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The Impact of Short Selling on Meme Stock Performance

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Abstract

This paper examines the performance of meme stocks during the 2021 short squeeze using daily short volume data and evaluates their impact in comparison to the market. By conducting a multivariate pooled regression, we observed that short volume has a significant impact on explaining excess returns for both short squeeze and non-short squeeze meme stocks. The meme stocks that experienced a short squeeze were found to have a excess return that was twice as high as the benchmark return. On the other hand, the non-short squeeze meme stocks exhibited returns that were slightly higher but relatively close to the benchmark. This emphasizes the significance of the short volume ratio as a factor in understanding the influence of the short squeeze phenomenon on the excess returns of meme stocks.

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1 Introduction

The rise in the popularity of meme stocks in 2020 and 2021 has taken the investment world by storm, making headlines and triggering debates investors. Meme stocks refers to stocks that gain their popularity through social media and internet communities such as Reddit. While some saw this trend as a new frontier in modern investing, others viewed it as a dangerous game fueled by greed and misinformation. But what happens when the tide turns and those who bet against the trend face a sudden and substantial wave of buying pressure? This is the reality of short squeezes, where the boundary between profits and losses can easily become unclear. The short squeeze of 2020 and 2021 was initiated and amplified by the actions of small individual investors who collaborated through platforms like Reddit and Discord to drive up the prices of companies that were heavily shorted, such as GameStop (Allen et al. (2021)).

The aim of this paper is to conduct a more in-depth analysis of this phenomenon and examine the performance of meme stocks compared to the market during this period using daily short volume data. This papers considers two groups of meme stocks, where one group experienced a short squeeze and the other group did not. We compare the performance of these two groups with the market by analyzing their daily short trades. The findings of our research indicate that short volume is a significant factor in explaining excess returns for both short squeeze and non-short squeeze meme stocks. The excess return of meme stocks that experienced short squeezes was found to be twice as high as the benchmark return.

Short selling is a special form of trading that differs from regular buying or selling. Instead of owning the securities, a short seller must first borrow the shares before selling them. The aim is to buy back the shares at a lower rate, thus generating a profit, and then returning them to the original lender. This strategy is primarily driven by the assumption that the stock's price will drop, allowing the short seller to benefit from the price difference. Short squeeze refers to a situation in which short sellers are compelled to buy the shares to cover their losses as the stock's price increases. This sudden increase in demand for a stock can create a wave of buying pressure, causing the price to go 'to the moon'.

Given the recent occurrence of the short squeeze of 2020 and 2021, research on this topic is limited. Desai et al. (2002) conducted a research using monthly short interest data and found that companies with high short interest experience significant negative abnormal returns. On the contrary, many other papers such as Vu and Caster (1987) and Brent et al. (1990) argue that the result of large increase in short interest adheres to the concept of market efficiency and thus is neither a bearish nor a bullish sign. The occurrence of the meme stocks during the short squeeze could prove a notable contradiction to these findings.

This paper differs from previous studies as it focuses on the daily short selling volume data of individual stocks whereas many prior studies have primarily relied on monthly reported short interest data. The benefit of using volume data is that it facilitates examination of daily or even intra daily data on short selling. This is an improvement in cases where many short sellers maintain their position for a short period of time (Boehmer et al. (2008)). Using data from 2020 to 2021, this paper tries to answers whether or not the meme stocks performed better than the market while being shorted more heavily. The first hypothesis is that the meme stocks involved in a short squeeze outperformed the meme stocks that did not experience a short squeeze. We believe that this is true because meme stocks lack strong fundamentals. Without upward price pressure from a short squeeze, there is no justification for a positive excess return.

The second hypothesis is that all the meme stocks in our sample outperformed the market. The occurrence of a short squeeze among certain meme stocks while others are left unaffected appears to be a random event with no clear underlying reason. It is possible that some investors attempt to predict the next potential short squeeze and therefore invest in other heavily shorted meme stocks with the hope of driving up their prices. Thus, we hypothesize that the excess return of other meme stocks that were not subject to a short squeeze also increased. In other words, it is possible that the occurrence of short squeezes in certain meme stocks could impact other meme stocks that are perceived to have similar potential for social media hype and attention.

To test the hypothesis, the chosen methodology is a pooled panel regression. To control for other factors that may impact the relationship between the variables, Book-to-Market ratio, Momentum, liquidity and firm size are included as control variables in the regression analysis. By including these control variables, this paper aims to ensure that the results of the regression analysis are not influenced by other factors.

The structure of this paper is outlined as follows: Chapter 2 presents a summary of prior

studies on the topic, followed by a discussion of the data and the variable construction in Chapter 3. Chapter 4 provides a thorough explanation of the research methodology. The primary empirical findings will be discussed in Chapter 5. Finally, Chapters 6 and 7 respectively address the conclusion and discussion.

2 Literature

The role of short selling in itself has been well documented in the financial literature, Boehmer and Wu (2013) suggest that short selling plays a significant role in the price discovery process and that it serves as a vital tool for uncovering private information. The presence of short sellers in the market is also essential for price efficiency according to Miller (1977). He states that absence of pessimistic investors in the market results in an upward biased prices since the prices reflect only the valuation of optimistic investors. This absence of pessimistic traders, and thus the lack of short selling, slows down the adjustment to private information and news, particularly to negative news (Diamond and Verrecchia (1987)).

The mechanism through which short selling reinforces market efficiency is by disciplining earnings management Saffi and Sigurdsson (2011). Earnings management refers to the manipulation of a company's financial results to present a more favorable picture of its financial performance. Short selling has the potential to counteract the impact of earnings management. That is because short sellers have an incentive to uncover any inconsistencies in a company's financial reporting and expose any attempts at earnings management. This creates a situation where companies are under greater scrutiny, leading to more accurate representation of their financial performance (Massa et al. (2015)).

While there is a general consensus about the role of short selling in finance, there is a great deal of disagreement when it comes to the relationship between short selling and returns. The literature on this topic dates back to Seneca (1967). He agrees that a short position involves an agreement to buy back at a later date, but it is primarily a perception of the near-term price movement, and that perception is that prices will fall. This is confirmed by the finding of Desai et al. (2002) in which they state that firms with a high level of short interest experience a substantial negative abnormal returns, falling within the range of -0.76 to -1.13 percent per month. Dechow et al. (2001) conducted a study using a large sample of firms listed on the NYSE and NASDAQ and reached a similar conclusion. They found that firms with higher levels of short selling tend to experience lower returns. Chang et al. (2014) have similar results but a slightly different perspective on the matter. They believe that short sellers in China, through their act of

betting against a particular stock, can have a negative impact on its price. Woolridge and Dickinson (1994) on the other hand, suggests that short sellers do not seem to force prices to decrease by going short or earn abnormal profit.

To determine the source for the profit of short sellers, some papers has sought to examine whether short sellers have an informational advantage and have better skills as investors generating abnormal returns. Boehmer et al. (2008) came to the conclusion that short sellers as a group are indeed well-informed, with institutional short sales being the most informative. Christophe et al. (2004) discovered that short sellers have a tendency to increase their short position even more before earnings announcements. This implies that short sellers possess information which indicates that the earnings will be worse than anticipated. Diether et al. (2009) investigated short selling in U.S. stocks using new data mandated by the SEC for the year 2005 and found that short sellers engage in short-term trades based on the overreaction of stock prices.

Furthermore, Engelberg et al. (2012) suggest that efficient information processors among short sellers benefit from trading opportunities that arise from publicly available information as they are more responsive to news announcements, especially to negative news. In a study using short selling data of mutual funds, Chen et al. (2013) found that mutual funds with a short position of 16% of the funds assets on average, outperform the benchmark by 1.5% percent per year. Jiao et al. (2016) used data for both long and short position for hedge funds from 2000 to 2012 and their evidence indicate that information drives opposing changes in hedge fund holdings and short interest. Using this intuition Jiao et al. (2016) identified that informed demand illustrates significant predicting ability over returns.

During a short squeezes, the role of information becomes even more crucial, however the methods through which this information is shared may vary. Retail investors, for example, may employ social media and other online communities such as Reddit to share information and synchronize their trading activities, thereby magnifying the impact of news and rumors. The availability and interpretation of this information can make a significant difference in the outcome of a short squeeze. Using intraday data for the meme stock GameStop (GME), Vasileiou et al. (2021) conclude that Google search data offers valuable insights that explains the performance of GME during the short squeeze of 2021. Anand and Pathak (2022) examines the role of the social media platform Reddit in the GameStop short squeeze. Using a difference-in-differences methodology, they find that the increase in GameStop share prices was more pronounced for stocks with a higher number of Reddit users who actively discussed the stock.

The short squeeze phenomenon that various stocks experienced in 2021 was a unique event that differed from previous short squeezes in its underlying characteristics. What made it distinct was the coordination of market participants, primarily retail investors, through social media. This coordination resulted in herding behavior by unsophisticated investors and amplified the impact of news and rumors on stock prices, increasing their volatility. According to Grossman and Miller (1988), and Hendershott and Menkveld (2014), short squeeze can lead to market disruption and create risks for liquidity providers, ultimately harming market liquidity.

To accurately assess the impact of a short squeeze on a stock's performance, it is important to account for other variables that may also affect short selling, such as firm size. Smith (1968), Ackert and Athanassakos (2005) and Boehme et al. (2006) previously reported a positive relationship between firm size and excess return. As a result, including firm size as a control variable is deemed appropriate. Kot et al. (2019) identified several other factors using short interest data for hospitality industry from 1996 to 2015. First, investors are more likely to short a stock that is overvalued hoping that the price will drop in the near future. Examples of other factors according to Kot et al. (2019) are momentum trading, arbitrage trading and liquidity demand. Shkilko et al. (2012) provides a slightly different perspective by suggesting that although short seller are active during a short squeeze event, the price declines are mainly driven by liquidity demanding non-short trading volume.

This research paper makes several new contributions and builds upon existing studies in various ways. First, the analysis goes beyond just examining the performance of meme stocks. Specifically, there is a distinguish made between stocks that experienced a short squeeze and those that did not or experienced it to a lesser degree. Second, instead of using short interest data, our approach utilizes the daily data on the volume of short selling activity for individual stocks.

3 Data

The data has been extracted from FINRA database which provides daily short sale volume data for all the stocks listed in the NYSE. The sample period is from 2020 to 2021, which coincides to the outbreak of COVID-19 pandemic. This period marks the inception and outburst of the meme stocks, accompanied by a series of unprecedented events in the stock market. The company fundamentals and daily security data is retrieved from WRDS database. The data from WRDS is then merged with the short volume data based on company tickers.

The sample consist of all the common stocks listed in the S&P 500 index and an additional 13 stocks that constitute the meme stocks samples as identified by Allen et al. (2021). These 13 firms are divided in two groups, where one group has experienced a short squeeze and the other group has not experienced a short squeeze. Compared to Allen et al. (2021), only SPCE has been added instead of NAKD. The latter stock is excluded due to insufficient data, while SPCE fits well within the sample of short-squeezed meme stocks as it has the same characterises . After accounting for missing observations, we have over 240,000 observations for the 13 meme stocks and the S&P 500 firms over a two-year period.

Figure 1 displays the price trend for two notable stocks: GameStop on the left panel and Sundial Growers on the right panel. In addition, both panels show the price trend for the S&P 500 index, which serves as a proxy for market benchmark. The S&P 500 index displays a general upward trend, with a sudden drop in March 2020 followed by a V-shaped recovery. GameStop's stock price experienced a significant surge in early 2021 when the short squeeze was at its height followed by a period of high volatility. GameStop is one of the meme stocks in our sample that underwent a short squeeze. Sundial Growers, on the other hand, is one of the meme stocks in our sample that did not experience a short squeeze. The price of the latter stock remained relatively stable after 2020, with a slight increase in mid-2021. Note that Figure 1 displays data from 2019 to highlight that before 2020, the price remained relatively stable, and most of the activities occurred after 2020. However, it is important to note that this data is not included in our sample, which covers the period from 2020 to 2021.
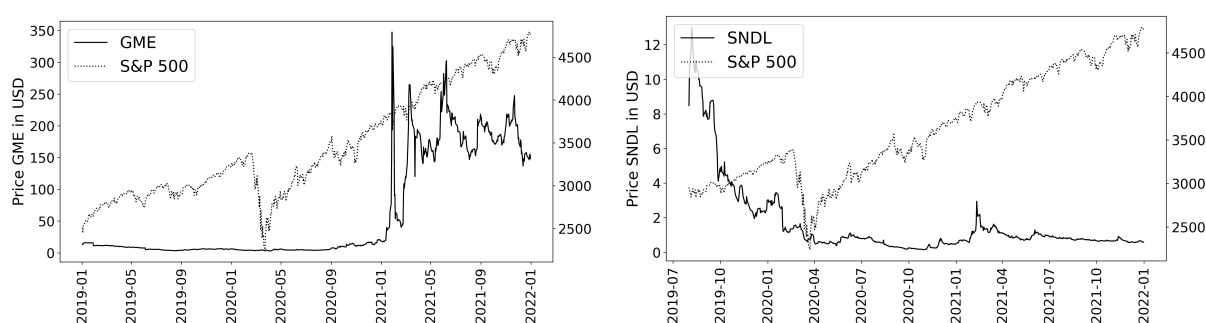
Figure 1: The left panel shows the price trend of the meme stock GameStop (GME) along with the price index S&P 500 for period 2019 to 2021. GME is one of the firms that experienced a short squeeze during 2021. The right panel show the price trend of meme stock Sundial Growers (SNDL). SNDL is one the forms that did not experienced a short squeeze.

Asquith et al. (2005) and Kot (2007) use short interest ratio (SIR) as a determinant of short selling activity, where SIR is defined as short interest divided by the shares out-

standing. In this paper, we use the same principle and define the determinant of short selling activity as the short volume ratio (SVR), as we have short volume data. SVR is calculated as the daily short volume divided by the total shares outstanding, where the short volume is the number of shares that are shorted per day and shares outstanding denotes the total number of shares that a company has issued.

As previously mentioned, short-selling can be driven by various factors including over-valuation, momentum, among others. To account for these factors, Book-to-Market ratio (BM), momentum, and short-term reversal variables are included. BM ratio is calculated as book value divided by the market value of a firm. Book value is denotes as the book values of common stocks and market values is the market capitalization of a firm. Momentum strategy is an investment strategy that aims to buy stocks that have shown positive performance in the past and sell those that have shown negative performance (Jegadeesh and Titman (1993)) . The idea behind this strategy is that stocks with a positive performance in the past are likely to continue performing well in the near future, while stocks that have performed poorly are likely to continue performing poorly. To calculate the momentum factor, we have analysed the price continuation of the past 12 month excluding the most recent month. The price continuation of the most recent month serves as the period to calculate the reversal factor.

In contract to momentum strategy, the short-term reversal strategy involves buying assets with poor performance in the past month and selling assets that have performed well. The reversal factor strategy is based on the belief that assets that have showed weak performance over the recent past are likely to rebound in the near future (Fama and French (1992) and De Bondt and Thaler (1985)). Note that Fama and French (1992) distinguish between short-term reversal and long-term reversal. Short-term reversal refers to the tendency of stocks to reverse their recent performance over a short period of time, such as a few weeks. On the other hand, long-term reversal describes the phenomenon where stocks eventually return to their historical average performance over a longer period of time, such as several years. In this paper, our focus is solely on short-term reversal.

Firm size and liquidity are included as two additional control variables. A lower market capitalization, or in other words, a limited supply of stocks, can lead to a more significant price impact of short interest levels, as reported by Smith (1968). Therefore, it is wise to include firm size as a control variable. In our case, the logarithm of the market capitalization has been selected as its proxy. In addition, short sellers must consider liquidity risk and as a result, including a liquidity factor can also enhance the results. One of the most commonly used measures for liquidity is the illiquidity measure as defined

by Amihud (2002). This illiquidity factor measures the effect of a one-dollar trade on the stock price movement for the past month. Appendix A (8) provides additional details on the construction of the momentum and reversal factors, as well as other variables.

Table 1 presents the descriptive statistics of all the variables including the control variables. The average SVR of the stocks in the short squeeze sample is lower than the stocks the market sample. This is not unexpected as the self-fulfilling prophecy of a short squeeze forces short sellers to buy back shares to restore their losing position. This is further supported by the fact that the average and maximum SVR of the non-squeezed sample are higher compared to the squeezed sample.

Naturally, repurchasing shorted shares reduces both the short interest and the short volume. The excess return and other variables shows a notably large maximum value, indicating the presence of outliers in our sample. However, dealing with outliers is a challenging task, as they can significantly distort the results of the analysis. This issue is even more pronounced in the context of our sample, which covers a short squeeze period characterized by extremely high levels of volatility. Simply removing outliers using methods such as winsorization can result in a loss of information, which may negatively impact the research outcomes. Therefore, we carefully approach this matter by removing outlier for the short volume variables and the excess return manually. For the other variable we use a 1% winsorization. Further details on the methodology are provided in Chapter 4.

Table 1: Descriptive Statistics for all the variables. The meme stock that experienced a short squeeze are denoted by the 'Squeeze', which consist of the following stock: GME, AMC, AAL, BBBY, EXP, SPCE and TR. 'Non-Squeeze' denotes the meme stocks that did not experience a short squeeze and consist of the firms: BB, CTRM, KOSS, NOK, SNDL and TRVG.

Variable	Obs.	Mean	Std Dev	Min	25%	50%	75%	Max
Excess Return (%)	244787	0.0104	2.500	-77.2667	-0.9815	-0.0280	0.9361	137.4036
SVR_{market} (%)	238243	0.2014	1.0791	0.0000	0.0239	0.0491	0.1117	72.8746
$SVR_{Squeeze}$ (%)	3534	0.0865	1.7959	0.0000	0.0000	0.0000	0.0000	237.1941
$SVR_{non-Squeeze}$ (%)	3010	0.0896	2.9888	0.0000	0.0000	0.0000	0.0000	490.9213
Firm Size (bln $)	244787	24.1076	1.2103	14.4024	23.3951	23.9951	24.7600	28.7157
BM	244787	0.3770	0.4599	-6.0098	0.1047	0.2578	0.5356	4.5950
Momentum	244787	0.2765	1.2359	-0.9607	-0.0520	0.1633	0.4125	72.3496
Reversal	244787	0.0231	0.1926	-0.8970	-0.0360	0.0197	0.0766	25.6667
ILLIQ*	244787	2.9235	25.3975	0.0106	0.3597	0.7574	1.4022	448.6119

Note: Descriptive Statistics for ILLIQ* are multiplied by 10^{10}.

Table 3 depicts the correlation among all variables. Most variable coefficients are consistent with the expected relationship with excess return. For example, excess return has a positive relationship with firm size and reversal factors. Book-to-market ratio, on the other hand, has a negative relationship with excess return. A high book-to-market

ratio suggests that the market undervalues a firm's equity compared to the book value of that firm. Hence, a negative correlation coefficient for BM is reasonable. Based on the expectations, a stock with a relatively high short volume in the market portfolio is likely to experience a decrease in its average price, leading to a negative correlation with excess return. However, in the sample, we observe a positive correlation between short volume ratio and excess return. This is not unexpected, given that our sample period includes an unprecedented time of high volatility and a short squeeze where the market did not behave rationally.

The portfolio of meme stocks that experienced a short squeeze are negatively correlated with the porfolio of meme stocks that did not experience a short squeeze. This negative correlation is a promising finding. It confirms that there is little to no overlap in our two meme stock samples, which is important in ensuring that our results are less likely to be biased. This suggests that any observed effects can be attributed to the short squeeze phenomenon and not to other factors that may be present in both samples.

4   Methodology

This paper aims to determine the performance of meme stocks during the short squeeze of 2021, by running multivariate regressions, following Kot (2007). More precisely, the methodology used is a pooled panel regression. This method is commonly used in to analyze the relationship between multiple variable, while accounting for both individual-specific and time-specific effects. By pooling data from multiple cross-sectional units over time, a more efficient estimation is possible by employing within-group variation and controlling for unobserved heterogeneity. The resulting β coefficients provides immediate information on the direction and magnitude of the relationship between the independent and dependent variables. When working with panel data, there are several model options, such as fixed effect or random effect models.

The reason for choosing pooled panel regression model is twofold. Firstly, pooled regression models can better control for omitted variable bias, especially when the omitted variables are time-invariant. Fixed effects models may not address this bias sufficiently, and random effects models may experience issues with the consistency of the estimates. Secondly, pooled regression models have a simpler interpretation than fixed effects and random effects models. The coefficients estimates denote the average effect of the independent variables on the dependent variable across all units and time periods. This make understanding the results significantly simpler.

First, a contemporaneous regression is constructed 1, which regresses the excess return

on the contemporaneous short volume ratio and other factors for company i at time t. Again, the variables *Squeezed* and *Non-Squeezed* are dummy variables for the short volume ratio of meme stock. The value of the former dummy is equal to one for the meme stocks experienced a short squeeze and zero otherwise. The opposite applies tot the latter meme stock dummy variable. The variable SVR represents the market short volume ratio. As previously stated, we have used S&P 500 companies as a representative of the overall market, while omitting the firms that are part of our meme stocks sample. We used this sample as our benchmark. The variable *Controls* contain the firms size and liquidity. For the latter we have used the calculation method of Amihud (2002).

$$
\begin{aligned}
Return_{i,t} =& \alpha + \beta_1 SVR_{i,t} + \beta_2 Squeezed_{i,t} + \beta_3 Non\text{-}Squeezed_{i,t} \\
&+ \beta_4 BM_{i,t} + \beta_5 Momentum_{i,t} + \beta_6 Reversal_{i,t} + \beta_7 Controls_t + \epsilon_t
\end{aligned}
\tag{1}
$$

As briefly discussed before, dealing with outliers is a challenging task and it is essential to approach it with care. This is especially true when working with a sample period that includes the COVID-19 pandemic and its effects on the market. During such times, the market does not behave as it typically would, and unconventional observations that would otherwise be considered outliers may occur. Therefore, simply removing these values under the guise of outliers can significantly affect the sample, resulting in the loss of valuable information. To address this issue, we have made a careful decision to avoid using winsorization on the short volume data and excess return variables. However, we have used 1% winsorization for the other variables. By doing so, we believe that we have effectively dealt with outliers while still retaining valuable information. It is important to note that this decision was made based on the nature of our data and the specific circumstances of the sample period.

Second, a predictive regression is formulated based on regression 2, incorporating lags of the explanatory variables. The regression also incorporates a lag of excess return as an independent variable.

$$
\begin{aligned}
Return_{i,t} =& \alpha + \beta_1 Return_{i,t-1} + \beta_2 SVR_{i,t-1} + \beta_3 Squeezed_{i,t-1} + \beta_4 Non\text{-}Squeezed_{i,t-1} \\
&+ \beta_5 BM_{i,t-1} + \beta_6 Momentum_{i,t-1} + \beta_7 Reversal_{i,t-1} + \beta_8 Controls_{t-1} + \epsilon_t
\end{aligned}
\tag{2}
$$

Since equation 2 is a predictive regression, the independent variables are included as their

first lag. The β_3 coefficient indicates the relationship between excess return for stocks in the short squeeze sample on a particular day and their short volume ratio from one day prior. To illustrate this relationship, let's take the example of GameStop (GME), which is a stock in the short squeezed meme stocks sample. If the short volume ratio of GME increases by 1% today, then the expected increase in excess return for GME tomorrow can be estimated using the β_3 coefficient. For instance, if the β_3 coefficient for GME is 0.05, then an increase of 1% in short volume ratio today would lead to an expected increase of 0.05% in excess return on average for GME tomorrow. It should be noted that accurately predicting the excess return of an individual stock is a very challenging task. Therefore, it is expected that the significance of these estimates will be lower. More detailed report of these findings is provided in the next section.

5 Results

The result of contemporaneous regression 1 are reported in table 4. The first column, $Model(1)$, shows the result of a regression that includes only the first explanatory variable, i.e., using the market short volume ratio to explain the excess return. The point estimate of 0.0792 states that the typical stocks excess return increases by about 0.08% whenever the market average SVR increases by 1% relative to the long-term average. With a t-statistic of $t = 4.33$, this coefficient is statistically significant. Note that all the models include the control variables firm size and liquidity. The R^2 values for the regression tend to increase as more variables are added, with the final model having an R^2 of 4.6%. While this may seem low, it is important to note that we are working with individual stock-level financial data, and such a percentage is within the expected range. In general, it can be challenging to achieve high R^2 values in individual stock-level financial regressions due to the diverse range of factors that can influence stock returns.

The second column, $Model(2)$, contains the coefficients for the regression that includes the market SVR the factors Book-to-market (BM) ratio, momentum and reversal effect. The BM ratio exhibits a small yet statistically significant negative coefficient. This statement suggests that when stocks are undervalued by the market, they tend to generate lower excess returns on average. In other words, investors may have overlooked or undervalued these stocks, leading to lower returns than what might have been expected based on their true value.

After Including the variables BM, momentum and reversal, the magnitude of market short volume ratio decreases slightly to 0.0632 ($t = 3.44$). This result indicates that the other variables included in the model play a significant role in explaining excess returns

as well. The momentum effect is is small and negative, which means that stocks with a positive momentum actually experience a lower excess return. On the other hand, the point estimate of the reversal factor is 0.0295 (t = 28.73), which is positive and highly significant. Recall that the reversal factor is computed as the return continuation from the preceding month, and thus for a reversal effect to be present, the coefficient value should be negative. This suggests that there is a short-term momentum effect and a long-term reversal factor. So, stocks that have performed well in recent weeks tend to continue performing well in the following weeks, while those that have performed well over the past year experience a reversal and perform poorly in the future.

In the third model, $Model(3)$, the three variables are once again excluded. Instead, the short volume ratio of the two meme stock samples is included. The resulting coefficients are all statistically significant at a 1% significance level. It is noteworthy to observe the magnitude of the coefficients. The coefficient for meme stocks in the non-short squeezed are sample is very similar to the coefficient for the market short volume ratio, although slightly higher. On the other hand, the coefficient for the meme stock sample that experienced a short squeeze is 0.1533 (t = 5.52). This indicates that the excess return for short-squeezed meme stocks increases by approximately 0.15% for every 1% increase in the short volume ratio of these firms.

In the last column, $Model(4)$, the results for the model with all variables are presented. It is evident that all short volume ratio variables remain statistically significant at the 1% level, and the reversal effect also shows significant results at the same level. These findings suggest that short volume ratios play a significant role in explaining excess returns for short squeeze and to some extent for non-short squeeze meme stocks. On the other hand, the coefficients for the momentum and BM variables are statistically insignificant. The table further demonstrates that the coefficient magnitude for non-short squeezed meme stocks is slightly higher than the market, but significantly lower than the short-squeeze meme stocks. As for the latter, although the coefficient estimate has slightly decreased to 0.1377 ($t = 4.96$) compared to the previous model, it is still twice as high as the market.

Considering that meme stocks are typically stocks that are popular but lack strong fundamentals, it would be reasonable to expect a negative coefficient for non-short squeezed meme stocks. This is because the excess return for meme stocks is mainly attributed to the upward price pressure resulting from a short squeeze, and since this is not the case for the non-short squeezed stock, there seems to be no reason for a positive relationship with excess return. However, this unexpected result may be due to spillover effects from meme stocks that did experience a short squeeze. The positive coefficient for non-short

squeezed meme stocks could be the result of investors' perception that these stocks are similar to the short-squeeze meme stocks in terms of their potential to become the subject of the next big hype and social media attention. This could leads to an increased demand and upward price pressure. Therefore, the results suggest that the spillover effect from short-squeeze meme stocks could have influenced the excess return of non-short squeezed meme stocks.

Another possible explanation for our findings could be the impact of external factors during our sample period, particularly the COVID-19 crash and government interventions to prevent a recession. The unprecedented nature of these events may have caused the market to behave irrationally, and the injection of capital by governments may have further distorted market mechanisms and increased the demand for risky assets. Thus, the positive coefficient for the market short volume ratio could be attributed to these external factors as well, rather than a true relationship with excess returns.

Table 5 presents the outcomes of the predictive regression as per equation 2, which includes a lag of excess return as well. The arrangement of columns in table 5 is similar to that of table 4. In the first column, $Model(1)$, only variables for excess return lag and market short volume ratio are considered. Results show that although the sign of both variables is positive and small, they are not statistically significant. The R^2 for the predictive regression is 0.2%, which is not surprising given the difficulty of predicting excess returns at the individual stock level, particularly during volatile times such as the period in our sample. This task is inherently challenging, and it is difficult to achieve accurate predictions due to the many unpredictable factors that can influence stock prices. Therefore, the low R^2 in this case is not necessarily indicative of a poor model, but rather a reflection of the complexity of the problem.

The results of the predictive regression reveals that only two variables, the SVR of the short squeeze meme stocks and the BM ratio, are statistically significant. The results for the BM ratio are consistent with the findings from the contemporaneous regression, although the effect size is slightly lower. In the final model, $Model(4)$, the coefficient estimate of 0.0513 ($t = 1.97$) indicates that the excess returns of short squeezed meme stocks increase by approximately 0.0513% when the average SVR of these stocks increases by 1% one day before. The table also indicates that the estimate for the short squeezed SVR is higher than both the market SVR and the non-short squeezed SVR, which is consistent with our previous findings. However, the estimates for the latter two variables are statistically insignificant. In other words, the results are not precisely estimated, making it difficult to accurately determine the extent of the actual effects.

Furthermore, Furthermore, we observe a negative coefficient for both momentum and reversal. This suggests that in a predictive regression, we can expect a reversal effect in both the short-term and long-term. Consequently, stocks that have performed well over the past week up to a year may perform poorly in the future. However, it is worth noting that neither of the results are statistically significant.

6 Conclusion

The sudden rise in popularity of meme stocks in 2020 and 2021 has left a significant impact on the investment world. Meme stocks are stocks that gained their popularity primarily through social media platforms such as Reddit and Discord. During this period, a series fo short squeezes occurred, which was initiated and amplified by the actions of small individual investors who collaborated through platforms like Reddit to drive up the prices of certain meme stocks. The aim of this paper is to investigate the performance of meme stocks compared to the market during this period using daily short volume data. This study considers two groups of meme stocks: one group that experienced a short squeeze and another group that did not. The performance of these two groups is compared to the market by analyzing their daily short trades.

To comprehensively examine the impact of short volume on the excess return of meme stocks, we have incorporated various other factors that also influence excess return. These factors include the book-to-market ratio, momentum and reversal, as well as firm size and liquidity, which have been included as control variables. By including these additional variables in our analysis, we can obtain a more thorough understanding of the relationship between short volume and excess return, while controlling for other potential factors that may affect the performance of meme stocks. Accordingly, the first hypothesis states that the meme stocks involved in a short squeeze outperformed the meme stocks that did not experience a short squeeze. This paper also hypothesizes that all the meme stocks in our sample have outperformed the market.

By using a pooled panel regression, we have discovered that the relationship between the short volume ratio (SVR) and excess return is positive for both meme stocks and the market (benchmark) during our sample period. The coefficient for the SVR for stocks in the short-squeezed meme stock sample is 0.1377, which is twice as high as our benchmark. This point estimate states that the excess return of a typical meme stocks in the short squeeze sample increases by about 0.14% whenever the market average SVR increases by 1%. For non-short squeezed meme stocks, the magnitude is slightly higher than the market but significantly lower than the short-squeeze meme stocks. In other words, the

excess return of short-squeezed meme stocks are more affected by short volume than for the other meme stocks and the market as a whole. These findings are consistent with the results obtained from the predictive regression analysis. However, it should be noted that the results of the predictive regression are statistically significant only for the short squeezed meme stocks.

Meme stocks are typically merely popular but lack strong fundamentals, which indicates that the positive relationship between excess return and short volume ratio is primarily driven by short squeezes. Thus, in the case of non-short squeezed meme stocks, the positive relationship between the short volume ratio and excess return is likely caused by spillover effects. Investors perceive these stocks to be similar to the short-squeeze meme stocks, which increases their potential to become the subject of the next big hype and social media attention. The high volatility in the market caused by the COVID-19 pandemic, accompanied by an increased government spending in the form of subsidies and capital injection has also had an impact on the irrationality of the market, causing a high demand for risky assets. These external factors may have contributed to the positive relationship between the market and excess return.

7 Discussion

In this paper, our aim is to examine the relationship between daily short volume and excess return for meme stocks, with a focus on identifying whether there is any predictive value for meme stocks during a short squeeze event. However, predicting the return of individual stocks is a challenging task on its own, and it becomes even more challenging during a recession, when volatility is high, and even more so during a short squeeze event. Although regression can be used to show the correlation between excess return and short volume, it is not an optimal method for predicting returns as it does not establish causality. This was further supported by the low R^2, particularly for the predictive regression.

Note that our research should be considered as a first step towards further research on this topic now that we have established a significant relationship between short volume and excess return for meme stock during the short squeeze of 2020 and 2021. Alternative methods for predicting returns, such as volatility modeling using various GARCH models, could potentially offer higher predictive power than regression. GARCH models take into account the time-varying volatility of returns, which can be especially important during periods of high volatility such as recessions or short squeezes. By incorporating this information, GARCH models may be able to provide more accurate predictions than regression.

Another interesting finding in this paper that needs to be explored further are the spillover effect of short squeezes on other meme stocks. While the study finds that meme stocks that are not subject to short squeezes also experience excess returns, it is unclear whether this is due to the anticipation of a future short squeeze or some other factor. Additionally, further research could examine the impact of social media on the spillover effect.

8 Appendix A

This appendix contains the formula according to which the variables are constructed. The formula for short interest ratio is as follow (3):

$$SVR = \frac{\text{Short volume}}{\text{Number of shares outstanding}} \tag{3}$$

The book-to-market ratio (BM) is defined as:

$$BM = \frac{\text{Book values}}{\text{Market value}} \tag{4}$$

The Momentum is calculated according Jegadeesh and Titman (1993), where the cumulative return of past year, excluding the most recent month is analyzed as proxy for momentum. The accumulated return of the last month serves as a proxy for the reversal factor (see equation 6). Note that equation 5 is a modified version of the momentum as we have daily data and therefore use eleven months of trading days. $R_{i,t-j}$ is the daily stock return for the $i-$th firm at the $(t-j)$-th day. The return is calculated according to equation 7, where $P_{i,t}$ is the daily price for stock i at time t.

$$Momentum_{i,t} = \prod_{j=1}^{230} (1 + R_{i,t-j}) - 1 \tag{5}$$

$$Reversal_{i,t} = \prod_{j=230}^{252} (1 + R_{i,t-j}) - 1 \tag{6}$$

$$R_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{7}$$

The logarithm of the market capitalization is used as a proxy for firm size:

$$FirmSize = \log(MarketCapitalization) \tag{8}$$

The illiquidity measure is calculated according to equation 9, where $ILLIQi,t$ is the illiquidity for the $i-$th stock at $t-$th day. Di,m is the number of trading days for $i-$th

stock in month m. R denotes the return and $VOLDi,t$ represent the daily dollar trading value for stock i on day t. Dollar trading volume is simply the total trading volume multiplied by the price of the stock on that day. The resulted value for $ILLIQ$ are multiplied by 10^{10} as they are very small.

$$ILLIQ_{i,t} = \frac{1}{D_{i,m}} \sum_{t=1}^{D_{i,m}} \frac{|R_{i,t}|}{VOLD_{i,t}} \tag{9}$$

9 Appendix B

Table 2: The composition of the sample of meme stocks that underwent a short squeeze and those that did not according to Allen et al. (2021), where the company NAKD is relaced with SPCE.

Short squeezed meme stocks	Non-Short squeezed meme stocks
GameStop (GME)	BlackBerry (BB)
AMC Entertainment Holdings Inc (AMC)	Castor Maritime Inc (CTRM)
American Airlines Group (AAL)	Koss Corporation (KOSS)
Bed Bath & Beyond (BBBY)	Nokia (NOK)
Eagle Materials Inc (EXP)	SNDL Inc (SNDL)
Virgin Galactic (SPCE)	trivago (TRVG)
Tootsie Roll Industries (TR)	

Table 3: Descriptive Statistics for all the variables. The meme stock that experienced a short squeeze are denoted by the 'Squeeze', which consist of the following stock: GME, AMC, AAL, BBBY, EXP, SPCE and TR. 'Non-Squeeze' denotes the meme stocks that did not experience a short squeeze and consist of the firms: BB, CTRM, KOSS, NOK, SNDL and TRVG.

	Excess Return	SVR_{Market}	$SVR_{Squeeze}$	$SVR_{non-squeeze}$	Firm Size	BM	Momentum	Reversal	ILLIQ
Excess Return	1.0000								
SVR_{Market}	0.0342	1.0000							
$SVR_{Squeeze}$	**0.1097**	-0.0090	1.0000						
$SVR_{non-squeeze}$	**0.1011**	-0.0056	-0.0014	1.0000					
Firm Size	0.0014	0.0114	-0.0191	-0.0129	1.0000				
BM	-0.0186	0.0337	-0.0586	0.0253	-0.1292	1.0000			
Momentum	-0.0020	-0.0136	0.0585	0.0275	0.0351	-0.1334	1.0000		
Reversal	**0.1646**	0.0450	0.0752	0.0541	0.0239	-0.0819	-0.0423	1.0000	
ILLIQ	0.0003	-0.0146	0.0062	0.1619	-0.0440	0.1037	-0.0415	-0.0225	1.0000

Table 4: Contemporaneous regression parameters where columns *Model* reports the coefficients and the t-statistics in the parentheses for the variables of regression 1. All the regressions models contain the control variables Firm size and ILLIQ.

	Model (1)	Model (2)	Model (3)	Model (4)
SVR_{market}	0.0792***	0.0632***	0.0829***	0.0666***
	(4.33)	(3.44)	(4.52)	(3.63)
$SVR_{Squeezed}$			0.1533***	0.1377***
			(5.52)	(4.96)
$SVR_{Non-Squeezed}$			0.0849***	0.0798***
			(3.88)	(3.74)
BM		-0.0004**		-0.0002
		(-2.26)		(-1.12)
Momentum		-0.0003		-0.0001
		(0.86)		(-0.94)
Reversal		0.0321***		0.0295***
		(27.93)		(28.73)
Constant	-0.0029	-0.0005***	-0.0003***	-0.0007***
	(-1.53)	(-5.01)	(-4.73)	(-6.03)
Firm Size	0.0001	-0.00007	0.0006***	0.0005***
	(1.52)	(-0.93)	(7.83)	(5.42)
ILLIQ	0.0012	0.0009	0.0016	0.0012
	(0.91)	(0.71)	(1.23)	(0.97)
R^2	0.001	0.028	0.024	0.046

t statistics in parentheses
*p > 0.10 , **p > 0.05 , ***p > 0.01

Table 5: Predictive regression parameters where columns *Model* reports the coefficients and the t-statistics in the parentheses for the variables of 2. All the regressions models contain the control variables Firm size and ILLIQ.

	Model (1)	Model (2)	Model (3)	Model (4)
$ExcessReturnLag$	0.0031	0.0033	-0.0013	-0.0008
	(0.24)	(0.26)	(-0.11)	(-0.06)
SVR_{market}	0.0178	0.0196	0.0189	0.0207
	(1.22)	(1.35)	(1.30)	(1.42)
$SVR_{Squeezed}$			0.0517**	0.0513**
			(1.98)	(1.97)
$SVR_{Non-Squeezed}$			0.0026	0.0032
			(0.15)	(0.19)
BM		-0.0014***		-0.0011***
		(-8.12)		(-5.92)
Momentum		-0.0002		-0.0003
		(-1.02)		(-1.45)
Reversal		-0.0007		-0.0012
		(-0.70)		(-1.18)
Constant	0.0001	0.0006***	0.0070***	0.0005***
	(1.545)	(5.69)	(3.89)	(4.89)
Firm Size	-0.0004***	-0.0005***	-0.0003***	-0.0004***
	(-5.29)	(-6.56)	(-3.92)	(-4.98)
ILLIQ	-0.0597	-0.0561	-0.0492	-0.0481
	(-0.85)	(-0.80)	(-0.67)	(-0.65)
R^2	0.001	0.001	0.002	0.002

t statistics in parentheses
*p > 0.10 , **p > 0.05 , ***p > 0.01

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