

Highlights

- We find explosivity and co-explosivity in meme stocks.
- Evidence of multiple explosive periods.
- Evidence of co-explosivity between cryptocurrencies and meme stocks.
- The rise of social trading appears to exacerbate price explosivity.

Bubbles across Meme Stocks and Cryptocurrencies

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Abstract

This study examines the price explosiveness of stocks whose purchase Robinhood restricted during the GameStop episode. We find that those “meme stocks” comprise multiple periods of explosiveness, indicating that they are unlikely to be an epiphenomenon. We also document evidence of price co-explosivity among meme stocks themselves and cryptocurrencies and meme stocks. Given the historical low correlation between the stock market and cryptocurrencies, our results highlight the impact of social media and emerging trading applications on interactions among equity and cryptocurrency markets, and their potentially destabilizing effects on both.

Keywords: Price Explosiveness; Co-explosivity; Meme Stocks; Cryptocurrencies; GameStop; Social Trading.

JEL classification: C12; C22; G14; G12.

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1. Introduction

In late January 2021, GameStop's shares and other stocks went "viral". In less than two weeks, the prices of some of these so-called meme stocks (MS) experienced an unprecedented surge of more than 1,000%.¹ This was partly due to the extraordinary buying pressure of a new type of retail investor who relies significantly on social media networks such as Reddit, Twitter, or StockTwits to form their beliefs and build their trading strategy (Allen et al., 2021).² While some media sources have ascribed the popularity of MS among these traders to diverse reasons such as nostalgia, irony, or the willingness to take revenge on hedge funds, Allen et al. (2021) argue that the MS phenomenon is the result of traders' new capacity to coordinate through social media and trading platforms. Indeed, during the GameStop episode, the authors observe a strong correlation between social media activity and market trading.

Social media and trading platforms can generate a singular communication dynamic among traders. As recently introduced in Pedersen's (2021) model, the echo chamber effect results when agents communicate in a closed system insulating them from rebuttal. Confirmation bias leads to unique belief amplification and reinforcement. This in turn may drive the irrational market behavior observed in the GameStop event. Such behavior is triggered, not necessarily by expressly coordinated strategic trades, but by this echo chamber effect inherent in social media. It is therefore important to know whether the GameStop episode in January 2021 was only an epiphenomenon, driven by exogenous factors,³ or the consequence of systematic irrational behavior (see Malz (2021),⁴ amplified by social media and new trading apps. Exploring

¹ Some hedge funds that bet against GameStop stock were forced to liquidate their positions, suffering huge losses. One of the boldest consequences was Citadel and Point72's bailout of Melvin Capital. They invested more than \$2.75 billion to rescue the firm, which lost more than 50% of its assets under management because of its GameStop position during the first month of 2021. Allen et al. (2021) and Klein (2021) provide a detailed and insightful analysis of the GameStop episode.

² Bradley et al. (2021) and Long et al. (2021) find that reddit activities played a major role in the GameStop Episode. Long et al. (2021) provides evidence that r/wallstreetbets user comments impact significantly GameStop stock return.

³ Such as the abnormally high short interest that can lead to a so-called "short squeeze". We should nonetheless note that during the GameStop mania, several MS that experienced an abnormal increase in stock price did not have a high short interest.

⁴ According to Malz (2021), some retail investors such as Robinhood investors may trade as a leisure activity of for emotional satisfaction, but not just in response to information or "rationality".

explosivity in MS, which represents the first objective of this study, sheds light on this issue since detecting the presence of explosiveness suggests irrational investing (Baker and Ricciardi, 2014), particularly in periods of co-explosivity between two or several MS, when there is no reasonable common economic or financial risk factors for their observed extreme co-movements. Consistent with Pedersen's (2021) theory, we find that MS prices are involved in multiple explosivity periods beyond the January 2021 event, and that they exhibit co-explosivity.

MS retail investors often considered pro-tech, and active on social networks, are likely to trade in cryptocurrencies (Hasso et al., 2022). Moreover, cryptocurrency investors are also prone to investment biases (Hackethal et al., 2021), and their trading is also influenced by social media (Philippas et al., 2019; and Shen et al., 2019). Finally, both MS and cryptocurrencies often exhibit similar extreme returns and volatility that can not necessarily be explained by news events.⁵ Consequently, the second objective of this study is to examine potential interactions between MS and cryptocurrency markets and their influence on price co-explosivity.

We document evidence of price co-explosivity between MS and cryptocurrencies. Due to the rise of social trading, we mobilize a behavioral perspective to explain our findings. On the one hand, several rational models have been short of calibrating and rationalizing the price dynamic of cryptocurrencies. For instance, in the leading Bitcoin equilibrium model of Biais et al. (2020), after calibration, a large part of the variation of Bitcoin is not explained by changes in fundamentals, like transactional cost and benefit of Bitcoin. On the other hand, given the lack of key common risk factors in the two markets, for example, the absence of mining network power (hashrate), critical transaction settlement problems,⁶ and blockchain security for MS, and the lack of cash flow news and default risk for cryptocurrencies, our behavioral channel is consistent

⁵ While common investors' irrational behavior should rationalize some extreme movements in these two markets, Pagnotta (2022) shows that price-security feedback in cryptocurrencies amplifies fundamental shocks' volatility impact and leads to booms and busts unconnected to fundamentals. This security feature is obviously absent from the equity market. Nevertheless Biais et al. (2020) show after calibration that a large part of the variation of Bitcoin is not explained by changes in fundamentals.

⁶ Interestingly, in Zimmerman (2020)'s theory, since blockchain technology limits the rapidity of transaction settlement, higher speculative demand can reduce prices, contrary to standard economic models. Obviously, this feature cannot exist in MS.

with Aloosh and Ouzan, (2020), Liu and Tsyvinski (2021), and Liu et al. (2022).⁷ Moreover the historical very low correlation between cryptocurrencies and traditional financial assets (Elendner et al., 2018; Baur et al., 2018) comfort the hypothesis that equity and cryptocurrency markets might interact more through an irrational, social network-driven investing channel than through common underlying fundamentals.

To our knowledge, this is the first study establishing a linkage between equity and cryptocurrency markets, particularly through a behavioral channel. The connectedness between MS and cryptocurrencies observed in their price explosivity, coupled with growing concerns about crypto assets' risk to financial stability should provide a rational basis on which regulators and policymakers may increase scrutiny of social trading platforms and related financial technologies. Our findings have also implications for portfolio and risk management. Co-explosivity among MS and across MS and cryptocurrencies hint at an emerging socio-behavioral risk factor due to the growing community of social traders.

2. Data

We employ the Yahoo Finance online API to collect hourly stock prices in USD, and we collected cryptocurrency hourly prices from Binance. The data spans July 10, 2019 to January 22, 2022. The sample consists of 4,280 observations. Our dataset covers Bitcoin, Ethereum, and stocks Robinhood Markets Inc. restricted purchases from January 28 to February 5, 2021. Moreover, we kept the stocks of firms that maintain market capitalization above \$1 billion during our sample period, namely (the tickers are in parentheses), GameStop Corporation (GME), AMC Entertainment (AMC), BlackBerry Limited (BB), and Nokia Corporation (NOK).

⁷ Liu et al. (2022) find that momentum, together with cryptocurrency market and size, capture the cross-sectional expected cryptocurrency returns and argue that the theories of momentum effect commonly involve behavioral explanations. Liu and Tsyvinski (2021) show that proxies for investor attention (constructed using Google searches), which is considered as an important behavioral factor, strongly forecast future cryptocurrency returns. They also find that momentum factors, which can also be considered as proxies for investor intention (at least partially), can forecast cryptocurrency returns (See Tables 2 and 7 in Liu and Tsyvinski (2021)).

3. MS price explosivity and collapse detection

In this section we analyze price explosivity and collapse in MS and cryptocurrencies. We start by presenting the methodology for the price explosivity and collapse detection, and then we present and interpret the price explosivity results. The next section will be devoted to the co-explosivity analysis. While it is possible to infer in this section some simultaneous explosive periods, the formal test, measure, and results of co-explosivity are presented in Section 4.

3.1 Methodology

We follow the methodology of Phillips et al. (2015; PSY), that has been successfully applied to identify explosive episodes in cryptocurrency markets (see Bouri et al., 2019). The rationale behind the model is that a price crash is generally seen as large movements in price without correspondingly large public news, due to a small change in fundamentals or perceptions of fundamentals (see Yuan, 2005; Ouzan, 2020).

The regression model employed for estimation and inference takes the following form:

$$\Delta P_t = \alpha + \beta P_{t-1} + \sum_{i=1}^j \varphi^i \Delta P_{t-i} + \varepsilon_t \quad (1)$$

where P_t alternatively represents the log of cryptocurrency or the stock price at a given time t ; α , β , and φ are parameters whose coefficients are estimated by ordinary least squares; j is the number of lags that are set according to BIC; and ε_t is the error term that is assumed to follow a normal distribution.

We use the backward sup augmented Dickey-Fuller (BSADF) statistics to detect and date stamp the multiple periods of bubbles and crises. Suppose the observation of interest is r . Let r_1 and r_2 be the start and end points of the regression sample. We denote the ADF statistic calculated from this sample as $ADF_{r_1}^{r_2}$. The end point of all samples on the observation of interest is fixed such that $r_2 = r$ and allow the start point r_1 to vary within the range $[0, r - r_0]$, where r_0 is the minimum window size required to initiate the regression.⁸

⁸ The recommended setting of $r_0 = 0.01 + 1.8/\sqrt{T}$ where T is the sample length, in our case a minimum length of eight hours (one trading day).

The PSY statistics are the ultimate values of all ADF statistics expressed as follows:

$$PSY_r(r_0) = \sup_{r_1 \in [0, r - r_0], r_2 = r} \{ADF_{r_1}^{r_2}\}. \quad (2)$$

Roughly speaking, the periods of explosive (and implosive) behavior are the periods in which the supremum ADF test statistics exceed the critical values calculated with a Monte Carlo simulation based on 2000 replications. A period is classified as a bubble (crash) in which the price at the end of the period exceeds (is lower than) the price at the beginning of the period.

3.2 Crisis and bubble periods in MS

As can be seen in Figure 1, MS prices exhibit multiple episodes of explosivity (shaded areas). The duration of the explosivity periods during the GameStop episode differs widely across the MS. GME and BB experienced a long explosive period lasting 15 and 12 days, respectively, whereas AMC and NOK both experienced two days of explosivity during the GameStop episode.⁹ The high number of explosiveness periods, coupled with their substantial duration, indicates that MS are unlikely to be mere by-products of an extraordinary event such as the GameStop episode. Rather, MS price explosiveness patterns seem to originate from traders' own irrational behavior – itself most likely exacerbated by trading platforms such as Robinhood – which facilitates MS trading. Furthermore, as can be seen in Figure 1, there are two major explosive periods common across all four meme stocks in our sample, namely the January-February 2021 and the May-June 2021.¹⁰ These two MS explosive periods have been significantly covered by conventional news media.¹¹

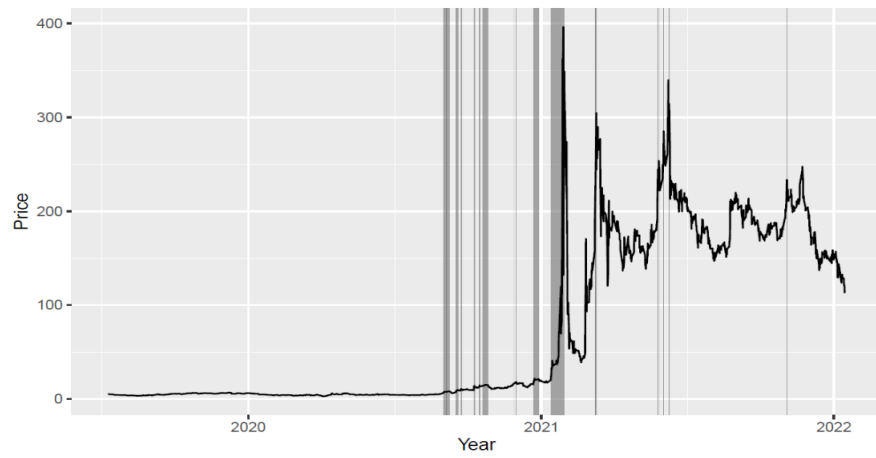
⁹ Some MS also exhibit crisis episodes in March 2020, coinciding with the COVID-19 pandemic-related market crash.

¹⁰ The January-February 2021 period is known as the "GameStop short squeeze."

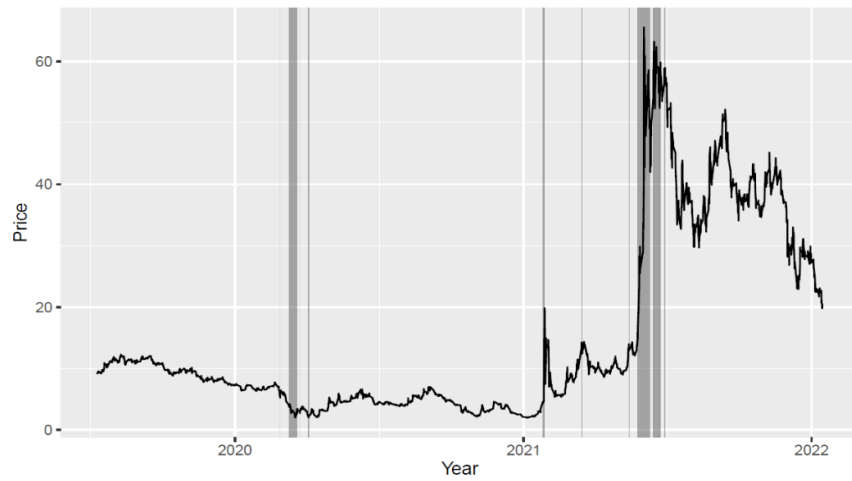
¹¹ See for example, among others, the CNBC article by Maggie Fitzgerald, written on May 27th 2021. With meme stocks on the move again, these are the next Reddit stocks to watch. Retrieved on May 1st, 2021. <https://www.cnbc.com/2021/05/27/with-meme-stocks-on-the-move-again-these-are-the-next-reddit-stocks-to-watch.html>. Moreover, These periods are associated with higher activities on social media platforms, like Reddit (see for example, Allen et al. (2021)). Given that our explosivity and implosivity measures are based on observed prices (not social media activities), the higher social activities provide an external validity of our results.

Figure 1. MS crises and bubbles

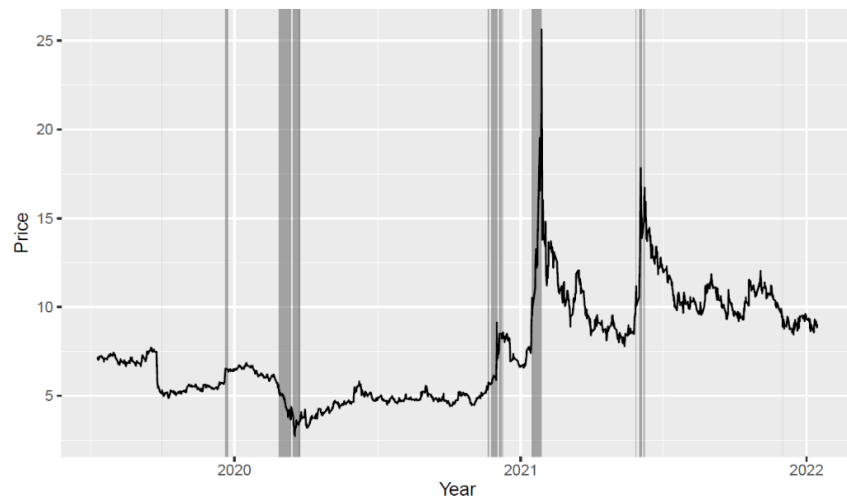
a. GME



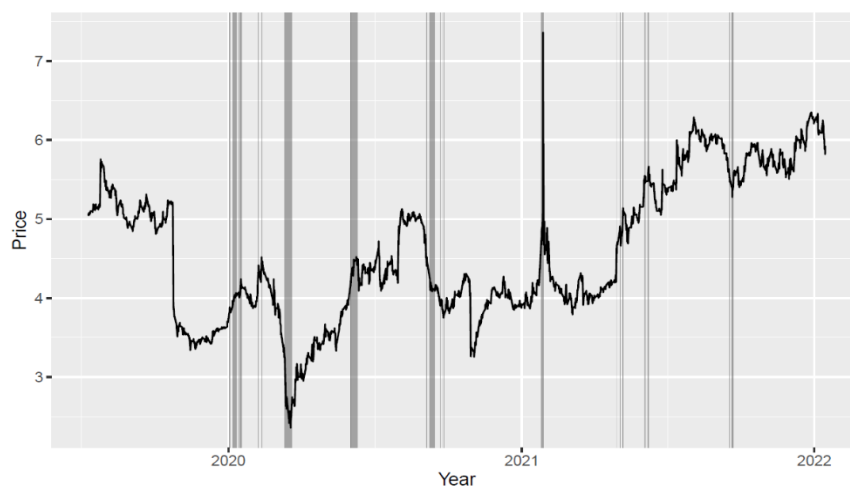
b. AMC



c. BB



d. NOK



Notes: These graphs show the evolution of MS prices (solid black lines). The shaded areas indicate periods of significant explosivity.

Interestingly, irrational investing in major cryptocurrencies, namely Bitcoin and Ethereum, measured by their price explosiveness (Baker and Ricciardi, 2014), is comparable to that in MS markets, as shown in Table 1.

Table 1. Statistics of explosive periods

	GME	AMC	BB	NOK	BTC	ETH
Panel A: Number of explosive periods						
2019	-	-	1	-	-	-
2020	9	2 (-)	6 (4)	6 (4)	13 (12)	9
2021	2	5	3	3 (2)	8	8
Sum	11	7 (5)	10 (8)	9 (7)	21 (20)	17
Panel B: Average length of explosive periods						
2019	-	-	3	-	-	-
2020	2	3 (-)	6 (3)	4 (3)	8	15
2021	8	5	5	1	19	23

Notes: This table presents the number of explosive periods lasting at least one day (Panel A). Panel B shows the average length (in days) of the explosive period. In parentheses, we report the statistics for bubble periods only when they differ from the overall explosiveness (bubbles and crises) statistics.

Both MS and cryptocurrencies exhibit frequent price explosivity in 2020 and 2021. Nonetheless, cryptocurrency prices exhibit more frequent and longer periods of explosivity. This is not surprising, given the ambiguous nature of cryptocurrencies,

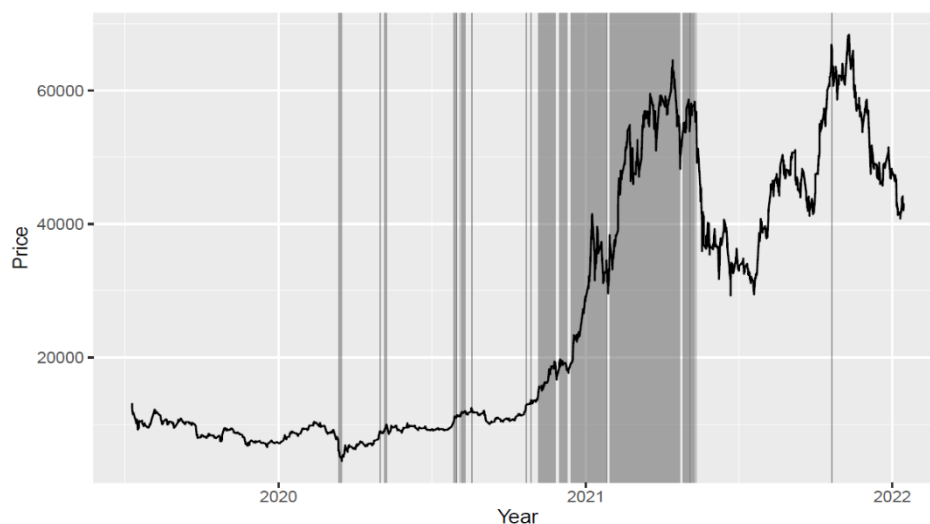
even concerning their primary function,¹² and their lack of fundamentals (such as earnings announcements, and dividend yields) compared to MS.¹³ Meanwhile, we will investigate further the observed explosiveness and the potential interactions across cryptocurrency and meme stock markets in the next section.

4. Co-explosivity across meme stocks and cryptocurrencies

The relevance of social media for both cryptocurrency and MS markets and the similarity of trader characteristics, as in pro-tech, lottery-type investors, and above average income class (Hackethal et al., 2021; Hasso et al., 2022), together with our evidence of their frequent price explosiveness in both markets, motivate us to explore a potential interaction between the two markets measured by their price co-explosivity. As can be seen in Figure 2, both BTC and ETH show surprisingly frequent and very long periods of price explosivity (up to a 79-day bubble period for BTC) during the GameStop episode. These crisis periods significantly overlap with those of MS in January-February 2021.

Figure 2. Crises and bubbles in the two major cryptocurrencies

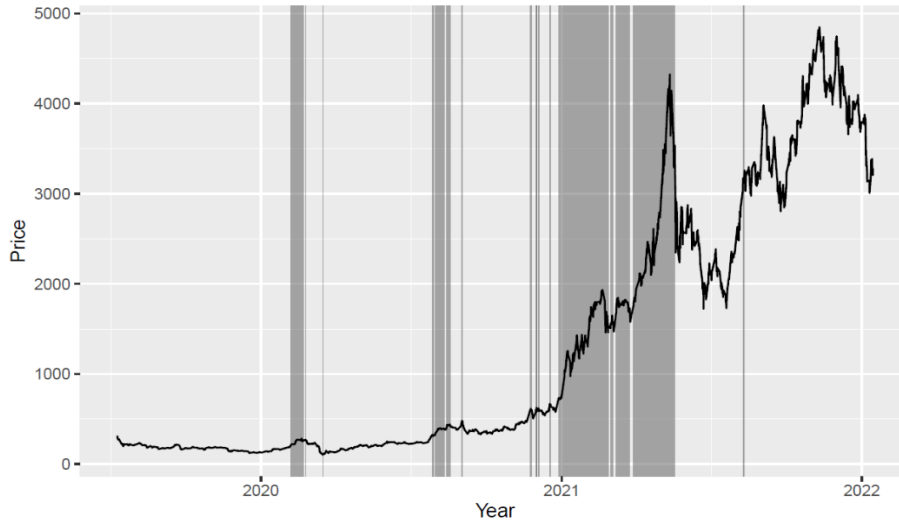
a. BTC



¹² There is indeed contradictory evidence about whether cryptocurrencies behave like traditional fiat currencies, commodities, stocks, bonds, or unrelated highly speculative assets (Corbet et al., 2019).

¹³ Price-security feedback effect in cryptocurrencies documented by Pagnotta (2022) might also partly explain the more frequent explosivity periods observed for cryptocurrencies, since this feature is obviously not present in MS.

b. ETH



Notes: These graphs show the evolution of cryptocurrency prices (solid black lines). The shaded areas indicate periods of significant explosivity.

4.1 Testing for price co-explosivity

To measure co-explosivity formally among MS and across MS and Bitcoin and Ethereum, we employ the following regression

$$\log \left(\frac{P(Y=1|X)}{1-P(Y=1|X)} \right) = \beta_0 + \beta_i X_{i,t} + \varepsilon_t \quad (3)$$

where the dependent dummy variable Y , associated with MS only, takes the value of one in the presence of price explosivity and zero otherwise. β_0 is a constant, $X_{i,t}$, $i = 1, 2, \dots, 5$, represents a set of five dummy variables, indicating the presence of price explosiveness in each of the remaining three MS, Bitcoin, and Ethereum,¹⁴ in which ε_t is the error term assumed to be distributed as a logistical distribution.

4.2 Price co-explosivity results

As reported in Panel A of Table 2, MS appear to co-explode simultaneously, strengthening the MS traders' irrational investing hypothesis. Indeed, from a rational viewpoint, it is unlikely that MS co-explode since these stocks do not share many

¹⁴ We have also tested for multicollinearity issue and find that correlation among dummy variables and VIF values of regressions are very low.

common characteristics despite being favored by social media and the MS trader community.

The results in Panel B, Table 2, indicate significant co-explosivity between MS and cryptocurrencies. While the explosivity of the Ethereum price does not increase the explosiveness probability for either AMC or Nokia, still, it co-explodes with both GameStop and Nokia. Bitcoin, however, negatively impacts the probability of explosiveness for both AMC and Nokia, while it has a positive impact on BlackBerry. For example, the co-explosivity coefficients of -0.947 suggests that the presence of bubbles in Bitcoin price reduces the probability of bubbles in AMC prices by around 95%. The existence of some negative co-explosivity coefficients in Table 2 is in line with our explanation of active investors in both markets, given their limited wealth. In other words, when investors allocate their limited funds in two assets and reallocate across them, we would expect that not all co-explosivity coefficients become positive. The magnitude of MS co-explosivity with cryptocurrencies suggests potential interaction across the equity and cryptocurrency markets via trading platforms and sharing of investment advice on social media among this growing community of retail investors. Consistent with the argument of Betermier et al. (2022) on the impact of investor asset allocation on asset returns, the existence of co-explosivity may happen across two assets because of significant asset allocation of their investors, no matter whether they share common factors. Indeed, the evidence of co-explosivity among MS and cryptocurrencies may highlight the emergence of a potential risk premium arising from portfolio choice and the investment decisions of their investors (Betermier et al., 2022; and Kozak et al., 2018). This risk premium may rise according to the degree to which the emerging social trader community favors a particular asset or asset class.

Finally, large contagion cannot be explained by the fundamentals alone.¹⁵ Our explosivity and co-explosivity results suggest that the irrational trading of a particular

¹⁵ Connolly and Wang (2003) show that the bulk of the observed co-movement in the intraday and overnight returns of the international equity markets cannot be attributed solely to public information about economic fundamentals. Karolyi and Stulz (1996) find that macroeconomic announcements and other public news do not affect the Japanese and American stock markets' co-movements, and King and Wadhvani (1990) also show that observable economic variables explain very partially international stock market co-movements.

asset or asset class – exacerbated by the echo chamber effect of social media (Pedersen, 2021) – may spread sporadically to a variety of assets, triggering significant contagion. Therefore, our reported overall findings may alert regulators as to the destabilizing impact of social trading on financial markets.

Table 2. Co-explosivity among MS and cryptocurrencies

	GME	AMC	BB	NOK
Panel A : Co-explosivity with MS				
GME		0.325**	1.490***	-0.398*
AMC	0.357**		1.744***	0.598***
BB	1.651***	1.729***		0.698***
NOK		0.495***	0.681***	
Panel B : Co-explosivity with cryptocurrencies				
BTC		-0.947***	1.088***	-0.654***
ETH	0.262**			0.528***
Constant	-1.857***	-1.927***	-2.875***	-1.979***
McFadden R-squared	0.143***	0.182***	0.432***	0.128***

Notes: This table presents the results from the logistic regression in Equation 3 ($\log(\frac{P(Y=1|X)}{1-P(Y=1|X)}) = \beta_0 + \beta_i X_{i,t} + \varepsilon_t$), ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusion

In revealing multiple explosive periods in MS, beyond the GameStop episode, we show that MS are unlikely to be an epiphenomenon. Our study also documents the co-explosivity among MS themselves and across MS and two major cryptocurrencies, namely Bitcoin and Ethereum. Given the low correlation across equities and cryptocurrencies, and the absence of fundamentals such as earnings for cryptocurrencies, our results emphasize the increasingly important influence social trading seems to exert on financial markets, and motivate further research on the behavioral economics of social trading.

Our co-explosivity evidence across MS and cryptocurrency is mainly driven by a common explosivity period in January-February 2021. Although these co-movement may be an epiphenomenon, future price co-explosivity across the two markets may reject such a hypothesis. In particular, as MS investors invest in a particular subset of assets (Welch, 2022), the negative co-explosivity across MS and crypto markets suggests potential portfolio rebalancing of the common investors in both MS and

crypto markets, which will probably persist in future. In addition, our results should alert regulators for the possibility of future market destabilization due to the strong tendency of MS prices to explode and co-explode. In other words, our results beg questions about the impact of social media and emerging trading applications on broader investor welfare and financial market stability, which have been so far considered mainly for crypto markets.¹⁶ By highlighting the dark side of trading democratization, our study emphasizes a need for (much) greater scrutiny of the technologies that facilitate such trends in equity markets.

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¹⁶ In February 16, 2022, the Financial Stability Board released a report indicating that crypto-asset markets are fast evolving and could reach a point where they represent a threat to global financial stability. The report is available online at <https://www.fsb.org/wp-content/uploads/P160222.pdf>.

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CRedit authorship contribution statement

Arash Aloosh: ; Data Curation; Investigations; Methodology; Formal analysis; Supervision; Software; Validation; Writing - original draft; Writing - review & editing.

Samuel Ouzan: Project administration; Conceptualization; Investigations; Methodology; Formal Analysis; Writing - original draft; Writing - review & editing.

Syed Jawad Hussain Shahzad: Data curation; Investigations; Methodology; Formal analysis; Software; Visualization; Validation; Writing - review & editing.