

Confirmation of T+35 Failures-To-Deliver Cycles: Evidence from GameStop Corp.

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Abstract

In this paper, we examine the potential of cycles in the valuation of GameStop Corp. (GME) stocks, due to the unique exemptions in exchange traded fund (ETF) creation/redemption activities. In order to satisfy liquidity in the market, a market maker and/or authorised participant is allowed to sell ETF shares that have not yet been created. With the use of wavelet coherence, we find evidence that ETF Failures to Deliver (FTDs) formed consistent cycles in the day T+35 FTD clearing period. Results also confirm less consistent but repeating cycles between the T+3 and T+6 periods. To the best of our knowledge, we are the first in the literature to empirically examine the potential of these cycles and their co-movement between FTD and stock prices.

1. Introduction

Failures to deliver (FTD) form in markets when one party in a trading contract fails to deliver on their obligation.¹ This failure should be *randomly* caused by human error or administrative delays, etc. Nevertheless, there is evidence and broad acceptance that using of FTDs to avoid fulfilment of obligations has been abused systematically (see for example Boni, 2006; Evans et al., 2008; Stratmann and Welborn, 2012; and Evans et al., 2021). One of the regulation actions conducted by the U.S. Securities and Exchange Commission (SEC) in 2009² led to a dramatic decline in common stock FTDs but a clear upward trend in ETF FTDs (Evans et al., 2021).

Due to the exclusive exception provided by the delivery requirement (Rule 204), an authorised participant (AP) and/or market maker in the stock market can legally delay delivery of shares for three additional trading days (referred to as T+6) beyond the standard T+3 clearing time, thus lawfully creating extra FTDs. In other

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¹ The following text contains numerous abbreviations. A full list of used abbreviations is available at the end of the appendix.

² See SEC regulatory rules 203 and 204, introduced in part to address short-selling activities.

words, the AP has the option to sell short ETF shares and then fail to deliver them at the settlement date. Additionally, Rule 204³ provides an extended period of up to 35 calendar days (referred to as T+35) to close out certain FTDs if an FTD position results from the sale of a security that a person is deemed to own and that such person intends to deliver as soon as all restrictions on delivery have been removed (SEC, 2015).

These exemptions have raised concerns about abuse of these T+d rules and its implications for financial markets. The possibility of unethical short-selling activities was highlighted by the action of the Financial Industry Regulatory Authority (FINRA) and Nasdaq in 2016 in fining Wedbush Securities, an ETF AP, for submitting ‘naked’ ETF redemption orders on behalf of broker/dealer clients. FINRA Executive Vice President and Head of Market Regulation Thomas Gira directly pointed out that ‘Timely delivery of securities is a critical component of sales activity in the markets, particularly in ETFs that rely on the creation and redemption process. Naked trading strategies that result in a pattern of systemic and recurring fails flout such principle and do not comply with Regulation SHO’ (FINRA, 2016). Therefore, the question arises, can these exceptions form systematic cycles, or are these failures exceptional?

In this paper, we test the hypothesis concerning the randomness of ETF FTDs in financial markets due to timely delivery of securities and unique exceptions for APs to close out FTD positions. According to our knowledge, we are the first in the literature to empirically examine the potential of these cycles and their co-movement between FTDs and stock price returns. In our analysis, we focus mainly on GameStop Corp (GME). GameStop is a video game retailer that caught the attention of investors when increasing stock demand caused hedge funds to close short positions and became one of the best-known short squeezes on the stock markets (Anand and Pathak, 2022). This one-of-a-kind event is often blamed for unethical practices in stock markets viewed as ‘discrimination’ of retail investors, which garnered significant attention from market regulators and the wider public, and the concept of failures to deliver become subject of interest raising an incentive to examine them in more detail in relation to the share price.

With the use of wavelet coherence, we find evidence that in case of GameStop, ETF FTDs created consistent cycles (up to one year in our data) in the T+35 FTD clearing period, and results also confirm less consistent but repeating cycles between the T+3 and T+6 periods. No other persistent cycles were found in other periods. Wavelet coherence measures the local correlation of two time series in the time-frequency domain and provides a detailed analysis of co-movements, specifically FTD of ETF (exposure to GME) to GME stock price in our data. We use data for the top 93 ETFs with exposure to GameStop Corp. Evidence suggests that more than 18% of examined ETFs formed cycles/patterns between a number of FTDs and stock prices for a period of around 35 days after delaying the delivery of shares.

³ The rule is a requirement for brokers and dealers participating in registered clearing agencies to close out failure to deliver positions. These counterparties are mandatory to deliver the securities „of like kind and quality“ either by purchasing or borrowing. The rule was created to restrict “naked” short selling when the investor would sell the shares he doesn’t own. This rule applies to the US market (SEC, 2015).

In the appendix we also present reproduced analysis for the AMC⁴ stocks arguably the second-largest representative of “meme stocks” and for the MSFT stock as representative of a large established company. These companies were analysed to validate the further robustness of the results for GME. No cycles were identified in these samples, which brings more reliability to the results since such a significant and long-lasting coherence in the case of GME does not indicate a random occurrence.

The paper is organised as follows. Section 2 contains the theoretical framework. An overview of data and methods is provided in Section 3. Section 4 presents the results of the wavelet coherence. Section 5 presents a robustness analysis. Section 6 concludes, and the paper ends with an appendix.

2. Theoretical Framework

This research focuses on the potential occurrence of certain cycles in the valuation of GME stocks, due to the unique exemptions in ETF creation/redemption activities. This exemption applies to ETF authorised participants (APs) and/or market makers (MMs)⁵, when in order to satisfy liquidity in the market, APs are allowed to sell ETF shares that have not yet been created. We can label these cycles as $T+d$, where d is a count of days that determines the cycle’s length, with the beginning of the cycle in day t , representing the day when the trading position was opened.

The creation process of ETF shares involves the buying of all the underlying securities in their appropriate weightings to reach creation unit size (ranging from 25,000 to 600,000 shares per creation unit). After creation, the AP delivers the securities to the ETF sponsor⁶, and in return the ETF sponsor bundles the securities into the ETF wrapper and delivers the ETF shares to the AP. The newly created shares are then introduced to the secondary market. Redemption is the reverse process, which involves ‘unwrapping’ ETF units back into the individual securities and selling them on the market. However, the AP has a choice in this redemption process to purchase ETF shares without redeeming them for the underlying securities. In this option, cumulating shares of ETF pose an inventory risk.

According to Evans et al. (2021), there could be scope for MMs to make a predictable return, if there is the belief that the net asset value (NAV) of ETF underlying securities will decrease in the following days. To do so, an AP can redeem ETF shares and delay creation beyond the standard $T+3$ settlement. If the ETF is an open-end fund, it can issue or redeem the number of outstanding shares (Ferri, 2009), which means that the bid of ETF shares is unlimited (if there is an ask) and this process can generate FTDs.

Despite this process, FTDs can occur for several reasons. The most cited reasons are human error, administrative delays, or *bona fide* activities. Stratmann and Welborn (2012) states that ETFs are popular vehicles for hedging market index

⁴ We choose AMC as a stock with similar characteristics to GME in the context of short selling. Both companies experienced a short-squeeze effect in January 2021, and both companies are considered „meme“ stocks when GME is arguably the most popular squeezed company, and AMC is the second.

⁵ We are referring to APs and/or MMs because an AP is typically a MM or large institution with legal agreements to carry out ETF creation/redemption activities. Most APs are MMs, and vice versa. It can be assumed that the AP is an MM, and thus we will use these terms interchangeably in this paper.

⁶ Antoniewicz and Heinrichs (2015) report that, on average, ETFs have around five active APs registered as MMs obligated to quote ETF shares on secondary markets.

movements, and ETF short interest often exceeds shares outstanding. Their study shows several findings. The first is the positive relationship between ETF daily short sale volume and ETF FTDs. Second, ETF FTDs increase as stock borrow costs rise and indicate short sellers' intention to avoid borrowing costs. Third, ETF FTDs contribute to market volatility. And lastly, ETF FTDs increase with put option open interest. FTDs are also associated with naked short selling. The term 'naked short selling' is used to describe a situation where a trading participant sells a share without owning or borrowing it (Putninš, 2009). In the case of naked short selling, an FTD occurs if such a trade is not covered by the T+3 date, i.e., the owner of the short position did not own or borrow the stock after that date. The reasoning behind this may differ, but according to Boni (2005), the main reason is linked to situations where the cost of borrowing the stock is too high – in this case, where the owner of the open short position does not voluntarily deliver the stock and an FTD occurs. Despite the fact that naked short selling has been restricted for stocks by SEC since rules 203, 204T, and 204 were applied, ETF APs can legally use an extended period of T+6 if operating due to *bona fide* market-making activities.

Not all cases of naked short selling can be considered harmful, and some can help shape or clean the market. According to Putninš (2009), the total share of FTD in publicly traded shares of major stock exchanges in the United States of America was between 1.5% and 5.0% of the average daily trading volume in the period 2004–2009, so it is obvious that FTDs played a significant role in shaping the market. From 2008, the FTD level by common stocks was reduced significantly due to SEC regulation. Although these restrictions, according to a study by Stratmann and Welborn (2012), led to a reduction in FTD's share of common stocks, there was a significant increase in FTDs by ETFs. These findings are also supported by SEC Office of Economic Analysis's (2011) research. The increase in FTDs by ETFs can be explained to some extent by the ETF boom after the financial crisis (beginning 2008) and increased investor interest in ETFs.

The issue of FTDs was further addressed by Stratmann and Welborn (2016), who, based on a case study and portfolio analysis using Fama-French factors, found that stocks that were more likely to experience FTDs and recorded abnormally negative returns proportional to their FTD levels. The authors' findings suggest that there may be an indication that the occurrence of FTD is not a random process. This may be more apparent for ETFs (Stratmann and Welborn, 2012) which suggests a T+6 relationship. In the case that the MM does not provide the share in the T+3 period, an FTD occurs. The MM has an extra T+6 period to settle the transaction, when he must deliver the underlying asset. Additionally, Rule 204 provides an extended period of up to 35 calendar days (referred to as T+35) to close out certain FTDs (see Fig. A3, for more detail), if an FTD position results from the sale of a security that a person is deemed to own and that such person intends to deliver as soon as all restrictions on delivery have been removed (SEC, 2015)⁷. In the Code of Federal Commodity and Stock Exchange Regulations, Section 17, §242204 (Legal Information Institute, 2021) there is an obligation for MMs in the case of FTDs that

⁷ SEC justifies this exception because the additional time warranted does not undermine the goal of reducing failures to deliver because these are sales of owned securities that cannot be delivered by the settlement date due solely to processing delays outside the seller's or broker-dealer's control.

each FTD trade must be covered before the start of regular trading hours on the 35th day after the date of transaction. Otherwise, the MM is prohibited from accepting any short sale orders or effecting further short sales in the particular security without borrowing or entering into a *bona fide* arrangement to borrow the security until the participant closes out the entire FTD position by purchasing securities of like kind and quantity.

According to SEC's interpretation of the final rule (SEC, 2004), the aforementioned exceptions for ETFs for MMs who issue new ETF shares should be based on the following logic:

- A market maker is deemed to own the security due to their authorisation to issue new ETF shares.
- Due to the complexity of the ETF share creation process, it is not reasonable to expect that the security will be in the physical possession or control of the broker-dealer by the settlement date.
- The Federal Reserve Board allows 35 days to pay for securities delivered against payment if the delivery delay is due to the mechanics of the transaction.

Despite the rules, FTDs are expected to occur randomly, and any systematic patterns of FTDs in stock markets do not comply with Regulation SHO. If it does not happen randomly or by accident, there could be a possibility that FTDs have been created systematically, which has implications for the market.

Additionally, there is another term associated with short selling: the 'gamma squeeze'. Gamma is the first derivative of delta and is used when trying to gauge the price movement of an option, relative to the amount it is in or out of the money. It essentially quantifies how delta will change per the change in the stock price. The squeeze can begin when a large investor, typically referred to as a whale, buys short-dated call options in a frenetic pace of stocks that they typically own (e.g., as a result of sharp changes in the price of the underlying asset relative to its current position). The MM who sells these options is usually not willing to take the risk involved and therefore buys the underlying assets at the same time. The more call options the investor buys, the more shares the MM that sold the options will have to buy to ensure they are net flat. This may result in driving underlying stock prices higher for a period of time. Subsequently, the investors may buy more and more options and the MMs must buy more and more of the underlying asset.

According to Saletta (2021), the squeeze effect is also partly responsible for the rise in the stock price of GameStop. Other 'meme' stocks, such as AMC, also recorded a squeeze effect during periods of high stock price volatility (Ahmed, 2021). However, it is clear that several variables played a role in the GME stock price movements. Consequently, if there is a sharp increase in FTDs during a squeeze effect, it can be deduced that the occurrence of FTDs may not be random but may be indicative of some market failure or intentional behaviour by MMs.

To empirically examine the potential of FTD cycles, we use the wavelet coherence approach. This method analyses time series on the time-frequency domain, which allows us to identify cycles and relationships between two variables, not only

for separate periods but also for different investment horizons. There are several uses for this methodology. For example, Umar et al. (2021) uses this methodology to study the relationship between fundamentals and ‘meme’ stock sentiment or to identify long-term cycles (Kapounek and Kučerová, 2019). Among other things, they focus on the volume of frequently shorted stocks in describing the formation of sentiment and its subsequent impact on the return of the stocks. ‘Meme’ stocks are often associated with high short interest and, in the case of GameStop, more than 100% of existing positions were shorted (McCrank, 2021; Wieczner, 2021), while it is estimated that about 260% of issued stocks were sold by short-sellers and promised delivery to buyers (Mackenzie, 2021). According to the authors, this has a positive correlation with the value of shares, due to a high number of shorted stocks on the one hand and a significant increase in demand on the other. This in turn leads to a rapid rise in price. This is where significant space opens up for FTD occurrence, as a huge number of short positions after the $T+d$ deadline from their opening must be covered before the start of trading on the 35th day according to the SEC 204 rule. When such a high number of short positions is opened, significant upward pressure on the stock price can be expected just at the end of the $T+35$ period, and thus there is space for FTDs due to the reluctance or inability of investors to deliver the stock under the circumstances (trading volume and price).

3. Methodology and Data

Our primary dataset consists of FTD data of all 93 identified ETF funds with exposure to GameStop Corp.⁸ These ETFs are diverse and not sector specific, etc. The data represent the daily frequency with a period starting in January 2020 and ending in December 2021, amounting to 505 observations for each of the funds. In order to test the robustness of the results, we reproduce the analysis for other stocks – AMC and MSFT and their ETFs that have exposure to them. The FTD data are downloaded from the official SEC websites and the data about stock prices are downloaded from the Yahoo Finance databases.

To analyse the time series for different time periods and frequencies separately, selected time series are examined using wavelet analysis. This method analyses time series on a time-frequency domain, which gives the opportunity to identify cycles and relationships between two variables not only for separate periods but also for different investment horizons. Using this method, we are able to identify periods with a significant relationship between FTD volumes and GME returns. These results are compared with relationships between FTD volumes of AMC and MSFT and their stock returns.⁹ Following other studies in this field (e.g., Fidrmuc et al., 2019), we chose the Morlet wavelet, defined as follows:

$$\psi_0(\eta) = \pi^{-1/4} e^{i\omega_0\eta} e^{-\frac{1}{2}\eta^2}. \quad (1)$$

⁸ Please note, that this number of ETF funds with exposure to specific stock may vary over time.

⁹ We select for robustness analysis two additional stocks, AMC and MSFT. The reasoning behind this is that AMC is arguably the second largest representative of ‘meme’ stocks, and MSFT is a representative of a large, established company.

The Morlet wavelet is used to analyse the time series using the time-frequency domain by the continuous wavelet transform (CWT). The ω_0 value describing frequencies is set to 6 following relevant research (Grinsted et al., 2004) and $\eta = s \times t$ dimensionless time by varying its scale s . CWT is used as a bandpass filter to time series ($x_n, n=1, \dots, N$) between periods of time and frequencies. The uniform time steps δt are defined as the convolution of x_n (Kapounek and Kučerová, 2019). The formula for CWT is as follows:

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} \sum_{n'=1}^N x_{n'} \psi_0 \left[(n' - n) \frac{\delta t}{s} \right]. \quad (2)$$

where the $W_n^X(s)$ is interpreted as the local phase with the scale s in time. While analysing different frequencies, the Morlet wavelet is expanded. This expansion forms a ‘cone of influence’ (Grinsted et al., 2004), as it omits the beginnings and ends of time series for lower frequencies.

We identify cyclical movements on markets and then observe the mutual coherence. This coherence is effectively identified for each investment horizon and each time period separately. Therefore, for what days is there a relationship between variables, and which one of the variables tends to lead the other. Following research in this economic field (Fidrmuc et al., 2019), we define wavelet coherence as:

$$R_n^2(s) = \frac{|s(s^{-1}W_n^{XY}(s))|^2}{s(s^{-1}|W_n^X(s)|^2) \times s(s^{-1}|W_n^Y(s)|^2)}. \quad (3)$$

where S is the smoothing operator defined as $S(W) = S_{scale}(S_{time}(W_n(s)))$; while S_{time} is a smoothing operator in time and S_{scale} is a smoothing operator of wavelet scale (Kapounek and Kučerová, 2019). By employing wavelet coherence, we are able to interpret each variable as a leading or lagging indicator for that specific time period and investment horizon. This interpretation could be provided by phase shifts representing lags in degrees, described in the following formula:

$$\begin{aligned} \bar{a} &= \arg(X, Y) & \text{with } X &= \sum_{i=1}^n \cos(a_i) & \text{and} \\ Y &= \sum_{i=1}^n \sin(a_i). & (a_i, i=1, \dots, n). \end{aligned} \quad (4)$$

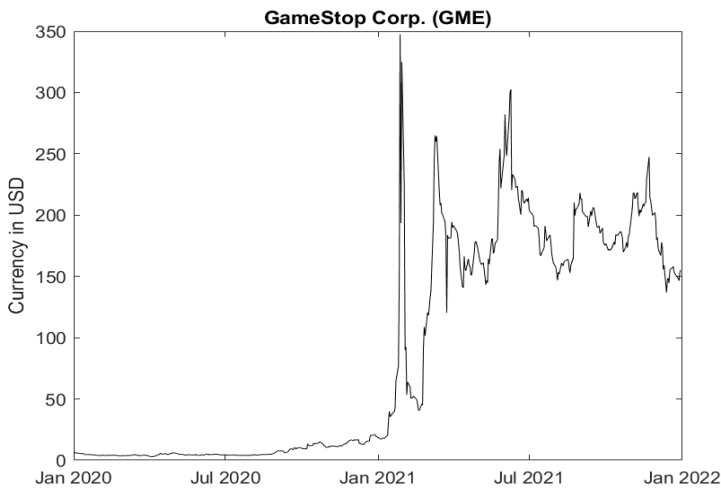
Based on the phases, the interpretation of phases from 90° to 270° (arrow pointing to the left) is lead or lag in negative value, and the arrow from 270° to 90° (arrow pointing to the right) is interpreted as lead or lag in positive value.

4. Results

The story of the GameStop squeeze began in December 2020, when the company announced disappointing earnings and the price of the stock continued to decrease after a few months’ decrease caused by the COVID-19 pandemic (Figure 1). It forced the company to replace some members of the company board at the beginning of January 2021. After that announcement stock prices surged by 50%, and the Reddit community began to unite. However, research companies predicted GME prices to drop and short positions constituted more than 100% of the volume of

existing stock positions at the time (McCrank, 2021). Another 50% surge caught the attention of the public, including Elon Musk. The stock price was more connected to behavioural factors than fundamental ones (Anand and Pathak, 2022). The rapid increase was multiplied as major short sellers were forced to close their positions at the end of January (27th). The next day, the stock price jumped to an all-time high of 486 USD per stock (Umar et al., 2021). But with the announcement of trading restrictions on some platforms, the stock price slumped and closed 60% lower the same day (Figure 1). During the end of January and the beginning of February, the stock price continued to decrease amid comments from regulators including SEC and Janet Yellen concerning stock trading. It dropped to 40 USD, and as the SEC re-allowed GME transactions, it jumped again to almost 350 USD (Umar et al., 2021). From March, it ranged from 115 to 350 USD, including several price spikes (Figure 1).

Figure 1 GME Stock Price Development



Source: Yahoo Finance (2022)

However, the merger of retail investors that forced the hedge funds to close their short positions might have contributed to the pattern formation of FTDs in the market which systematically affect the price. Therefore, these results aim to analyse to what extent the FTD volume of selected ETF funds is connected with the GME stock price.

The abnormality of GME stock FTD volumes are analysed in Figure A2 with comparison to the FTD volumes of AAPL, MSFT, and companies that are similar in size (average FTD volumes of S&P SmallCap companies). Compared to MSFT and AAPL as large established companies, GME has higher FTD volumes on average despite the average trading volume being many times lower. Compared to the average SmallCap company, these results are non-comparable without normalization, as the FTD volumes are several tens of times lower. Since this article

focuses on ETF FTDs, we also conducted this exercise with the top 100 ETFs with exposure to GME, MSFT, and AAPL and compared their FTDs.

Table 1 presents selected ETF funds, whose wavelet coherence results will be presented from the 93 analysed funds with GME stock in their portfolio. The funds should have the stock in their portfolio during the whole selected period (thus, seven ETFs were excluded), and the ETF funds have different market focus, market capitalisation, and allocation of GME in the portfolio. These conditions are valid for the 93 ETF funds. For more detail, we provide a normalised comparison between the FTD development of these ETFs and GME stock price, as well as the aggregated volume of these FTD between the years 2020 and 2021, in Figure A1.

Table 1 Selected ETF Funds (January/2022)

| <i>Ticker</i> | <i>Fund Name</i> | <i>GME Allocation</i> | <i>GME Market Value (mil. USD)</i> |
|---------------|---|-----------------------|------------------------------------|
| VBR | Vanguard Small-Cap Value ETF | 0.20% | 49.91 |
| SLYV | SPDR S&P 600 Small-Cap Value ETF | 0.87% | 34.06 |
| IJJ | iShares S&P Mid-Cap 400 Value ETF | 0.36% | 30.79 |
| VIOO | Vanguard S&P Small-Cap 600 ETF | 1.12% | 19.74 |
| XRT | SPDR S&P Retail ETF | 0.71% | 8.05 |
| FEX | First Trust Large-Cap Core AlphaDEX Fund | 0.32% | 3.92 |
| FDIS | Fidelity MSCI Consumer Discretionary Index ETF | 0.20% | 3.19 |
| DSI | iShares MSCI KLD 400 Social ETF | 0.04% | 1.39 |
| VONE | Vanguard Russell 1000 ETF | 0.03% | 0.75 |
| MXDU | Nationwide Maximum Diversification U.S. Core Equity ETF | 0.47% | 0.57 |
| TILT | FlexShares Morningstar US Market Factor Tilt Index Fund | 0.02% | 0.36 |
| SHE | SPDR SSGA Gender Diversity Index ETF | 0.11% | 0.30 |
| SFYX | SoFi Next 500 ETF | 0.20% | 0.08 |
| JHMC | John Hancock Multifactor Consumer Discretionary ETF | 0.20% | 0.08 |
| AVUS | Avantis U.S. Equity ETF | 0.00% | 0.05 |
| VEGN | U.S. Vegan Climate ETF | 0.05% | 0.03 |

Source: ETF.com (2022)

Notes: Column 'GME Allocation' shows the percentage of GME in the fund's portfolio; 'GME Market Value' shows the market value of stocks owned by the selected ETF fund out of the total market value of 772,20 mil. USD.

The results of the wavelet coherence between ETF FTDs and the GME stock price returns can be seen in Figures 2 and 3. Figure 2 represents the wavelet coherence between FTD volumes of ETFs focused on the investments according to their market capitalisation. Because of GME's market volatility, its market capitalisation ranged between small, medium, and large during 2020 and 2021¹⁰. VBR and SLYV are focused on companies with small-cap value. IJJ, VIOO, and SFYX represent funds investing in the mid-cap valued companies. VONE, SHE, and VEGN are ETF funds investing in companies with large market capitalisation.

¹⁰ Companies with a market capitalization above 10 bil. USD are considered as Large Cap; companies with market capitalization between 2-10 bil. USD are considered as a Mid Cap and companies with market capitalization between 0,3-2 bil. USD are considered as a Small Cap.

The analysis in Figure 2 shows a persistent cycle for all the selected ETFs around day 35. These results indicate that there is a relationship between GME price and FTDs, mainly around the 35th day after the FTD occurs. The findings in Figure 2 confirm the results of Stratmann and Welborn (2012), who conclude that the results were not consistent enough to support the claim that FTDs occur randomly. A common feature of the analyses in Figure 2, in fact, is that significant cycles through wavelet coherence emerge just around T+35, when it is the last date to fill the obligations. These ETFs represent different market capitalisation categories, different allocations of GME, and different sizes, so there appears a regular question of whether these FTD volumes are systematic. These findings are in agreement with authors who point out that the FTD settlement obligations are not random. These cycles are different in persistence, but some manner of cycle is identified during T+35 for all the selected ETFs. The findings also confirm the results of Stratmann and Welborn (2012) that the FTD volumes might have been shifted to ETFs after the Great Financial Crisis and SEC regulatory actions.

Figure 2 Wavelet Coherence Between FTDs of Selected ETF Funds and GME

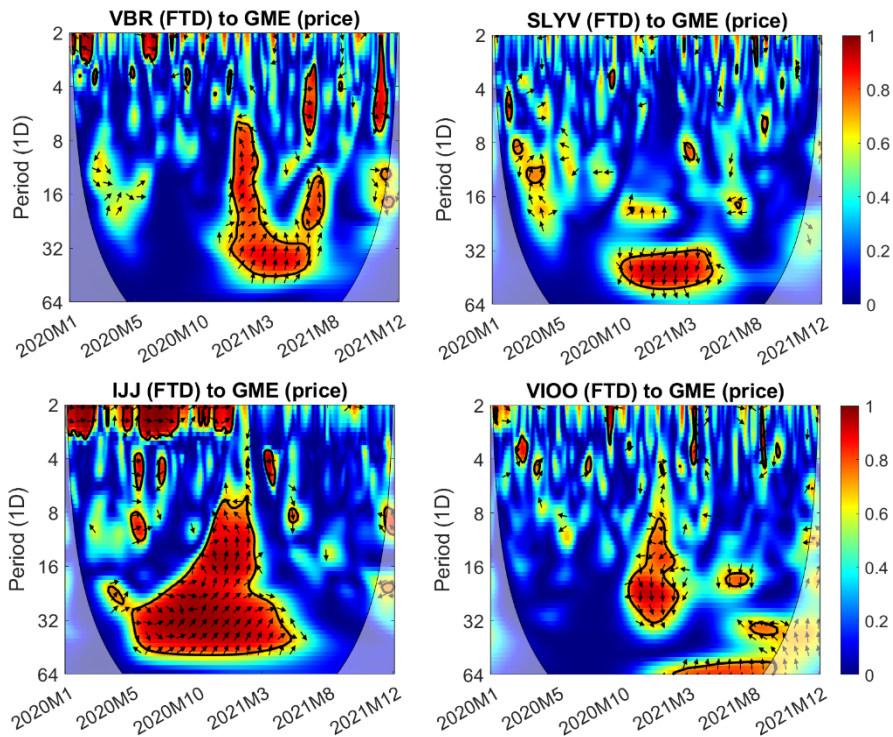
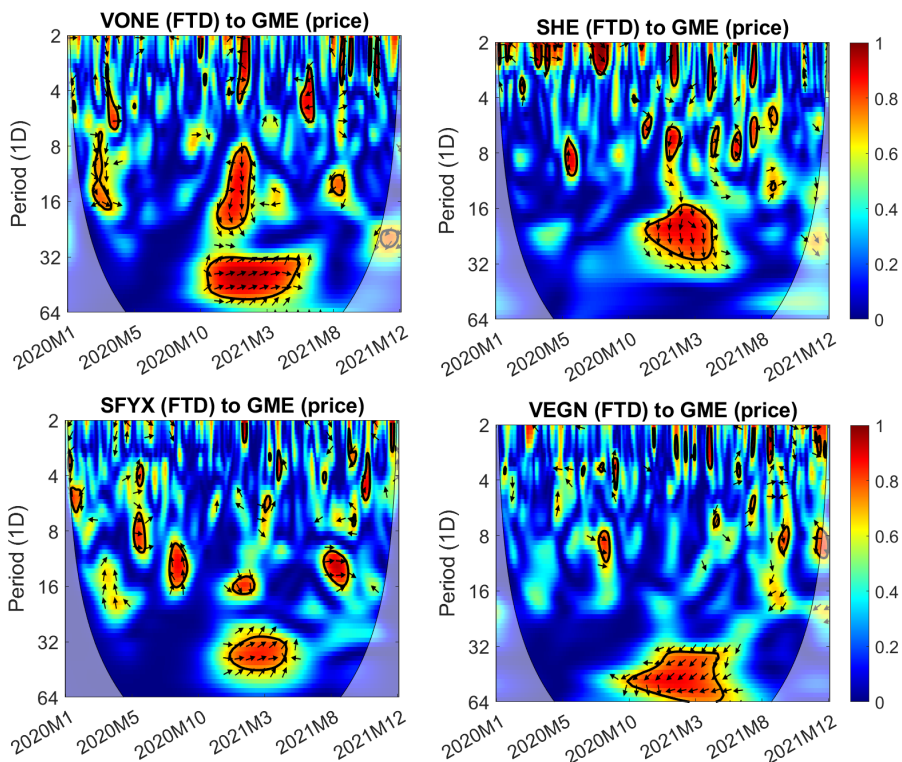


Figure 2 Wavelet Coherence Between FTDs of Selected ETF Funds and GME Continued



Source: Own estimation.

Note: The coloured scale gives information about the coherence. The stains limited by the black line represent the areas with 5% significance against red noise. The relationship is identified by the arrows that point out the leading indicator. An arrow that points to the top right indicates FTD of the selected ETF as a leading indicator to GME stock return, while an arrow pointing to the bottom left indicates FTD to be a leading indicator to negative returns. A top left pointing arrow indicates negative GME returns to be the leading indicator of increasing FTDs, while an arrow pointing to the bottom right is interpreted as GME being the leading indicator of FTDs.

Another interesting aspect that could be explored in more detail is the leading/lagging indicator analysis (Figure 2). The ETFs focused on the companies with large capitalization is similar that the FTD volumes are a leading indicator to GME returns in negative value mainly around the 35th day. For VONE and SHE, this cycle was valid approximately 100 days during the events connected to the highest volatility. A period of 100 days suggests that the FTDs on the T+35 cycle have not occurred accidentally. The significant cycle for these two ETFs was valid for almost one year and mainly for T+35. It indicates that FTD have shaped the share price for a long period. These cycles are consistent in sequence with the delivery periods defined by the SEC (2015) in Rule 204. However, the SEC further states that any systematic patterns of FTD should not occur, which is inconsistent with large-cap companies' results in Figure 2. Very similar evidence is given for small- and mid-cap

ETFs (Figure 2). IJJ is a small-cap representative and an example of a very strong cycle, mostly during T+35. This cycle lasted almost a year, from May 2020 until July 2021, which is half of the observed period. Interestingly, a long cycle (around 200 days) is also observable for VBR. For both funds, the FTD volumes were a leading indicator of GME stock returns. This means that there was significant coherence between FTD volumes and the stock returns around the 35th day. Also important is the finding that IJJ and SHE show significant wavelet coherence for intervals of 2–3 days. As the FTD occurs on the 4th day from the realisation of trade, the second and third days of FTD represent T+5 and T+6. These results are in agreement with the exception that MMs have an additional 3 days to deliver their obligation. VIOO shows results of significant coherence, mainly during price jumps. This cycle lasted almost 200 days, indicating that FTD volumes could have been abused. SLYV shows similar evidence to VEGN, with a significant cycle lasting around 200 days. SFYX's wavelet coherence identifies a significant cycle, mainly during January 2021, the month of highest volatility (Anand and Pathak, 2022). Evans et al. (2021) interpret the results among ETFs to be due to short selling, which increased counterparty risk and subsequent connectedness among market makers. The findings of cycles follow the results of the study of Evans et al. (2021) that since SEC regulations, FTD volumes have increased for ETFs (SEC Office of Economic Analysis, 2011).

Figure 3 represents the wavelet coherence between FTDs of selected ETF funds and GME stock returns. These ETFs are not focused on companies with specific market capitalisation but on the entire market. The analysis shows that there is a cycle around the 35th day from the presence of an FTD. Wavelet coherence results indicate more systematic patterns than the random ones for T+35, mainly from the beginning of 2021. Although the results for the ETFs with investments not focused on specific market-cap categories are not as significant as those with a focus on market capitalisation, all selected ETFs co-move with the GME stock returns on the T+35 from the beginning of FTD. The fact that there is almost no robust coherence besides what T+35 brings gives further evidence that FTD volumes might be the result of systematic failures. Interestingly, long cycles lasting around 300 days from July 2020 to April 2021 only for T+35 could be seen for DSI and FEX. This range also covers the period of price jumps. For DSI, the relationship was mixed. Also important is the significant wavelet coherence from the first to the third day. As MMs have three extra days to fulfil their obligation after the FTD appears, these cycles give further robustness to our results, as they form in clearing periods. The same results can be found for MXDU, JHMC, and TILT. These cycles found in T+3 further confirm our assumptions, as they represent the T+6 period for MMs to cover the position. The results for these particular periods are of interest in the context of regulations by the SEC (2015). In order to reduce naked short selling, the SEC has set specific T+3 or, exceptionally, T+6 dates for the fulfillment of obligations from their securities trades. The results suggest the significant cycles for later settlement dates that also indicate the pattern near the T+35 date.

The results for other ETFs are less significant, but there are always cycles to be found around T+35, with the shortest observable cycle being around 100 days. These cycles are robust, as they mainly occur in the T+35 period. The lead/lag structure varies a lot among different ETFs, but this might be due to the assumption of rebalancing between different ETFs. Cycles were identified for different

investment horizons for XRT and TILT covering the stock most volatile period. However, XRT was hugely affected by FTDs as GME stock was hit by speculation positions (SEC, 2021).

Figure 3 Wavelet Coherence Between FTDs of Selected ETF Funds and GME

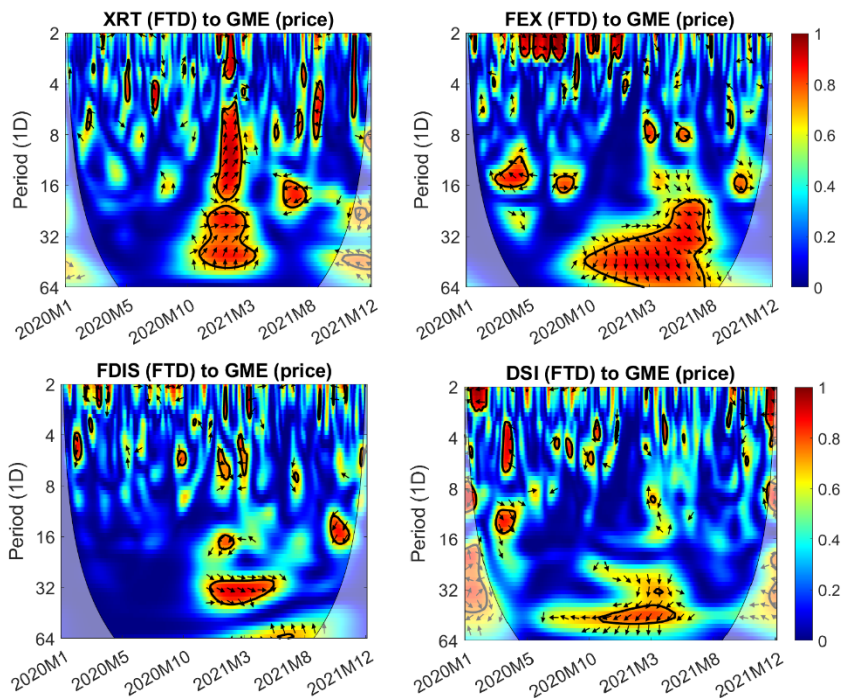
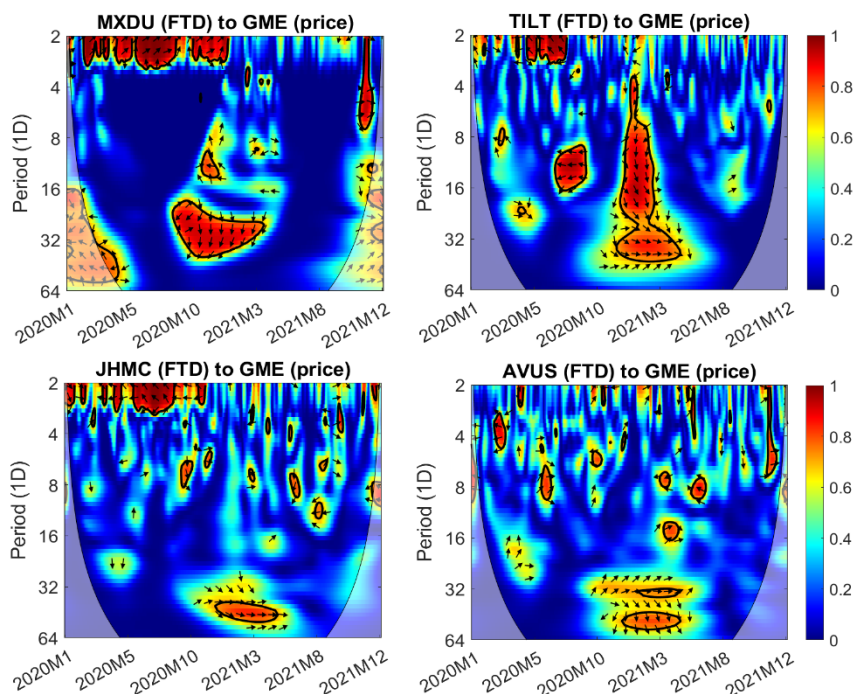


Figure 3 Wavelet Coherence Between FTDs of Selected ETF Funds and GME Continued



Source: Own estimation.

Notes: The coloured scale gives information about the coherence. The stains limited by the black line represent the areas with 5% significance against red noise. The relationship is identified by the arrows that point out the leading indicator. An arrow that points to the top right indicates FTD of the selected ETF as a leading indicator to GME stock return, while an arrow pointing to the bottom left indicates FTD to be a leading indicator to negative returns. A top left pointing arrow indicates negative GME returns to be the leading indicator of increasing FTDs, while an arrow pointing to the bottom right is interpreted as GME being the leading indicator of FTDs.

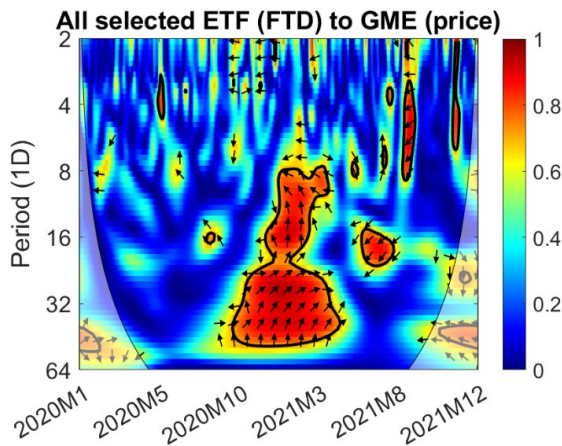
5. Robustness Analysis

The way ETF FTDs could create systematic pattern may be more complex than just deciding to fail and wait. We are not able to answer the hypothesis that different ETFs are used for rebalancing its FTDs, but the lead/lag structure between price and FTDs supports that suggestion. These findings follow those of Evans et al. (2021) who observe that the increase in short selling on ETFs increased the linkage of market makers, and hence this may be the reason why consistent cycles for multiple ETFs emerged. Thus, as a robustness check, we aggregated FTD volumes of all ETFs presented in Table 1 In order to check the validity of the above analyses, we performed wavelet coherence between aggregated FTD volumes and GME stock returns.

Results of this robustness check show that the cycle is very robust between all aggregated volumes of all selected ETF funds with GME stock in their portfolio (Figure 4). The cycle is significant until T+35 and lasts from 2020M10 until

2021M5. As the definition of FTDs most purchases should be delivered by T+6, and any undelivered stocks after this date should be exceptional. Such a long-lasting cycle points to the interpretation that FTD volumes are not random. Similar suggestions are made in the study of Stratmann and Welborn (2012), as the authors find that either short selling or increased prices for borrowing or options contract expiration dates might increase the obligations not delivered. What is also important is that these findings are confirmed by the relationship between FTD volumes and GME stock returns of selected ETF funds invested in specific market cap companies or the whole market.

Figure 4 Wavelet Coherence Between Aggregated FTDs of ETF Funds and GME



Source: Own estimation.

Notes: The coloured scale gives information about the coherence. The stains limited by the black line represent the areas with 5% significance against red noise. The relationship is identified by the arrows that point out the leading indicator. An arrow that points to the top right indicates FTD of the selected ETF as a leading indicator to GME stock return, while an arrow pointing to the bottom left indicates FTD to be a leading indicator to negative returns. A top left pointing arrow indicates negative GME returns to be the leading indicator of increasing FTDs, while an arrow pointing to the bottom right is interpreted as GME being the leading indicator of FTDs.

The results of this paper are also confirmed by dividing the reaction period of GME stock returns to FTD increases into quartiles. Table A2 shows that GME stock price reacts in more cases to FTD volumes in the T+35 period than in any other period. Observations were divided into three subperiods where the squeeze effect was the main dividing point. GME reacted to FTD volumes in T+35 more in all the three subperiods. The period under study also corresponds to the events during which GME became the most well-known example of the squeeze effect (Amand and Pathak, 2022), and it is interesting to note how significant cycles are detected just around the pivotal dates for the fulfillment of the obligations set by Rule 204 by SEC (2015). What is notable, however, is that the fulfillment of obligations between T+6 and T+35 does not show consistency in random occurrence. Thus, the results of this

research support the results of Stratman and Welborn (2012), but also Evans et al. (2021).

Then, we analysed the robustness of the results by comparing the stock with similar (AMC) and different (MSFT) characteristics. Analysis of Figures A4 and A5 presents wavelet coherence results for AMC and MSFT and provides more robust results, as it shows that cycles only exist to a very small extent. Very little significant coherence can be identified for AMC as it is also in the ‘meme’ stocks group, and in comparison to GME, it seems to be rather random than systematic. For MSFT, there are also very few significant cycles between FTD volumes and MSFT stock returns. The fact that we did not identify any relationship in the analysed stocks and the failures of ETFs that hold them shows that in the case of GameStop, there is a definite reason that has created such a significant and long-lasting relationship across the various ETFs and GameStop, and it is not a random coincidence.

6. Discussion and Conclusions

This study focuses on the potential occurrence of certain cycles in the valuation of GME stocks, due to the unique exemptions in ETF creation/redemption activities. With the use of wavelet coherence, we find evidence that ETF FTDs created consistent cycles (up to one year in our data) that systematically affected the price in the T+35 FTD clearing period, and results also confirm less consistent but repeating cycles between the T+3 and T+6 periods. To validate our findings, we also performed the analysis on other stocks, specifically AMC, as arguably the second-largest representative of ‘meme’ stocks that experienced a significant increase in the value of shares and MSFT, as a representative of a large established company. The results showed that examined stocks did not exhibit such cycles/patterns. This confirms the results that in the case of GameStop and ETF funds failures (with exposure to GameStop) such a significant long-lasting coherence is not a random coincidence but there is a definite reason for the relationship. Based on our analysis, it is reasonable to consider that there may be cases in the stock market where ETF FTDs are not formed randomly and could create systematic patterns that affect the stock prices. Similar results for other funds have been suggested by other authors that the FTDs do not occur randomly (Evans et al., 2021; Stratamann and Welborn, 2012).

Any systematic patters in failures to delivery do not comply with Regulation SHO. These findings raise concerns about whether these unique exemptions are purely used for bona fide market-making activities or are to some extent abused for the intention of investors benefitting from delaying settlement. Although we are the first to validate these cycles using wavelet analysis, authors such as Stratmann, T. and J.W. Welborn (2012) point to reasons why increased the short selling can lead to more FTDs. However, these reasons should not lead to long-lasting cycles as we have identified in the case of GameStop. Significant co-movements were identified between GME returns and 16 ETFs. Significant cycles were also identified between T+3 and T+6. The results are very similar among ETFs focused on specific market capitalisation, but also among ETFs invested in the whole market. Robustness analysis by aggregating these ETF FTDs provides very similar results and supports our findings.

These co-movements occurred during important delivery periods, but lead/lag analysis did not identify any concrete structure that would be robust between selected ETFs. The shortest identified cycles lasted 100 days, and there are ETFs with a relationship lasting more than one year. Further evidence points to the fact that these cycles were mainly around the 30th day after the FTD occurred. The results of this research are relevant because they bring indications that could provide valuable information for regulating institutions about patterns in FTD volumes. These patterns related to GME prices should be rather random for the obligations' fulfillment in T+35. To the best of our knowledge, we are the first to identify such a relationship with an aim on specific days since FTD occurred. Results open a path for future research. However, if other studies confirm that these FTDs create systematic patterns on a large scale, further market regulations are needed.

APPENDIX

Figure A1 The Left Figure Presents the Normalised FTD Volume of Selected ETF Funds and GME Stock Price Development Used in Our Analysis. The Right Figure Presents Aggregated Volume of These FTDs in Millions. The Period is from 2020:1 to 2021:12.

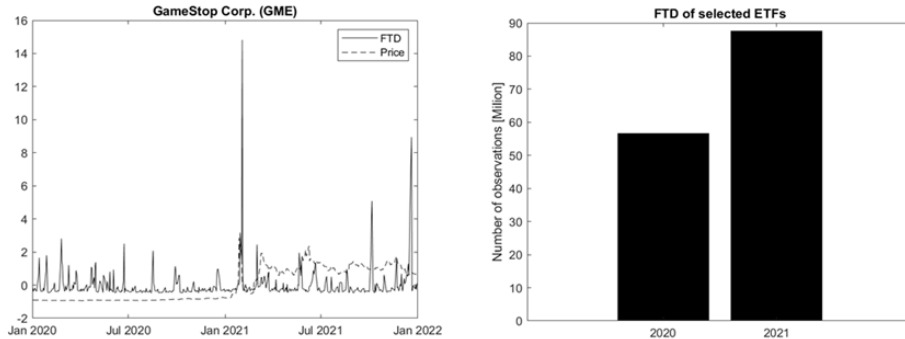
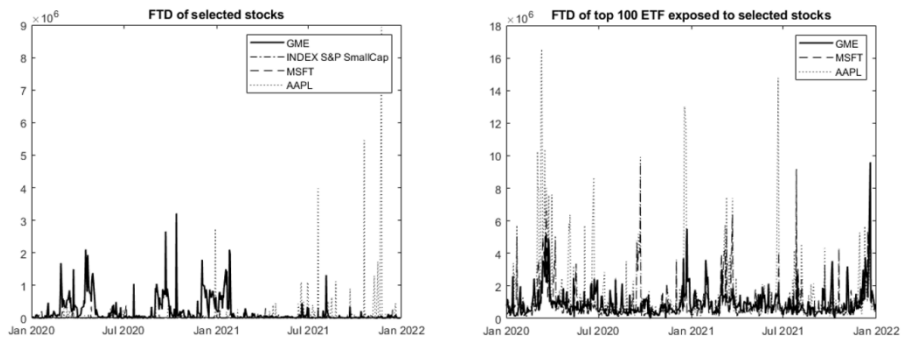


Figure A2 The Left Figure Presents a Comparison of FTDs of Selected Stocks of GME, Index S&P SmallCap, MSFT, and AAPL



Notes: Index S&P SmallCap was chosen as benchmark to GME as a small-sized company in the US (before rapid increase in price in late 2021). We calculated all FTDs of individual companies in index and then averaged them. To highlight the huge volume of FTDs of the small company GME, we compared results with MSFT and AAPL, large, established companies. In the right figure, we present a comparison of FTDs of the top 100 ETFs with exposure to selected stocks (different ETFs for individual stocks).

Figure A3 ETF Settlement Failure Timeline. The Figures Display Timeline Dates for an AP in the Creation Process of ETFs.¹¹

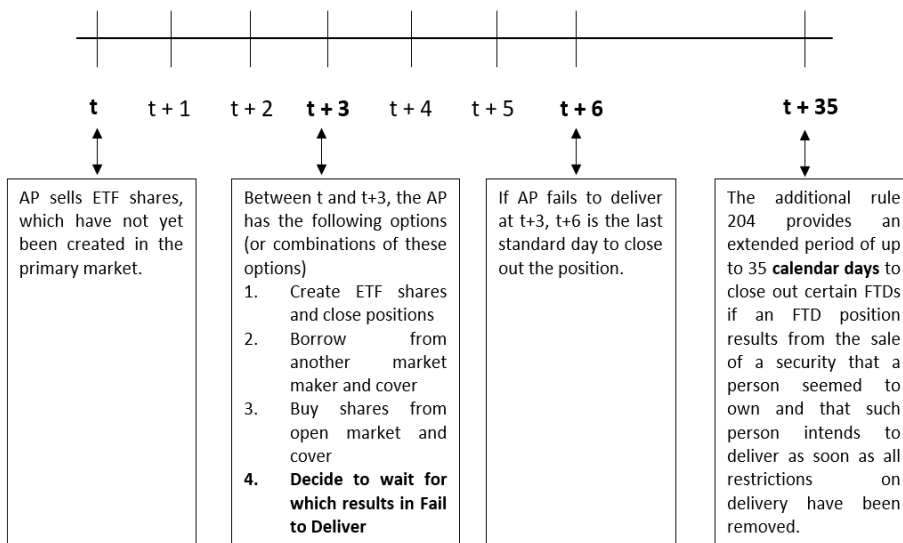


Table A1 Descriptive Statistics

| Variables | Obs. | Mean | St. Dev. | Min | Mdn | Max | Skewness | Kurtosis |
|-------------------|------|-----------|-----------|------------|------------|------------|----------|----------|
| GME | 504 | 88.14 | 91.04 | 2.80 | 19.05 | 347.51 | 0.44 | -1.41 |
| GME ETF FTD | 504 | 965 750 | 892 630 | 0.00 | 710 460.00 | 9 592 500 | 3.50 | 21.07 |
| GME FTD | 504 | 201 570 | 389 340 | 0.00 | 30749.00 | 3 210 100 | 3.32 | 14.36 |
| MSFT | 504 | 234.20 | 51.49 | 135.42 | 222.67 | 343.11 | 0.40 | -0.69 |
| MSFT ETF FTD | 504 | 888 020 | 1 130 100 | 0.00 | 533 740 | 9 543 700 | 3.64 | 16.95 |
| MSFT FTD | 504 | 15584.00 | 46599.00 | 0.00 | 724.00 | 405 230 | 5.11 | 30.03 |
| AAPL | 504 | 118.01 | 29.35 | 56.09 | 123.65 | 180.33 | -0.29 | -0.79 |
| AAPL ETF FTD | 504 | 1 525 600 | 2 164 200 | 0.00 | 792 220 | 16 549 000 | 3.51 | 15.10 |
| AAPL FTD | 504 | 94013.00 | 535 470 | 0.00 | 5343.50 | 8 930 600 | 12.11 | 171.90 |
| GME diff | 503 | 0.30 | 18.09 | -153.91 | -0.03 | 199.53 | 1.11 | 53.32 |
| GME ETF FTD diff | 503 | 226.27 | 850 650 | -8 504 600 | 10 581.00 | 5 745 600 | -1.26 | 24.90 |
| GME FTD diff | 503 | -20.80 | 339 500 | -2 129 400 | -27.00 | 3 210 100 | 1.42 | 25.48 |
| MSFT diff | 503 | 0.36 | 4.25 | -23.41 | 0.29 | 19.77 | -0.32 | 3.21 |
| MSFT ETF FTD diff | 503 | 577.84 | 1 243 400 | -9 076 300 | -3563.00 | 8 857 800 | -0.60 | 17.29 |
| MSFT FTD diff | 503 | -32.13 | 65237.00 | -376 430 | 0.00 | 404 940 | 0.19 | 15.81 |
| AAPL diff | 503 | 0.21 | 2.42 | -10.52 | 0.18 | 10.07 | -0.20 | 1.82 |
| AAPL ETF FTD diff | 503 | 224.41 | 1 997 100 | -8 765 200 | 34018.00 | 12 810 000 | 0.32 | 9.61 |
| AAPL FTD diff | 503 | -1.27 | 756 580 | -8 925 900 | 0.00 | 8 921 600 | 0.01 | 88.77 |

Source: Own estimation.

¹¹ We follow the timeline presented by authors Evans et. al. (2021) and extend this timeline by date $t+35$. Please note, that dates $t+3$ and $t+6$ refer to trading days, and $t+35$ refers to calendar days.

Figure A4 Wavelet Coherence Between Aggregated FTDs of ETF Funds and AMC

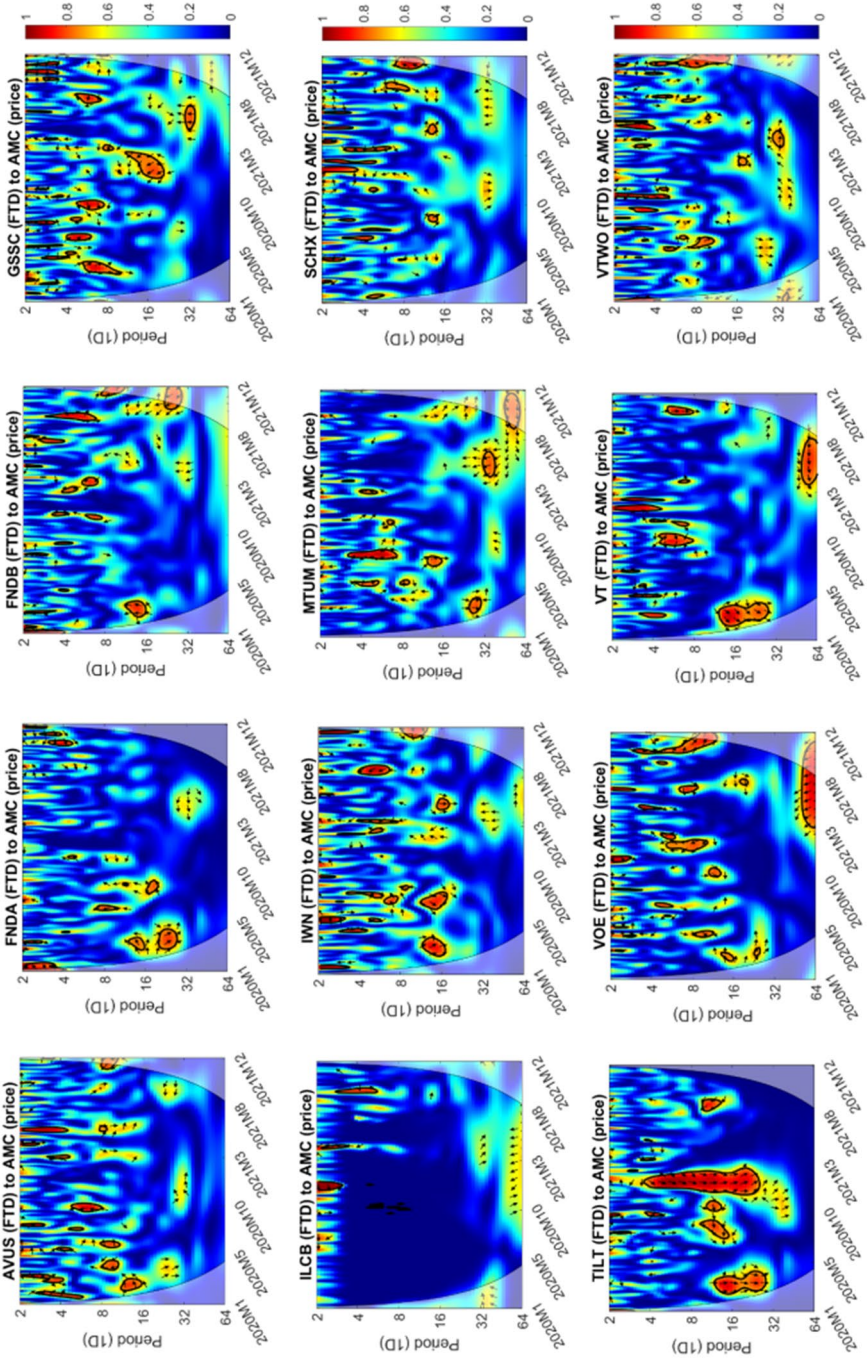


Figure A5 Wavelet Coherence Between Aggregated FTDs of ETF Funds and MSFT

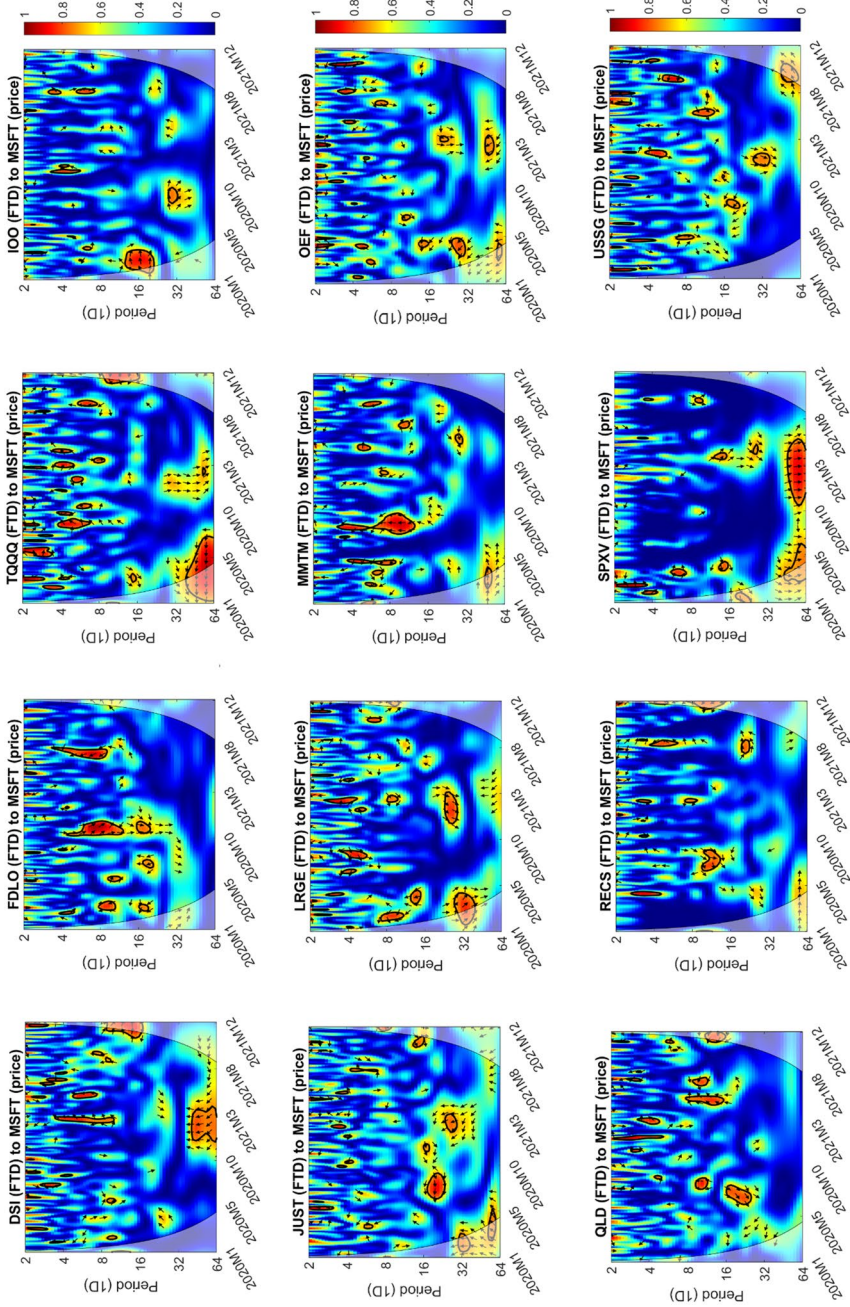


Table A2 Average Returns of GME Stock Price after an FTD Occurs

| <i>Average returns after FTDs (%)</i> | | | | | | | | |
|--|---------------------------|--------|--|--------|---|--------|---------------------------|--------|
| <i>Volume of FTD by quantiles</i> | <i>< Quantile 0.25</i> | | <i>> Quantile 0.25 & < Quantile 0.50</i> | | <i>> Quantile 0.5 & < Quantile 0.75</i> | | <i>> Quantile 0.75</i> | |
| <i>Date of ETF shares sell (T) + key dates</i> | T+6 | T+35 | T+6 | T+35 | T+6 | T+35 | T+6 | T+35 |
| <i>Whole period</i> | 5.81% | 28.13% | 16.11% | 66.99% | 12.36% | 32.60% | 11.43% | 16.72% |
| <i>Period before 1/21/2021</i> | 8.56% | 35.09% | 7.83% | 89.94% | 12.51% | 40.67% | 5.46% | 21.34% |
| <i>Period after 1/21/2021</i> | 1.05% | 15.86% | 25.55% | 39.38% | 12.41% | 29.23% | 17.40% | 12.09% |

Notes: The following figure presents the average returns of GME stock price after an FTD occurs, specifically, the difference in price 6 days after the AP sells ETF shares and after 35 calendar days. The volume of FTDs represents aggregated volumes in our ETF selection in Table 1. The period runs from 1/1/2021 to 12/31/2022. For greater detail, we divided the period into the time before the rapid increase in price, the so-called 'squeeze' in January 2021, and the time after. We also divided FTDs into quantiles to see how returns differ depending on the size of FTD volume. All numbers are positive.

Table A3 Selected ETF Funds (January 2022)

| <i>Ticker</i> | <i>Fund Name</i> | <i>AMC Allocation</i> | <i>AMC Market Value (mil. USD)</i> |
|---------------|---|-----------------------|------------------------------------|
| AVUS | Avantis U.S. Equity ETF | 0.02% | 0.37 |
| FNDA | Schwab Fundamental U.S. Small Company Index ETF | 0.05% | 0.25 |
| FNDB | Schwab Fundamental U.S. Broad Market Index ETF | 0.00% | 0.02 |
| GSSC | Goldman Sachs ActiveBeta U.S. Small-Cap Equity ETF | 0.13% | 0.59 |
| ILCB | iShares Morningstar U.S. Equity ETF | 0.03% | 0.22 |
| IWN | iShares Russell 2000 Value ETF | 0.75% | 10.48 |
| MTUM | iShares MSCI USA Momentum Factor ETF | 0.28% | 3.34 |
| SCHX | Schwab U.S. Large-Cap ETF | 0.02% | 0.83 |
| TILT | FlexShares Morningstar US Market Factor Tilt Index Fund | 0.01% | 0.20 |
| VOE | Vanguard Mid-Cap Value ETF | 0.28% | 4.56 |
| VT | Vanguard Total World Stock ETF | 0.01% | 0.33 |
| VTWO | Vanguard Russell 2000 ETF | 0.35% | 2.39 |

Source: ETF.com (2022)

Notes: Column 'AMC Allocation' shows the percentage of AMC in the fund's portfolio; 'AMC Market Value' shows the market value of stocks owned by the selected ETF fund out of the total market value of 7.96 billion USD.

Table A4 Selected ETF Funds (January 2022)

| Ticker | Fund Name | MSFT Allocation | MSFT Market Value (mil. USD) |
|---------------|--|------------------------|-------------------------------------|
| DSI | iShares MSCI KLD 400 Social ETF | 10.23% | 408.22 |
| FDLO | Fidelity Low Volatility Factor ETF | 6.25% | 29.72 |
| TQQQ | ProShares UltraPro QQQ | 8.75% | 1760.00 |
| IOO | iShares Global 100 ETF | 11.81% | 449.49 |
| JUST | Goldman Sachs JUST U.S. Large Cap Equity ETF | 6.29% | 17.87 |
| LRGE | ClearBridge Large Cap Growth ESG ETF | 7.08% | 15.04 |
| MMTM | SPDR S&P 1500 Momentum Tilt ETF | 7.97% | 7.21 |
| OEF | iShares S&P 100 ETF | 8.86% | 766.94 |
| QLD | ProShares Ultra QQQ | 8.69% | 485.70 |
| RECSU | Columbia Research Enhanced Core ETF | 7.19% | 2.40 |
| SPXV | ProShares S&P 500 Ex-Health Care ETF | 6.90% | 0.29 |
| USSG | Xtrackers MSCI U.S.A. ESG Leaders Equity ETF | 10.72% | 351.19 |

Source: *ETF.com* (2022)

Notes: Column 'MSFT Allocation' shows the percentage of MSFT in the fund's portfolio; 'MSFT Market Value' shows the market value of stocks owned by the selected ETF fund out of the total market value of 2107 billion USD.

List of Abbreviations

| | |
|--------------|---|
| AAPL | Apple Inc. |
| AMC | AMC Entertainment Holdings Inc |
| AP | Authorized participant |
| CWT | Continuous wavelet transform |
| ETF | Exchange-traded fund |
| FINRA | Financial Industry Regulatory Authority |
| FTD | Failure to deliver |
| GME | GameStop Corp. |
| MM | Market maker |
| MSFT | Microsoft Corporation |
| NAV | Net asset value |
| SEC | Securities and Exchange Commission |

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