utilizing a 90-day moving average ($\mu$), and a corresponding 90-day moving standard deviation ($\sigma$) for standardization. This methodology is adopted to integrate the strength of the observed weekend return signal directly into the position sizing decision, allowing for a more nuanced and responsive allocation of capital.

By applying this metric, we observe that in general the kurtosis of the strategies increases substantially while the sharp ratio decreases. In the same example as given above the info sharp drops to 0.87 (excluding fees) while the kurtosis increases to 28.8 from 10.5, showcasing suboptimal positioning.

### *Volatility Z-Score*

First, we compute the rolling 30-day standard deviation of daily Bitcoin returns, which serves as a proxy for realized volatility. This rolling volatility measure is then normalized using the Z-score to account for deviations from the trend. The effect of the metric shows with the same given example, that the kurtosis drops back to the 12.4 and the sharp increases again to 1.04 (excluding fees).

### *Volatility of Volatility Z-Score*

To mitigate potential signal noise arising from periods of structural changes in volatility, we incorporated a measure based on the Z-score of volatility of volatility. This metric is constructed as follows: first, we calculate the 30-day moving volatility of daily Bitcoin returns. Subsequently, we compute the 30-day volatility of this initial volatility measure. The primary advantage of utilizing the volatility of volatility Z-score lies in its ability to quantify the rate of change in volatility, as opposed to merely reflecting the absolute level of volatility. This distinction is crucial, as rapid fluctuations in the change of volatility may serve as leading indicators of shifts within the broader macroeconomic environment.

*Aggregate Portfolio*

Our backtesting across the four sub-strategies shows crypto-based equities and ETFs outperform traditional assets, especially in long-short and short-only strategies. Bitcoin-related assets show more pronounced market inefficiencies from weekend price swings than traditional assets like equities, bonds, or commodities. This phenomenon aligns also with findings from Kaiko Research (Cointelegraph, 2024), which indicates that spot Bitcoin ETFs experience a concentration of trading volumes during weekdays. This trading pattern can exacerbate weekend price swings in Bitcoin and, consequently, amplify inefficiencies in the pricing of related equities and ETFs.

Further, our analysis of Sharpe ratios[1] demonstrated that crypto-exposed assets, including MicroStrategy (MSTR), HUT 8 Corp (HUT), XTRA Bitcoin Inc (CBTC), CoinShares Valkyrie Bitcoin Miners ETF (WGMI), and Bitwise Crypto Industry Innovators ETF (BITQ), consistently delivered superior risk-adjusted returns compared to traditional macroeconomic assets (equity indices, bonds, forex, and gold). The relative underperformance could be attributed to several factors. Firstly, while Bitcoin is increasingly gaining recognition as a macro-relevant asset, its full integration into established macroeconomic dynamics may not have been complete during our analysis period. Secondly, Bitcoin's historical tendency towards speculative trading introduces idiosyncratic risks, leading to weekend return fluctuations that are often uncorrelated with broader macroeconomic drivers. This results in noisier signals than in traditional macro assets. Finally, the continuous trading of currencies may lead to more efficient pricing of macro-relevant news before the start of the trading week on Monday, potentially erasing the relationship between weekend Bitcoin price movements and subsequent Monday currency returns.

Given the observed underperformance of macro assets and the identified strengths within the Bitcoin-related assets, our portfolio focused specifically on Bitcoin-related assets. Consequently, we initially selected the following five assets for inclusion in our aggregate portfolio: MSTR, HUT, CBTC, WGMI, and BITQ. Through sensitivity analysis, we observed that MSTR, HUT, and CBTC tend to follow Bitcoin's weekend trends, so we applied the volatility of volatility strategy to capture momentum. In contrast, WGMI and BITQ showed mean-reversion tendencies, making the binary strategy more suitable. For all assets within the portfolio, the correlation filter was set to zero. This was done to maximize trading days and to reduce kurtosis, smoothing the overall return profile of the individual asset return series. Furthermore, a macro shock experienced on the weekend should have an impact on the pricing no matter the preceding correlation between all assets, and therefore also Bitcoin.

To determine the optimal asset weights, we employed an iterative optimization process[2], testing the impact of different weighting schemes across all five selected assets on the Information Sharpe ratio, the maximum drawdown and positive trading days (as a percentage). The objective of this optimization was to maximize the portfolio's Info-Sharpe over both the in-sample period (2021-2023) and the total sample period (2021-2025). Please refer to Exhibit 1, showcasing the different scenarios tested for our aggregate portfolio. Our analysis indicated that an optimal portfolio allocation, consisting of equal weights in HUT, CBTC, and WGMI (excluding MSTR and BITQ), yielded an Information Ratio of 1.39 during the in-sample period and 1.49 across the total sample period, both inclusive of transaction fees. This portfolio demonstrated a positive trading day frequency of 52.9% (based on Mondays), a positive monthly return frequency of 64%, and a maximal drawdown of 15.58%. Furthermore, the return distribution exhibited a positive skew of 4 and a high kurtosis of 54.78. The consistent Info-Sharpe ratio observed across varying market conditions,

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[1] The full analysis can be found in the provided Excel for each strategy. It incoperates the options long-short, long-only and short-only for each correlation filter.

[2] The results of this iteration can be found in the Excel in the sheet named "Portfolio" and in the appendix

from a Bitcoin downtrend in 2022 to ranging markets in 2023 and uptrends from late 2023 to the present, suggests a robust relationship between Bitcoin's price movements and the returns of the selected Bitcoin-related assets, mitigating concerns of spurious correlations. This consistency, alongside the strategy's sustained uptrend and high percentage of positive months, further supports our findings. Statistically, the stable Information Ratio across different market regimes indicates the strategy's potential robustness. However, the high kurtosis suggests a distribution with fat tails and the potential for extreme events, necessitating careful risk management considerations.

## *Conclusion*

While our analysis did not establish a statistically significant predictive relationship between Bitcoin's weekend returns and the subsequent Monday performance of traditional macroeconomic assets (potentially due to the reasons previously discussed), we did identify a clear impact on the performance of Bitcoin-related assets. This observed relationship, however, is subject to potential evolution with the continued growth and broader adoption of Bitcoin. For instance, the establishment of a strategic Bitcoin reserve in the United States, as outlined in a recent White House fact sheet (The White House, 2025), could signify a growing recognition of Bitcoin's macroeconomic importance. Such developments could enhance Bitcoin's predictive power across various asset classes in the future, while simultaneously potentially diminishing the currently observed pricing inefficiencies within Bitcoin-related assets as these markets mature and become more integrated into mainstream financial markets.

*Appendix:*

Exhibit 1: Sensitivity Analysis of the portfolio weighting

| MSTR | HUT | CBTC | WGMI | BITWISE | IS | Pos. Days | Max. DD |
|------|------|------|------|---------|------|-----------|---------|
| 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,98 | 46,15% | -39,80% |
| 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 1,05 | 56,00% | -32,61% |
| 0,00 | 0,00 | 1,00 | 0,00 | 0,00 | 0,86 | 58,00% | -52,39% |
| 0,00 | 0,00 | 0,00 | 1,00 | 0,00 | 0,96 | 42,00% | -21,27% |
| 0,00 | 0,00 | 0,00 | 0,00 | 1,00 | 0,50 | 50,00% | -25,19% |
| 0,25 | 0,25 | 0,25 | 0,25 | 0,00 | 1,38 | 64,00% | -16,27% |
| 0,25 | 0,25 | 0,25 | 0,00 | 0,25 | 1,28 | 58,00% | -16,55% |
| 0,25 | 0,25 | 0,00 | 0,25 | 0,25 | 1,23 | 61,00% | -16,17% |
| 0,25 | 0,00 | 0,25 | 0,25 | 0,25 | 1,12 | 61,00% | -22,90% |
| 0,00 | 0,25 | 0,25 | 0,25 | 0,25 | 1,33 | 64,00% | -15,82% |
| 0,20 | 0,20 | 0,20 | 0,20 | 0,20 | 1,31 | 58,00% | -14,74% |
| 0,00 | 0,33 | 0,33 | 0,33 | 0,00 | 1,39 | 64,00% | -15,58% |
| 0,00 | 0,50 | 0,50 | 0,00 | 0,00 | 1,26 | 67,00% | -23,08% |
| 0,00 | 0,50 | 0,00 | 0,50 | 0,00 | 1,32 | 58,00% | -16,99% |
| 0,00 | 0,00 | 0,50 | 0,50 | 0,00 | 1,06 | 64,00% | -26,46% |

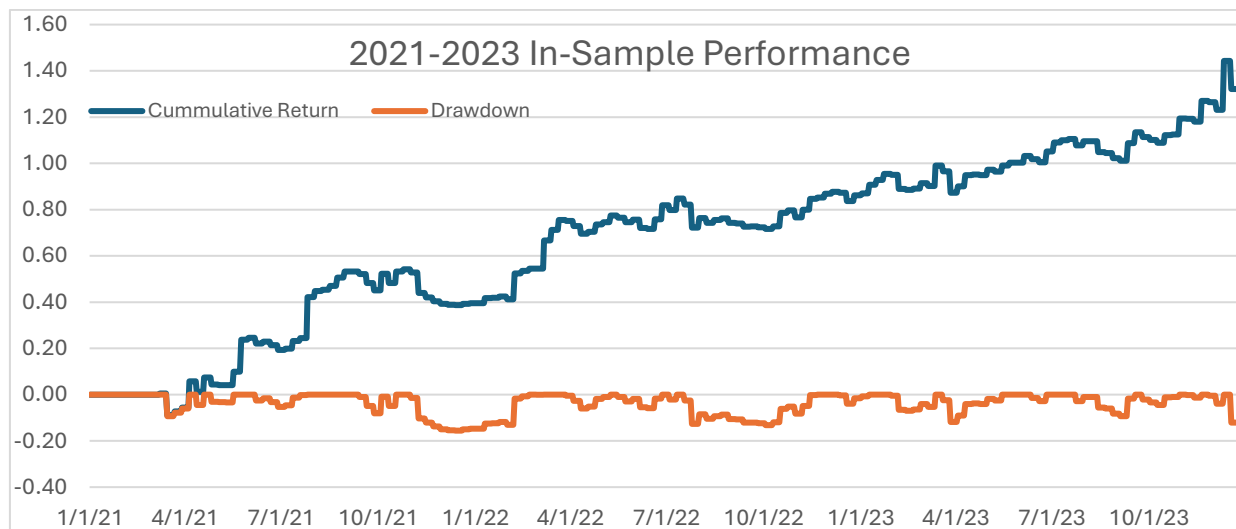Exhibit 2: In-Sample Performance of the Aggregate Portfolio

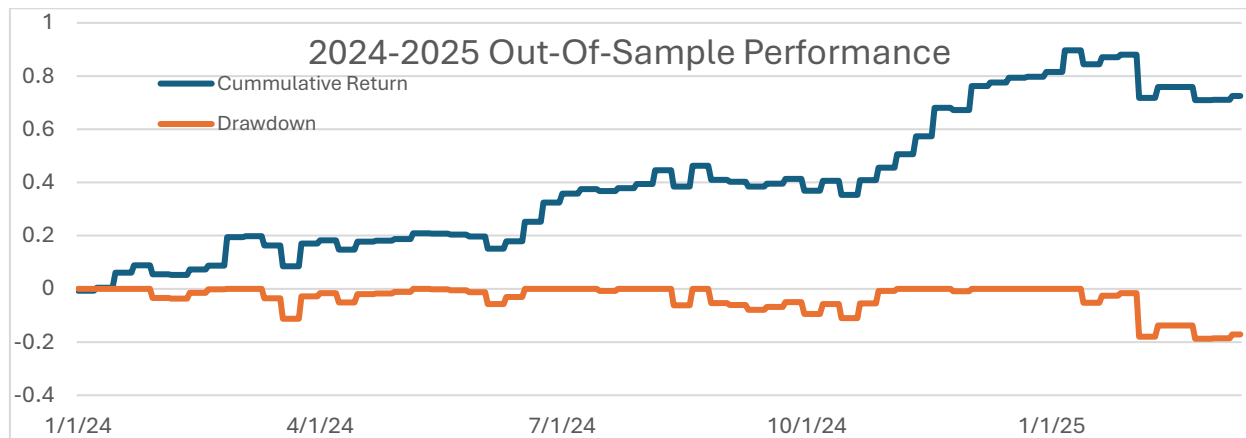Exhibit 3: Out-Of-Sample Performance of the Aggregate Portfolio



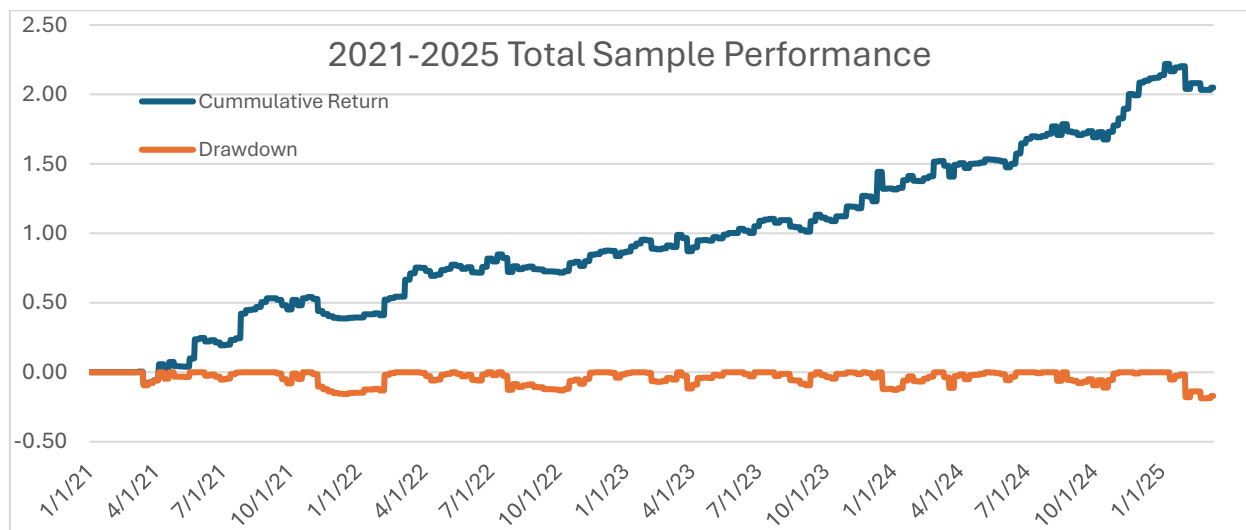Exhibit 4: Total Sample Performance of the Aggregate Portfolio



Exhibit 5: Comparison of the maximum Sharpe Ratios realized with each Strategy

*Some Sharpes are 0 because we also filtered for Kurtosis and a minimum of positive days

| | | Metric | SPX Index | DAX Index | XAU Curncy | 10 year us future | XBT Curncy | 2 year us future | EC1 COMB Curncy | JY1 COMB Curncy | MSTR US Equity | HUT CN Equity | CBTC US Equity | WGMI US Equity | BITWISE CRYPTO IND INNOV ETF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Binary | 2021-2023: Positive =1, Negative =-1 | Max Sharpe (absolut) | 0.44 | 0.63 | 0.73 | 0.43 | 0.59 | 0.79 | 0.47 | 0.61 | 1.11 | 1.09 | 0.87 | 1.01 | 0.91 |
| | 2021-2023: Positive =1, Negative =0 | Max Sharpe (absolut) | 0.27 | 0.83 | 0.38 | 0.84 | 0.27 | 0.94 | 0.80 | 1.27 | 0.52 | 0.77 | 0.95 | 0.17 | 0.52 |
| | 2021-2023: Positive =0, Negative =1 | Max Sharpe (absolut) | 0.18 | 0.61 | 0.74 | 0.69 | 0.57 | 0.68 | 0.37 | 0.96 | 0.70 | 0.94 | 0.83 | 1.25 | 1.31 |
| Z-Score | 2021-2023: Positive =1, Negative =-1 | Max Sharpe (absolut) | 0.82 | 0.51 | 0.31 | 0.63 | 0.39 | 0.00 | 0.68 | 0.91 | 0.81 | 0.83 | 0.89 | 1.14 | 0.68 |
| | 2021-2023: Positive =1, Negative =0 | Max Sharpe (absolut) | 0.43 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 1.03 | 0.97 | 0.75 | 0.72 | 0.62 | 0.35 | 0.46 |
| | 2021-2023: Positive =0, Negative =1 | Max Sharpe (absolut) | 0.54 | 0.81 | 0.49 | 0.20 | 0.39 | 0.34 | 0.38 | 0.56 | 0.00 | 0.59 | 0.82 | 1.34 | 0.95 |
| Vol | 2021-2023: Positive =1, Negative =-1 | Max Sharpe (absolut) | 0.31 | 0.85 | 0.49 | 0.73 | 0.25 | 1.00 | 0.76 | 0.73 | 0.95 | 1.42 | 1.00 | 1.06 | 0.84 |
| | 2021-2023: Positive =1, Negative =0 | Max Sharpe (absolut) | 0.19 | 0.85 | 0.44 | 0.86 | 0.35 | 1.10 | 0.94 | 0.84 | 1.02 | 1.25 | 0.25 | 0.53 | 0.91 |
| | 2021-2023: Positive =0, Negative =1 | Max Sharpe (absolut) | 0.41 | 0.81 | 0.37 | 0.31 | 0.44 | 0.71 | 0.23 | 0.87 | 1.09 | 1.42 | 1.35 | 0.94 | 1.04 |
| Vol-Vol | 2021-2023: Positive =1, Negative =-1 | Max Sharpe (absolut) | 0.29 | 0.78 | 0.62 | 0.86 | 0.58 | 1.10 | 0.93 | 0.76 | 1.03 | 1.46 | 0.88 | 1.06 | 0.65 |
| | 2021-2023: Positive =1, Negative =0 | Max Sharpe (absolut) | 0.22 | 0.80 | 0.37 | 0.84 | 0.58 | 0.93 | 0.77 | 1.07 | 0.52 | 0.65 | 0.76 | 0.88 | 0.80 |
| | 2021-2023: Positive =0, Negative =1 | Max Sharpe (absolut) | 0.20 | 0.78 | 0.26 | 0.46 | 0.26 | 0.73 | 0.29 | 0.94 | 1.52 | 1.46 | 1.24 | 0.00 | 1.04 |

Exhibit 6: Optimal Portfolio Characteristics

|  | IN-SAMPLE | OUT-OF-SAMPLE | TOTAL |
|---|---|---|---|
| AVERAGE ANNUAL RETURN | 44,11% | 60,46% | 48,78% |
| STANDARD DEVIATION | 31,63% | 34,89% | 32,58% |
| INFO SHARPE EX TRADING FEES | 1,3948 | 1,7329 | 1,4972 |
| POSITIVE DAYS | 52,56% | 65,08% | 56,16% |
| POSITIVE MONTHS | 64% | 50% | 58% |
| DAILY SKEW | 4,09 | 0,14 | 2,72 |
| DAILY KURT | 54,78 | 25,89 | 44,23 |
| DAILY MAX | 21,21% | 10,75% | 21,21% |
| DAILY MIN | -12,12% | -16,28% | -16,28% |
| MAX DD | -15,58% | -18,75% | -18,75% |

*References:*

Fidelity Digital Assets. (2021). Bitcoin's potential role as a leading macro asset. Fidelity Digital Assets. Retrieved from https://www.fidelitydigitalassets.com/research-and-insights/bitcoins-potential-leading-macro-asset

Cointelegraph. (2024, March 18). Bitcoin ETFs worsened liquidity, weekend price swings: Kaiko. Cointelegraph. https://cointelegraph.com/news/bitcoin-etfs-worsened-liquidity-weekend-price-swings-kaiko

The White House (2025, March 6). Fact Sheet: President Donald J. Trump Establishes the Strategic Bitcoin Reserve and U.S. Digital Asset Stockpile. https://www.whitehouse.gov/fact-sheets/2025/03/fact-sheet-president-donald-j-trump-establishes-the-strategic-bitcoin-reserve-and-u-s-digital-asset-stockpile/