



Full length article

A tale of company fundamentals vs sentiment driven pricing: The case of GameStop

Zaghum Umar^{a,b}, Mariya Gubareva^{c,d,e,*}, Imran Yousaf^f, Shoaib Ali^f^a College of Business, Zayed University, P.O. Box 144534, Abu Dhabi, United Arab Emirates^b South Ural State University, Lenin Prospect 76, Chelyabinsk, 454080, Russian Federation^c ISCAL – Lisbon Accounting and Business School, Instituto Politécnico de Lisboa, Av. Miguel Bombarda, 20, 1069-035 Lisbon, Portugal^d SOCIUS/CSG – Research in Social Sciences and Management, Rua Miguel Lupi, 20, 1249-078 Lisbon, Portugal^e National Research University Higher School of Economics/Centre for Financial Research & Data Analytics, Pokrovsky Blv. 11, Room T-408, 109028, Moscow, Russian Federation^f Air University School of Management, Air University, Islamabad, Pakistan

ARTICLE INFO

Article history:

Received 17 March 2021

Accepted 19 March 2021

Available online 22 March 2021

JEL classification:

C58

G12

G14

G28

G40

G41

Keywords:

Reddit investors

Wallstreetbets

GameStop

Short squeeze

Investors sentiments

Twitter publication count

News publication count

Put–call ratio

ABSTRACT

By means of the wavelet coherence approach, we study the relationship between the GameStop returns and the sentiment driven pricing, as described by the following indicators: twitter publication count, news publication count excluding twitter, put–call ratio, and short-sale volume. The documented impacts of media-driven sentiment suggest that regulators and policymakers should continuously monitor the investing groups on social media platforms as they can create inefficiency in the market. The put–call ratio strongly and positively affects the GameStop returns prior to the peak of the GameStop saga, being one of the drivers of the January skyrocketing prices. Our results also reveal a positive relationship between the GameStop returns and the short sales volume during the GameStop episode, confirming the short squeeze phenomenon. We highlight the importance for the regulators to consider limiting some predatory short-selling practices, namely “naked” short selling, as excessive short selling may move the market towards inefficiency.

© 2021 Elsevier B.V. All rights reserved.

1. Introduction

De Long et al. (1990) documented three decades ago that noise traders' sentiments lead to deviations in stock prices from their fundamentals. During the last three decades, we have witnessed a revolution in information and communication technologies that have led us to the current era, characterized by

an incredible ascent of social media, allowing us to access diverse information platforms that help us to disseminate news at an ever-increasing speed amidst an ever-increasing audience. Over the last decade, the social-media-enabled platforms have been profoundly affecting financial markets around the globe. The most recent GameStop episode is a good case illustrating this information revolution.

GameStop attracted the worldwide financial community's attention when its price increased from \$16 to \$347 within a span one month during January 2021. However, a unique feature of this upsurge was the contest between a large number of small retail investors and institutional investors such as hedge funds rather than the GameStop underlying fundamentals. Thus, this episode provides a unique case of the impact of investor sentiments on share prices. The episode started when the Wallstreetbets group on the Reddit platform, comprising a large number of small retail investors, started its campaign against the big hedge funds in order to show the power of crowd against the big hedge

* Corresponding author at: ISCAL – Lisbon Accounting and Business School, Instituto Politécnico de Lisboa, Av. Miguel Bombarda, 20, 1069-035 Lisbon, Portugal.

E-mail addresses: zaghum.umar@zu.ac.ae (Z. Umar), mgubareva@iscal.ipl.pt (M. Gubareva), imranyousaf.fin@gmail.com (I. Yousaf), shoaibali.fin@gmail.com (S. Ali).

¹ The author is grateful for the support by the Portuguese national funding agency for science, research and technology (FCT), under the Project UID/SOC/04521/2020, and by the Instituto Politécnico de Lisboa as a part of the IPL/2020/MacroRates/ISCAL project.

funds, involved with GameStop. This group of the retail investors on the Reddit platform (the Reddit investors) countered the massive short positions on the GameStop shares, contracted by the involved hedge funds, by taking long positions in the shares of GameStop. The basic reason behind the massive short selling was the weak fundamentals of the GameStop company from last three years, and there was an expectation of a further decline in share prices. However, despite the weak fundamentals, the Reddit investors started buying GameStop shares that led to a 21-fold increase within one month inflicting huge on the institutional investors. For example, one of the biggest US hedge funds, Melvin Capital Management, lost 53 percent of its investments in January 2021 due to the short squeeze on the GameStop shares (Chung, 2021).

One of the unique features of this episode was role of investor sentiment and social media in attracting investor's attention toward GameStop. The effect of emotions on investment decisions is well documented (Kahneman and Riepe, 1998; Kuhn and Knutson, 2011; Gambetti and Giusberti, 2012). As mentioned above, the latest social media revolution enables investors to express their sentiments on different social media platforms at an unprecedented level. This increasing role of social media in investment decisions has led to a new strand of literature focusing on the impact of such media-driven sentiments on investment decisions (Tetlock, 2007; Yang et al., 2015; Azar and Lo, 2016; Sul et al., 2017; Oliveira et al., 2017; Reboredo and Ugolini, 2018; Duz Tan and Tas, 2020).

One of the major benefits of the social media revolution is a wider access to information available to all kinds of investors including both retail and institutional investors. Chen et al. (2014) argue that institutional investors have many ways to monitor the stocks constantly, however retail/small investors now also can easily access the market information through diverse channels, including social media platforms. The stock price reflects the trading activity of both institutional and retail investors (Behrendt and Schmidt, 2018), so if retail investors are dominantly affected by sentiments from social media platforms, then the stock price will adjust accordingly and may deviate from its fundamentals based value, thereby leading to inefficient price discovery. It is widely acknowledged that institutional investors are well informed and, therefore, they are more rational investors (Boehmer and Kelley, 2009). On the contrary, retail/individual investors seem to be less rational because their investment decisions are affected by various psychological and cognitive biases (Black, 1986). In the case of GameStop, a huge emotions-based campaign involving a large number of retail investors has succeeded and strongly influenced the stock prices. Therefore, we focus on examining the relationship between investor sentiments and the GameStop prices, especially during this rivalry episode. Following Behrendt and Schmidt (2018) and Kraaijeveld and De Smedt (2020), we use twitter publications as a proxy of social-media-wise investor's sentiments and find that media-wise Reddit investor sentiments may have positively affected the GameStop returns during the recent episode of tension between the social media investors and the involved hedge funds.

To obtain further insights regarding the influence of retail investors, we advance our study further by using an additional sentiment indicator, namely, news publication count excluding twitter, which we posit is a good proxy for less social-media oriented and more old-style traditional retail investors. In this case, we come to the opposite results suggesting the that media-averse investor sentiments are unlikely to have positively affected the GameStop returns during this period, and, hence, we conclude that this strata of investors is not responsible for the recent rivalry episode between the social media Reddit investors and the hedge funds.

Another aspect that has played an important role in the case of GameStop was that the call option volume hold by the Reddit investors were considerably higher than the outstanding put options. Easley et al. (1998) and Pan and Poteshman (2006) report that the options volume contains information about future equity prices. When big hedge funds were shorting the GameStop shares in January, the Reddit investors were buying the shares and options of GameStop (Phillips, 2021). In this context the information of bought put options relative to outstanding call options seems to be especially useful from market economics point of view. In fact, the put-call ratio is a clear-cut options market indicator of investor sentiment: a large proportion of calls to puts signals bullish market sentiment, and vice versa. This indicator is widely used by both market practitioners and researchers and proved to be an accurate predecessor to market price movements, suitable for predicting market returns at different time scales (Houlihan and Creamer, 2019; Jena et al., 2019; among many others). Therefore, it can be expected that the connection between the options market put-call ratio and the share prices of GameStop ought to vary at the peak of the battle between the Reddit and institutional investors. Hence, we examine the interrelations between the put-call ratio and the GameStop share prices.

In addition, the factor that has played a pivotal role in the GameStop saga is short sale activity in the GameStop stock. In fact, the massive short selling resulted in an overcrowded position on the short side, which, hence, was inherently vulnerable to a reversal. The Reddit investors, many of which were not amateurs, have correctly detected this vulnerability and succeeded in inflicting a squeeze on hedge funds betting on a fall in stocks of GameStop. At this point it is worth noting that the short selling polemics and the respective academic works are not new. For instance, Cohen et al. (2007) find that shorting demand is one of the vital predictors of future equity returns. Boehmer and Wu (2013) also find that an increase in shorting activities expedites the incorporation of public information into prices. Therefore, we include the short sale volume in our analysis as short selling may affect the demand and, hence, price of the underlying stock. Rational investors short a stock on the expectation of future decrease in company's value driven by its deteriorating fundamentals. We can segregate short selling into two distinct phases, (a) initial phase, when an investor borrows shares of a particular company and sell these shares in the market having expectation of price decline in future, (b) closing phase, when investor returns the borrowed shares by buying the shares at a lower price from the market. In case of huge volume of short selling, the first phase increases the supply of shares and second phase increase the demand for shares which leads towards the rise in stock prices. In case of GameStop, more than 100 percent of shares in existence were shorted (Wieczner, 2021; McCrank, 2021), being estimated, in fact, that short sellers had sold and promised to deliver to buyers as much as 260 percent of outstanding shares (Mackenzie, 2021). Overall, it is more than expected that an excessive short sale volume ought to influence the price shares, what, in fact, has been observed in the case of GameStop.

An important element that investors always take into account when making investment decisions is the intended investment horizon for a particular investment. It is well known in finance literature that the desirability of an investment may vary depending upon short-term or long-term investment horizons (Spierdijk and Umar, 2014). Therefore, it is worth accounting for this important parameter. Towards this end, we employ the wavelet coherence methodology, which enables us to analyze the comovements between variables across both time and frequency domains. Wavelet methods have been employed in recent literature to analyze the impact of media sentiment on financial markets and to study comovements of different financial variables (Zaremba et al., 2019; Gubareva and Umar, 2020; Goodell

and Goutte, 2021; Umar and Gubareva, 2020). Therefore, in this study we apply the wavelet coherence technique using the daily data of the GameStop stock prices, twitter and non-twitter publication counts, options market put–call ratio, and the volume of short sale contracts. Our sample period ranges from January 01 to January 30, 2020, thereby allowing us to study the dynamics of the above enumerated variables before and during the current GameStop battle.

Our results report a significant positive co-movement between the GameStop returns and twitter/non-twitter publications, proxying market sentiment of investors who are more/less involved with social-media platform, during the recent heated brawl episode (January 15 to January 30, 2020). Our results highlight that the GameStop returns and the options market put–call ratio demonstrate a significant co-movement during the intensified tussle episode between the GameStop social media investors and the involved hedge funds. Our findings also reveal a strong relationship between the GameStop returns and the number of short sale contracts, confirming the short squeeze phenomenon.

The remaining paper is structured as follows: Section 2 describes the econometric framework, Section 3 provides the data and descriptive statistics, Section 4 provides results and analyses, and Section 5 concludes the whole study.

2. Econometric framework

The wavelet coherence technique, unlike traditional time series modeling, captures the co-movement between two time series in both the time and frequency domains. The wavelet technique utilizes a bivariate framework established on a continuous wavelet transform (Morlet set to 6). This allows for a variety of scaled localizations (Rua and Nunes, 2009). To test the co-movement between time series both in frequency and time domains, we use continuous wavelet coherence technique.

Following Torrence and Compo (1998), The cross-wavelet transform of two-time series variables $x(t)$ and $y(t)$ is defined using their cross-wavelet transformations (CWT) $W_n^x(u, s)$ and $W_n^y(u, s)$ as stated below in Eq. (1).

$$W_{x,y}(u, s) = W_x(u, s) W_y^*(u, s), \quad (1)$$

where $W_x(u, s)$ and $W_y^*(u, s)$ are continuous wavelet transforms of two time series variables $x(t)$ and $y(t)$. Here 'u' is position index, 's' indicates the scale and '*' sign denotes the complex conjugate. The wavelet transform assumes the local covariance between two time series variables.

Torrence and Compo's (1998), approach to wavelet coherence remain robust to quantify the cross-wavelet power to display the areas of greater covariance at each scale between time series variables. The wavelet coherence is applied to analyze the time regions in which co-movement in time series variable may happen but may have not high wavelet power. In addition, Torrence and Webster (1999) expanded the work of Torrence and Compo (1998) by including the squared wavelet coherence coefficient, which is defined in the following Eq. (2):

$$R^2(u, s) = \frac{|S(s^{-1}W_{x,y}(u, s))|^2}{S(s^{-1}|W_x(u, s)|^2)S(s^{-1}|W_y(u, s)|^2)} \quad (2)$$

where 's' represent operator over time and space and squared wavelet coefficient is in the range of $0 \leq R^2(u, s) \leq 1$ (Rua and Nunes, 2009). As discussed, the definition is aligned with the traditional correlation coefficient. We further write the smoothing operator 's' in time and frequency space.

$$S(W) = S_{Scale}(S_{Time}(w_n(s))) \quad (3)$$

where S_{Scale} is smoothing along the wavelet scale axis and S_{Time} shows the smoothing across time.

The higher wavelet squared coherence values $R^2(u, s)$ reflect higher the co-movement between the two variables and vice versa. The wavelet squared coherence is constrained to positive values within the range of 0 to 1. Hence, the difference between positive and negative co-movements in two-time series cannot be examined. Therefore, to overcome this issue, Torrence and Compo (1998) and Grinsted et al. (2004) advocate to use the phase difference, which allows for differentiating between positive and negative co-movements of the two analyzed time series. The expression for the phase-difference is stated as follows:

$$\phi_{x,y}(u, s) = \tan^{-1} \left(\frac{\text{Im} \{S(s^{-1}W^{xy}(u, s))\}}{\text{Re} \{S(s^{-1}W^{xy}(u, s))\}} \right), \quad (4)$$

where Im and Re are the imaginary and the real components of the smoothed cross-wavelet transform, respectively. The phase differences in the wavelet coherence plot are represented by black arrows. The arrows pointing towards the right (left) side signify that time series are in-phase (out-of-phase). Herein, 'in-phase' ('out-of-phase') means positive (negative) correlation between the two time series variables. Accordingly, the upward (downward) indication of arrows state that first (second) series leads the second (first) series by $\pi/2$. The phase difference of zero shows that both time series are moving simultaneously. The study also used Monte Carlo simulations to estimate the statistical significance at each scale by making a large number of data pairs. The level of significance at 5% is indicated by a solid line in wavelet coherence plots.

3. Data and descriptive statistics

We use the daily data of the GameStop share prices, of the put–call ratio, of the short selling volume, as well as of the twitter and non-twitter news publication counts, proxying investor sentiment for media-platforms-'literate'/'illiterate' investors. The firm-specific data is taken from Ortex.² Regarding the twitter publication counts, note that Twitter is an online social media service that allows users to send short 280-character messages called tweets. Before November 2017, user tweets were limited to 140 characters. Using hashtags and cashtags in front of the term, platform users can easily find related tweets. Users can reach other users' profiles and previous tweets by clicking on a username tagged with at-sign (@). By the end of 2020, Twitter had 330 million monthly and 145 million daily active users. The twitter publication count figures are extracted from Bloomberg.

Table 1 exhibits the descriptive statistics of the employed data.

4. Empirical results

We start our analysis by looking at the evolution in the GameStop prices as well as by following the dynamics of the short sale contracts, the put–call ratio, the news publication count, and the twitter publications count or count of tweets. The respective charts are presented in Fig. 1. We find a noticeable change in the evolution of all series during the last stages, which motivates us to study the relationship among these variables.

We apply the wavelet coherency framework to analyze the interdependence between the returns of GameStop and investor sentiments of media-platform users (e.g., the Reddit investors), proxied by the twitter publication count, or the number of tweets. Fig. 2 shows the wavelet coherence plot of the GameStop returns and the tweet count with phase differences represented by

² <https://www.ortex.com>.

Table 1

Descriptive statistics; January 01, 2020 to January 30, 2021.

	GameStop	News_pubs	Put_Call	Short_volume	Twitter_pub
Mean	0.012	43.346	0.741	6261.437	1079.986
Median	0.000	15.000	0.550	5058.960	132.500
Maximum	0.854	2772.000	5.945	28 225.640	67 325.000
Minimum	-0.585	1.000	0.128	703.120	17.000
Std. Dev.	0.108	183.457	0.623	4491.230	5963.253
Skewness	2.458	12.561	3.375	1.231	10.003
Kurtosis	23.854	179.517	21.904	4.720	107.199
Jarque-Bera	5355.679	370 877.100	4700.649	105.217	131 339.500
Probability	0	0	0	0	0
Observations	280	280	280	280	280

Note: This table shows the sample statistics of the variables. The variable GameStop depicts the return on the GameStop stock, the variable News_Pubs is the "News Publication Count", the variable Put_call is the Put-Call ratio, Short_Volume is the volume of shorted stocks and Twitter_Pub denotes the twitter publication counts.

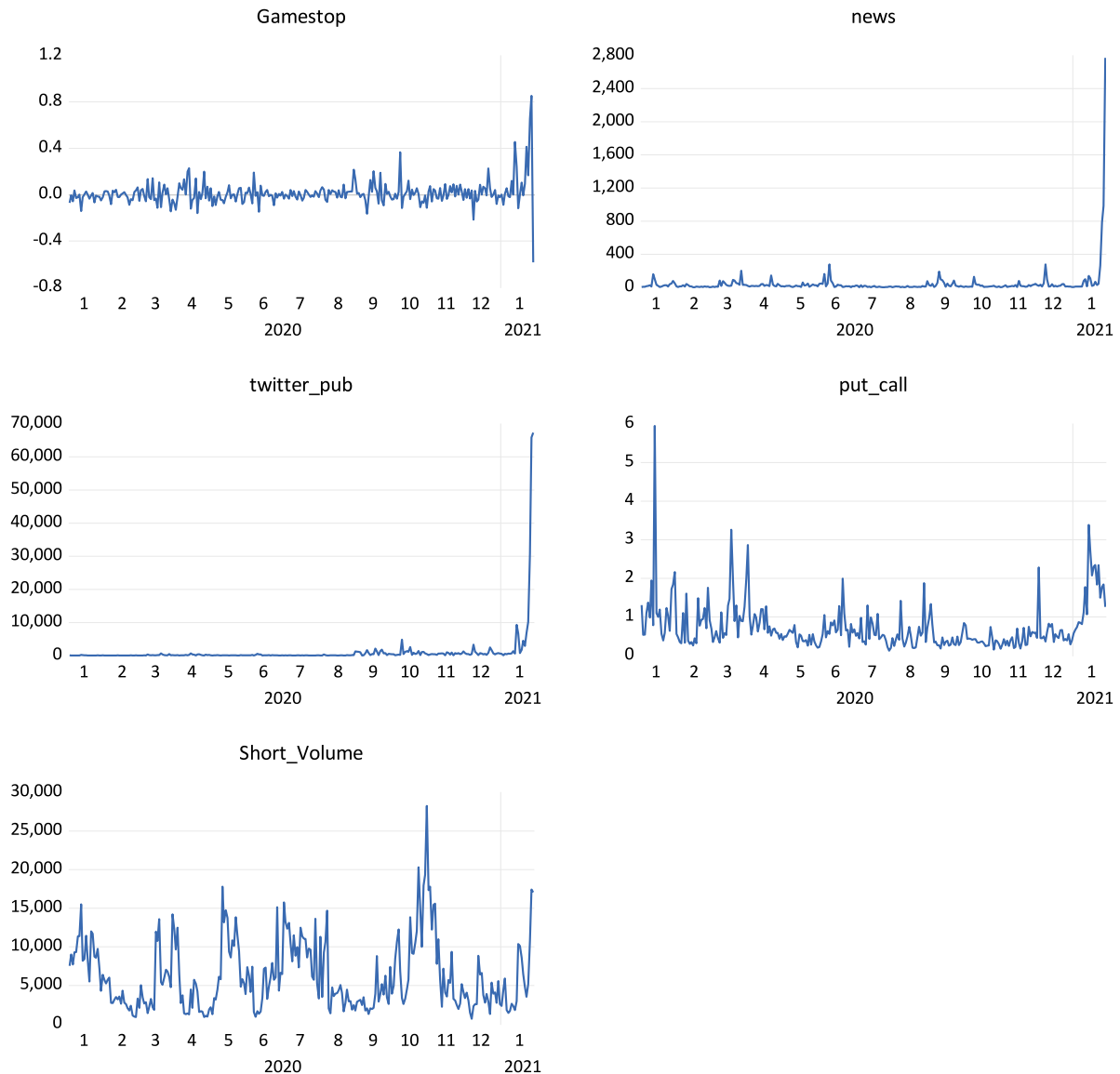


Fig. 1. The variable GameStop depicts the return on the GameStop stock, the variable News_Pubs is the "News Publication Count", variable Put_call is the Put-Call ratio, Short_Volume is the volume of shorted stocks, and Twitter_Pub denotes the twitter publication counts.

arrows. The vertical axis in the plot presents period or frequency band of interdependence, while the horizontal axis captures time in days. The regions with strong co-movements are represented by warm colors (red), and colder colors (blue) disclose areas with weak co-movements between the variables. The black arrows

in the wavelet coherence plots provide information about the causality and interdependence between two time series. Arrows pointing towards the right side (\rightarrow) show that the GameStop share prices returns and the twitter publication count are positively correlated, and the arrows directed towards the left side

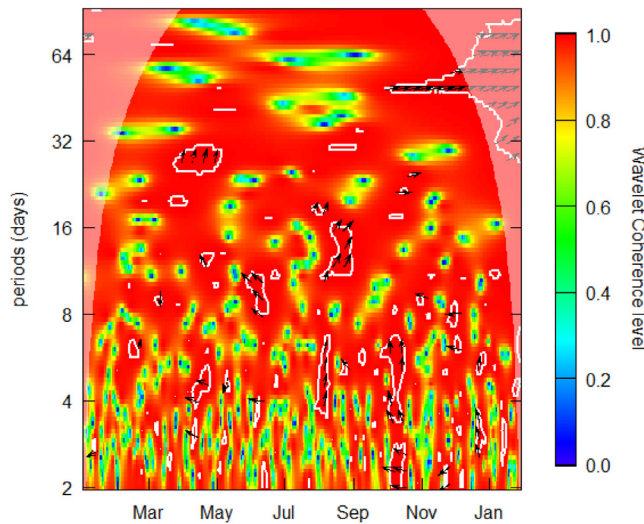
Wavelet Coherence between Gamestop and twitter_pub

Fig. 2. Shows the wavelet coherence plots between GameStop returns and Twitter Publication Count, where the horizontal axis shows time in days and the vertical axis displays the period. The correlation is displayed by colors on the right side of the plot; moving from blue to red color shows the higher absolute correlation value concerning $R^2(u, s)$. The more intensely colored zone of the plot is the cone of influence, and the white contours show the regions of significance at 5% level. The phase differences are indicated by arrows, where the arrows pointing towards the right side \rightarrow show an in-phase (positive) relationship and vice versa. The \uparrow (\downarrow) pointing of arrows shows that the first (second) series leads the second (first) time series.

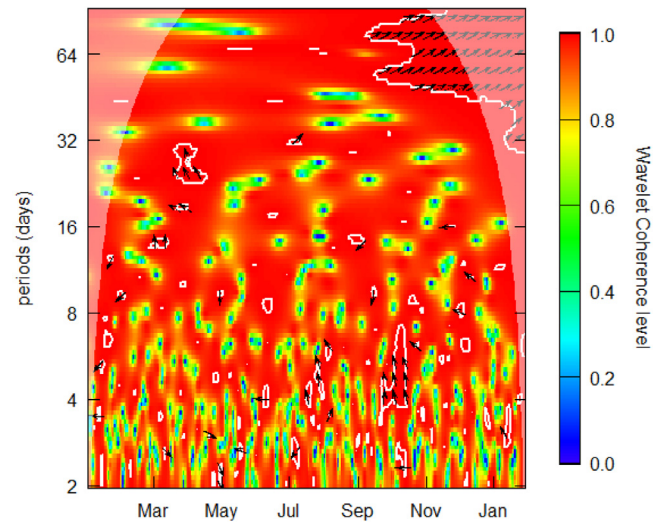
Wavelet Coherence between Gamestop and news_pubs

Fig. 3. Shows the wavelet coherence plots between GameStop returns and News Publication Count, where the horizontal axis shows time in days and the vertical axis displays the period. The correlation is displayed by colors on the right side of the plot; moving from blue to red color shows the higher absolute correlation value concerning $R^2(u, s)$. The more intensely colored zone of the plot is the cone of influence, and the white contours show the regions of significance at 5% level. The phase differences are indicated by arrows, where the arrows pointing towards the right side \rightarrow show an in-phase (positive) relationship and vice versa. The \uparrow (\downarrow) pointing of arrows shows that the first (second) series leads the second (first) time series.

(\leftarrow) display that the two time series are negatively correlated. The upward (\uparrow) pointing arrows indicate the leading effect of first series, and downward (\downarrow) pointing arrows indicate the second series leading effect.

In Fig. 2, the predominantly red color of the plot suggests high levels of coherence between the GameStop returns and the media-wise investors' sentiments. In the top right-hand corner, the rightward-directed upward-pointing (\nearrow) arrows show an in-phase relationship (positive correlation) between the GameStop returns and the tweet count, with the lead by the former, for around six-weeks frequency ranges since October 2020 onwards, implying positive influence of the GameStop returns on twitter publications and, hence, on the respective media-platforms-wise investors' sentiments. However, in the second half of December, 2020 and in mid-January, 2021 for the 3-4-days frequency band we observe the two a white-line contours suggesting a statistically significant co-movement between the two series in a very short-run just at the very beginning and in the middle of the GameStop episode. This finding suggests that media-wise Reddit investor sentiments may have positively affected the GameStop returns during the recent episode of tension between the social media investors and the involved hedge funds.

At this point, we extend our analysis to scrutinize the interdependence between the returns of GameStop and investor sentiments of non-users of media platforms (e.g., the more traditional style investors), proxied by the news publication count, excluding tweeter. Fig. 3 shows the wavelet coherence plot of the GameStop returns and the news publication count with phase differences represented by arrows.

Similarly to the previous case, the predominant tonality of the heatmap in Fig. 3 is red, signaling high levels of coherence between the GameStop returns and investor sentiments of media-platform-averse investors. Once again, in the top right-hand corner, for the 40-days-plus frequency band, since September-

October, 2020 we observe the rightward-directed upward-pointing (\nearrow) arrows indicating an in-phase relationship (positive correlation) between the GameStop returns and the news publication count, with the lead by the former. This implies positive influence of the GameStop returns on news publications and, hence, on the respective media-platforms-averse investors' sentiments. However, since September 2020 onwards, in the 2- to -16-days high frequency band we observe that all the phase difference arrows are pointing to the left, meaning an out-of-phase relationship between the two time series. This finding suggests that media-averse investor sentiments are unlikely to have positively affected the GameStop returns during this period, and, hence, we conclude that this group of investors is not responsible for the recent episode of tension between the social media Reddit investors and the involved hedge funds.

In Fig. 4 the rightward directed arrows (\rightarrow) confirm the positive relationship between the GameStop returns and the put-call ratio, evidencing an in-phase synchronicity of increase in the GameStop returns and in increase in put-call options mainly due to increase in put options volume. In fact, the increase in put options volume is consistent with the fact that buying put options allows an investor to hedge against a potential drop in share price. It is especially so, as the initial price, paid for put option represent a modest upfront premium, which limits the respective risk exposure, while a potential upside from a put option at plunging stock prices can be impressive. That is why put options are always considered to be an appropriate instrument to hedge against market declines. However, the risk is always going side by side with return; if stock keep climbing until the expiry date of one's put option, such investor loses not only what he/she invested, but also expected profits. This was the case of many retail investors during the recent short-squeeze mania relative to GameStop stock. The results are more significant during the

Wavelet Coherence between Gamestop and put_call

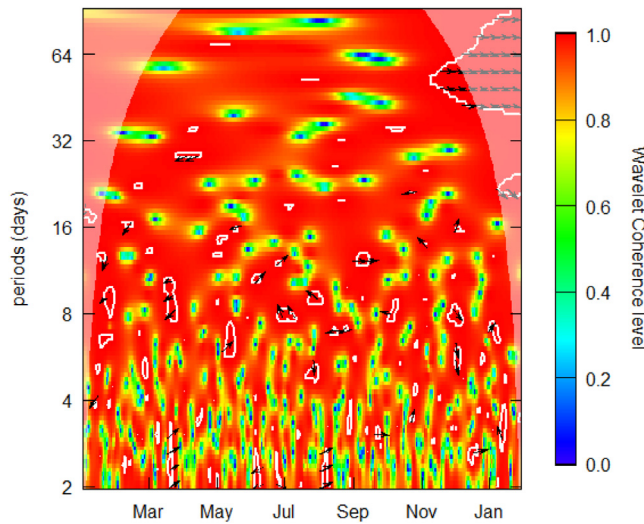


Fig. 4. Shows the wavelet coherence plots between GameStop returns and put-call ratio, where the horizontal axis shows time in days and the vertical axis displays the period. The correlation is displayed by colors on the right side of the plot; moving from blue to red color shows the higher absolute correlation value concerning $R2(u, s)$. The more intensely colored zone of the plot is the cone of influence, and the white contours show the regions of significance at 5% level. The phase differences are indicated by arrows, where the arrows pointing towards the right side \rightarrow show an in-phase (positive) relationship and vice versa. The \uparrow (\downarrow) pointing of arrows shows that the first (second) series leads the second (first) time series.

Wavelet Coherence between Gamestop and Short_Volume

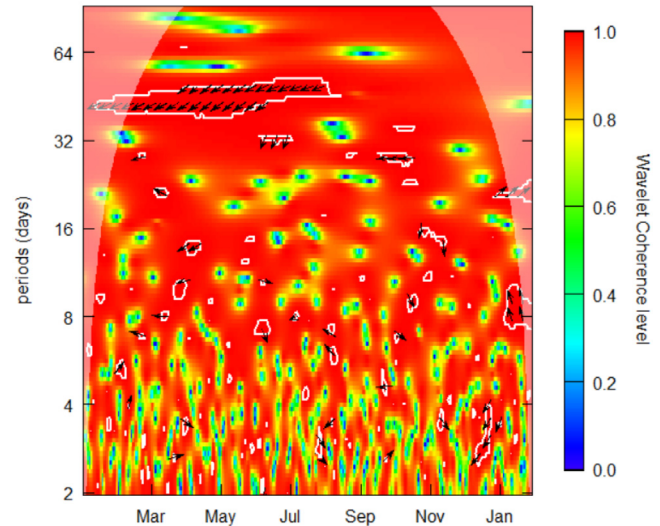


Fig. 5. Shows the wavelet coherence plots between GameStop returns and number of short contracts, where the horizontal axis shows time in days and the vertical axis displays the period. The correlation is displayed by colors on the right side of the plot; moving from blue to red color shows the higher absolute correlation value concerning $R2(u, s)$. The more intensely colored zone of the plot is the cone of influence, and the white contours show the regions of significance at 5% level. The phase differences are indicated by arrows, where the arrows pointing towards the right side \rightarrow show an in-phase (positive) relationship and vice versa. The \uparrow (\downarrow) pointing of arrows shows that the first (second) series leads the second (first) time series.

latest episode of price hike, said relationship is also as per the theory, which suggests a positive relationship between the put-call ratio and the price of the underlying stock. A statistically significant cloud of the rightward-directed downward-pointing arrows (\searrow) visible around the 3-weeks frequency from mid-January onwards clearly indicated a lead by the put-call ratio vis-à-vis the GameStop stock price in for the respective period. Our findings confirm that the put-call ratio, growing due to the increase in the put options volume, caused mostly by derivative trading activity of retail investors, is one of the drivers of the January skyrocketing prices of the GameStop shares. In addition, analyzing our results it could be inferred that investor are more inclined towards options during the period of increasing uncertainty.

Fig. 5, the leftward-directed downward-pointing arrows (\swarrow) represent the negative relationship between the GameStop returns and the number of short contracts with a lead by the short sales volume. The relationship is as per the theoretical prediction, which suggests a negative relationship between prices and short selling. In fact, from Fig. 5 it can be inferred that in January–August, 2020 the increasing number of short contracts was reflected in the decreasing price of the GameStop stock.

The interesting thing in the result is the rightward-directed and upwards-pointing arrows (\nearrow) on the 16–24 frequency cycle since late-December 2020 onwards. This feature confirms a positive relationship between return and the number of short contracts with a lead by the price of the GameStock shares. In addition, the arrows cloud seen around 8-days frequency cycle also confirms the leading role of the GameStock price.

The study's finding is supported by the concept of 'short squeeze', as a sudden rise in the price of a stock is mostly due to an excess of short selling of a stock rather than related to the underlying fundamentals. However the GameStop price

movements in this case have been anticipating increases in short sale volumes, resulting in some kind of a selfforcing cycle. The results also support our argument that excessive short selling can have a positive effect on the price of the GameStop stock.

5. Conclusion

This study explores the relationship between the GameStop returns, on one side, and, on the other side, the investor sentiments of media-wise and media-averse players, respectively proxied by the tweets count and the new publication count; put-call volume ratio; and the short sale volume. The wavelet coherence approach is fed by the daily data from January 01, 2020 to January 30, 2021.

Our findings suggest that media-wise Reddit investor sentiments may have positively affected the GameStop returns during the recent episode of tension between the social media investors and the involved hedge funds. It implies that investors can get reasonable returns in short run following big social media groups like Reddit. On the other hand, for the more tradition media-averse investors we observe out-of-phase relationship between the news publication count and the GameStop stock price, meaning negative correlation and suggesting the that media-averse investor sentiments are unlikely to have positively affected the GameStop returns during this period, and, hence, allowing to conclude that this strata of investors is not responsible for the recent rivalry episode between the social media Reddit investors and the involved hedge funds.

The results also highlight that the GameStop returns and the put-call volume ratio demonstrate a significant positive co-movement during the intensified tussle episode between social media investors and hedge funds. Our findings confirm that the put-call ratio, growing due to the increase in the put options

volume, caused mostly by derivative trading activity of retail investors, is one of the drivers of the January skyrocketing prices of the GameStop shares. We also find that investors are more inclined towards option trading during the period of increasing uncertainty.

The findings also reveal a positive relationship between the GameStop returns and the short sales volume during the GameStop battle episode, confirming the short squeeze phenomenon. It implies that mass short selling increases the demand, prices, and ultimately returns excessively, and this phenomenon leads towards the inefficiency due to big deviation in market prices from the actual stock value, which leads to the inefficiency. According to the concept of 'short squeeze', an excessive increase in short selling, rather than the underlying fundamentals, is an important driver in a sudden rise in the price of a stock, which we evidenced in the case of the GameStop saga.

Wrapping up, the findings of the study have important implications for regulators and policymakers, they should continuously monitor the investing groups on social media platforms as they can create inefficiency in the market, which may lead to a bubble creation or crisis ignition as in the recent episode of the GameStop tussle when S&P 500 decline 3% and the involved hedge funds have lost a lot of their wealth. Furthermore, regulators should consider limiting predatory short sales on assets as excessive, especially "naked" short selling could drive market towards inefficiency, however always bearing in mind that short sellers play an important role in the financial ecosystem helping to identify overvalued and struggling companies.

Acknowledgments

This work was supported by FCT, I.P., the Portuguese national funding agency for science, research and technology, under the Project UIDB/04521/2020 and by the Instituto Politécnico de Lisboa as part of the IPL/2020/MacroRates/ISCAL project. The article was prepared within the framework of the Basic Research program at HSE University.

References

- Azar, P.D., Lo, A.W., 2016. The wisdom of Twitter crowds: Predicting stock market reactions to FOMC meetings via Twitter feeds. *J. Portfolio Manage.* 42 (5), 123–134.
- Behrendt, S., Schmidt, A., 2018. The Twitter myth revisited: Intraday investor sentiment, Twitter activity and individual-level stock return volatility. *J. Bank. Financ.* 96, 355–367.
- Black, F., 1986. Noise. *J. Finance* 41 (3), 528–543.
- Boehmer, E., Kelley, E.K., 2009. Institutional investors and the informational efficiency of prices. *Rev. Financ. Stud.* 22, 3564–3594.
- Boehmer, E., Wu, J., 2013. Short selling and the price discovery process. *Rev. Financ. Stud.* 26 (2), 287–322.
- Chen, H., De, P., Hu, Y.J., Hwang, B.H., 2014. Wisdom of crowds: The value of stock opinions transmitted through social media. *Rev. Financ. Stud.* 27 (5), 1367–1403.
- Chung, Juliet, 2021. Melvin capital lost 53% in January, hurt by gamestop and other bets. *Wall Street J.* Retrieved from <https://www.wsj.com/>.
- Cohen, L., Diether, K.B., Malloy, C.J., 2007. Supply and demand shifts in the shorting market. *J. Finance* 62 (5), 2061–2096.
- De Long, J.B., Shleifer, A., Summers, L.H., Waldmann, R.J., 1990. Noise trader risk in financial markets. *J. Political Economy* 98 (4), 703–738.
- Duz Tan, S., Tas, O., 2020. Social media sentiment in international stock returns and trading activity. *J. Behav. Finance* 1–14.
- Easley, D., O'hara, M., Srinivas, P.S., 1998. Option volume and stock prices: Evidence on where informed traders trade. *J. Finance* 53 (2), 431–465.
- Gambetti, E., Giusberti, F., 2012. The effect of anger and anxiety traits on investment decisions. *J. Econ. Psychol.* 33 (6), 1059–1069.
- Goodell, J.W., Goutte, S., 2021. Co-movement of COVID-19 and Bitcoin: Evidence from wavelet coherence analysis. *Finance Res. Lett.* 38 (10162).
- Grinsted, A., Moore, J.C., Jevrejeva, S., 2004. Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlin. Processes Geophys.* 11, 561–566. <http://dx.doi.org/10.5194/npg-11-561-2004>.
- Gubareva, M., Umar, Z., 2020. Emerging market debt and the COVID-19 pandemic: A time-frequency analysis of spreads and total returns dynamics. *Int. J. Finance Economics* <http://dx.doi.org/10.1002/ijfe.2408>.
- Houlihan, P., Creamer, G., 2019. Leveraging a call-put ratio as a trading signal. *Quant. Finance* 19 (8), 1–15. <http://dx.doi.org/10.1080/14697688.2018.1538563>.
- Jena, S., Tiwari, A., Mitra, A., 2019. Put-call ratio volume vs. Open interest in predicting market return: A frequency domain rolling causality analysis. *Economics* 7 (1), 24. <http://dx.doi.org/10.3390/economics7010024>.
- Kahneman, D., Riepe, M.W., 1998. Aspects of investor psychology. *J. Portf. Manag.* 24 (4), 52–+.
- Kraaijeveld, O., De Smedt, J., 2020. The predictive power of public Twitter sentiment for forecasting cryptocurrency prices. *J. Int. Financial Mark. Instit. Money* 65, 101188.
- Kuhnen, C.M., Knutson, B., 2011. The influence of affect on beliefs, preferences, and financial decisions. *J. Financ. Quant. Anal.* 46 (3), 605–626.
- Mackenzie, M., 2021. Short sellers face the rage of an army of small traders. *Financial Times* <https://www.ft.com/content/1236e026-9c7f-49f1-9ed3-2b7540dc9b35>.
- McCrack, John, 2021. Explainer: How were more than 100% of gamestop's shares shorted? Reuters Retrieved from <https://www.reuters.com/>.
- Oliveira, N., Cortez, P., Areal, N., 2017. The impact of microblogging data for stock market prediction: Using Twitter to predict returns, volatility, trading volume and survey sentiment indices. *Expert Syst. Appl.* 73, 125–144.
- Pan, J., Potesman, A.M., 2006. The information in option volume for future stock prices. *Rev. Financ. Stud.* 19 (3), 871–908.
- Phillips, Matt, 2021. 'Dumb Money' is on GameStop, and it's Beating Wall Street at its Own Game. *The New York Times*, Retrieved from <https://www.nytimes.com/>.
- Reboredo, J.C., Ugolini, A., 2018. The impact of twitter sentiment on renewable energy stocks. *Energy Econ.* 76, 153–169.
- Rua, A., Nunes, L., 2009. International comovement of stock market returns: A wavelet analysis. *J. Empir. Finance* 16 (4), 632–639. <http://dx.doi.org/10.1016/j.jempfin.2009.02.002>.
- Spierdijk, L., Umar, Z., 2014. Stocks for the long run? Evidence from emerging markets. *J. Int. Money Finance* 47, 217–238. <http://dx.doi.org/10.1016/j.jimonfin.2014.06.003>.
- Sul, H.K., Dennis, A.R., Yuan, L., 2017. Trading on twitter: Using social media sentiment to predict stock returns. *Decis. Sci.* 48 (3), 454–488.
- Tetlock, P.C., 2007. Giving content to investor sentiment: The role of media in the stock market. *J. Finance* 62 (3), 1139–1168.
- Torrence, C., Compo, G., 1998. A practical guide to wavelet analysis. *Bull. Am. Meteorol. Soc.* 79, 605–618.
- Torrence, C., Webster, P., 1999. Intercadal changes in the ENSO-Monsoon system. *J. Clim.* 12, 2679–2690.
- Umar, Z., Gubareva, M., 2020. A time-frequency analysis of the impact of the Covid-19 induced panic on the volatility of currency and cryptocurrency markets. *J. Behav. Exp. Finance* 28, 100404.
- Wieczner, Jen, 2021. Hedge funds and other short-sellers have lost an astounding amount betting against gamestop. *Fortune* Retrieved from <https://fortune.com>.
- Yang, S.Y., Mo, S.Y.K., Liu, A., 2015. Twitter financial community sentiment and its predictive relationship to stock market movement. *Quant. Finance* 15 (10), 1637–1656.
- Zaremba, A., Umar, Z., Mikutowski, M., 2019. Inflation hedging with commodities: A wavelet analysis of seven centuries worth of data. *Economic Letters* 181, 90–94. <http://dx.doi.org/10.1016/j.econlet.2019.05.002>.