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Comovements between Heavily Shorted Stocks during a Market Squeeze: Lessons from the GameStop Trading Frenzy

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Comovements between heavily shorted stocks during a market squeeze: Lessons from the GameStop trading frenzy

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ABSTRACT

We examine the comovements between stock prices of different heavily shorted companies during a short-squeeze incident. Using the recent GameStop trading frenzy as a case study, we employ wavelet coherence analyses to determine its link with other frequently shorted stocks. We demonstrate a robust positive association between GameStop prices and the performance of high short interest indices. The bubble behavior driven by retail investor herding transmits between different stocks, even from unrelated sectors. Consequently, a single short-squeeze incident may build up into a potentially broader systemic risk, casting doubt on market integrity and stability.

1. Introduction

In 1995, the Nobel-prize winning Yale economist Robert Shiller wrote, "In most cases, many people independently choose their actions based on their own signals, without observing the actions of others." Clearly, Shiller has not experienced the power of social media at that time. Had he faced Twitter, r/wallstreetbets, stock market gamification, and online influencers, his conclusions could have been vastly different. Technological innovations, social media, and retail investor booms, without a doubt, have had a disruptive impact on financial markets and the economy. However, can they also be destructive? Are there negative externalities as well? Indeed there are, and the recent GameStop trading frenzy may serve as an excellent example. This short-squeeze episode caught the attention

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of the media worldwide by leading to massive losses of many sophisticated financial institutions. However, how broad can the consequences of such retail investor-driven short squeezes be? Are they limited to this individual stock, or do they affect other distressed companies as well? Can the trading frenzy be transmitted to other similar securities and sectors? Using the latest GameStop bubble as a unique natural experiment, we aim to shed some light on these issues.

The development of commission-free brokerage over the last decade attracted a new large group of potentially less educated investors and profoundly affected the stock market landscape (Van der Beck and Jaunin, 2021). Some of these changes are explicitly positive. For example, users of Robinhood Markets Inc., the first platform offering costless trading to households, concentrate mainly on low-priced attention-grabbing stocks, thus, contributing to their turnover (Ozik et al. 2020; Van der Beck and Jaunin, 2021). They may also serve as liquidity providers during a crisis (Glossner et al., 2020; Welch, 2020), and employ contrarian strategies that may help stabilize stock prices (Pagano et al., 2021). On the other hand, Barber et al. (2021) argue that the Robinhood app's certain features may induce herding behavior, potentially impacting market prices.

The recent collective buying of selected companies brings the concept of investor herding (Spyrou, 2013) to an entirely new dimension. A standard narrative suggests that retail traders, using r/wallstreetbets, a subforum on the Reddit message board, coordinate purchases of options and stocks deemed undervalued.[1] Anecdotal evidence links this phenomenon with several spectacular surges in valuations in the years 2019−2021. In May 2020, shares of Hertz, a popular car renting company that filed for bankruptcy, increased tenfold right after 140,000 Robinhood traders added it to their portfolios. In July, a similar story happened to Kodak, with share prices soaring 2,000 %. Nevertheless, perhaps the most spectacular is the frenetic activity around the GameStop stocks in January 2021.

GameStop, a heavily distressed video retailer, was subject to substantial institutional short interest (Van der Beck and Jaunin, 2021). Though there was a widely held belief that GameStop may soon join the ranks of many other bankrupt retailers, an alternative narrative indicated that the company may capitalize on a pivot towards online gaming and survive. Consequently, two diverging opinions emerged, frequently colorfully depicted as a battle between "little guys" and "greedy hedge funds" (Angel, 2021; Ortutay and O'Brien, 2021). The buying pressure of retail investors lifted the prices and forced many short-sellers to buy back stocks to limit losses. The effect was further amplified by call option trading. Market makers typically hedge their written call options with long positions in the underlying stocks. In consequence, retail betting in options markets translated into additional stock purchases, contributing to further demand pressure. As a result, over two weeks, the GameStop share prices jumped from $20 to $486, just to fall to $40 at the end of February.

Notably, the GameStop incident did not happen entirely in isolation. For example, at the same time, the shares of the movie theater chain AMC, another heavily shorted stock, exhibit an impressive price surge from $2 to $20. This coincidence poses an important question: can the short-squeeze frenzy in the style of the GameStop event be transmitted to other firms with high short interest, leading to potentially significant systemic risks? Did the GameStop episode affect other similar heavily-shorted companies?

The answers to the questions mentioned above are essential because apparent stock market overvaluation is harmful to all involved. It has a battery of negative consequences for financial markets and investors. Stock market bubbles tend to "suck" less sophisticated investors, leading to eventual significant losses. It also affects bystanders, as, for example, index funds are forced to buy overpriced securities. Excessive volatility undermines the trust in stock market integrity, discouraging new market participants. This, in the end, harms the entire economy, relying on the capital market as an efficient capital transfer mechanism.

From the theoretical perspective, at least two mechanisms may lead to transferring the bubble-like price increases from GameStop to other heavily shorted securities. First, style herding may gravitate investors towards stocks sharing similar characteristics (Barberis and Shleifer, 2003; Teo and Woo, 2004; Barberis et al., 2005; Froot and Teo, 2008; Choi and Sias, 2009; Andreu et al., 2015). Notably, social media and online forums may facilitate the spread of information on other investors' positions (Earl et al., 2007; Yarovaya et al., 2020), enabling mimicking trading behavior (Wang and Wang, 2018). Finally, inexperienced investors are particularly prone to herding (Menkhoff et al., 2006). Consequently, the retail newcomers may be inclined to quickly copy each other's trading patterns, exerting coordinated buying and selling pressure on other distressed securities with high short interest. Second, the transmitting of bubbles from one distressed company to another may also result from the funds' transactions. Having experienced heavy losses, managers of dedicated short-bias portfolios are likely to face fund outflows. Also, higher margin requirements can trigger a search for additional liquidity (Brunnermeier and Pedersen, 2009). Both effects may force managers to unwind some of the short positions, generating extra buying pressure. In consequence, the short squeeze may be transmitted into other similar securities.

To resolve our research questions, we examine daily stock market data from the years 2020−2021. We scrutinize the GameStop share prices and Barclays High Short Interest indices, reflecting the performance of the most heavily shorted stocks in the U.S. market. We apply the wavelet coherence approach to explore their dynamic comovements, originating from Torrence and Compo (1998).

The principal findings of our study can be summarized as follows. We demonstrate powerful positive coherence in January 2021 between prices of GameStock and the High Short Interest Indices representing various sectors. In other words, the short squeeze affected not only the prices of the mentioned game distributor, but also other heavily-shorted companies, even from completely unrelated sectors. The price momentum that is built up on one shorted security transmits during a market squeeze to other industries as well. As a result, the trading frenzy in the style of the recent GameStop incident can bear an indirect effect on a broader market, resulting in a potentially substantial systemic risk. The phenomenon is particularly evident for consumer products and technology sectors while visibly weaker for other industries. Our findings are robust to several methodological modifications, including subperiod

[1] Reddit is an online platform. As of February 15, 2021, there were 9 million members of the r/wallstreetbets group on the Reddit platform. Link: https://www.reddit.com/r/wallstreetbets/.

analysis and alternative significance thresholds.

Our study contributes to several streams of research. First, we add to the investigation of the impact of the recent retail investor boom on the financial market (e.g., Welch, 2020; Barber et al., 2021; Ozik et al., 2021; Pagano et al., 2021; Van der Beck and Jaunin, 2021). Second, we extend the discussion of herding's role in the occurrence of asset bubbles (e.g., Banerjee, 1992; Earl et al. 2007; Galariotis et al., 2015). Finally, we contribute to the novel applications of wavelet coherence methods in financial time series analysis (e.g., Zaremba et al., 2019; Umar and Gubareva, 2020; Goodell and Goutte, 2021).

The remainder of the article proceeds as follows. Section 2 summarizes the methodology. Section 3 presents the data. Section 4 reports the empirical findings. Section 5 outlines additional robustness checks. Finally, Section 6 concludes.

2. Methodology

We use the wavelet coherence approach to examine the comovements between GameStop prices and short stock indices. This approach takes into consideration both time and frequency factors in analyzing the comovements between the two series. This approach consists of a bivariate framework established based on a continuous wavelet transform (Morlet set to 6), allowing for several scaled localizations (Rua and Nunes, 2009). We utilize the wavelet coherence using cross wavelet transform and cross wavelet (coherence) to estimate the comovements. Following Torrence and Compo (1998), the cross wavelet transform (CWT) of x(t) and y(t) time series can be specified using their own cross wavelet transform $W_n^x(u,s)$*and* $W_n^y(u,s)$ as:

$$W_n^{xy}(u,s) = W_n^x(u,s) * W_n^y(u,s) \tag{1}$$

where u, s, and $*$ denote the location, scale, and complex conjugate, respectively. The CWT shows an area in the time-frequency domain where time series highlights a high common power. This means that it reveals the local covariance between both time series at each scale.

In the time and frequency domains, the wavelet coherence between time series can be specified (Torrence and Webster, 1999) as:

$$R^2(u,s) = \frac{|S(\, s^{-1} W^{xy}(u,s)|^2}{S(s^{-1}|W^x(u,s)\,|^2)S(s^{-1}|W^y(u,s)\,|^2)} \tag{2}$$

where S refers to the smoothening operator over time and scale, with $0 \le R^2(u,s) \le 1$ (Rua and Nunes, 2009). $R^2(u,s)$ refers to the wavelet-squared-coherence, which ranges between 0 and 1, where higher (lower) values represent the strong (weak) comovements between two time series. The wavelet squared coherence is different from the conventional correlation because it only has positive values. This approach cannot differentiate the positive and negative comovements (or correlations). In the time and frequency domains, the graphical display of wavelet squared coherence allows us to detect the area of comovement between two time series.

As the wavelet squared coherence cannot differentiate positive and negative comovements, this issue is resolved by the phase difference of Torrence and Compo (1998) to distinguish the positive and negative comovements. Additionally, the wavelet squared coherence explains the causal relationships between two time series. The phase difference wavelet coherence is specified as:

Table 1
Research Sample.

	GameStop	Consumer	Energy	Financials	Healthcare	Industrials	Market	REITs	Technology
Panel A: Baseline Summary Statistics									
Mean	15.01	88.40	74.01	119.13	98.06	99.46	46.06	87.67	94.00
Median	5.03	82.54	68.74	119.62	96.77	95.77	44.52	88.75	88.50
Maximum	347.51	237.97	148.1	166.34	177.6	195.19	105.84	139.41	193.76
Minimum	2.8	35.47	28.53	71.12	55.89	47.72	22.05	45.13	49.83
Std. Dev.	36.42	35.24	25.36	22.06	21.15	34.39	14.99	22.58	28.03
Skewness	6.75	1.09	0.70	0.02	1.13	0.83	1.12	0.15	1.29
Kurtosis	54.1	4.70	3.31	2.43	5.35	3.01	4.86	2.34	4.60
Jarque-Bera	30614.98	83.49	22.6	3.61	116.57	30.06	92.97	5.83	100.82
P-Values	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.05	0.00
Panel B: Pairwise Correlation Coefficients									
Consumer	0.68								
Energy	0.52	0.91							
Financials	0.43	0.92	0.88						
Healthcare	0.60	0.95	0.94	0.88					
Industrials	0.53	0.97	0.92	0.96	0.94				
Market	0.67	0.99	0.93	0.93	0.97	0.97			
REITs	0.48	0.94	0.87	0.99	0.87	0.97	0.94		
Technology	0.64	0.98	0.93	0.93	0.96	0.98	0.99	0.94	

The table presents the basic statistical properties of our research sample. The considered assets include the *GameStop* company and the High Short Interest Indices calculated for the entire *Market* and seven different industries: *Consumer*, *Energy*, *Financials*, *Healthcare*, *Industrials*, *REITs*, and *Technology*. The P-values for the Jarque-Bera test are reported. The study period runs from February 7th, 2020 to February 9th, 2021. Panel A reports baseline statistical properties, and Panel B reports pairwise Pearson product-moment correlation coefficients.

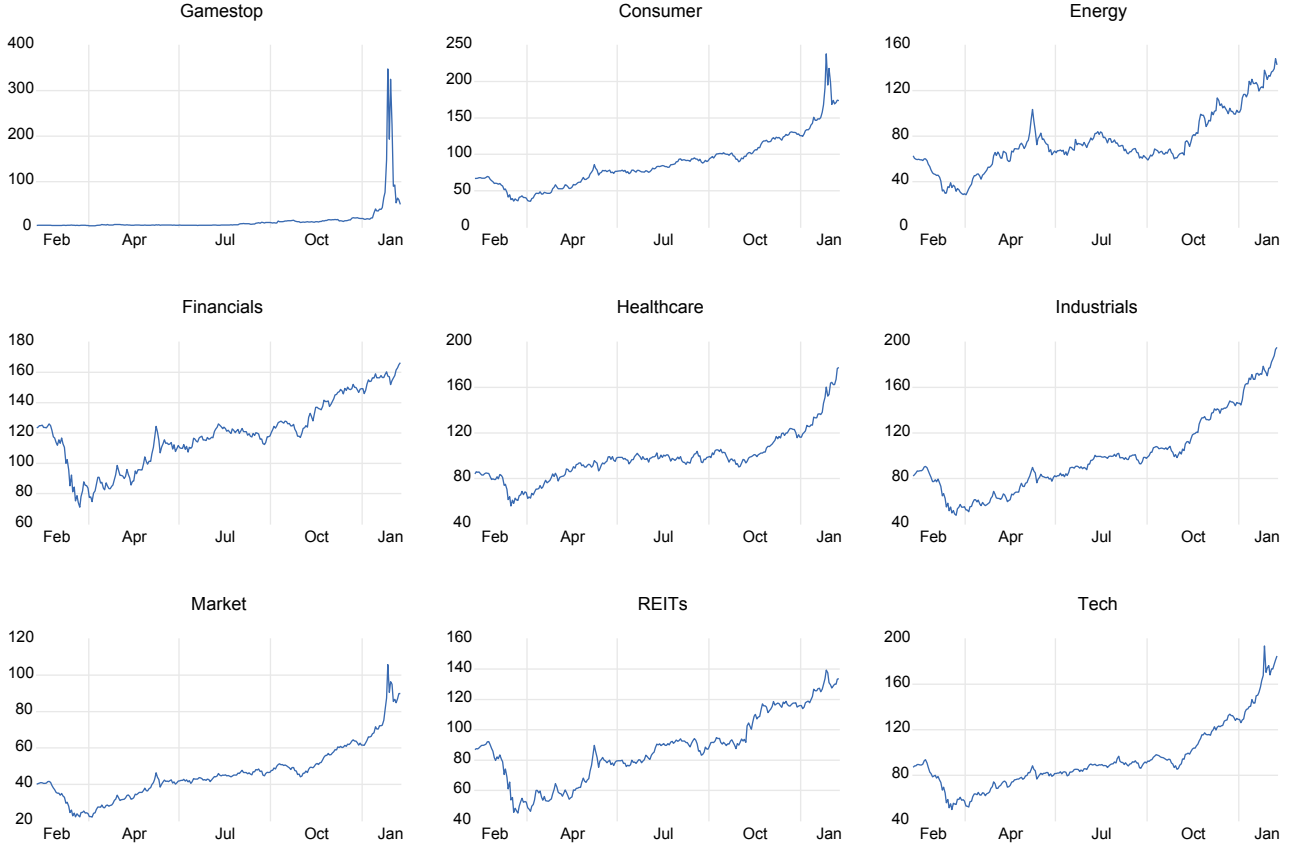

Fig. 1. Security Prices.
The figure represents the prices and index levels of the assets considered in the sample. These include the GameStop company and the High Short Interest Indices calculated for the entire *Market* and seven different industries: *Consumer*, *Energy*, *Financials*, *Healthcare*, *Industrials*, *REITs*, and *Technology*. The study period runs from February 7th, 2020 to February 9th, 2021.

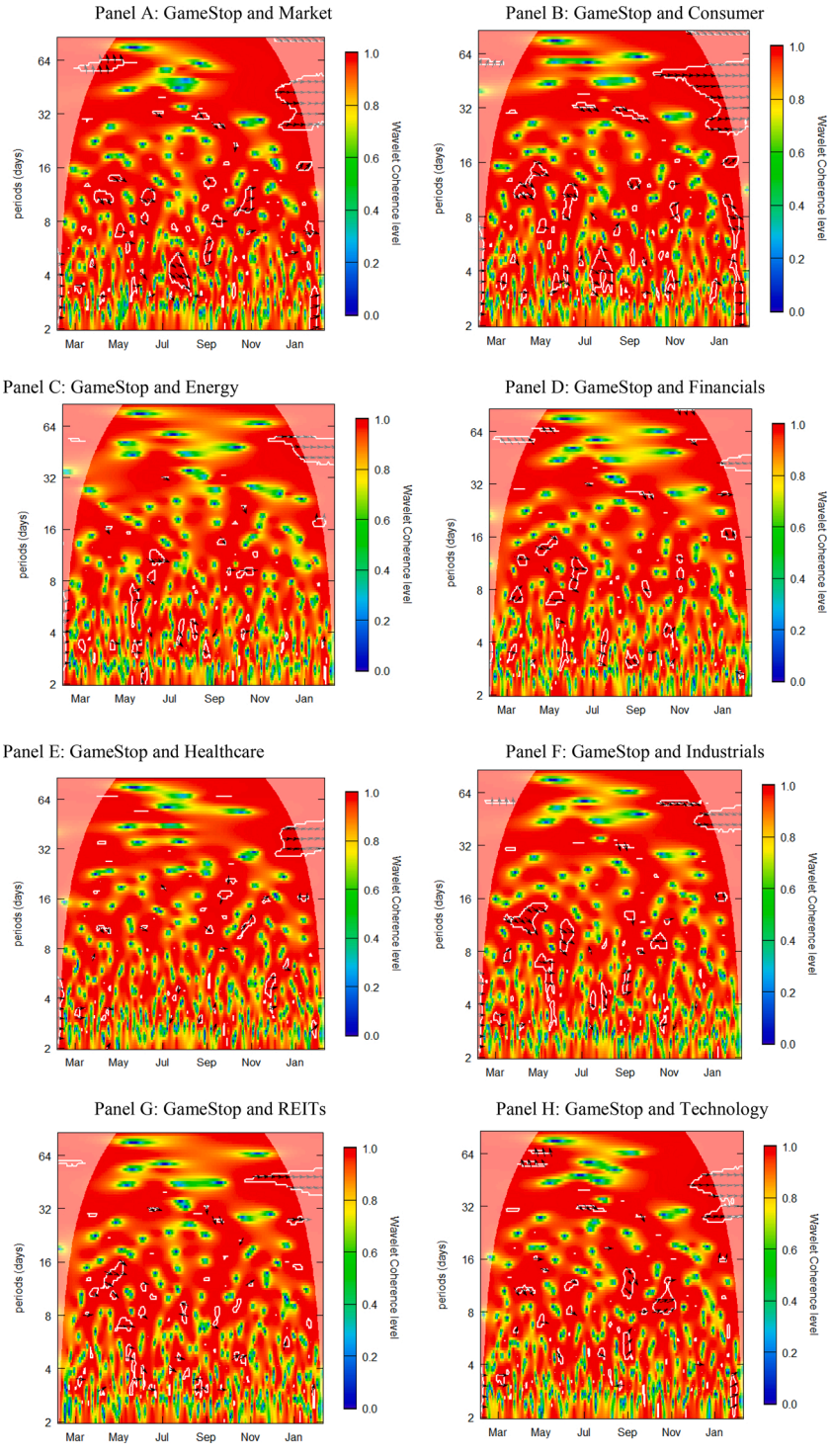

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Fig. 2. Wavelet Coherence between GameStop and High Short Interest Indices.
The figure presents the wavelet coherence between the GameStop stock prices and High Short Interest Indices representing different market segments: *Consumer*, *Energy*, *Financials*, *Healthcare*, *Industrials*, *REITs*, and *Technology*, as well as the broad market portfolio representing the entire U.S. equity universe. The study period runs from February 7th, 2020 to February 9th, 2021.
Panel A: GameStop and Market.
Panel B: GameStop and Consumer.
Panel C: GameStop and Energy.
Panel D: GameStop and Financials.
Panel E: GameStop and Healthcare.
Panel F: GameStop and Industrials.
Panel G: GameStop and REITs.
Panel H: GameStop and Technology.

$$\varnothing_{xy}(u,s) = tan^{-1}\left(\frac{Im\{S(s^{-1}W^{xy}(u,s))\}}{Re\{S(s^{-1}W^{xy}(u,s))\}}\right) \tag{3}$$

where *Im* is the imaginary and *Re* is the real part of the smoothed cross wavelet transform. The black arrows represent the phases on the wavelet coherence diagrams. The → (←) indicates the in-phase (out of phase) in the charts. In step (out of phase) refers to the positive (negative) correlations between two time series. Furthermore, ↗ and ↙ show that *x(t)* leads the *y(t)*, while ↘ and ↖ reveal that *y(t)* leads *x(t)*.

3. Data and preliminary analysis

We obtain all stock-level and index-level data from Bloomberg. Our research sample contains GameStop Corp. stock prices and High Short Interest Indices calculated by Barclays. These indices reflect the equal-weighted performance of the most heavily shorted stocks in the United States. To be included in the index portfolios, the securities are classified according to their short interest, calculated as the number of shares shorted over the total free float. We consider the composite High Short Interest Index representing the broad U.S. equity market and seven sector indices focusing on the consumer, energy, financials, healthcare, industrials, REITs, and technology industries. The companies in the high short interest portfolios come from the Russell 3000 index universe, which contains the 3000 largest U.S.-traded firms, representing about 98 % of all U.S. incorporated equity securities. These novel indices have not been extensively explored in the earlier finance literature.

Our sample contains daily prices from February 7th, 2020, to February 9th, 2021, and includes the recent GameStop trading frenzy. All the price and return data are expressed in U.S. dollars.

Table 1 provides the summary statistics of GameStop prices and High Short Interest Indices of different sectors. The average price of GameStop shares is $15.01, and the maximum (minimum) price is $347 ($2.80). In comparing GameStop prices and High Short Interest Indices, the standard deviation is highest for GameStop and relatively lower for the respective index portfolios. The skewness is positive in all series, kurtosis is greater than 3 in a majority of the cases, and Jarque-Bera statistics are significant in all series.

Fig. 1 illustrates GameStop's prices and the performance of the considered indices over the full sample period. The GameStop share price is stable from January 2020, but sharply increases during the second half of January and then declines in February 2021. The GameStop stock attracted investors' attention worldwide due to the rapid increase in price during the second half of January 2021. The retail Reddit investors jointly drove up GameStop's share price to beat Wall Street-based short-sellers and significant hedge funds (Smith, 2021). Moreover, the High Short Interest Indices for all sectors and the aggregate market show a negative trend from January to March 2020, but then reveal an upward trend from March 2020 onward.

Lastly, all High Short Interest Indices reach their highest peaks during the last week of January 2021. Apart from GameStop, the Reddit small investors also affect the prices of those other companies on which Wall Street significant hedge funds have done massive short selling (Sonnemaker, 2021); therefore, the prices of other heavily shorted companies also increased. Panel B of Table 1 provides the unconditional correlation matrix for the GameStop prices and High Short Interest Indices. For the GameStop prices and sectoral indices, the correlation is positive and ranges between 0.48 for real estate to 0.68 for the consumer sector. Moreover, a high correlation is observed between GameStop prices and the global market-wide High Short Interest Indices. Among industries, correlations are higher because of the similarity of the indexes of shorted stocks.

4. Empirical findings

This section discusses the results of the wavelet coherence analysis of the High Short Interest Indices (sectoral and market-based) and GameStop prices. Fig. 2, Panels A to E and G to H, illustrates the wavelet coherence between High Short Interest Indices representing various sectors and GameStop prices. In contrast, Fig. 2, Panel F, focuses on the entire market's High Short Interest Index. In diagrams, the level of wavelet coherence is displayed by colors on the right vertical axis. The coherency level increases in the following order of colors: blue (lowest coherency), green, yellow, and red (highest coherency). The white islands in diagrams indicate the significance, whereas frequency (i.e., analysis period, days) is displayed on the left vertical axis. Arrows show the phase difference between the short stock index and GameStop prices; for example, ⟵ and → denote the out-phase and in-phase relationships. The out-phase (in-phase) shows the negative (positive) correlations between GameStop prices and the shorted stocks index. Furthermore,

↗and ↙ show that GameStop leads a High Short Interest Index, while ↘ and ↖ reveal that the index leads the GameStop prices.

We start our analysis of Fig. 2 by looking at the wavelet coherence between GameStop prices and the overall market portfolio of heavily shorted firms given in Panel A. This graph helps us analyze the comovement between GameStop and the most heavily shorted firms index, enabling us to explore the spillover between them. Let us now examine the spillover and comovement at lower frequencies (2–4 days). We notice relatively sparse areas of significant comovement between the two series, at lower frequencies, during most of the sample period until the second half of January 2021. Interestingly, this is the period during which the GameStop short squeeze frenzy was at its peak. During the second half of January 2021, we notice a big white island, indicating that the coherence is positive and significant between GameStop prices and the portfolio of highly shorted firms. Furthermore, we notice that the arrow's directions in this region are ↗, indicating that the two series have positive comovement with GameStop leading. Thus, we may infer a positive spillover from GameStop to the portfolio of highly shorted firms during the peak of the GameStop short squeeze frenzy at lower frequencies. Next, we analyze the coherence in the medium term (4–16 day frequency bands). We notice two dominant islands of coherence from July until November. This period coincides with $4.01 (31/07/2020) to $16.56 (30/11/2020), a more than fourfold increase. For more extended frequencies (above 16 days), we see two islands at the top, but they are partly outside the cone of influence.

To analyze the impact of GameStop's short squeeze frenzy on various sectors, we compute the wavelet coherence with major sectorial indices. This analysis will allow us to distinguish between the comovement of GameStop and the sectorial portfolios of the highly shorted firms. We report these sectorial results in Panel B to Panel H of Fig. 2. We notice that there are specific sectors that exhibit significant coherence with GameStop and vice versa, thus underscoring our choice of analyzing the sectorial coherence. Panel B shows the wavelet coherence between the short index representing the consumers' sector and GameStop. Overall, we notice a sizable coherence between GameStop and the consumer index. In particular, at the peak of the GameStop short squeeze frenzy, during the second half of January 2021, we notice significant coherence for both the short term and medium term. As with the Market Index, we also notice dominant islands of significant coherence during July-September 2020. Panels C, D, and E of Fig. 2 exhibit the wavelet coherence results for the energy, financial, and healthcare sectors. We notice that these sectors do not exhibit major noticeable significant coherence patterns during the sample period over most frequencies. Panel F and Panel G of Fig. 2 display the wavelet coherence between GameStop prices and the short portfolio of the industrial and REITs sectors, respectively. The results show that wavelet coherence is only significant in the upper bands of 16–32 and 32–64, but no considerable coherence exists in the lower bands of 2–4, 4–8, and 8−16. Lastly, Panel H of Fig. 2 shows the wavelet coherence between GameStop prices and the technology sector's short stock index. We notice significant coherence exhibited by the white island ↗ arrows for 2–4 bands for the second half of January 2021.

In sum, the strong and positive coherence between prices of GameStock and the market portfolio of stocks with high short interest reveals that Reddit retail investors influence GameStock on other shorted stocks. Moreover, it indicates that the momentum of GameStock prices moves towards the other shorted stocks. Our sectorial analysis shows that the consumer and the technology sectors are the main areas exhibiting significant positive coherence with GameStop at the peak of its short squeeze frenzy. Phillips (2021) shows that other shorted stocks (AMC, BlackBerry, and others) also increased after the massive rise in GameStop prices. The above findings indicate that momentum build-up by small investors on GameStop through digital platforms transmit to other sectors as well. The collective action of a large number of small investors can affect the financial markets on a huge scale, directly or indirectly. As Reddit investors targeted few firms (direct effect), the coherence between GameStop and the heavily shorted companies from other sectors reveals the transmission of a phenomenon from few firms to a short stock market (indirect effect). It also implies that the investors can get a benefit, in the short run, from these Reddit-type trends by directly investing in those firms where Reddit users invest and by indirectly investing in related companies/sectors.

5. Further robustness analysis

To ensure the robustness of our findings, we perform two additional robustness checks. Specifically, we modify our baseline wavelet coherence methodology in two ways. First, we shorten the study period. In this approach, our sample for stock market data runs from August 3rd, 2020, to February 9th, 2021. In the second test, we relax the required significance threshold for the coherence analysis. Instead of the original 5%-level, we utilize a 10 %-significance threshold.

The results of the two tests do not alter our findings qualitatively. Hence, for the brevity, we summarize them in Fig. A1 and A2 in the Online Appendix. Let us first focus on the modified study period (Fig. A1). In this scenario, the relationship between the GameStop prices and the broad market-wide High-Short Interest Index (Fig. A1, Panel A) reveals an even stronger relationship than in our baseline tests. The white islands in January 2021 indicating significant coherence are now more substantial. Interestingly, the direction of arrows reveals that the casual relationship is not always unequivocal. Whereas for short- and long-period frequencies, the GameStop prices lead the changes in other stocks, for the medium term, the pattern is partly opposite – the GameStop securities tend to lag the broad market.

Further analysis of sectoral indices (Panels B to H) uncovers the primary sources of the wavelet coherences. The effect is the strongest for the highly shortened stocks from the consumer and technology sector. The relationship seems to be driven by firms performing a somewhat similar operational activity and active in related sectors. The link with other industries is visibly weaker and less significant.

The wavelet coherence investigations using the modified significance threshold (Fig. A2 in the Online Appendix) lead to consistent conclusions. GameStop's effect on the broad stock market index in January is strong and visible, though the casual relationship is not always consistent. Furthermore, the relationship is compelling for the consumer and technology sectors, while visible weaker for other

industries.

Finally, in an unreported analysis, we experiment also with a 1%-significance level. While the white islands in the figures are visibly smaller, the conclusions remain qualitatively unchanged. We still observe significant relationship driven by the consumer and technology sectors – especially for high return frequencies

6. Concluding remarks

Our study scrutinizes the relationship between different heavily shorted stocks during the recent GameStop trading frenzy. We employ the wavelet coherence approach and apply it to GameStop stock prices and High Short Interest Indices in the period February 2020 to February 2021. We demonstrate a strong and positive link between different seemingly unrelated securities. The sectoral analysis reveals an essential role played by consumer product and technology companies. The short squeeze is transmitted from one shorted stock, such as GameStop, to other heavily shorted stocks, uncovering the potential systemic risks stemming from these circumstances.

Our findings not only extend our understanding of asset pricing implications of the new retail investor boom, but they also have clear policy implications. Our conclusions help visualize the potential risks to market integrity and stability stemming from investor herding on online trading platforms.

Future studies could expand our findings to other markets and study periods. While we focus on a spectacular, though isolated incident, retail investor-driven flash bubbles have emerged multiple times over the last year. It would be valuable to explore to what extent our conclusions could be generalized to other settings.

CRediT authorship contribution statement

Zaghum Umar: Conceptualization, Software, Resources, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Imran Yousaf:** Conceptualization, Resources, Methodology, Writing - original draft, Writing - review & editing. **Adam Zaremba:** Conceptualization, Resources, Writing - original draft, Writing - review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ribaf.2021.101453.

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