

Exchange Traded Funds vs. Nonredeemable Investment Trusts:

A Natural Experiment from Cryptocurrency Funds

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Abstract

As cryptocurrencies continue to dominate fintech innovations and gain wider acceptance, there is an escalating demand for investment vehicles that offer convenient access to these complex digital assets. This study presents a comparative analysis of Exchange Traded Funds (ETFs) and Nonredeemable Investment Trusts in the context of the cryptocurrency market. Our results indicate that the market price of nonredeemable trusts can significantly deviate from their net asset value, while ETFs tend to exhibit better pricing efficiency. In addition, our analysis reveals that the Bitcoin ETF has better tracking performance and faster correction of mispricing compared to the nonredeemable Bitcoin investment trust. Finally, our study provides empirical support to the notion that ETFs offer a more efficient and effective investment substitute to closed-end funds. These findings have important implications for investors, portfolio managers, and policymakers.

JEL Classification: G12, G14

Keywords: Exchange-traded Funds; Nonredeemable Trust; Valuation Premium/Discount; Tracking performance; Cryptocurrency

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1. Introduction

The emergence and ongoing development of blockchain technology have paved the way for secure ownership and seamless transfer of digital assets on public decentralized ledgers, resulting in pioneering financial innovations in the form of cryptocurrencies such as Bitcoin, Ethereum, and numerous other digital tokens. Since Bitcoin's emergence on the global scene in 2009, cryptocurrencies have undergone periods of remarkable volatility, with price surges and tumultuous downturns, while continuing to mature and dominate the landscape of fintech innovations. For instance, Bitcoin began trading at \$0.05 in July 2010, reached a high of \$18,674 in December 2017, and subsequently plummeted to \$3,157 by December 2018. Despite this setback, Bitcoin rebounded and skyrocketed to an all-time high of \$67,734 in November 2021, only to fall again to \$15,632 in November 2022 before recovering to \$27,308 in May 2023.

During the past 14 years, cryptocurrencies have made significant strides in gaining broader acceptance across business transactions and financial services. Rapid advancements in crypto infrastructure, such as crypto technologies, exchanges, wallets, processors, and custodial solutions, have propelled user adoption, with regulatory recognition in focus. As of May 31, 2023, the cryptocurrency market is composed of 23,161 digital assets with a combined market capitalization of \$1.139 trillion, with Bitcoin and Ethereum as the leading cryptocurrencies with market capitalizations of \$525 billion (46.1%) and \$225 billion (19.8%), respectively, according to CoinMarketCap.

As cryptocurrencies become more mainstream, there is rising demand for investment vehicles that offer investors simple and convenient access to these intricate digital assets while also addressing concerns related to security, custody, liquidity, and the technical nature of the assets. Investing in cryptocurrencies can offer significant wealth-enhancement opportunities. As a high-reward asset, however, it comes with high risks for those seeking exposure to this market, as the data compellingly demonstrate.

The Grayscale Bitcoin Trust was launched in September 2013 to offer direct exposure to Bitcoin (BTC) through a conventional investment vehicle, becoming the first cryptocurrency fund accessible to accredited investors via private placements. Since May 2015, the trust has been publicly listed on OTCQX under the ticker GBTC, enabling both retail and institutional investors to access it through secondary market trading. Being the first and largest publicly traded trust that holds Bitcoin, GBTC offers investors a convenient way to gain exposure to the cryptocurrency without the complexities of storing and securing Bitcoin themselves. Similar to GBTC, the Ethereum Trust (ETHE) was launched by Grayscale Investments in December 2017 and became available for trading on the OTCQX market since June 2019. As of March 2023, GBTC and ETHE hold 629,310 Bitcoin and 3.02 million Ethereum, representing 3.3% and 2.5% of the number of Bitcoin and Ethereum in circulation, respectively. However, a major drawback of GBTC and ETHE arises from their non-redeemable trust structure, preventing investors from exchanging their shares for the underlying cryptocurrency. As a result, GBTC and ETHE often trade at a considerable premium or discount relative to their respective net asset value (NAV).

Currently, the Securities and Exchange Commission (SEC) has yet to approve applications for Exchange Traded Funds (ETFs) on spot Bitcoin, as it remains concerned about the susceptibility of the spot Bitcoin market to manipulative and fraudulent trading practices. In

contrast, SEC granted approval for Bitcoin futures ETFs such as the ProShares Bitcoin Strategy ETF (BITO) and the Van Eck Bitcoin Strategy ETF (XBTF) in October 2021.¹ These ETFs allow investors to gain exposure to cryptocurrencies through investments in Bitcoin futures contracts that trade on the regulated Chicago Mercantile Exchange, without taking possession of the digital currency. Since its launch in October 2021, BITO has quickly emerged as one of the most actively traded securities, offering investors liquidity, transparency, and cost-effectiveness, attributes that promote efficient market pricing.

The presence of both non-redeemable spot-based products such as the GBTC trust and ETHE trust, and redeemable futures-based ETFs such as BITO offers a valuable opportunity to analyze and compare the benefits and drawbacks of ETFs versus non-redeemable investment trusts. Our study seeks to address two key questions: First, how well do these funds replicate the performance of the cryptocurrency market? Second, what are the factors behind any potential tracking errors in these funds?

Our results show that the market price of non-redeemable trusts can deviate significantly from their corresponding NAV. As an illustration, GBTC exhibits an average market valuation premium² of 20.83% and a median of 21.23%, with a range spanning from a discount of 48.9% to a premium of 141.7%. The Grayscale Ethereum Trust (Ticker: ETHE) has exhibited an average market valuation premium of 79.59%, with a range of -59.6% to 202.2%. In contrast, the ProShares Bitcoin Strategy ETF (Ticker: BITO) exhibits a significantly lower premium magnitude,

¹ The first spot-based Bitcoin ETF was initiated in Canada (ticker: BTCC CN Equity) on February 24, 2021. Since it is not traded in the U.S., the data may not be as comparable to the U.S. traded instruments, we didn't include it in our sample.

² See Appendix Table A1 for variable definitions. The market valuation premium of a fund measures the percentage deviation of the fund's market price from its NAV. A positive premium indicates that the fund is trading at a higher price than its NAV, while a negative premium suggests that the fund is trading at a discount to its NAV.

with an average of 0.00%, median of 0.01%, and a range of -0.45% to 0.22%. These results reveal that ETFs with creation and redemption features are notably more efficient in reflecting the NAV than non-redeemable trusts.

The BITO ETF's price movements align more closely with Bitcoin's price movements, as demonstrated by BITO's beta deviation of 0.48% vs. GBTC's beta deviation of 8.97%. BITO's market return and NAV return exhibit almost perfect tracking of the underlying Bitcoin return, whereas the nonredeemable investment trusts of GBTC and ETHE display considerable deviations in both total return and NAV return from the underlying Bitcoin and Ethereum returns, respectively. BITO also demonstrates stronger capacity to correct its lagged valuation premium and is less influenced by momentum trading when compared to GBTC. Overall, our findings suggest that ETFs are more effective in accurately reflecting the intrinsic value of their underlying assets compared to non-redeemable trusts. This improved efficiency affords investors with more effective instruments for achieving their desired exposure to the underlying assets.

Our research advances the existing literature in several ways. First, it makes a novel contribution to the literature on ETFs by conducting a systematic examination of the pricing and tracking performance of crypto ETFs, which, to the best of our knowledge, is the first of its kind. Second, it broadens the existing literature on non-redeemable financial instruments, such as closed-end funds. Third, it adds to the growing body of research on cryptocurrency by analyzing and comparing the tracking performance of the two types of publicly traded investment vehicles: non-redeemable spot-based cryptocurrency trusts and futures-based cryptocurrency ETFs.

Our findings from this study also hold significant relevance for investors, portfolio managers, and policy makers. For investors, this research offers valuable insights into the efficacy of investment funds in achieving their desired exposure to cryptocurrencies. Furthermore, portfolio

managers can use the findings to assist them in their portfolio diversification and optimization efforts. Moreover, regulators can benefit from this research because it can inform policies and decisions regarding the approval, regulation, and oversight of cryptocurrency funds.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature. Section 3 describes our data collection and presents summary statistics. Section 4 presents the empirical analysis. Finally, Section 5 provides the summary and implications.

2. Literature Review

Cryptocurrency trusts, such as GBTC and ETHE, which invest directly in spot Bitcoin and Ethereum, were initially offered to accredited investors through private placements. Following a lockup period of 6 months to 1 year, they became available to all investors for secondary market trading. Upon expiration of the lockup period, these trusts operate similarly to closed-end funds (CEFs) in that they can be publicly traded like stocks but are unable to be redeemed for their underlying assets. One of the most intriguing aspects of CEFs is that their market price per share often differs from its NAV per share, resulting in a percentage difference between the exchange-traded price and NAV (Lee et al., 1990). Furthermore, it is not uncommon for a new closed-end fund to trade initially at a premium and then later move to a substantial discount relative to its NAV. We observe a similar pattern in the cryptocurrency trusts included in our sample. During their early years, both GBTC and ETHE experienced significant premiums. However, in later years, they both fell to substantial discounts.

Malkiel's (1977), Lee et al. (1990), Dimson and Minio-Kozerski (2002), and Cherkes (2012) provide explanations for the puzzling deviation between the market prices and NAVs of closed-

end funds. These explanations may involve factors such as management fees, management performance or skills, the fund's holding of restricted stocks or market segmentation, taxation of unrealized capital gain, and investor sentiment. While none of the above explanations alone can fully address the CEF puzzle, significant advancements have been made through two approaches. Lee et al. (1991) offers one approach. Using investor sentiment theory, they provide a behavioral finance perspective. Essentially, the optimism of small investors creates excess demand for new CEFs, whereas sentiment risk causes CEF shares to be traded at a discount to compensate for the noise traders' risk premium.

An alternative approach is based on the neoclassical explanation, which focuses on the role of management fees. Ross (2002) argues that a closed-end fund will trade at a discount that is equal to the difference between the value added by a fund manager and the capitalized management fees. Berk and Stanton (2007) and Cherkes et al. (2009) further develop the neoclassical model by incorporating asymmetric information on the manager's ability and liquidity transformation with the management fees.

As ETFs become increasingly popular, researchers have turned their focus to studying the deviations of ETF prices from their NAVs, and their implications for price discovery and market efficiency. Engle and Sarkar (2006) show that pricing errors are responsible for majority of the perceived deviations in ETFs, and that the pricing efficiency of ETFs can be improved through information from index futures trading. Petajisto (2017) finds that certain ETFs that invest in international or illiquid assets may still exhibit significant deviations even in the presence of the creation/redemption arbitrage mechanism.

The rising demand for ETFs also provides an opportunity to compare the performance of CEFs and ETFs. In fact, a number of studies have used the introduction of ETFs as a natural

experiment to gain further insights into the CEF puzzle. Patro (2001) shows that the announcement of the World Equity Benchmark Shares (WEBS) ETFs listing led to a substantial decrease in premiums for closed-end country funds. Additionally, Barnhart and Rosenstein (2010) demonstrate that the advent of ETFs led to larger discounts and reduced trading volume for the CEFs in the same asset class. These findings lend support to the notion that ETFs can be considered as feasible substitutes for similar CEFs. According to Harper et al. (2006), international equity ETFs outperform closed-end country funds in terms of risk-adjusted returns. The authors suggest that this can be attributed to the passive investment strategy employed by ETFs, which differs from the active investment strategy typically used by closed-end country funds. However, to our knowledge, no prior research has compared the tracking performance of cryptocurrency ETFs and CEFs. Therefore, this study is the first of its kind to compare cryptocurrency CEFs and ETFs and to offer new insights and perspectives into possible reasons for the discount puzzle of CEFs.

While there are some existing studies on cryptocurrency funds, they primarily employ data from before the launch of cryptocurrency ETFs in October 2021. According to Almudhaf (2018) findings, GBTC consistently demonstrated a significant premium over its NAV, suggesting a pricing inefficiency. Shynkevich (2020) has demonstrated the pricing inefficiency of GBTC and highlighted that the positive autocorrelation of GBTC has played a role in the fluctuations of the fund's premium over its NAV. Kwok (2020) suggests that the prices of GBTC partially adjust to short-term deviations, whereas the NAV remains unresponsive. Huang et al. (2021) found an intriguing relationship between GBTC premium changes and Bitcoin's daily return, where the former can be used as a predictor for the latter. The GBTC premium was found to be a more significant predictor than commonly used sentiment indicators, such as Google and Twitter searches or lagged Bitcoin returns. The authors also suggest that the GBTC premium reflects

excess demand from traditional investors rather than Bitcoin's technological fundamentals or supply factors.

Bianchi and Babiak (2022) examine the performance of actively managed funds that invest in cryptocurrencies and find positive alphas for such funds relative to passive benchmarks. However, their primary sample is comprised of hedge funds, which are generally not accessible to retail investors due to the high minimum investments. In addition, only 8% of the funds analyzed by Bianchi and Babiak (2022) are subject to SEC regulation. In contrast, our analysis of non-redeemable spot-based cryptocurrency trusts and futures-based cryptocurrency ETFs provides investors, portfolio managers, and regulators new guidance into the efficiency and efficacy of these two investment channels, both of which are available to retail investors.

3. Data Collection and Summary Statistics

Our study employs a comprehensive dataset collected from Bloomberg and various fund sponsor websites, covering daily data on publicly traded cryptocurrency funds from their inception to March 31, 2023. We start from all publicly traded funds tracking returns on either Bitcoin or Ethereum, which are listed in Appendix Table A2 along with their characteristics. To streamline our research, we focus our analysis on three funds that have assets under management (AUM) over \$500 million as of March 2023: Grayscale Bitcoin Trust (Ticker: GBTC), Grayscale Ethereum Trust (Ticker: ETHE), and ProShares Bitcoin Strategy ETF (Ticker: BITO). This final sample represents the three largest and most widely traded cryptocurrency funds in the U.S., including two spot-based nonredeemable investment trusts, GBTC and ETHE, and one futures-based ETF, BITO.

To gain an in-depth understanding of these funds, we have compiled data on various critical variables, including their daily fund closing price, NAVs, total return, AUM, shares outstanding, trading volume, market valuation premium, fund flow, and fund turnover. Furthermore, to contextualize our analysis, we have included Bitcoin and Ethereum prices from the inception of each fund. Grayscale Investments, LLC sponsors both GBTC and ETHE, with GBTC having an AUM of \$17.9 billion in Bitcoin and ETHE having an AUM of \$5.5 billion in Ethereum as of March 31, 2023. GBTC charges a management fee of 2% per year, while ETHE charges an even higher management fee of 2.5% per year. It should be noted that, according to the Grayscale Investments, LLC website, share redemptions are not permitted for either GBTC or ETHE.

In contrast, the ProShares Bitcoin Strategy ETF (BITO) is the first Bitcoin-linked ETF available to U.S. investors, providing a convenient, transparent, and liquid vehicle to accessing Bitcoin returns. According to the ProShares website, the fund aims to offer capital appreciation primarily by providing managed exposure to Bitcoin futures contracts. As of March 31, 2023, the fund possessed an AUM of \$955 million and charged a management fee of 0.95% per annum. It is noteworthy that this fund creates or redeems shares in Creation Units in cash rather than in-kind.

Table 1 provides the summary statistics for the variables. Panel A reports those of the original unwinsorized variables. Of all the funds, GBTC has the longest trading history, with an inception date of May 5, 2015. The market close price of GBTC has an average of \$12.88 per share and a standard deviation of \$12.93, ranging from \$0.25 to \$56.7. Our sample comprises of 1,974 daily return observations. On average, GBTC generates a daily return of 34 basis points with a standard deviation of 5.84% and a median return of 0. The daily return ranges from -28.55% to 41.16%, indicating a high level of volatility. GBTC's average market valuation premium is 20.83%, with a standard deviation of 34.36% and a median of 21.23%, ranging from -48.89% to 141.66%. This

suggests that the market price can significantly differ from the NAV. Additionally, GBTC's AUM has an average of \$7.6 billion and a median of \$1.8 billion, ranging from \$28.8 million to \$43.6 billion.

Our sample consists of 348 daily observations on BITO, the first U.S. Bitcoin-linked ETF launched on October 19, 2021. The price of BITO varies between \$9.59 and \$43.32, with a mean of \$19.82 and a median of \$14.80. The average daily return of BITO is -0.24%, with a standard deviation of 3.97%, a median of -0.20%, and a range of -20.22% to 12.42%. Additionally, BITO experiences a daily inflow of 5.37%, indicating a growing trend in AUM. It is important to note that the average and median daily returns of BITO are significantly different from those of GBTC due to the different sample periods between the two funds. To enable a meaningful comparison of the two funds, we use a common sample period for both funds, as shown in Panel B.

Our ETHE sample consists of 936 daily observations from its initial trading day on June 20, 2019 to March 31, 2023. ETHE fund displays an average daily return of 28 basis points, with a standard deviation of 9.15% and a median of -10 basis points, indicating a considerable amount of volatility within a range of -77.24% to 93.33%. Moreover, ETHE boasts an average market premium of 79.59% and a median of -2.02%, with premiums ranging from -59.64% to 2022.2%. These substantial premiums reveal that the market price of ETHE can significantly deviate from its NAV.

In Panel B, we apply winsorization to recode the top and bottom 1% of observations for all continuous variables to mitigate the effect of outliers. BITO shows an average daily return of -0.23% with a standard deviation of 3.83%. To facilitate comparisons across funds, we present summary statistics for both GBTC and BITO during the same period from October 19, 2021 to March 31, 2023. GBTC has an average daily return of -0.23%, which is similar to that of BITO,

but with a higher standard deviation of 4.48%, indicating a 65 basis point difference. The average daily NAV return for BITO is -0.24% with a standard deviation of 3.81%, which is similar to the market price return. As a result, the average inefficiency return deviation is only 0.01% with a standard deviation of 0.13%, consistent with typical ETF tracking performance. The creation and redemption feature of ETFs ensures that market prices do not significantly deviate from NAV, resulting in an average market valuation premium of 0% and a standard deviation of 0.1% for BITO.

GBTC has an average daily NAV return of -0.22% and an average inefficiency return deviation of -0.04%. The standard deviation of this inefficiency measure is 2.34%, which is notably greater than BITO's corresponding measure of 0.13%. This market price inefficiency is also reflected in the average GBTC market valuation premium of -30.78%, which is much larger in magnitude than BITO's near-zero premium. The paired t-test (t-statistic = 61.82) shows that the difference in the premium is highly statistically significant. These significant differences show that market pricing efficiency can vary widely across ETFs and close-end counterparts. BITO and GBTC differ significantly in terms of their bid-ask spread, assets under management (AUM), and turnover. BITO has a lower bid-ask spread (0.08% vs 0.19%), smaller AUM (\$0.87B vs \$20.2B), and higher turnover (0.17 vs 0.01) than GBTC. These statistics suggest that while BITO has a smaller asset base, it offers superior liquidity compared to GBTC.

Table 2 shows the pairwise correlations among variables for BITO and GBTC over the common sample period from October 2021 to March 2023. The correlation between GBTC's daily market price return and NAV return is 0.83, while for BITO, it is 0.999, indicating that BITO's market price aligns more closely with its NAV than GBTC's. In terms of the correlation between

daily return and Bitcoin return, GBTC scores 0.88, whereas BITO scores 0.96. These figures suggest that BITO's market price more accurately tracks Bitcoin's price than GBTC's.

4. Main Empirical Analysis Results

4.1 Exposure of Funds to the Underlying Crypto Indices

Table 3 presents the results of single index regressions, demonstrating the exposure of the funds to the underlying Bitcoin and Ethereum returns. To preserve the extreme returns, we intentionally use the raw, unwinsorized data in this table. Panel A reports regression results over the full sample period for both GBTC and BITO funds. As shown in column (1), when the market price return of GBTC is regressed on the Bitcoin return, the coefficient of Bitcoin return is 0.9775. As shown in column (2), when the NAV return of GBTC is regressed on the Bitcoin return, the coefficient of Bitcoin return is 0.6609. These coefficients diverge from the target exposure of one. It is worth noting that the GBTC NAV return, which is calculated by using NAV values from Bloomberg³, displays a large deviation from the Bitcoin return. In contrast, the coefficient of BITO market return on Bitcoin return is 1.0048, while the coefficient of BITO NAV return on Bitcoin return is 1.0037. Both coefficients are highly consistent with the target coefficient of 1. These results demonstrate that the BITO ETF tracks Bitcoin price more closely than does GBTC. The higher R-squared values in single index model regressions for BITO (93.0% for total return regression and 93.1% for NAV return regression) compared to GBTC (53.6% for total return

³ Specifically, our daily NAV value is obtained from Bloomberg. According to Bloomberg, this value may be obtained from various sources, including the fund manager.

regression and 52.8% for NAV return regression) further confirm the superior tracking ability of BITO, notwithstanding the disparate sample periods.

To address concerns about the potential effect of different sample periods, we present regression results for the common sample period of BITO and GBTC in Panel B. Column (1) shows that the coefficient of GBTC market price return over Bitcoin return is 1.0897, which is significantly different from the target value of 1. Similarly, column (2) shows that the coefficient of GBTC NAV return over Bitcoin return is 0.8931, also significantly different from one. On the other hand, both the coefficients of BITO total return (column (3)) and NAV return (column (4)) over Bitcoin return are not significantly different from one. These results suggest that the observed difference in tracking performance between the two funds cannot be fully attributed to the disparity in sample periods.

Panel C presents the regression results for the entire sample period of the ETHE fund. In column (1), the coefficient for ETHE's total return on Ethereum return is 0.9720, with an R-squared of 0.352. In column (2), when the ETHE NAV return is regressed on Ethereum return, the coefficient is 0.731, which falls below the expected value of 1. These results suggest that the ETHE fund is not an ideal investment for tracking daily Ethereum returns.

The findings presented in Table 3 indicate that BITO is the most effective in providing exposure to Bitcoin return, with a coefficient close to one on a daily horizon throughout the sample period. This underscores the efficacy of the ETF fund structure in accurately tracking the underlying crypto index.

4.2 NAV Return Deviation Analysis

Table 1 demonstrates that although the fund is designed to track Bitcoin, there may be differences between the fund's NAV return and the Bitcoin return. Multiple factors could contribute to this disparity. The fund's tracking error is one possible explanation, resulting in either over or underexposure to the underlying Bitcoin return index. To address this issue, we incorporate Bitcoin return as an independent variable in our regression model. The presence of evaluation errors in the NAV values is another possible reason. We source our daily NAV values from Bloomberg, which can be obtained from multiple providers, including the fund manager. Therefore, there may be discrepancies between the reported NAV value and the actual NAV value. In case this evaluation error is corrected the following day, we can expect a mean reversion in the NAV return deviation. Hence, we incorporate the lagged NAV return deviation as an independent variable. Additionally, non-synchronization between the NAV and Bitcoin valuation can also cause a difference in returns, which can be more pronounced in the volatile crypto market. Lastly, the fund management fee will reduce the NAV return, leading to a lower constant term in the regression.

As shown in Table 4, when we include Bitcoin return and lagged NAV return deviation as independent variables, both variables show negative coefficients for GBTC fund. In column (1), over the entire sample period of GBTC, the coefficient on the Lagged GBTC NAV return deviation is -0.4842, indicating a mean reversion of this deviation. The coefficient on the Bitcoin return is also significant at the 1% level, with a value of -0.2923. These coefficients remain robust in column (2) after adding a set of control variables, even after the addition of control variables such as holding period Federal Fund interest, VIX index, GBTC fund turnover, S&P 500 Index return, and dollar index return.

In Table 4, column (3) demonstrates a negative association between BITO's NAV return deviation and the lagged term. The coefficient of -0.5117 indicates a mean reversion, which is consistent with the previous interpretation of misevaluation and/or non-synchronization between the NAV and Bitcoin valuation. The coefficient on the Bitcoin return is not statistically significant, suggesting that the fund provides exposure that is close to the targeted 1:1 ratio. In column (4), the mean reversion persists even after controlling for other factors, and the coefficient on the Bitcoin return remains non-significant, with a coefficient of zero. As shown in columns (5) and (6), when the sample period is constrained to the common period of both GBTC and BITO funds, the coefficients on the lagged term and Bitcoin return remain significantly negative for GBTC fund. These findings suggest that BITO tracks Bitcoin more accurately, and it has no significant over or underexposure to the Bitcoin return after controlling for the mean reversion of NAV return deviation.

4.3 Inefficiency Return Deviation Analysis

As shown in Table 1, a fund's total return (calculated from fund market price) can differ from its NAV return (calculated from fund NAV), resulting in inefficiency deviation. Ideally, in a liquid and efficient market, the market price return should mirror the NAV return, thus yielding a zero inefficiency deviation.

There are several possible reasons for the inefficiency deviation between the fund market price and NAV returns. Firstly, it could be attributed to the lack of synchronization between the market close price and the NAV. If these values are obtained from different time points, a difference may exist between them. Secondly, it could be attributed to the short-term trading behavior of investors. If investors engage in momentum trading and tend to buy on days with

positive returns, the market price may be driven up above the NAV. Conversely, if investors tend to sell on days with negative returns, the market price may be driven down below the NAV, leading to a positive correlation between the inefficiency deviation and the Bitcoin return. However, if investors tend to sell on days with positive returns for profit-taking purposes, the market price may be pushed down below the NAV. Similarly, if investors tend to buy on days with negative returns, the market price may be pushed up above the NAV, resulting in a negative correlation between the inefficiency deviation and Bitcoin return. Finally, the previous trading day's market valuation premium or discount could also be a factor contributing to the inefficiency deviation. For ETFs, the creation/redemption feature allows authorized participants to engage in arbitrage when the market price deviates significantly from the NAV, which tends to bring market price closer to the NAV for ETFs. However, for non-redeemable funds like GBTC, this effect is expected to be much weaker since there is no mechanism for authorized participants to arbitrage away the deviation between the market price and NAV.

Table 5 shows that the inefficiency deviation has a negative correlation with the lagged valuation premium. In column (1), the regression coefficient on the lagged GBTC premium is -0.0111, which is statistically significant at the 1% level. However, the magnitude of the coefficient is not economically substantial. Furthermore, the highly significant coefficient of 0.3187 on Bitcoin return provides support for the explanation of momentum trading behavior. Columns (2) and (3) indicate that these two coefficients remain significant even after including a set of control variables.

Column (4) of Table 5 indicates a more economically significant coefficient for the lagged BITO premium, with a value of -0.8196, highlighting that the BITO fund is more efficient in correcting the lagged valuation premium than the GBTC fund, which has a much smaller

coefficient of -0.0111 as shown in Column (1). This greater efficiency is further supported by the mean valuation premium of 0 for BITO compared to -30.78% for GBTC during their common sample period, as shown in Panel B of Table 1. Moreover, it should be noted that BITO's coefficient for Bitcoin return in column (4) is significantly lower at 0.0052, as opposed to GBTC's coefficient or Bitcoin return of 0.3187 in column (1). This finding suggests that investors' momentum trading behaviors have a lesser impact on BITO market price compared to GBTC. The coefficient on the lagged BITO premium stays highly significant even after adding control variables, as shown in columns (5) and (6).

In columns (7)-(9) of Table 5, we re-estimate the GBTC results based on the common period of BITO and GBTC. The statistical significance of the coefficient on Bitcoin return persists even after the inclusion of a set of control variables, and the magnitude of the coefficient is considerably higher compared to that of BITO. In addition, the negative coefficient on the lagged GBTC premium remains smaller and not as significant relative to the case of BITO, confirming GBTC's weaker correction of any valuation inefficiency.

Comparing the GBTC and BITO funds, it is evident that BITO exhibits a higher coefficient magnitude on the lagged valuation premium, indicating its superior efficiency in correcting mispricing as compared to the nonredeemable trust. In contrast, the positive coefficient on the Bitcoin return for BITO is smaller, indicating that the short-term momentum trading behavior of investors has a relatively weaker influence on the ETF market price as compared to the nonredeemable trust. These differences between the two funds remain consistent even after controlling for a set of variables and hold true for both the full and common sample periods.

4.4 Total Return Deviation Analysis

Table 6 presents the results of the total return deviation analysis. As shown in columns (1) through (3), during GBTC's full sample period, there is no significant association between the total return deviation and its lagged autoregressive term, indicating the lack of self-correction in GBTC's total return deviation. Conversely, as shown in columns (4) through (6), during BITO's sample period, the total return deviation is negatively associated with its lagged autoregressive term, with a coefficient of -0.4994 and statistically significant at the 1% level. This finding suggests that BITO is capable of correcting approximately half of its return deviation on the following trading day. For both funds, the coefficient on the S&P 500 index return is positive, indicating that these Bitcoin funds tend to increase more than the Bitcoin return when the S&P 500 index rises, likely due to market sentiment. Comparing across columns (6) and (9), the impact of market sentiment on GBTC is much larger than on BITO, with coefficients of 0.4299 and 0.0766, respectively.

As shown in column (3), during the entire sample period of GBTC, the total return deviation is positively associated with Gold return, which is marginally significant. This positive association indicates that GBTC's return tends to be pushed up relative to Bitcoin's return when the price of Gold is increasing. This finding suggests that GBTC investors may view it as a complement to Gold.

4.5 Valuation Premium Analysis

Table 7 presents the findings of the analysis on daily changes in valuation premium. Both funds show a negative association between the change in valuation premium and the lagged premium. The magnitude of the premium correction is much larger for BITO than for GBTC. Columns (4)-

(6) show negative coefficients on the lagged BITO premium with a magnitude exceeding 0.8. These findings indicate that the change in valuation premium corrects over 80% of the premium from the previous trading day for the BITO fund. During the common sample period, a negative coefficient also exists on the lagged premium for GBTC as shown in columns (7), but the magnitude is not significant economically or statistically (-0.01). For GBTC fund, the change in market valuation premium is positively associated with Bitcoin return, which is consistent with the momentum trading behavior explanation. However, the coefficient for BITO is much smaller.

The change in valuation premium of both funds is positively associated with the SPX index return, but the effect is much stronger for GBTC than for BITO (0.27 vs. 0.01) as shown in columns (9) and (6) of Table 7. These findings suggest that when the equity market performs well, the valuation premium tends to increase more for GBTC than for BITO.

Figure 1, Panel A depicts the highly erratic nature of GBTC's valuation premium, which began with a substantial premium of 81% on the initial trading day and surged to 142% by the second trading day. This premium fluctuated over time but continued to be positive until the introduction of the first spot-based Bitcoin ETF in Canada (ticker: BTCC CN Equity) on February 24, 2021. In Panel B, it is evident that after the ETF's launch, GBTC's premium turned negative and remained so thereafter. Table 8 analyzes the time series pattern of the decline in GBTC's valuation premium. Column (1) shows that the premium decreased by 61% after the introduction of the first ETF.⁴ Even after controlling for the decreasing time trend of 0.016% premium per day, column (2) indicates a significant decrease in the valuation premium of 38% after the ETF introduction. This decrease in valuation premium remains significant at 1% even after adding a set of control

⁴ As previously mentioned, the first spot-based Bitcoin ETF was initiated in Canada (Ticker: BTCC CN Equity) on February 24, 2021.

variables, as shown in columns (3) through (6). Our results are consistent with the findings of Patro (2001) and Barnhart and Rosenstein (2010) on the substitution effect of ETFs over closed-end funds. We provide compelling evidence that the introduction of the first crypto ETF is strongly associated with a substantial decrease in GBTC's valuation premium, suggesting that the ETF serves as a viable substitute for closed-end redeemable trusts such as GBTC.

Table 9 examines the change in GBTC's share turnover following the introduction of the first ETF. Column (1) indicates that, on average, the daily shares turnover of GBTC decreased by 0.74% after the ETF's introduction. This decrease remains significant both economically and statistically, even after controlling for time trend and other factors. Our results are consistent with the findings of Barnhart and Rosenstein (2010), who report a decrease in trading volume for closed-end funds in the same asset class following the introduction of ETFs. These findings provide additional support to the notion that ETFs serve as an effective substitute to closed-end nonredeemable trusts.

5. Conclusions

Our research focuses on analyzing two distinct types of cryptocurrency funds, exchange-traded funds and non-redeemable investment trusts. Our results indicate that the market price of non-redeemable funds can differ significantly from their NAV. For instance, the market price of ETHE is higher than its NAV by up to 2022% at its peak premium. On the other hand, ETFs have much smaller market valuation premiums, ranging from -0.45% to 0.22% for the BITO fund in our sample. Furthermore, the Bitcoin ETF in our study has more accurate tracking performance than the non-redeemable Bitcoin trust. The BITO fund is able to correct more than 80% of its lagged premium on average, while GBTC trust only corrects a small proportion of its lagged premium, if at all. Our analysis indicates that the GBTC valuation premium shifted to a discount around the

time the first cryptocurrency ETF was introduced, and the ETF inception was also accompanied by a substantial decrease in GBTC fund turnover. In summary, our findings suggest that the ETF structure provides better pricing efficiency and serves as a more effective alternative to the non-redeemable investment trusts.

Our research has several policy implications for investors, regulators, and policymakers in the cryptocurrency market. First, investors who are interested in investing in cryptocurrency should consider investing in ETFs rather than non-redeemable trusts, as ETFs have better pricing efficiency and tracking performance. Second, regulators should consider implementing stricter regulations and oversight on non-redeemable trusts to ensure they are pricing their assets efficiently and transparently. This could include requirements for more frequent and detailed reporting on NAV and market price discrepancies. Finally, policymakers should consider promoting the use of ETFs in the cryptocurrency market to improve market efficiency and reduce the potential risks associated with non-redeemable trusts. This could include providing incentives for ETF providers to enter the market and making it easier for investors to access cryptocurrency ETFs.

In conclusion, our study underscores the benefits of the ETF structure as a more efficient and transparent approach for investors to gain exposure to the cryptocurrency market. Our findings have important implications for policymakers and regulators, who could consider promoting the ETF structure to enhance the overall functioning of the market. By doing so, they could encourage greater investor participation, boost market efficiency, and ultimately facilitate the development of a more robust and sustainable cryptocurrency ecosystem.

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Table 1: Summary Statistics

Panel A: Daily summary statistics of original unwinsorized sample

Variable	Mean	Std. Dev.	Median	N	Min	25 Percentile	75 Percentile	Max
Bitcoin Price	14062	16297	8074	1974	215.17	1258	19425	67734
Bitcoin Return	0.33	4.37	0.17	1974	-27.19	-1.38	2.10	33.99
Ethereum Price	1165	1196	537	1278	81.79	209	1793	4799
Ethereum Return	0.22	5.72	0.00	1277	-33.29	-2.38	2.98	36
GBTC Price	12.88	12.93	9.85	1974	0.25	1.48	14.97	56.70
GBTC Total Return	0.34	5.84	0.00	1973	-28.55	-2.73	3.22	41.16
GBTC NAV Return Deviation	-0.02	3.11	0.03	1973	-31.12	-1.14	1.18	20.44
GBTC Inefficiency Return Deviation	0.04	4.63	-0.08	1973	-28.23	-2.31	2.08	32.87
GBTC Total Return Deviation	0.02	3.97	-0.11	1973	-28.34	-1.80	1.61	32.14
GBTC NAV Return	0.30	3.98	0.17	1973	-20.07	-1.42	2.06	19.97
GBTC NAV	13.30	15.19	7.90	1974	0.22	1.28	18.02	62.95
GBTC Total Assets	7639	11141	1823	1974	28.76	218	12302	43583
GBTC Premium	20.83	34.36	21.23	1974	-48.89	-5.75	41.48	141.66
GBTC Short Interest Ratio	1.40	1.42	0.81	1882	0.01	0.32	2.07	6.26
GBTC Bid Ask Spread	0.70	3.03	0.19	1974	-0.28	0.08	0.51	118.18
Change in GBTC premium	-0.06	6.57	-0.05	1973	-63.59	-2.75	2.40	60.69
BITO NAV Return Deviation	-0.01	1.04	0.05	347	-4.15	-0.56	0.54	3.58
BITO Inefficiency Return Deviation	0.01	0.16	0.00	347	-1.29	-0.08	0.08	0.97
BITO Total Return Deviation	-0.01	1.05	0.02	347	-4.05	-0.57	0.54	3.62
BITO Total Return	-0.24	3.97	-0.20	347	-20.22	-2.31	1.91	12.42
BITO NAV Return	-0.25	3.96	-0.17	347	-20.12	-2.27	1.78	13.72
BITO Price	19.82	9.05	14.80	348	9.59	12.47	26.41	43.32
BITO NAV	19.82	9.05	14.80	348	9.61	12.47	26.39	43.30
BITO Total Assets	868	265	787	348	20.98	639	1097	1443
BITO Premium	0.00	0.12	0.01	348	-0.80	-0.05	0.07	0.34
BITO Short Interest Ratio	1.68	1.06	1.58	340	0.06	0.88	2.19	5.18
BITO Bid Ask Spread	0.08	0.03	0.08	348	0.02	0.07	0.09	0.33
Change in BITO premium	0.00	0.14	0.00	347	-1.14	-0.08	0.08	0.53
BITO Fund Flow	5.37	42.53	0.43	348	-61.54	-2.19	6.15	567.16
ETHE Total Return	0.28	9.15	-0.10	935	-77.24	-4.22	4.72	93.33
ETHE NAV Return	0.31	5.14	0.18	935	-26.49	-2.19	2.86	36.92
ETHE Price	14.99	10.56	11.63	936	2.41	6.87	21.64	64.44
ETHE NAV	14.79	12.65	12.86	936	1.20	2.49	24.08	48.28
ETHE Total Assets	4390	4106	3956	936	14.20	288	7469	14974
ETHE Premium	79.59	179.41	-2.02	936	-59.64	-21.89	110.92	2022.20
ETHE Short Interest Ratio	0.50	0.49	0.35	930	0.01	0.19	0.68	2.88
ETHE Bid Ask Spread	0.93	1.54	0.25	936	-0.14	0.09	1.05	17.26
Change in ETHE premium	-1.19	68.70	-0.17	935	-1675.57	-3.25	2.90	962.83

Panel B: Paired t-test between GBTC and BITO funds using daily observations in the common sample period from October 19, 2021 to March 31, 2023 (The results in this panel are from winsorized sample.)

	BITO Fund		GBTC Fund		Difference (GBTC - BITO)		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Err.	Paired t
Fund Total Return	-0.23	3.83	-0.23	4.48	0.00	0.10	0.00
Fund NAV Return	-0.24	3.81	-0.22	3.59	-0.03	0.08	-0.33
Fund Valuation Premium	0.00	0.10	-30.78	9.27	30.78	0.50	61.82
Fund Total Return Deviation	-0.01	1.03	-0.04	2.06	0.04	0.10	0.38
Fund Inefficiency Return Deviation	0.01	0.13	-0.04	2.43	0.04	0.13	0.32
Fund NAV Return Deviation	-0.02	1.01	0.02	1.49	-0.04	0.07	-0.53
Fund Bid Ask Spread	0.08	0.03	0.19	0.16	-0.11	0.01	-13.11
Fund Total Assets under Management	870.33	261.32	20178.91	9051	-19308.58	472.73	-40.84
Fund Short Interest Ratio	1.68	1.06	0.53	0.29	1.16	0.05	23.92
Fund Turnover	0.17	0.11	0.01	0.00	0.16	0.01	28.64

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 2: Pairwise Correlations

This table shows the daily pairwise correlations between variables.

Variable Name	Label	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
GBTC Total Return	(1)	1																						
GBTC NAV Return	(2)	0.8324*	1																					
GBTC NAV Return Deviation	(3)	-0.134	0.1587	1																				
Lagged GBTC NAV Return Deviation	(4)	-0.06	-0.204	-0.4813*	1																			
GBTC Inefficiency Return Deviation	(5)	0.6207*	0.0897	-0.4723*	0.1741	1																		
Change in GBTC premium	(6)	0.6286*	0.1396	-0.4924*	0.1821	0.9573*	1																	
Lagged GBTC Premium	(7)	-0.107	-0.062	0.0601	-0.037	-0.104	-0.105	1																
GBTC Total Return Deviation	(8)	0.6120*	0.2453*	0.1883	-0.161	0.7673*	0.7220*	-0.068	1															
Lagged GBTC Total Return Deviation	(9)	-0.02	0.0328	-0.008	0.1808	-0.08	-0.095	0.0641	-0.105	1														
GBTC Turnover	(10)	-0.161	-0.199	0.0949	0.0527	-0.039	-0.061	0.2205	-0.015	0.0132	1													
GBTC Bid Ask Spread	(11)	-0.023	0.0124	0.0414	-0.033	-0.058	-0.057	-0.2411*	-0.03	0.0071	-0.12	1												
BITO Total Return	(12)	0.9121*	0.9172*	-0.141	-0.07	0.3402*	0.3716*	-0.091	0.3054*	-0.026	-0.22	-0.008	1											
BITO NAV Return	(13)	0.9114*	0.9183*	-0.139	-0.067	0.3376*	0.3698*	-0.088	0.3040*	-0.025	-0.222	-0.008	0.9993*	1										
BITO NAV Return Deviation	(14)	0.2476*	0.2197	0.4830*	-0.3055*	0.1139	0.0857	-0.022	0.4968*	-0.21	-0.032	-4E-04	0.2814*	0.2830*	1									
Lagged BITO NAV Return Deviation	(15)	-0.075	-0.022	-0.21	0.4830*	-0.093	-0.06	-0.012	-0.2545*	0.4968*	0.0375	0.0057	-0.086	-0.083	-0.5090*	1								
BITO Inefficiency Return Deviation	(16)	0.1283	0.0797	-0.032	-0.123	0.1016	0.0827	-0.052	0.0901	-0.04	0.0083	0.0485	0.1459	0.1124	0.0404	-0.179	1							
Change in BITO premium	(17)	0.1262	0.086	-0.014	-0.143	0.0931	0.0801	-0.02	0.0935	-0.051	0.0132	0.0613	0.1497	0.1197	0.0732	-0.194	0.9618*	1						
Lagged BITO Premium	(18)	0.0493	0.0972	0.0458	0.0571	-0.056	-0.054	-0.064	-0.029	0.0829	-0.009	-0.057	0.0691	0.0893	0.0595	0.1436	-0.6306*	-0.6457*	1					
BITO Total Return Deviation	(19)	0.2543*	0.2184	0.4765*	-0.3260*	0.1288	0.0983	-0.029	0.5085*	-0.209	-0.036	0.0046	0.2876*	0.2842*	0.9878*	-0.5310*	0.182	0.2021	-0.028	1				
Lagged BITO Total Return Deviation	(20)	-0.058	-0.01	-0.208	0.4765*	-0.084	-0.062	-0.016	-0.2413*	0.5085*	0.0324	-0.01	-0.065	-0.059	-0.4660*	0.9878*	-0.222	-0.2375*	0.219	-0.4957*	1			
BITO Turnover	(21)	-0.105	-0.089	0.1033	0.069	-0.098	-0.115	0.1935	-0.062	0.0075	0.6619*	-0.121	-0.138	-0.141	-0.059	0.0438	0.0169	-0.001	-0.008	-0.067	0.0467	1		
BITO Bid Ask Spread	(22)	-0.049	-0.025	0.0306	0.0279	-0.057	-0.07	-0.3331*	-0.048	0.0058	0.0248	0.1581	-0.03	-0.031	0.0084	0.0272	0.0419	0.0472	-0.142	0.0106	0.0183	-0.054	1	
BITO Fund Flow	(23)	-0.017	-0.004	0.1127	0.0489	-0.026	-0.023	0.2339*	0.0437	0.1008	0.2038	-0.118	-0.051	-0.052	-0.029	0.0324	0.0074	0.0115	0.0593	-0.027	0.0331	0.2829*	-0.087	1
Bitcoin Return	(24)	0.8834*	0.8972*	-0.2721*	0.0039	0.3162*	0.3584*	-0.086	0.1789	0.0158	-0.2	-0.012	0.9624*	0.9624*	0.0255	0.0384	0.1129	0.1087	0.077	0.0302	0.0521	-0.102	-0.032	-0.049

The significance at 5% level is denoted using "**".

To ensure comparability across the variable pairs, we have utilized the BITO sample period (October 19, 2021 to March 31, 2023) for this table. All variables are winsorized at 1% level.

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 3: Beta Estimation

This table shows the estimation results of the single-index model for the exposure of cryptocurrency funds to their respective underlying index using daily observations.

Panel A: Comparison between GBTC and BITO funds during their respective full sample periods

Fund Ticker	GBTC Fund (May 2015-March 2023)		BITO Fund (October 2021 - March 2023)	
Dep. Var.	Total Return	NAV Return	Total Return	NAV Return
	(1)	(2)	(3)	(4)
Bitcoin Return	0.9775*** (0.033)	0.6609*** (0.027)	1.0048*** (0.017)	1.0037*** (0.017)
Constant	0.0267 (0.088)	0.0855 (0.060)	-0.0049 (0.056)	-0.0104 (0.055)
Observations	1,973	1,973	347	347
R-squared	0.536	0.528	0.930	0.931

Panel B: Comparison between GBTC and BITO funds during their common sample period (October 2021 - March 2023)

Fund Ticker	GBTC Fund		BITO Fund	
Dep. Var.	Total Return	NAV Return	Total Return	NAV Return
	(1)	(2)	(3)	(4)
Bitcoin Return	1.0897*** (0.028)	0.8931*** (0.026)	1.0048*** (0.017)	1.0037*** (0.017)
Constant	-0.0102 (0.115)	-0.0266 (0.085)	-0.0049 (0.056)	-0.0104 (0.055)
Observations	347	347	347	347
R-squared	0.790	0.818	0.930	0.931

Panel C: Exposure of ETHE fund to Ethereum index

Fund Ticker	ETHE Fund (June 2019-March 2023)	
Dep. Var.	Total Return	NAV Return
	(1)	(2)
Ethereum Return	0.9720*** (0.084)	0.7310*** (0.029)
Constant	-0.0531 (0.230)	0.0588 (0.101)
Observations	935	935
R-squared	0.352	0.632

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 4: NAV Return Deviation Analysis

This table presents the daily results from the NAV return deviation analysis. All variables are winsorized at 1% level on both sides.

Sample Period Fund Name	Dependent Variable = NAV Return Deviation					
	Full Sample Period			BITO Sample Period		
	GBTC		BITO	GBTC		
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged GBTC NAV Return Deviation	-0.4842*** (0.025)	-0.4833*** (0.025)			-0.4848*** (0.086)	-0.4841*** (0.086)
Lagged BITO NAV Return Deviation			-0.5117*** (0.056)	-0.5078*** (0.055)		
Bitcoin Return	-0.2923*** (0.014)	-0.2966*** (0.015)	0.0121 (0.015)	0.0000 (0.019)	-0.1069*** (0.024)	-0.1186*** (0.029)
Holding Period Federal Funds Interest		-0.3992 (7.562)		-1.3312 (4.305)		-4.3781 (7.623)
VIX Index		-0.0057 (0.007)		0.0029 (0.009)		-0.0069 (0.017)
GBTC Turnover		7.1352 (5.334)				5.7476 (22.418)
SPX Index return		0.0146 (0.046)		0.0516 (0.045)		0.0220 (0.065)
Dollar Index Return		-0.1508 (0.107)		-0.0218 (0.105)		-0.2030 (0.150)
BITO Turnover				-0.4495 (0.723)		
BITO Fund Flow				-0.0007 (0.004)		
Constant	0.0852* (0.045)	0.0947 (0.145)	-0.0219 (0.047)	-0.0049 (0.263)	-0.0198 (0.071)	0.1425 (0.471)
Observations	1,972	1,972	346	346	346	346
R-squared	0.456	0.458	0.261	0.267	0.303	0.310
F	456.8	132.0	42.25	11.36	29.81	9.576

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 5: Inefficiency Return Deviation Analysis

This table presents the daily results from the inefficiency return deviation analysis. All variables are winsorized at 1% level on both sides.

Sample Period Fund Name	Dependent Variable = Inefficiency Return Deviation								
	Full Sample Period			BITO Sample Period					
	GBTC			BITO			GBTC		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged GBTC Premium	-0.0111*** (0.003)	-0.0144*** (0.003)	-0.0301*** (0.005)				-0.0205 (0.016)	-0.0290 (0.019)	-0.0665*** (0.025)
Lagged BITO Premium				-0.8196*** (0.057)	-0.8307*** (0.056)	-0.8522*** (0.061)			
Bitcoin Return	0.3187*** (0.026)	0.3160*** (0.027)	0.2925*** (0.027)	0.0052*** (0.002)	0.0053*** (0.002)	0.0032 (0.002)	0.1987*** (0.036)	0.2070*** (0.038)	0.1453*** (0.046)
GBTC Turnover		16.6268 (11.731)	19.5433* (11.715)					41.9239 (47.923)	34.8515 (47.715)
GBTC Bid Ask Spread		0.1277 (0.118)	0.0526 (0.118)					-1.1147* (0.644)	-1.2417** (0.608)
BITO Fund Flow					0.0004 (0.000)	0.0005 (0.000)			
SPX Index return			0.3430*** (0.092)			0.0115** (0.005)			0.3628*** (0.100)
Dollar Index Return			0.4862** (0.224)			0.0067 (0.014)			0.5473* (0.292)
Change in Federal Funds Rate			1.1623 (1.437)			0.0640 (0.074)			-0.8620 (0.880)
VIX Index			-0.0562*** (0.020)			-0.0002 (0.002)			-0.0485 (0.035)
Gold Return			0.2119** (0.101)			0.0067 (0.006)			-0.0153 (0.133)
Financial Stress Index			0.3372* (0.200)			-0.0243 (0.018)			0.7278* (0.400)
CPI Year over Year			-0.1565** (0.075)			-0.0063 (0.010)			0.1087 (0.228)
GDP Year over Year Nominal			0.0019 (0.025)			-0.0004 (0.006)			0.0194 (0.167)
BITO Turnover					0.0168 (0.080)	0.0135 (0.082)			
BITO Bid Ask Spread					-0.1712 (0.181)	-0.2096 (0.195)			
Constant	0.1420 (0.087)	-0.1022 (0.160)	1.7967*** (0.482)	0.0088 (0.005)	0.0185 (0.021)	0.0485 (0.073)	-0.6142 (0.491)	-0.9581 (0.723)	-1.0691 (2.041)
Observations	1,973	1,973	1,973	347	347	347	347	347	347
R-squared	0.113	0.116	0.139	0.420	0.425	0.448	0.097	0.108	0.150
F	80.18	40.89	19.84	109.7	48.37	20.16	17.10	8.854	6.758

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 6: Total Return Deviation Analysis

This table presents the daily results from the total return deviation analysis. All variables are winsorized at 1% level on both sides.

Sample Period Fund Name	Dependent Variable = Total Return Deviation								
	Full Sample Period			BITO Sample Period					
	GBTC			BITO			GBTC		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged GBTC Total Return Deviation	-0.0404 (0.034)	-0.0444 (0.034)	-0.0388 (0.034)				-0.0792 (0.067)	-0.0809 (0.068)	-0.0700 (0.068)
Lagged BITO Total Return Deviation				-0.4994*** (0.058)	-0.4971*** (0.059)	-0.4906*** (0.059)			
Bitcoin Return	-0.0040 (0.024)	-0.0075 (0.024)	-0.0286 (0.025)	0.0141 (0.015)	0.0123 (0.014)	-0.0011 (0.019)	0.0924*** (0.028)	0.1003*** (0.031)	0.0240 (0.037)
GBTC Turnover		12.9256 (10.223)	12.9868 (10.503)					30.1742 (39.583)	23.4757 (42.958)
GBTC Bid Ask Spread		-0.0579 (0.092)	-0.0618 (0.099)					-0.2515 (0.612)	-0.4795 (0.580)
BITO Fund Flow					-0.0001 (0.004)	0.0001 (0.004)			
SPX Index return			0.3968*** (0.076)			0.0766* (0.046)			0.4299*** (0.095)
Dollar Index Return			0.1874 (0.205)			0.0398 (0.128)			0.3514 (0.297)
Change in Federal Funds Rate			0.3418 (1.135)			0.2921 (0.347)			-0.7627 (1.040)
VIX Index			-0.0059 (0.015)			-0.0006 (0.015)			-0.0175 (0.026)
Gold Return			0.1675* (0.092)			0.0693 (0.060)			0.1711 (0.127)
Financial Stress Index			0.0482 (0.152)			-0.0308 (0.166)			0.1140 (0.341)
CPI Year over Year			0.0067 (0.062)			0.0201 (0.090)			0.0477 (0.183)
GDP Year over Year Nominal			-0.0022 (0.021)			0.0005 (0.063)			-0.1181 (0.137)
BITO Turnover					-0.4615 (0.699)	-0.5336 (0.744)			
BITO Bid Ask Spread					0.6772 (1.947)	0.5480 (2.121)			
Constant	0.0037 (0.075)	-0.1443 (0.145)	-0.0453 (0.306)	-0.0101 (0.048)	0.0133 (0.206)	-0.1502 (0.696)	-0.0220 (0.115)	-0.1870 (0.335)	1.2618 (1.613)
Observations	1,972	1,972	1,972	346	346	346	346	346	346
R-squared	0.002	0.006	0.022	0.248	0.251	0.261	0.031	0.036	0.093
F	0.714	1.128	3.348	37.01	15.40	6.505	6.191	3.214	4.285
adjr2

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 7: Change in Valuation Premium Analysis

This table presents the results of the analysis of daily change in valuation premium. All variables are winsorized at 1% level on both sides.

Sample Period Fund Name	Dependent Variable = Daily Change in Valuation Premium								
	Full Sample Period			BITO Sample Period					
	GBTC			BITO			GBTC		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged GBTC Premium	-0.0171*** (0.004)	-0.0196*** (0.004)	-0.0412*** (0.007)				-0.0146 (0.011)	-0.0210* (0.012)	-0.0477*** (0.017)
Lagged BITO Premium				-0.8030*** (0.053)	-0.8141*** (0.052)	-0.8254*** (0.054)			
Bitcoin Return	0.3837*** (0.034)	0.3820*** (0.035)	0.3578*** (0.035)	0.0050*** (0.002)	0.0050*** (0.002)	0.0030 (0.002)	0.1473*** (0.024)	0.1542*** (0.026)	0.1057*** (0.031)
GBTC Turnover		11.6970 (16.544)	15.2810 (16.535)					33.7229 (30.768)	27.9424 (29.378)
GBTC Bid Ask Spread		0.1058 (0.161)	0.0008 (0.161)					-0.7780* (0.428)	-0.8826** (0.393)
BITO Fund Flow					0.0005 (0.000)	0.0005 (0.000)			
SPX Index return			0.2959** (0.115)			0.0122** (0.005)			0.2700*** (0.068)
Dollar Index Return			0.6470** (0.292)			0.0121 (0.013)			0.3396* (0.173)
Change in Federal Funds Rate			1.8553 (1.801)			0.0765 (0.079)			-0.6095 (0.650)
VIX Index			-0.0789*** (0.025)			-0.0005 (0.002)			-0.0368 (0.025)
Gold Return			0.2966** (0.129)			0.0053 (0.006)			-0.0111 (0.094)
Financial Stress Index			0.4641* (0.249)			-0.0206 (0.017)			0.4984 (0.313)
CPI Year over Year			-0.2082** (0.094)			-0.0030 (0.009)			0.0963 (0.166)
GDP Year over Year Nominal			-0.0029 (0.030)			0.0021 (0.006)			0.0240 (0.123)
BITO Turnover					-0.0079 (0.074)	-0.0092 (0.075)			
BITO Bid Ask Spread					-0.1525 (0.178)	-0.1695 (0.194)			
Constant	0.1284 (0.092)	-0.0505 (0.218)	2.6111*** (0.635)	0.0045 (0.005)	0.0167 (0.021)	0.0052 (0.065)	-0.4666 (0.352)	-0.7505 (0.462)	-1.0371 (1.481)
Observations	1,973	1,973	1,973	347	347	347	347	347	347
R-squared	0.101	0.102	0.122	0.439	0.444	0.463	0.116	0.131	0.178

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 8: Valuation Premium over Time Analysis

This table presents the results of the analysis of GBTC's daily valuation premium. All variables are winsorized at 1% level on both sides.

Fund Name	Dependent Variable = Valuation Premium				
	GBTC				
	(1)	(2)	(3)	(4)	(5)
After ETF Indicator	-61.5187*** (0.802)	-38.3652*** (1.024)	-38.1111*** (1.019)	-30.1079*** (1.052)	-31.3136*** (1.598)
Time Trend		-0.0160*** (0.001)	-0.0161*** (0.001)	-0.0204*** (0.001)	-0.0148*** (0.001)
Bitcoin Return			0.4108*** (0.102)	0.3097*** (0.095)	0.2987*** (0.099)
GBTC Turnover				418.5508*** (36.639)	392.8014*** (36.533)
GBTC Bid Ask Spread				-2.0987*** (0.704)	-0.9735 (0.675)
SPX Index return					-0.6502** (0.324)
Dollar Index Return					0.5976 (1.048)
Change in Federal Funds Rate					-1.8698 (5.389)
VIX Index					-0.9338*** (0.079)
Gold Return					0.1807 (0.465)
Financial Stress Index					4.8217*** (0.628)
CPI Year over Year					0.6276* (0.365)
GDP Year over Year Nominal					-0.0899 (0.097)
Constant	36.5840*** (0.608)	377.6008*** (18.145)	378.3080*** (18.112)	464.6156*** (22.936)	360.7698*** (25.203)
Observations	1,991	1,991	1,991	1,991	1,991
R-squared	0.630	0.693	0.696	0.735	0.750

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

See Appendix Table A2 for the specifications of each cryptocurrency fund.

Table 9: Fund Turnover over Time Analysis

This table presents the results of the analysis of GBTC's daily fund turnover over time. All variables, except for the time trend, are winsorized at 1% level on both sides.

Dependent Variable = Daily Turnover of the Fund in Percentage					
Fund Name	GBTC Fund				
	(1)	(2)	(3)	(4)	(5)
After ETF Indicator	-0.7431*** (0.051)	-1.4387*** (0.078)	-1.3270*** (0.065)	-0.9224*** (0.071)	-1.0680*** (0.109)
Time Trend		0.0005*** (0.000)	0.0004*** (0.000)	-0.0001 (0.000)	0.0001** (0.000)
Absolute Value of Bitcoin Return			0.2008*** (0.012)	0.1898*** (0.011)	0.1932*** (0.011)
GBTC Bid Ask Spread				-0.4217*** (0.038)	-0.3613*** (0.034)
SPX Index return					-0.0144 (0.021)
Dollar Index Return					-0.0116 (0.062)
Change in Federal Funds Rate					-0.1974 (0.454)
VIX Index					-0.0266*** (0.005)
Gold Return					-0.0131 (0.027)
Financial Stress Index					-0.1208** (0.050)
CPI Year over Year					-0.0067 (0.022)
GDP Year over Year Nominal					-0.0116* (0.007)
Constant	1.6137*** (0.045)	-8.6318*** (0.979)	-7.3232*** (0.829)	2.7222* (1.410)	-1.2665 (1.451)
Observations	1,991	1,991	1,991	1,991	1,991
R-squared	0.046	0.075	0.260	0.312	0.335

Robust standard errors in parentheses

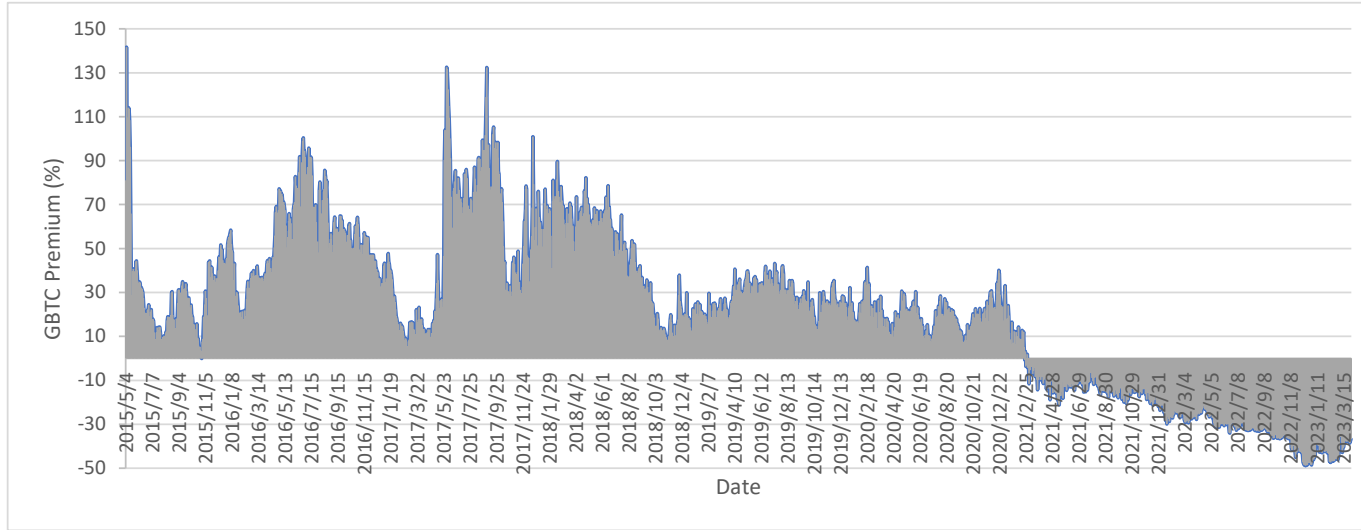
*** p<0.01, ** p<0.05, * p<0.1

Note: See Appendix Table A1 for variable definitions.

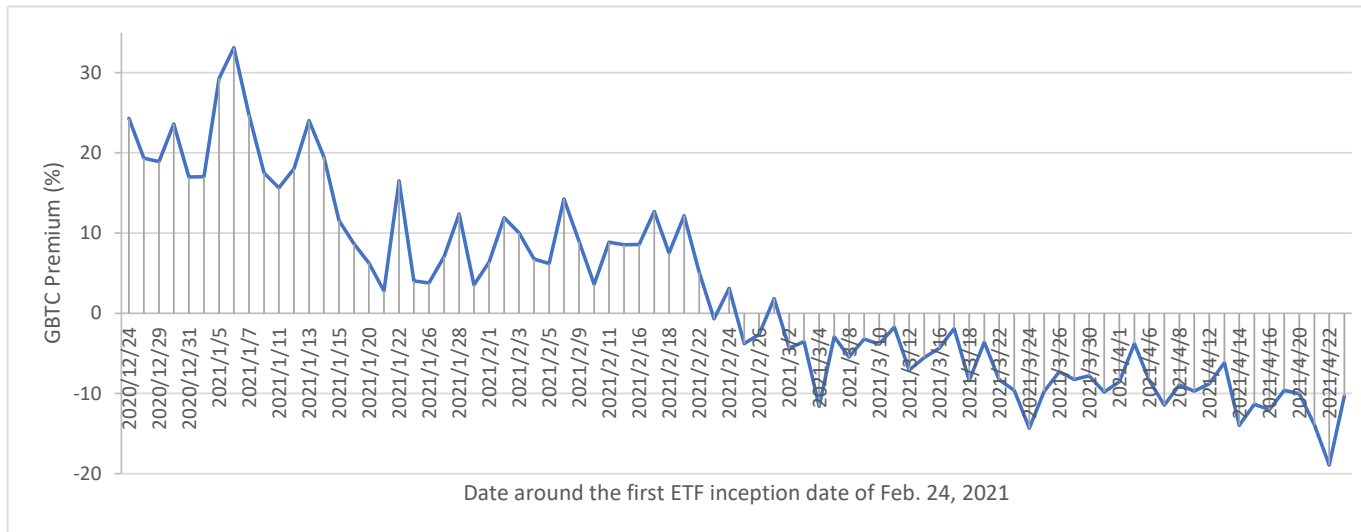
See Appendix Table A2 for the specifications of each cryptocurrency fund.

Figure 1: GBTC Market Valuation Premium over Time

Panel A: GBTC market valuation premium over the entire sample period (May 2015-March 2023)



Panel B: GBTC market valuation premium around the first ETF inception date of February 24, 2021



Appendix Table A1: Variable Definitions

Variable Name	Definition
Bitcoin Price	Daily closing price (PX_LAST from Bloomberg) of XBT Index from Bloomberg showing Bitcoin price in US Dollar
Bitcoin Return	Daily percentage change in XBT Index showing Bitcoin daily return
Ethereum Price	Daily closing price (PX_LAST from Bloomberg) of XET Index from Bloomberg showing Ethereum price in US Dollar
Ethereum Return	Daily percentage change in XET Index showing Ethereum daily return
Fund Total Assets	Total Assets under Management (AUM) of the cryptocurrency fund in million dollars (FUND_TOTAL_ASSETS from Bloomberg)
Fund Price	Daily closing price (PX_LAST from Bloomberg) of the cryptocurrency fund
Fund NAV	Net Asset Value (FUND_NET_ASSET_VAL from Bloomberg) of the cryptocurrency fund
Fund Total Return	Daily total return (TOT_RETURN_INDEX_GROSS_DVDS from Bloomberg) the cryptocurrency fund
Fund NAV Return	Daily percentage change in NAV of the cryptocurrency fund
Fund Total Return Deviation	Daily total return of the cryptocurrency fund less daily return of underlying cryptocurrency index
<i>GBTC Total Return Deviation</i>	<i>Daily total return of the GBTC fund less daily Bitcoin return (XBT return)</i>
<i>ETHE Total Return Deviation</i>	<i>Daily total return of the ETHE fund less daily Ethereum return (XET return)</i>
<i>BITO Total Return Deviation</i>	<i>Daily total return of the BITO fund less daily Bitcoin return (XBT return)</i>
Fund NAV Return Deviation	Daily NAV return of the cryptocurrency fund less daily return of underlying cryptocurrency index
<i>GBTC NAV Return Deviation</i>	<i>Daily NAV return of the GBTC fund less daily Bitcoin return (XBT return)</i>
<i>ETHE NAV Return Deviation</i>	<i>Daily NAV return of the ETHE fund less daily Ethereum return (XET return)</i>
<i>BITO NAV Return Deviation</i>	<i>Daily NAV return of the BITO fund less daily Bitcoin return (XBT return)</i>
Fund Inefficiency Return	Daily total return of the cryptocurrency fund less daily NAV return
Fund Premium	The fund's market valuation premium. Computed as the percentage deviation of the fund's market price from its NAV. A negative market valuation premium indicates a market valuation discount.
Change in Fund Premium	Daily change in the market valuation premium of the cryptocurrency fund
Fund Short Interest Ratio	The fund's Short interest ratio (SHORT_INT_RATIO from Bloomberg)
Fund Bid Ask Spread	Daily bid-ask spread as a percentage of the mid price of the cryptocurrency fund; calculated as $[100\% * 2 * (\text{ask price} - \text{bid price}) / (\text{ask price} + \text{bid price})]$
Fund Flow	Daily percentage fund inflow to an ETF
Fund Turnover	Daily trading volume divided by the number of shares outstanding of the cryptocurrency fund (and then times 100 for Table 9 only).
SPX Index return	The daily percentage change of the S&P 500 Total Return Index (SPXT Index from Bloomberg)
Dollar Index Return	The daily percentage change of US dollar spot index (BBDXY Index from Bloomberg)
Federal Funds Rate	U.S. Federal Funds Rate in % (FDFD Index from Bloomberg)
Daily Change in Fed Funds Rate	The Daily Change in Federal Funds Rate $[t] = \text{FDFD Index } [t] - \text{FDFD Index } [t-1]$
Holding Period Federal Funds Inte	Federal Funds Rate times the number of calendar days from the previous trading day
VIX Index	Chicago Board Options Exchange Volatility Index (VIX Index from Bloomberg)
Gold Return	Daily percentage change in Gold Price in USD (PX_Last of XAU BGN Currency from Bloomberg)
Financial Stress Index	U.S. Financial Stress Index (SLFXFSI3 Index from Bloomberg)
CPI Year over Year	U.S. Consumer Price Index Year over Year Percentage Change (CPI YOY Index from Bloomberg)
GDP Year over Year Nominal	U.S. Nominal GDP Growth Year over Year (GDP CURY Index from Bloomberg) in percentage
Credit Spread	Yield spread (in %) between the US Corp BBB/Baa and 10-Year Treasury (CSI BBB Index from Bloomberg)
Unemployment Rate	US Unemployment rate in percentage (EHUPUS Index from Bloomberg)
After ETF Indicator	Dummy variable that equals 1 on or after February 24, 2021, when the first spot-based Bitcoin ETF in Canada (ticker: BTCC CN Equity) was launched.
Time Trend	Date in consecutive STATA date format.

Appendix Table A2: List and Characteristics of U.S. Publicly-traded Cryptocurrency Funds

Ticker	Fund Name	Fund Inception Date	Trading Inception Date	Fund Total Assets (AUM in million \$)	Market Cap (in million \$)	Shares Outstanding (in millions)	Fund Valuation Premium (%)	Bid-Ask Spread (%)	Annual Expense Ratio (%)	Underlying Cryptocurrency
<u>Nonredeemable Investment Trusts</u>										
GBTC	Grayscale Bitcoin Trust BTC	9/13/2013	05/05/2015	17,902.26	11,327.17	692.37	-36.73	0.13	2.00	Spot Bitcoin
ETHE	Grayscale Ethereum Trust	12/14/2017	06/20/2019	5,522.10	2,658.06	310.16	-51.87	0.20	2.50	Spot Ethereum
OBTC	Osprey Bitcoin Trust	1/22/2019	05/24/2021	79.02	49.86	8.34	-36.90	1.29	0.49	Spot Bitcoin
<u>Exchange-Traded Funds</u>										
BITO	ProShares Bitcoin Strategy ETF	10/19/2021	10/19/2021	954.99	955.37	54.53	0.04	0.06	0.95	Bitcoin Futures
XBTF	Vaneck Bitcoin Strategy ETF	11/16/2021	11/16/2021	40.04	40.05	1.40	0.02	0.12	0.65	Bitcoin Futures
BTF	Valkyrie Bitcoin Strategy ETF	10/22/2021	10/22/2021	29.37	29.37	2.63	0.01	0.09	0.95	Bitcoin Futures

This Table presents the fund characteristics as of March 31, 2023.

Note: See Appendix Table A1 for variable definitions.

Our study sample includes the three cryptocurrency funds (GBTC, ETHE, BITO) that have AUM over half a billion dollars as of March 31, 2023.