IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF FINANCIAL ECONOMCS

MASTER THESIS

THE IMPACT OF MEME EQUITIES ON THE STOCK MARKET: GAMESTOP MANIA

NAEF AHMED NAIF SAEED ALKAMEL

THESIS SUPERVISOR

ASSIST. PROF. NIHAT GÜMÜŞ

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by

NAEF AHMED NAIF SAEED ALKAMEL

A thesis submitted to the School of Graduate Studies in partial fulfilment of the requirements for the degree of Master of Science in Financial Economics

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APPROVAL PAGE

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Financial Economics.

Thesis Jury Members

Title - Name Surname	Opinion	Signature
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This is to confirm that this thesis complies with all the standards set by the School of Graduate Studies of Ibn Haldun University.

Date of Submission Seal/Signature

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ÖZ

MEME HISSE SENETLERİNİN BORSA ÜZERINDEKİ ETKİSİ: GAMESTOP MANIA

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Popüler Reddit platformundaki WallStreetBets forumu, yalnızca finansal piyasa katılımcılarının değil, aynı zamanda forumda toplanan perakende yatırımcılar olarak politika yapıcıların da dikkatini çekti, belirli menkul kıymetleri dolaştırıyor ve fiyatları yükseltmek için çoğunluğa atlıyor. Bu çalışma, bir meme hissesi ve Redditors'un yıldızı haline gelen GME'de Ocak 2021 ticaret çılgınlığında ve forumda toplanan perakende yatırımcılar ile Wall Street riskten korunma fonları arasında bir savaşı ateşleyen diğer manyadan etkilenen hisse senetlerini incelemektedir. Çalışma, perakende yatırımcılar arasında en popüler hisse senetlerine odaklanarak iç içe geçmiş bir ilişkinin destan öncesi zaman ufkundan önemli ölçüde farklı olup olmadığını ampirik olarak araştırarak ticaret çılgınlığının etkisini incelemek için bir VAR(p) süreci ve yapısal analiz araçlarını kullanıyor. Maninin zirvesi; GameStop (GME), AMC Entertainment Holdings Inc (AMC), Naked Brand Group (NAKD) and Koss Corporation (KOSS) ve geniş pazara yayılmaları. 23 Temmuz 2020'den 29 Haziran 2021'e kadar olan dönemi kapsayan günlük zaman dilimi verileri iki eşit veri kümesine bölünür ve iki ayrı modelde bağımsız olarak analiz edilir. Çalışmanın bulguları, ticaret çılgınlığının, efsaneden önceki zaman diliminde mevcut olmayan, hedeflenen menkul kıymetler arasında iç içe geçmiş bir korelasyona neden olduğunu gösteriyor. Bu, hisse senetleri yüksek oranda ilişkili hale geldikçe, bu tür alım satım faaliyetleri sırasında alım satım riskinin arttığı anlamına gelir. Bağlantılılık analizleri, geniş pazarın getiri oynaklığının

açıklanmasına katkısında önemli bir artışa rağmen, GME'nin verici olmayan bir hisse senedi olarak kaldığını göstermektedir. Çalışma, yatırımcıların, tüccarların, portföy yöneticilerinin ve kurumsal yatırımcıların alım satım veya yatırım kararlarını yalnızca geleneksel verilere dayandırmamaları gerektiğini, mem hisse senetlerinin fiyatlarını etkilemede önemli bir rol oynadıkları için alternatif verilerin de dikkate alınması gerektiğini belirtiyor.

Anahtar kelimeler: Mem hisse senetleri, Reddit çılgınlığı, Piyasa verimliliği, VAR

ABSTRACT

THE IMPACT OF MEME EQUITIES ON THE STOCK MARKET: GAMESTOP MANIA

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WallStreetBets forum on the popular Reddit platform has drawn the attention of not merely financial market participants, but also policymakers as retail investors gathering in the forum circulate tickers of certain securities and jump on the bandwagon in an attempt to push up the prices. This study examines what transpired in January 2021 trading frenzy in GME which became a meme stock and the star of Redditors and other mania-influenced stocks igniting a battle between retail investors gathering in the forum and Wall Street hedge funds. The study deploys a VAR(p)-process and its structural analysis tools to examine the impact of the trading frenzy by empirically investigating whether an intertwined association significantly differs from the pre-saga time horizon by focusing on the most popular stocks among retail investors during the peak of the mania; GameStop (GME), AMC Entertainment Holdings Inc. (AMC), Naked Brand Group (NAKD) and Koss Corporation (KOSS) and the spillovers to the broad market. The daily time frame data covering the period from 23 July 2020 up to 29 June 2021 is divided into two equal data sets and analyzed independently in two separate models. The findings of the work suggest that the trading frenzy caused an intertwined correlation between the targeted securities which was absent in the timespan prior to the saga. This implies that trading risk increases during such trading activity as the stocks become highly correlated. The interconnectedness analyses shows that GME

remains a non-transmitter stock despite a considerable increase in its contribution to the explanation of the broad market's return volatility. The study pinpoints that investors, traders, portfolio managers and institutional investors should not base their trading or investment decisions based merely on traditional data, alternative data should also be taken into consideration as they play a crucial role in influencing prices of the to become meme stocks.

Keywords: Meme stocks, Reddit frenzy, Market efficiency, VAR

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AMC	AMC Entertainment Holdings Inc
CAPM	Capital Asset Pricing Model
EMH	Efficient Market Hypothesis
ERS	Elliot, Rothenberg and Stock Test
FEVD	Forecast Error Variance Decomposition
FPE	Final Prediction Error criterion
GME	GameStop Corporation
HQ	Hannan-Quinn information criterion
IRF	Impulse Response Functions
KOSS	Koss Corporation
KPSS	Kwiatkowski, Phillips, Schmidt, and Shin Test
NAKD	Naked Brand Group Limited
NASDAQ	The National Association of Securities Dealers Automated Quotations
NFT	Non Fungible Token
NPV	Net Present Value
NYA	NYSE Composite
OLS-CUSUM	The Ordinary Least Square Cumulative Sum Test
PP	Phillips-Perron Test
RUT	RUSSEL 2000
SC	Schwarz criterion
SI	Short Interest
SPX	Standard and Poor's 500
VAR	Vector Autoregression Model

CHAPTER I

INTRODUCTION

1.1. General Introduction

The new year of the second decade of the 21st century had a rough start for all humanity as people lost their loved ones, the world economy tumbled upside down, and financial markets were rattled. States trying to win a battle against an invisible enemy causing human and economic losses, COVID-19. The pandemic was quick in growing and rapidly spreading to every corner of the globe. The viral started to appear in China by the end of 2019 and spread fast to the rest of the world as the new year was approaching. The public health emergency became a concern for every country as the effects of the virus started to eat its victims. Infected individuals with the severe form of the viral account for 15% of total cases reported (WHO, 2020). Older people and those with pre-existing medical conditions were likely to develop serious illnesses (Li et al. 2020). COVID-19 was diagnosed for the first time in Wuhan, China December, 2019 from thereafter bringing its negative effects to every country (Akanni and Gabriel, 2020). The virus was declared to be a pandemic after it hit the whole globe and caused countries to shout down in order to distance themselves from those who are most affected and to stop the spread of the virus. Due to the stay-at-home measures the world went into a period of economic meltdown. Figure 1.1 below is the Refinitiv Global Index which tracks the performance of global equities. The index has 4,020 constituents selected from different countries from a variety of sectors and industries. Figure 1.2 displays the Bloomberg Commodity Index for the year of 2020. The index is a basket of 21 commodities ranging from energy, grains, industrial metals, precious metals, softs, and livestock. The price of the index sharply decreased as the year approached sinking 26.7% in the first three months. Recovery signals were observed in late April as positive news of possible vaccines from different companies was announced. The lifting of lockdowns in some countries, successful vaccine trials and

granted authorisations for emergency use of some vaccines all contributed to the V-shape global economic recovery as depicted in Figure 1.1.

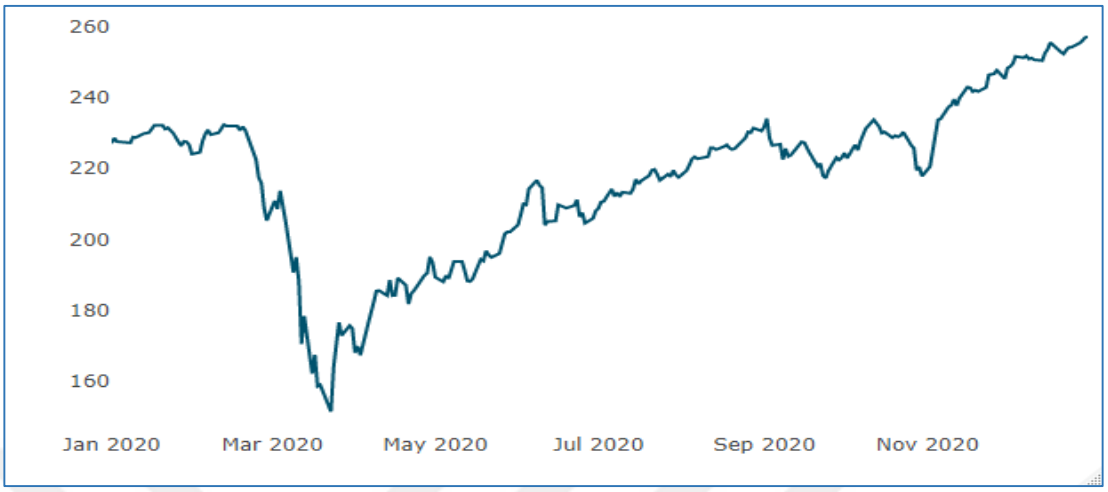

Figure 1.1. 2020 Refinitiv Global Index
Source: Data Retrieved from Refinitiv Database

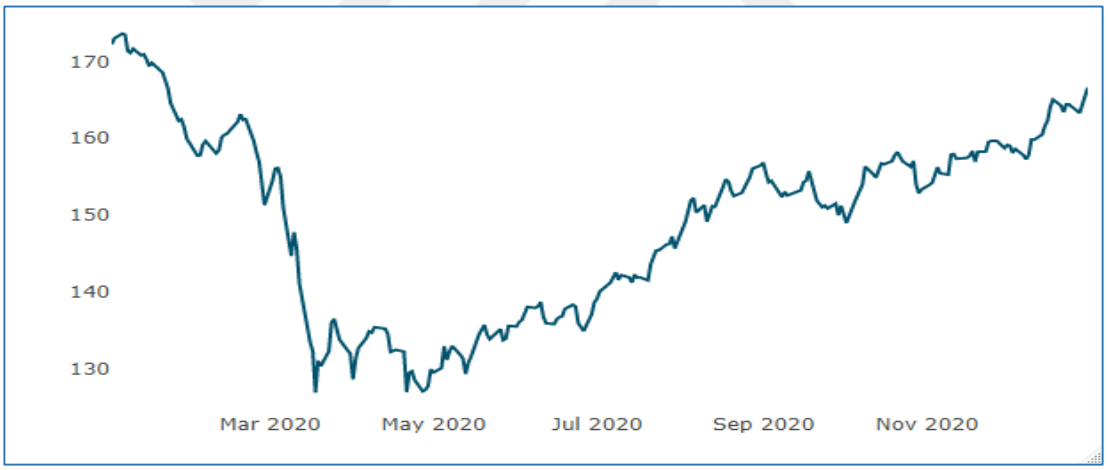

Figure 1.2. 2020 Financial Year Bloomberg Commodity Index Total Return
Source*:* Data Retrieved from Refinitiv Database

The curbs imposed in several countries caused a demand shock with consumption decreasing as people spent most of their time at home. All sectors saw a sharp weakening performance as they had their supply chains disrupted and several companies harmed – and that is where the standoff between hedge funds and retail investors gathering on the Reddit social media platform erupted. AMC Entertainment Holdings Inc (AMC) for instance which operates theatres around the globe had to close

down all its theatres globally facing a fall in revenue and weak fundamental results making it attractive for shorting.

GameStop (GME) which later caused a trading frenzy had to close its retail stores worsening its already weak performance and not delivering profits since 2017. Owing to that, hedge funds saw it as an opportunity to bet against such stocks with the belief that the stocks will sink further triggering huge short interest positions. There are a variety of motives for short selling that could be due to internal factors, for instance poor governance or high operating costs. Another motive is the expectations of a price decline based on technical analysis or bad fundamental results that missed market expectations. What makes short selling attractive is also the overall outlook of the market that increase systematic risk and cause a supply chain disruption and this was the main driver behind the GME frenzy. According to (McDonald & Baron, 1973), “Speculative "bear raids" by short-sellers were no longer practicable in the U.S. following the legislation of the early 1930s. Also, the prevailing opinion of technical analysts began to regard high short-interest as bullish rather than bearish. The demand of short sellers in buying to cover their positions was expected to result in higher subsequent market prices” (p. 98).

Subsequently, on the other side of the river, high short interest attracted individual investors and those stocks became meme stocks with GME at the top of the retail investors’ interests. A forum on Reddit named WallStreetBets is the gathering place where retail investors share tickers and arguably make a collective move to push prices of circulating tickers higher. Those stocks usually carry high SI as it is inevitable that short positions will need to be covered at some point in the future or at the F&O expiry date and those covering first would be the once to record lower losses. As retail investors started pilling money into the stocks, they saw a massive spike in the shares prices.

There are a number of beleaguered stocks that were targeted by the trading frenzy including GameStop (GME), AMC Entertainment Holdings Inc. (AMC), Naked Brand Group (NAKD) and Koss Corporation (KOSS) that are the focus of this study. Those stocks saw a massive price surge as the mania erupted. The paper shed the light on the Reddit herding effect aiming at examining its substantiality in the context of disturbing

the market and its efficiency by utilizing the VAR model and its structural analysis tools to examine the intertwined association of the four securities.

1.2. Background

1.2.1. Market Analysis

The rhythm and functionality of the financial markets have been the most controversial and most-talked-about topics in the world of finance as economists, practitioners, and academicians have been striving unceasingly to come up with a theory to explain how markets operate and identify the forces moving them in either direction. The efficiency of markets is broad in terms of definition and the criteria based on which a market may be said to be efficient. One of the convenient definitions is that a capital market is said to be efficient if it reflects information efficiently (Fama, 1976, as cited in Charted Financial Analyst [CFA], 2011, p. 319). There are a number of markets in advanced, emerging and underdeveloped countries which have been examined to whether be classified as efficient. A study by (Amoah, 2020) found five major factors that play a big role in classifying a market as weak form efficient which are small size and liquidity, lack of awareness of financial markets' products and activities, lack of availability of financial education programs, lack of efficient operational framework, and lack of competitive landscape.

In early 2021, a phenomenon took place in the US markets challenging the foundation of the financial system, its efficiency, and the basis for valuation as a battle between a vociferous army of buyers including WallStreetBettors[1] on one side and short sellers and hedge funds on the other. The historic moment in markets did not merely drew the attention of market participants but the White House as well and became the most-talked about stock among investors. As the battle intensified, the symptoms were seen in the overall market as a systematic contiguous effect prevailed. In just four days, the Standard and Poor's 500 (S&P 500) tumbled about 450 bps, the RUSSELL 2000 was down 420bps, and the Dow Jones Industrial Average (DJI) was down 320 bps over the same period between 26-29 January.

[1] Wall Street Bettors: are a group of retail investors gathering in a forum "r/wallstreetbets" on the popular social platform Reddit to discuss and share content related to investing.

The three charts depicted on the following page demonstrate the market movement of the prices and total logarithmic returns of the three major US indexes; S&P 500, New York Stock Exchange Composite (NYSE Composite), and National Association of Securities Dealers Automated Quotations (NASDAQ) for the month of January 2021.

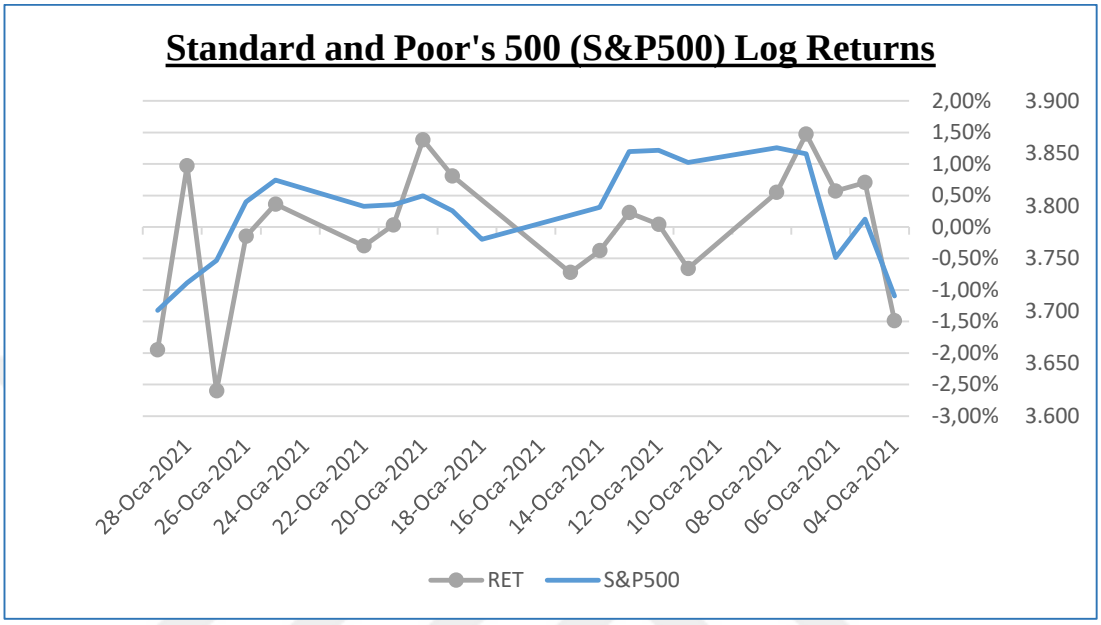

Figure 1.3. Standard and Poor's 500 (S&P 500), Log Returns and Price Chart, January 2021
Source: Data Retrieved from Refinitiv Database

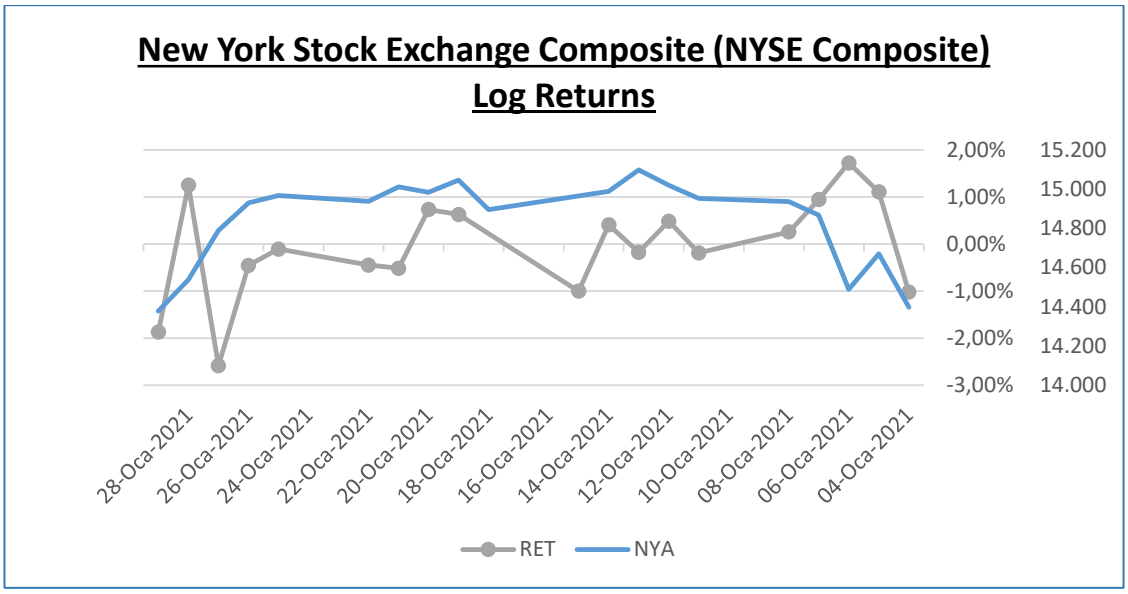

Figure 1.4. New York Stock Exchange Composite (NYSE Composite), Log Returns and Price Chart, January 2021
Source: Data Retrieved from Refinitiv Database

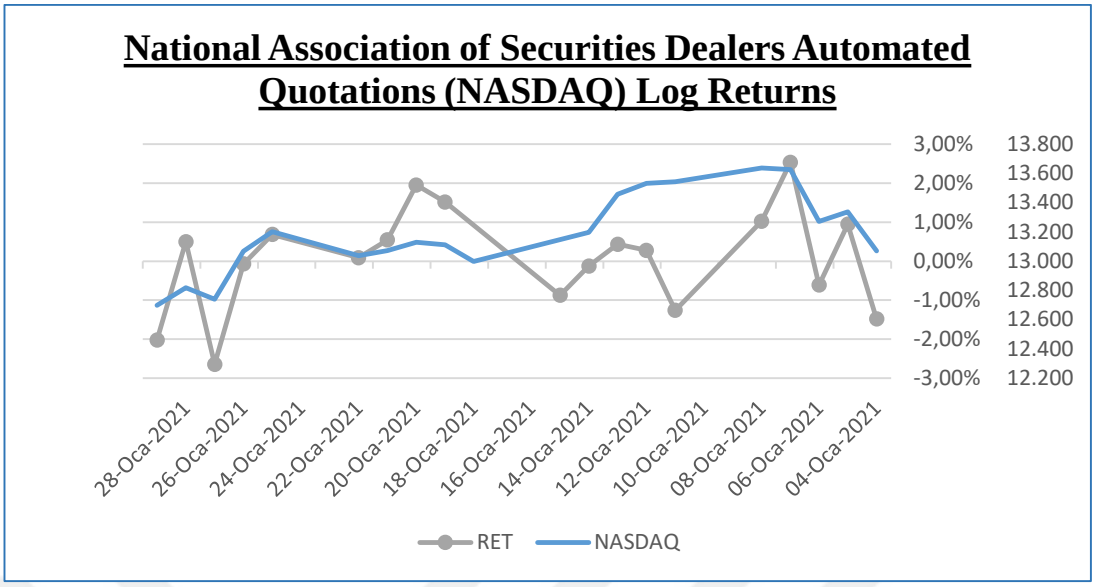

Figure 1.5. National Association of Securities Dealers Automated Quotations (NASDAQ Composite), Log Returns and Price Chart, January 2021
Source*:* Data retrieved from Refinitiv Database

1.2.2. GameStop

The name behind the frenzy was a Delaware retail company that has been trying to survive since the pre-pandemic time. GameStop is a US-based retail company offering video games, entertainment products, and second-hand games through its online platform and stores. GME is also a market player in the toy market. The company does not merely operate in the US; it also offers its products in three other geographic segments: Canada, Australia, and Europe. The retail stores total 4,816 as of January 30, 2021; 3,192 in the US, 253 in Canada, 417 in Australia and 954 in Europe – a total number of 1,624 international stores. With 1.7 million square footage, the company was forced to close down its stores worldwide. The store closure severely affected the performance of the gaming industry though not to the extent other sectors suffered. The temporary stay-at-home measures implemented again in some countries in response to the resurgence of reported cases, and the spread of the delta variant continued to adversely affect the performance of GME.

1.2.3. Fundamental Analysis

The company's results were a disappointing event before the pandemic came viral. Table 1.1 below displays some selected GME financial ratios for a period of five years as retrieved from the TD Ameritrade platform https://www.tdameritrade.com/. The ratios of the company seem to be modest over the past five years with some critical negative results. The company reported negative earnings per share of 6.81, 5.38 and 3.31 for three consecutive periods 2018, 2019, and 2020. The financial performance of GME is also fairly weak as it delivered disappointing ROE results of -37.9, -48.354 and -41.1 respectfully. The ROA is also not promising as the record shows suggesting poor use of resources. Regarding its liquidity, the company has sufficient funds to continue its operations for the foreseeable future.

GameStop has been struggling due to insufficient funds to scale up its operations and expend its range of stores in the geographies where they already exist. Another challenge is the rapidly changing technology as people move to other alternatives and the intense competition from the rivals in market size of roughly $18 billion as of 2020 in the geographic segments where it operates. In the following section, the thesis will look into the competition and, compare, and contrast the performance of GameStop to one of its aggressive rivals.

Table 1.1. 2016-2020 GME Financial Ratios (TD Ameritrade Data)

	2016	2017	2018	2019	2020
SHARE VALUES					
Earnings Per Share - TTM	$3.40	$0.34	($6.81)	($5.38)	($3.31)
Dividends Per Share - TTM	$1.48	$1.52	$1.52	$0.38	$0.00
Book Value Per Share	$22.32	$21.86	$13.10	$9.51	$6.69
Free Cash Flow Per Share	$2.53	$2.54	$1.45	($0.26)	($1.81)
Sales Per Share	$82.93	$84.21	$81.15	$73.90	$78.30

Table 1.1. (cont.)

PROFITABILITY					
Return on Equity (ROE)	16.295	1.5531	-37.908	-48.354	-41.08
Return on Assets (ROA)	8.4268	1.4732	-14.308	-13.28	-7.2348
Gross Profit Margin	33.041	27.642	26.583	29.519	24.746
Operating Profit Margin	6.9239	5.2532	3.8249	0.87844	-4.9845
Interest Rate	6.6012	6.9446	6.9201	9.171	9.3741
Net Profit Margin	4.1032	0.40599	-8.1228	-7.2827	-4.23
ACTIVITY RATIOS					
Total Asset Turnover	1.7507	1.7502	2.1261	2.3627	2.0585
Inventory Turnover	4.9001	4.9701	4.7632	4.2281	5.1286
FINANCIAL RATIOS					
Long-term Debt to Capital	26.555	26.972	26.087	40.706	33.093
Financial Leverage	2.1813	2.2052	2.9165	4.4754	5.662
Fixed Charge Coverage Ratio	10.381	7.7588	-12.259	-10.086	-6.9382
Quick Ratio	0.51297	0.51543	0.80799	0.51951	0.53906
Current Ratio	1.2153	1.5633	1.434	1.32	1.1553

1.2.4. Peer & Industry Comparison

The gaming industry is one of the most intensely competitive businesses and is vulnerable to the frequently changing consumer preferences and rapid upgrade of products. GME competes with various businesses including but not limited to mass merchants, PC and electronic shops, stores of video games and retail chains and other online platforms. In the region of Europe, GameStop competes with the Japanese gaming giant Sony and Microsoft along with other electronics retail stores among which are Media Market and FNAC in addition to Saturn. Its main competitors in the US include, among others, Wal-Mart stores, Target, Amazon, and most importantly

Best Buy Corporation. BBY is also a US company operating in North America. The company provides several products and services including consumer electronics and entertainment. Table 1.2 compares the two companies using fundamental and valuation ratios.

Table 2.3 compares and contrasts the analysis of GME compared to BBY and the overall industry. The data is subtracted from the stock profile of TD Ameritrade brokerage firm. The valuation ratios show that GME is highly valued in all three ratios. GME has a price to sales ratio of 2.77x, which is among the highest, compared to 0.51x for BBY and 1.1 for the speciality retail industry. The highest Price backs this outcome to Book value in the industry compared to a ratio of 6.14x for BBY and 6.27 for the industry. In terms of profits, the data shows mixed results as the retail company appears to outperform the industry in two critical ratios though the result is still negative while missing out on the gross profit margin that is still higher than its rival. The company reports a 24.63% GPM while reporting a -1.20% Net Profit Margin. The profit was most likely erased due to high operating and impairment expenses. The earning per share ratio is one of the most widely used ratios by financial analysts and market participants in evaluating a company's performance. The two EPS ratios shown in the table appears to be positive in percentage terms while relatively seem disappointing as the industry levels off at roughly 115% in the EPS Growth considering twelve trailing months. The most shocking results come from the effectiveness measures as GME shows poor results relative to its peers and the industry average as well. The records in the fourth section of the table show GME values of -6%, -2.26%, and -3.92% for ROE, ROA and ROI respectfully which is arguably the result of the low bottom line, inefficient use of assets and financial leverage balance. GME however appears to be liquid by holding sufficient cash to finance its operations, fuel expansion, increase the pay-out ratio and limit its financial vulnerability. This high liquidity is most likely due to the two at-the-market offering of shares programs the company completed raising $551 million and $1.13 billion. It was a smart move to make the most out of the monstrous rally of its stock owing to retail investors. The next technical analysis section deeply discusses and analyses the favourite meme stock of the WallStreetBets forum, "GameStonk".

Table 1.2. 2016-2020 GME & BBY Financial Ratios (TD Ameritrade Data)

	GME					BBY				
	2016	**2017**	**2018**	**2019**	**2020**	**2016**	**2017**	**2018**	**2019**	**2020**
Share Values										
EPS	$3.4	$0.34	($6.8)	($5.38)	($3.31)	$3.81	$4.18	$5.12	$5.75	$6.84
Sales Per Share	$82.9	$84.21	$81.2	$73.9	$78.30	$122.14	$137.25	$152.38	$162.77	$179.70
Profitability										
ROE	16.3	1.55	-37.91	-48.35	-41.08	27.03	24.04	42.32	45.42	44.58
ROA	8.4	1.47	-14.31	-13.28	-7.23	9.6	7.94	11.83	11.2	10.62
Gross Profit Margin	33	27.64	26.58	29.52	24.75	22.3	21.81	21.44	21.17	20.6
Operating Profit Margin	6.92	5.25	3.82	0.88	-4.98	4.81	4.4	4.53	4.7	5.6
Activity Ratios										
TAT	1.75	1.75	2.13	2.36	2.06	2.91	3.27	3.34	2.8	2.48
Inventory Turnover	4.9	4.97	4.76	4.23	5.13	6.04	6.41	6.2	6.35	-
Financial Ratios										
Financial Leverage	2.2	2.21	2.92	4.48	5.66	2.88	3.57	3.89	4.48	4.16
Quick Ratio	0.51	0.52	0.81	0.52	0.54	0.77	0.56	0.43	0.45	0.62
Current Ratio	1.22	1.56	1.43	1.32	1.16	1.48	1.26	1.18	1.1	1.19

Table 1.3. Peer & Industry Comparison as of October 2021 (TD Ameritrade Data)

	GME	BBY	Industry
Valuation			
Price/Sales	2.36x	0.51x	1.1
Price/Book	7.05x	6.14x	6.27
Price/CF	207.66	7.26	72.61
Profitability			
Gross Profit Margin	24.63%	22.75%	25.61%
Operating Profit Margin	-2.56%	6.04%	-8.96%
Net Profit Margin	-1.20%	4.84%	-12.17%
Growth Rates			
EPS Growth MRQ	16.17%	25.26%	256.12%
EPS Growth TTM	81.24%	58.56%	115.82%
Revenue Growth MRQ	-7.32%	1.82%	36.97%
Revenue Growth TTM	-0.15%	20.36%	26.33%
Effectiveness			
ROE	-6.07%	62.52%	670.01%
ROA	-2.26%	14.06%	12.45%
ROI	-3.92%	32.54%	22.48%
RPE	$465,583	$512,510	$404,273
Financial Strength			
Total Debt/Total Capital MRQ	2.50%	23.97%	67.58%
Quick Ratio	1.73x	0.54x	0.57x
Interest Coverage MRQ	(-116x)	267x	46.57x

1.2.5. Technical Analysis

Before GME became the start of retail investors gathering on Reddit, the spike in the price of GME started with the rumours of the coming of the co-founder and previous CEO of Chewy who is praised for his success in turning the e-commerce company into a successful business. The rumours of the appointment of the well-known Ryan Cohen as chairman of the board at GME were received as a surprise shock by the retail investors causing a parabolic surge in the company's price over a short period. Figure 1.6 shows the historical monthly line chart of GME for the period up to the end of 2020 reaching as high as 63.77 as the peak point on the 12th of July 2007 before starting

to decline in the months ahead. What should be notable here is the 2008 financial crisis that arguably contributed to the persistent downward trend of GME for months ahead. After the crisis started to fade and economies started to recover, the company's performance was doing better and the stock achieved another low high of 57.74 in November 2013 with the 60sh level not breaking out until January 2021.

The first month of the New Year was drastic for GameStop. The new comer was expected to transform the company and expand its online commerce operations. The event was arguably a complete changing point for GameStop as it was at a crucial time of its life cycle as the battle between retail investors and hedge funds erupted. The company suffered from the sudden stop affecting almost all industries. While the virus had not as severely influenced the gaming industry as certain other consumer businesses, store closures during the stay-at-home orders hurt the operations and sales of the company. GME reported worse than expected revenue in the third quarter of the year 2020 down 30% from the same period the previous year causing its share to plummet around 20% the following day; the 9th of December 2020 to end the trading session at around $13.66. The company outlook did not look promising for the downward benefiting groups encouraging them to have the stock heavily shorted. While the outlook did not look attractive for the hedges, the extent of short interest was looking promising for the group on the other side of the battle.

Figure 1.6. GameStop Company (GME), 01-02-2002 up to 01-12-2020 Historical Price Chart

Source: Historical Prices Retrieved from Refinitiv Database

Figure 1.7 below depicts the short interest of GME ranging from 2007 up to February 2021. The SI is computed by taking the number of shares shorted in the nominator divided by the shares outstanding. As the graph shows, the short interest of GME is a lot ambiguously greater than the market average. The upward trend started to shape early 2009 and since then it has been increasing with some drawbacks. Since early 2019, the year before the pandemic hit, GME SI had been rising mainly due to weak fundamental results. In early 2020, SI massively increased breaking above 100% in January reaching 122.97% as a percentage of float, which is not common and seldom happens in the financial markets. GME SI is the only stock that observed shares lent more than its float that is due to the lending of the same shares shorted. GME SI is thus greater than the other meme stocks influenced by the saga including DDS with around 77%, BBBY 66%, AMC 11.4% and NAKD 7.3%. Retail investors anticipated an inevitable short squeeze – which is notoriously swinging in nature - as short sellers must cover their positions en masse. When the time comes this would have the stock experience the same scenario that KBIO, and Volkswagen experienced in October 2008. The buying pressure was not merely coming from the lovers of "the mother of all short squeezes", institutional investors with at least $50 million in assets including short sellers were also pilling into "GameStonk". Some of those buys most probably owing to the potential to cover short positions by some hedge funds that usually cause a quick spike in a share price, which is the case in GME price. This purchase to cover is referred to as a short squeeze.

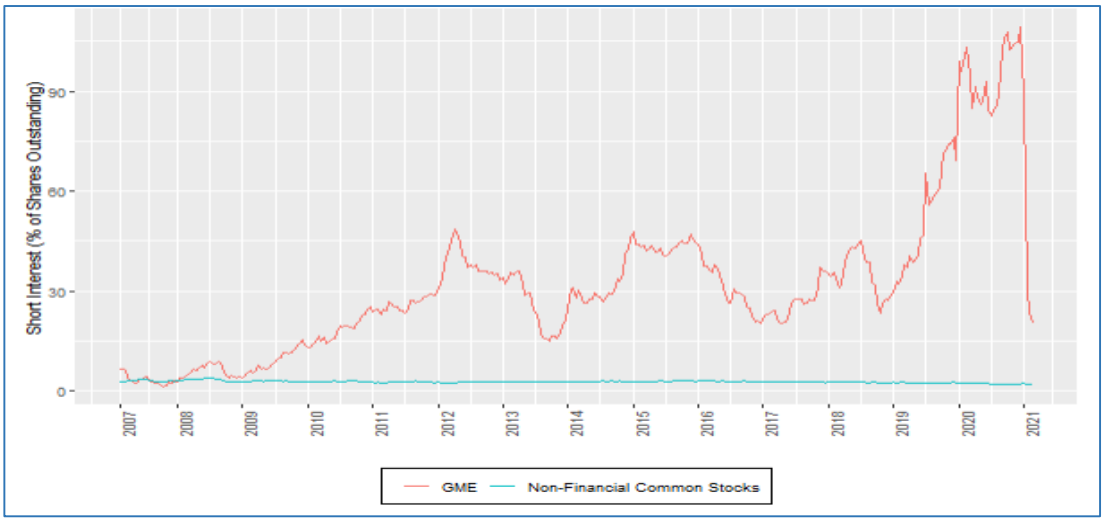

Figure 1.7. Historical Short Interest in GME against the Market, January 2007 to February 2021
Source: SEC report

Figure 1.8 below shows the portion of purchases by segments for the month of January 2021. Retail investors represent the biggest buyers with a share purchase spike by the end of the month emphasizing the thesis that GME's sharp spike was mainly driven by individual buying pressure. The number of accounts considered unique was around 10,000 while on January 27th reached as high as 900.000 accounts. The graph suggests that the bullish sentiment is what sustained the price surge for weeks rather than the buying-to-cover process and this sentiment could be due to either the intention to squeeze hedge funds or a belief in a promising future for GameStop where the first is more likely to be true.

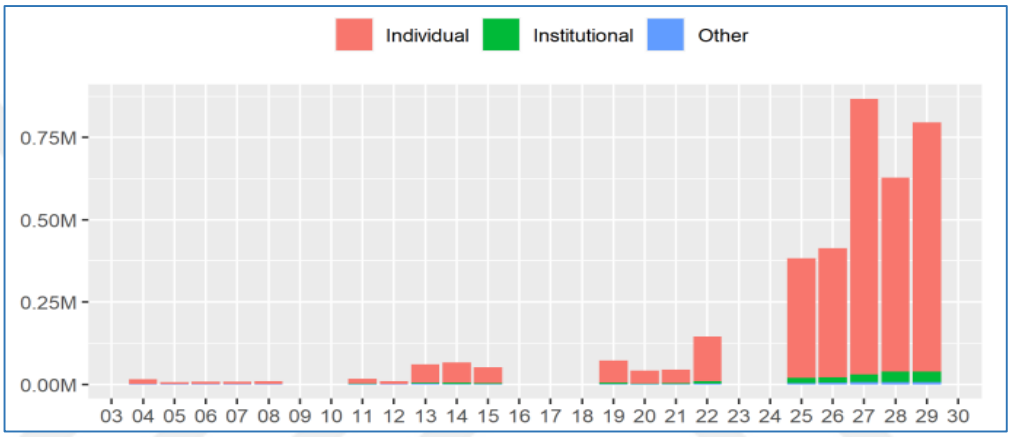

Figure 1.8. Daily Numbers of Accounts Trading GameStop by Category For The Month of January 2021
Source: Consolidated Audit Trail

In line with price action, GME option trading was a massive surge as the mania started. For the first nine month of 2020, the traded options of GameStop were at a median of approximately 16,000 contracts in a day with a peak level of 172,000 in a single day. In terms of dollars, the median is $800,000 with a maximum of around $42 million in a single day. In the last quarter of 2020, options traded were at a median of around 84,000 with as high as 560,000 in a single day. However, as shown in the graph below, on the single day of 27th January 2021 around 2 million contracts were exchanged accounting for almost $8 billion just for that day. A drastic change a day before restrictions took place. Most of the traded contracts were call options with short expiry dates. The large call volume indicates a bullish sentiment in the stock however with this high options trading volume, implied volatility also spiked. IV incorporates among other inputs the volatility of the security itself. The nice graph by Bloomberg in Figure 1.11 depicts the IV of three different durations with the security price.

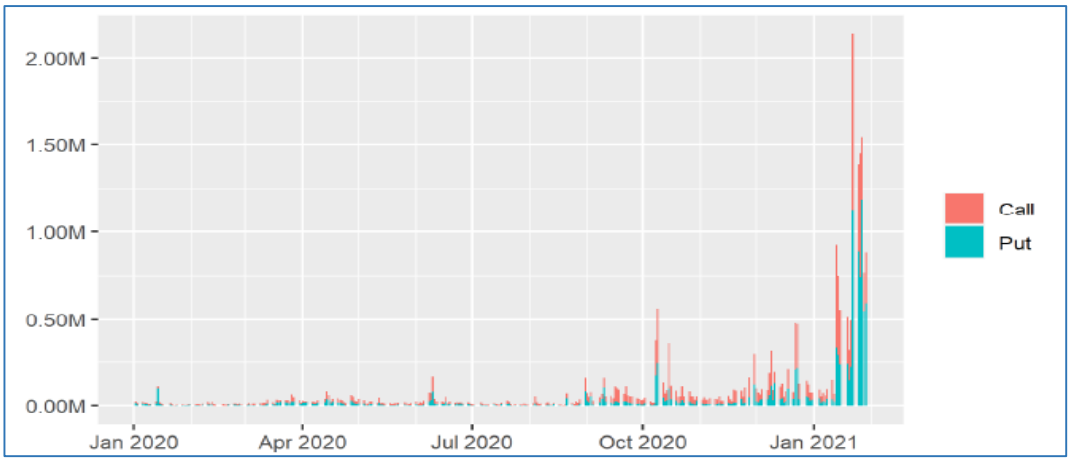

Figure 1.9. The Volume of GME options Contracts 2020 up to January 2021
Source: OPRA, MIDAS Vendor-Supplied

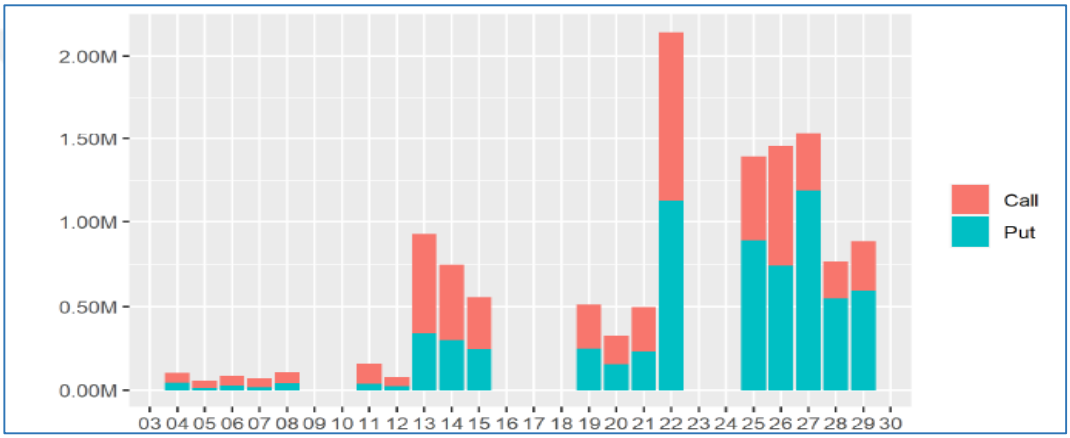

Figure 1.10. The Volume of GME Options, January 2021
Source: OPRA, MIDAS Vendor-Supplied

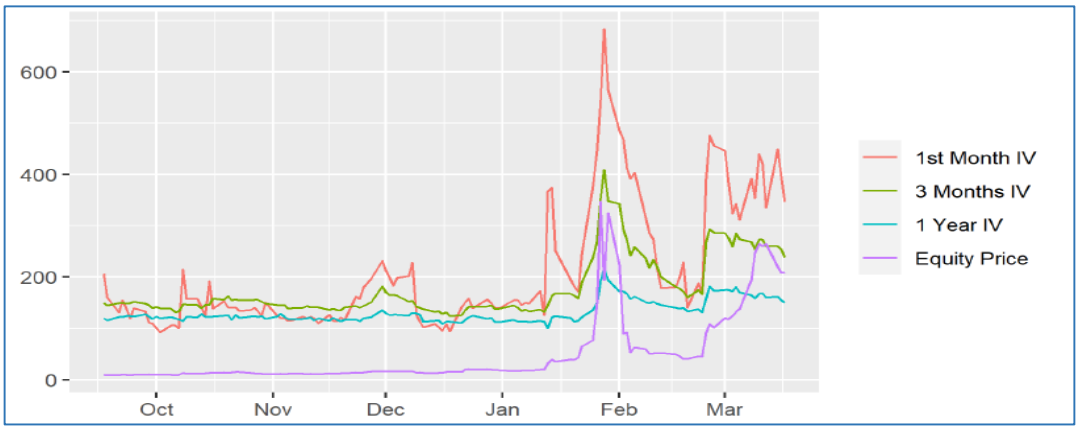

Figure 1.11. IV for Three Types of GME Contracts against Closing Price
Source: Bloomberg

Retail investors anticipated an inevitable short squeeze, which is notoriously swinging in nature - as short sellers must cover their positions en masse. When the time comes

this would have the stock experience the same scenario that KBIO and Volkswagen experienced in October 2008.

With that sentiment, the price of GME and other saga-influenced stocks were set to witness a drastic rise. The to-become-meme-stock GME soared more than 170,000 bps from January 13 to the 27th market close of the same month. The frenzy contagion was also evident in the other stocks. AMC spiked a modest 86,000 bps in the same period. The drama in the financial market is detailed below. Figure 1.12 displays the price action and volume of GME for the months of January-February 2021. The ticker of the company started circulating in the Reddit forum after the company announced the appointment of three new directors to its team on 11th January, which was accompanied by a spike in volume as depicted in the graph. The announcement effect was reflected in the price in the following few hours hovering around $38.65 on the 13th before levelling off at $31.4 with the volume exploding on that day from around 6.4 million up to 144.5 million. A spike of 5000 (50%) bps since the announcement. The coming of the new management appoints triggered the thoughts of the retail investors about the company being undervalued and its growth potential not witnessed. An investor who is popular in the r/wallstreetbets named Gill - playing a big role in the frenzy - was already holding position and shared a video where the stock was trading at around $4 and indicated that many would not pile into the stock right now.

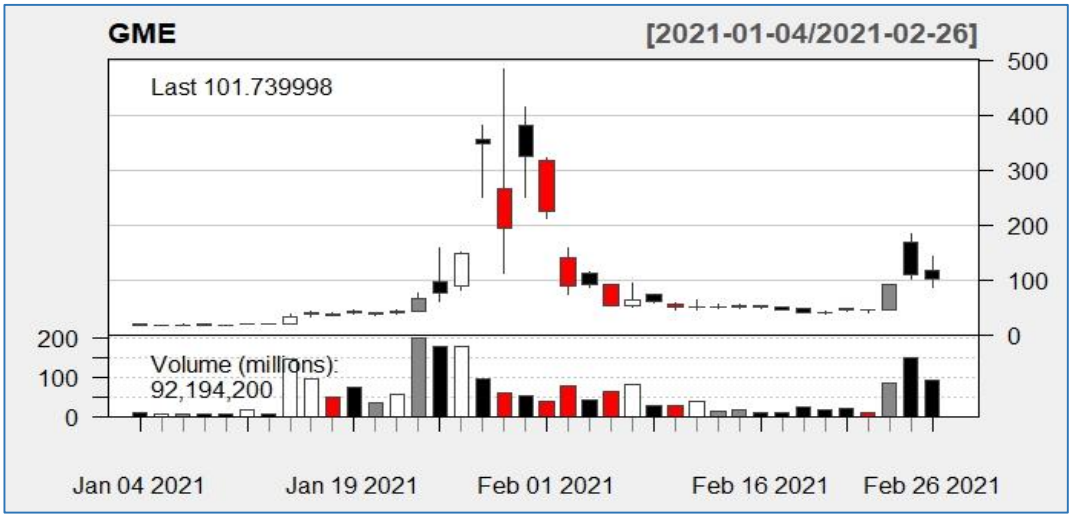

Figure 1.12. GME Price Chart for January 2021- February 2021
Source: Historical Prices retrieved from Refinitiv Database

The other driver of the stock is the high amount of SI positions explained earlier and shown in Figure 1.7 held by hedge funds betting against the stock. People started circulating the ticker more frequently in the forum and sharing screenshots of their positions and profits cheering more people to participate.

From 153 on the first day of January, the mentions of GME in the social network increased up to 6,543 on the 13th of January reaching its highest on the 27th, which is the peak day. The other three stocks were lagging behind as they witnessed high frequency of mentions at the saga peak. The tweet by Citron Group on the 19th was added to the kindling. “Tomorrow am at 11:30 EST Citron will livestream the 5 reasons GameStop $GME buyers at these levels are the suckers…” (Citron Research). In a matter of days, GME skyrocketed another %50 to close at $65.01 from an opening price of $42.59.

The beast continued to rise during the extended hours before opening the session of the new week, 25th January at $96.73 reaching as high as $159.18 where it tumbled to close the session lower at $76.79. The drawback was more likely some rest for the stock to take a breath before it saw a continuation the following day. What fouled the frenzy is a tweet from Tesla's Elon Musk on 26th January in the extended trading hours with one word “Gamestonk!!” sending the price flying at a whopping140,000 (140%) bps at $354.83 on the 27th January closing session. Musk is a popular figure not merely in the Reddit forum but around the globe thanks to his transformational leadership and the implausible success with SpaceX, Neuralink and Tesla striving to change the way people live and combat the most pressing issue threatening all humanity; Climate Change.

By this far some of the short positions were closed with Citron Research recording a loss of 100% on their GameStop position and Melvin Capital losing 53% of its summed investments in that month. Other stocks also benefited from the saga. Figures 1.13, 1.14, 1.15, and 1.16 display the historical data of Reddit mentions as retrieved from (Quiver Quantitative) https://www.quiverquant.com/ for GME, AMC, NAKD and KOSS, which are the Reddit favourite tickers.

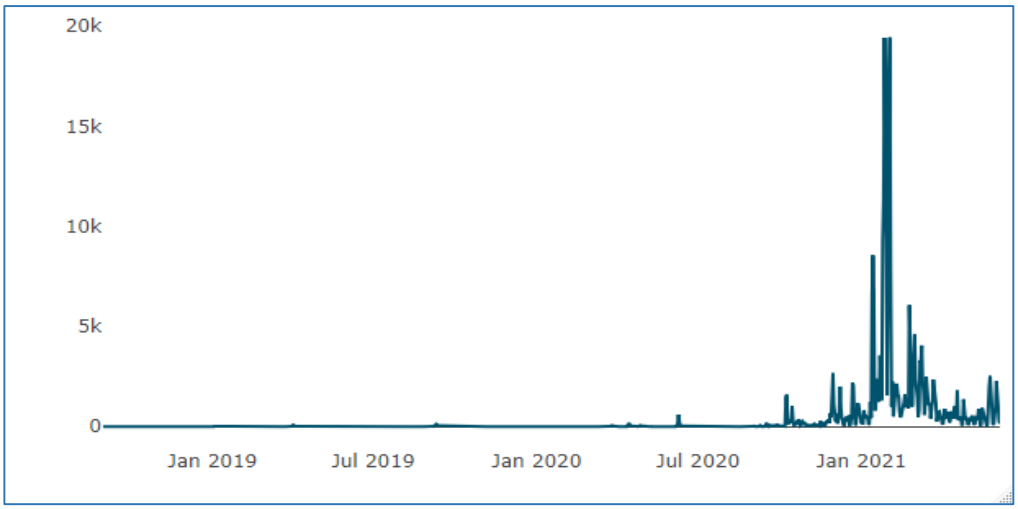

Figure 1.13. 31-08-2018 up to 06-06-2021 GME Historical Reddit Mentions
Source: Data Retrieved from Quiver Quantitative

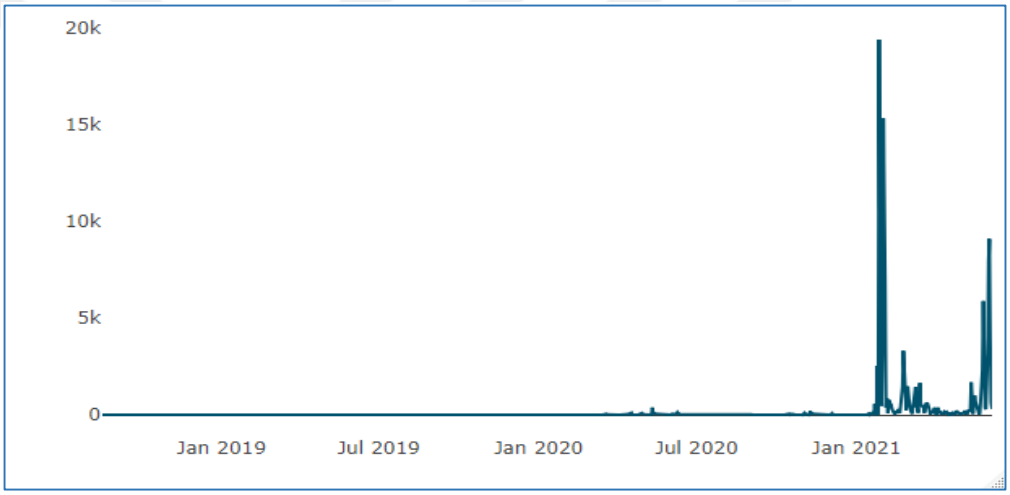

Figure 1.14. 17-08-2018 up to 06-06-2021 AMC Historical Reddit Mentions
Source: Data Retrieved from Quiver Quantitative

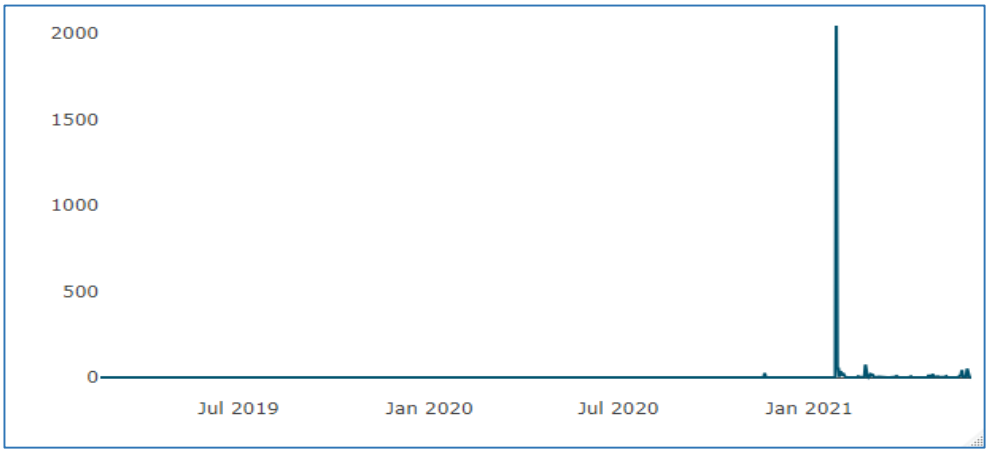

Figure 1.15. 18-02-2019 up to 06-06-2021 NAKD Historical Reddit Mentions
Source: 1 Data Retrieved from Quiver Quantitative

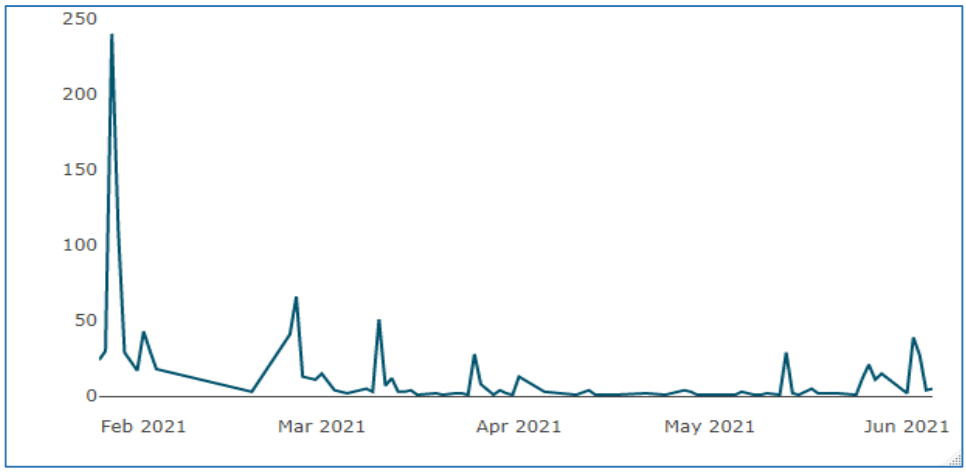

Figure 1.16. 25-01-2019 up to 05-06-2021 KOSS Historical Reddit Mentions
Source: Data Retrieved from Quiver Quantitative

1.2.6. Market Structure

It is of great importance to comprehend the market structure to understand what happened in January. In the financial markets, a retail investor starts investing in the financial market by first opening an account with a retail broker-dealer, Fidelity Investments, Charles Schwab, Robinhood, TD Ameritrade, and Robinhood among others. The investor places an order through the individual account they already established. Then the dealer takes the order and routes it to a trading centre for execution, such as market makers, securities exchanges, or alternative trading systems. Once the trade is executed, the investor receives a notification of that and the transaction is reported by the assigned agency which then collects and distributes the price and volume to data providers. The transaction is also sent to a registered clearing house whose job is to verify the trade and match the information of the two sides involved in the trade and settle the trade within two days known as (T+2) by transferring the stock from the seller's to the buyer's account and the amount in dollars among the brokerage firms Cox et al. (2021, p.340).

When people decide to trade, they can open two types of accounts, a cash account or a margin account. In the first type, an investor is responsible for and has to pay the whole amount of a security while in the margin account a loan can be taken from the broker-dealer with the available stocks in the account serving as collateral. To trade options, an account holder should fill out a form asking questions about their income and their risk tolerance, and accordingly, the dealer-broker may limit the options

trading to options with a certain amount of risk. Brokers have developed new ways to attract customers including offering free commission trading which was pioneered by Robinhood[2]. Some brokers generate most of their revenues from payment for order flow mechanisms, advisory services, and loan interests among others encouraging more and more individual investors to participate.

The execution of an option is identical to that of stocks with little difference. In terms of a settlement, options settle in one business day (T+1). The number of options series is pretty large at around one million series compared to 10,000 listed securities which make it less subjected to limit orders on a trading order book and prices are recorded as per market makers' quotes. Those self-regulated agencies such as securities exchanges, clearinghouses, and the national securities associations mainly FINRA are monitored by a watchdog which is the commission. Those agencies in turn work as regulators for the brokers who have memberships.

1.2.7. Trading Restrictions

As the mania intensified, on the 28th of January 2021 retail investors were sent in a shock when they logged in to their accounts and could not make a buy order on GME and other stocks. It was realized that eight stocks were restricted from trading including GME, AMC, NAKD, and KOSS and account holders are only allowed to place a position closing order. On January 29, the PCO was left by the broker-dealer to set quotes on the purchase of stocks and options with a margin requirement of 80% before lifting it to 100% on accounts with a position on GME. The table below shows the first list of all the companies that were restricted by Robinhood. The broker released a statement later stating that the firm made a hard decision to restrict some of the stocks in order to meet financial duties among which are the SEC net capital obligation and the clearing agency deposits which could be substantial in a highly volatile environment (Robinhood, 2021). The decision provoked retail investors and prompted an atmosphere of rage in the Reddit forum as the action was seen as a way of market manipulation or a tactic to save hedge funds shorting mainly GME. The transparency and democracy of the market were under question and the broker was attacked by

[2] Robinhood: is a brokerage firm that provides among its other services a trading platform where retail and institutional investors trade stocks, options, cryptocurrencies …etc.

several decision makers and public figures in response to the unanticipated move. Alexandria (2021) who is a member of the Financial Services Committee wrote in a tweet that the action is not acceptable and criticized restricting the retail investors while hedge funds can purchase with no limits; supporting a hearing to know more about the decision by Robinhood. Another tweet by the congresswoman Rashida (2021) attacked the decision taken by Robinhood and called it a market manipulation to protect the hedge funds using the financial market as casino for several years.

The event did not end here and indeed a hearing was called. The CEO of Robinhood appeared in a Congressional hearing to testify over what the firm did and if the narrative that pressure from hedge funds played a role besides others including Gill of Reddit forum. The question that many were wondering about is whether the limitation of buying certain amounts of a security or its options is right. The tables below and in the next pages shows the stocks restricted by Robinhood.

Table 1.4. Initial List of Robinhood Restricted Equities

Symbol	Shares	Options Contracts
AAL	55	50
AMC	115	100
BB	65	100
BBBY	30	50
CTRM	1650	N/A
EXPR	200	100
GME	5	10
KOSS	25	N/A
NAKD	750	N/A
NOK	110	100
SNDL	1200	100
TR	25	50

Source: https://www.theverge.com/2021/1/29/22256419/robinhood-limits-wall-street-bets-stock-buys

This question was answered in a report about what transpired in January, 2021 by the SEC released on October 14, 2021. “In their customer account agreements, some

broker-dealers reserve the right to decline customer orders or cancel trades without prior notice. Such actions could be taken, for example, for legal, compliance, or risk management reasons" (SEC, 2021). The response maintains that the limitation of stock purchasing is permissible so long as it is indicated in the agreement signed by the customer when establishing an account with a broker-dealer. As volatility was high, the brokers took advantage of the enclosed rule in the agreement and exercised the right to limit certain stocks as a risk management tool according to a tweet (Robinhood, 2021).

As things cooled down restrictions were eased though other stocks were added to the list. The table below shows the updated list and Table 1.6 displays the third updated list as the data provided by The Verge before all restrictions were removed

Table 1.5. Second List of Robinhood Restricted Equities

Symbol	Shares	Options Contracts
AAL	5	10
AG	5	S
AMC	10	10
AMD	1	S
BB	5	10
BBBY	2	N/A
CTRM	100	N/A
EXPR	5	10
GME	1	5
GTE	150	S
JAGX	30	S
KOSS	1	N/A
MRNA	1	S
NAKD	50	N/A
NCITY	5	N/A
NOK	20	10
RYCEY	75	S
SLV	5	S

Table 1.5. (cont.)

SNDL	**600**	**10**
TR	25	10
TRVG	400	10
WKHS	3	S
XM	2	S

Source: https://www.theverge.com/2021/1/29/22256419/robinhood-limits-wall-street-bets-stock-buys

Table 1.6. Third List of Robinhood Restricted Equities

Symbol	Shares	Options Contracts
AAL	1	10
ACB	1	Standard limits apply
AG	1	STANDARD
AMC	1	10
AMD	1	S
BB	1	10
BBBY	1	10
BYDDY	1	N/A
BYND	1	S
CCIV	1	S
CLOV	1	S
CRIS	1	S
CTRM	5	N/A
EXPR	5	10
EZGO	5	N/A
GM	1	S
GME	1	5
GTE	5	S
HIMS	1	S
INO	1	S
IPOE	1	S
IPOF	1	S
JAGX	5	S
KOSS	1	N/A

Table 1.6. (cont.)

LLIT	**5**	**N/A**
MRNA	1	S
MUX	5	S
NAKD	5	N/A
NCTY	1	S
NOK	5	10
NVAX	1	S
OPEN	1	S
RKT	1	S
RLX	1	S
RYCEY	5	S
SBUX	1	S
SHLS	1	N/A
SIEB	1	S
SLV	1	S
SNDL	5	10
SOXL	1	S
SRNE	1	S
STPK	1	S
TGC	5	N/A
TIRX	1	N/A
TR	1	10
TRVG	5	10
TRXC	5	S
WKHS	1	S
XM	1	S
ZOM	5	N/A

Source: https://www.theverge.com/2021/1/29/22256419/robinhood-limits-wall-street-bets-stock-buys

Figures 1.17, 1.18 and 1.19 depict the January-June charts of GME, AMC, NAKD and KOSS orderly. The effect of the restrictions caused a plunge in all the four stocks on the date of the imposition. GME on January 28th reached a high of 483 when it fast plummeted 77% falling to 112.25 before it bounced back due to a reaction from the

market to the tweets and comments of public figures and critics of policy makers to level off 193.6. GME dragged down others as well with AMC, NAKD and KOSS falling about %47, %59, and 67% respectively from the intraday highs.

Another spike emerged on the 24th of January, the fourth day of trading after the testimony of Vlad (CEO of Robinhood Markets, Inc., Griffin (CEO of Citadel LLC), Plotkin (CEO of Melvin Capital Management LP), Huffman (CEO & Co-Founder of Reddit), Schulp (Director of Financial Regulation Studies of Cato Institute), and Gill (investor) in a virtual hearing before the U.S. House Committee on Financial Services. In a span of less than two weeks, GME redefied gravity rising about %585 to close at $265 on the 10th of March from a close of $40.69 on the 18th of February. The mania cooled down thereafter and the price of GME was hovering around above $100 until late May when a Pennant pattern shaped as depicted in Figure 1.17 drawing the attention for a breakout and a run to the upside.

The week starting on the 24th of May 2021 regained the drama in the equity markets. GME saw a price increase fuelled mostly by "Reddit-geddon" as they are bullish on the news coming out from the first quarter of 2021 earnings report to be public on the 8th of June 2021 in the extended hours trading session combined with the high positions of those betting for the decline of the price. The gains accelerated further as short sellers saw persistent price increases pushing higher that gouged some of them to squeeze. "Around 958,000 shares of GameStop, worth $201 million, were bought to cover short sales over the last week, S3 data showed. Roughly 11.55 million shares of GameStop, or 20.3% of its float, are currently sold short, Dusaniwsky said" (Carew, 2021). The same article indicates that incurred losses by bearish investors increased up to $6.7 billion only on GME and $1.37 on AMC since the start of the year with currently around 20% of its floating shares shorted as of this date (Carew, 2021).

Figure 1.17. GME Daily Price Candle Chart for the Period January 2021 - June 2021

Source: Historical Prices Retrieved from Refinitiv Database

Figure 1.18. AMC Daily Price Candle Chart for the Period January 2021 - June 2021

Source: Historical Prices Retrieved from Refinitiv Database

Figure 1.19. NAKD Daily Price Candle Chart for the Period January 2021 – June 2021

Source: Historical Prices Retrieved from Refinitiv Database

Figure 1.20. KOSS Daily Price Candle Chart for the Period January 2021 - June 2021

Source: Historical Prices Retrieved from Refinitiv Database

Since the epic rise of the stock in January, investors look at the price chart differently as new patterns emerge. The stock almost touched its resistance point on May 25th which was cautiously followed by investors to witness whether an upward breakout will take place leading to a continuation. The level built is on a Pennant pattern as depicted in Figure 1.17. Flags and Pennants exhibit similar characteristics and are common in financial markets. They are "…among the most reliable of continuation patterns and only rarely produce a trend reversal" (Murphy, 1999, p 142) and are followed by market practitioners particularly technicians. The sharp decrease in the price after its drastic spike was normal in the eyes of technical analysts as the stock takes time off to cool down. The *flag* and *pennant* represent brief pauses in a dynamic market move. In fact, one of the requirements for both the flag and the pennant is that they are preceded by a sharp and almost straight line move. They represent situations where a steep advance or decline has gotten ahead of itself, and where the market pauses briefly to "catch its breath" before running off again in the same direction. (Murphy, 1999, p 141)

As evident in the GME price chart, the pennant shape is constructed and reached its final stage where it is set to reverse back to its previous direction. The following two days of the week were critical to see where the direction of the meme stocks led by GameStop was. GME opened higher the following day and saw its Pennant resistance level get broken with three factors arguably behind the surge. First, the technical

analysis indicates an upward movement. Second, the company revealing that it will launch an Ethereum-based NFT marketplace platform, for which it has already begun hiring a team. The company released an NFT-themed website, nft.gamestop.com, which reads “Power to the players. Power to the creators. Power to the collectors.” (Cnbc, 2021). Third, the earing announcement of the first quarter. The 217sh level set as a resistance point was finally broken the following day along with an increasing volume from 14.9m on May the 25th to 21.1m on May the 26th and the price held above the pattern line continuing the rally to close on June 8th at $300 up around 44% from its closing session price of 209.43 on the 25th. The earnings on the 9th of June bet market expectations with better than expected financial outcomes. The company reported negative 0.45 EPS vs the market Wall Street estimate of negative 0.67 however the reaction of the market was otherwise. The stock ended in two days sinking about 27% from its previous close on June 8. The plunge is mostly attributed to the announcement of the company to raise capital through a sale offer and the news of an investigation with the SEC ending the surge continuation of the star of retail investors and ending on a sour note.

On 27, January 2021, the peak date of the frenzy a day before retail investors were barred from buying GME and other stocks by some platforms, GME levelled off at the close of roughly 200 points or 13500 (135%) bps. Some of the stocks that also surged thanks to the GME effect - but not limited to - AMC Entertainment Holding, Nakd Brand Group, and KOSS corporation. AMC ended the trading session skyrocketing approximately 300,000 (300%) bps, NAKD spiked roughly 260,000 (260%) bps higher, while KOSS recorded a meteoric rally of 500,000 (500%) bps in just one day.

CHAPTER II

LITERATURE REVIEW

2.1. Theoretical Literature Review

The ownership of the company has changed significantly over the past few months and investors adjusted their holdings on GameStop. Morgan Stanley more than doubled its stake in GME during the last quarter of 2020 lifting its position from 2.2 million shares to roughly 4 million shares in total that is worth around $80.5 million. Senvest Management LLC grew its position by around 57% accounting for 1.8 million shares in the same period. It now owns a total holding of roughly 5.05 million shares amounting to $95 million. Must Asset Management Inc. took a new position pilling $18.4 million in the retail company in the last period. BlackRock Inc. increased its position in GME by 616 thousand – around 7% increase - shares in the fourth quarter and has now around 9.2 million shares with a value of $172 million. Arrowstreet Camital Limited Partnership entered a new stake in GME in the first period valued at roughly $32 million. The total equity of GameStop owned by institutional investors and hedge funds stands at 36.56% (Rhoads, 2021).

Alexander argues that there are two assumptions for the “random walks” theory in the prices of stocks to be valid which are first the price of a security today should be independent of the prices of the past and second the price changes should exhibit some probability distribution. The most critical hypothesis is the independence of prices otherwise, the theory is considered to be invalid. Regarding the form or the shape in the random walks general theory, there is no need for specification. Therefore and regardless of the distribution shape, if the distribution chimes with the process for the price changes generation then it is a random walk and the theory applies (Alexander, 1961).

However, indicating the form of the distribution plays a big role in the eyes of investors. It is not uncommon for the shape of the data to be a factor when evaluating

the extent to which an investment is risky in common equities. It is possible to have two different price-changes shapes sharing identical means and expected changes in price with one of which having a high probability of possessing much greater price changes than the other. Knowing the shape of the distribution is also vital in academia as it provides descriptive statistics regarding the nature of the data and how the changes are generated. For instance, if we observe frequent large price changes meaning a high dispersion in the data, one could conclude that frequent shifts from period to period occur in the source of the changes generation itself. Moreover, the shape of the data is also important for those conducting imperial research in the area. The data under analysis greatly determines the appropriate statistical tool to which it is deployed (Fama, 1965).

The GameStop saga raises severe concerns and calls into doubt the "efficient markets hypothesis." The ripple effect of the GME tale spread, driving the prices of several other meme stocks circulating on social media platforms - mainly the Reddit forum - to skyrocket as abnormal returns were made in a short period. As per Fama (1970), an efficient financial market fully includes all publicly available information, implying that efficient markets exist in real life, such as the US bond and stock market. A study by Kristoufek & Vosvrda (2013) on global indices averred that Markets that are more efficient are mostly found in Europe, with Japan being the most efficient, whereas markets that are less efficient are primarily found in Asia, Latin America, and the Oceania region. On top of that, Daniel & Titman (1999) affirms in their research that “adaptive efficiency” testing for whether the U.S. equity market is somewhat represents a weak form of efficiency rejects the hypothesis.

In plain English, an investor or a financial institution operating in the financial market does not have the potential to consistently outperform the market, and all resources devoted to the analysis and selection of assets are futile. Rather than wasting valuable resources in the expectation of earning superior returns by adopting an active money management approach, an investor should pursue a passive strategy in which the portfolio is not frequently modified to changes in market prices. By stating the three argument in which EMH has its basis. One of the arguments is that securities’ valuation is based on rationality where the value of a security is derived from its fundamentals by applying present value models as investors are assumed to be rational.

Doing so, when new information or announcements that have fundamental roots pops up and investors receive this information, they rapidly react positively when the news is positive and negatively when the news is negative. Therefore, the information that is available to the public is fully reflected in the price of a security almost immediately and as the NPV changes due to the new information effect, the adjustment in the price level will follow the same direction. Second, when irrational acts take place, those positions will be random without the valuation of fundamentals counted for canceling one another to seize the effect on the market prices. Third, in an identical way to participants in the financial market that are not rational, their behaviour will attract rational arbitrageurs whose reactions will eliminate the non-fundamental effects (Shleifer, 2000).

Arbitrage has been given several definitions in academia; however, a definition in a book by Sharpe & Alexander (1994) specifies arbitrage as the trade of the same security or identical securities in different listing venues simultaneously at favoured prices. Due to irrational participants in the market, an arbitrage opportunity will be created as the price of the security is pushed higher due to the correlated trades of those unsophisticated participants causing the stock to be unfavourable as it is overpriced when compared to its fundamentals based price. Bearing this value exceeding the adjusted to risk NPV of a given securities flows, rational investors and arbitrageurs would close their positions or take a short-selling position in the stock and concurrently execute purchase transactions in other identical stocks to hedge their positions against risk. Consequently, those transactions will have an impact on the price of the security to the extent that it is brought back to its fair price. The transactions by arbitrageurs will yield gains however, as they compete with one another it is not possible to earn abnormal returns and the value of the stock can never deviate much from its fundamentally based price in the case that arbitrageurs react quickly and effectively. A similar process occurs in the market when a security is undervalued. Investors and arbitrageurs open positions in the under-priced security and short identical securities for hedging purposes against risk. This process will bring the security back to its fair value through unsophisticated or irrational investors participating in the market, so long as close substitutes for a given security exists in the market place.

2.2. Empirical Literature Review

The evidence for the theoretical EMH is impressing nonetheless, the empirical evidence that came out in the sixth and seventh decade of the past century was even more thought provoking. The quick and effective response of securities' prices to new announcements and information posits the hypothesis that stale information does not have an influence in making money (Fama, 1970). This hypothesis had been evaluated empirically after initially "stale information" and "making money" defined where the latter is controversial. Sharpe (1964) proposed a model to compute the risk-return fair relationship that is widely accepted, the Capital Asset Pricing Model (CAPM). The deep insights Fama (1970) put forth have been igniting debates in the filed since then. When an investor makes money out of stale information, researchers would react quickly to figure out a convincing risk associated model that would justify the profits made are due to high risk and reduce those profits by adjusting them to the risk taken to arrive at a fair return or compensation. In other words, superior returns do not exist. The first is to some extent less controversial. Stale information comes in three types attributed to the forms of the EMH that are three too, weak, semi-strong and strong EMH forms. The weak form exhibits the random walk characteristics where the attributed stale information is historical prices and returns. It states that past prices do not predict subsequent prices and abnormal profits cannot be earned as returns are completely unpredictable based on historical prices. The semi-strong form posits that by utilizing any public information market participants cannot get abnormally adjusted to risk profits. However, trading on information that is not yet public "insider trading" could possibly yield superior gains. The strong form suggests that there is no way to make abnormal returns even if the trade is based on inside information that is not public yet as the information will quickly spread out and the effect is reflected in the securities' prices (Fama, 1965).

Aloosh, Choi, and Ouzan (2021) conducted a research for the period ranging from 11 December 2018 to 5 March 2021 on the meme stocks that were subject to the restrictions by Robinhood at the peak of the GameStop saga to scrutinize whether MS[3] improve market efficiency or degrade it. Aloosh et al. (2021) in their findings revealed

[3] MS: Meme stocks

that the U.S market is not a weak form efficient while MS being weakly efficient cannot be rejected. In addition, they surprisingly indicate that the collective move combined with the ability to access deep market information by retail investors contribute to the improvement of market efficiency.

Umar, Yousaf, Zaremba (2021) deployed a wavelet coherence model to examine the price nexus during the GameStop saga between the different tickers that were heavily shorted. Umar et al. (2021) obtained sample data starting from 07 February 2020 up to 9 February 2021 for GME and seven indices of different sectors whose SI is heavy and a broad U.S. market index. The findings of the paper suggests that the sectorial indices of consumer and technology exhibit a considerable positive significance of coherence with GME price movements concluding that the collectively coordinated transactions executed by retail investors on GME created a momentum that additionally transmits to other indices with heavy SI. The authors further argues that one incident of a short squeeze in a stock has the potential to disrupt the overall market and challenge its integrity and stability as the herding effect widely spreads to other irrelevant sectors. Furthermore, using the same variables, Aharon, Kizys, Umar, Zaremba (2021) conducted a study by utilizing the time-varying parameter vector autoregression (TVP-VAR) to ascertain whether a static and dynamic connectedness of returns and volatility exists. The authors, on the other hand, used high frequency data, with a sample spanning from 7 December 2020 to 29 January 2021 and a ten-minute TF. GME stock is a net beneficiary of other firms' returns and volatility, which attracted short sellers, according to the research, which refutes the hypothesis that GME is a net transmitter and a key indication of the US stock market seeing a surge in financial contagion.

Furthermore, their arguments for what occurred to GME and other heavily shorted stocks in early 2021. In their exposition of the epic, Waters and Wesep (2021) focused on the function of option. Fusari et al. (2021) used options data to see if there was a price bubble in GME from December 2020 to January 2021, and they discovered that there was a price bubble in GME in the period under study.

Away from traditional data analysis, Jarrow and Li (2021) use alternative data to examine the impact on stock prices of the coordinated purchases gathering on a media group. Contrary to financial authorities concerns regarding Reddit’s Wallstreetbets

(WSB) trading advices, Bradley, Hanusek, Jame, Xiao (2021) finds that the investment advices circulating in WSB yielded positive gains with around 2% return over the month ahead of the announcement and 5% over a quarter. Lyócsa, Baumöhl, Výrost (2021) conduct a study based on daily time frame data for the period 01 July 2020 up to 12 February 2021, a total of 155 days, to examine GME, AMC, BB, and NOK in terms of their price variation. The authors use stock prices besides WSB Subreddit and Google searches. The study tries to find whether the social medial forum while taking into consideration Google searches has an effect and if it could explain the price movement of the four stocks. The analysis suggests that the effect was significant and as he talks about the four stocks in the Subreddit group heightened; this was evident in the variation of prices. This explanation was less evident in the pre-saga period. On the contrary, by applying a linear regression to study the relationship between the frequency of comments in the discussions in WSB with the returns of stocks and their volumes, Wong (2021) finds that the Reddit discussions do not have a significant impact on the price variations while it has a positive correlation with the volume.

Another study based on alternative data finds an interesting outcome. Costola, lacopini, Santagiustina (2021) deployed the "regime-switching cointegration" model to examine whether a "momentum" between price and tweets and between the second and the volume exists. The paper postulate that a correlation exists and they simultaneously occur. To take into account the "persistence of the meme period" a condition for the minimum period is imposed that ignores short-lived events. The findings reveal that meme stocks possess different characteristics from other securities that exhibit high frequency on the platforms of social media and the phenomena of meme stock impacts financial markets.

CHAPTER III

DATA AND METHODOLOGY

3.1. Data Source

The securities under study were identified and selected according to their popularity amongst retail investors on the SubReddit forum during the peak period of the frenzy. The inclusion criterion is based on the measurement of the price spike and the frequency of the tickers circulated by the members in the forum. The investigation is based on a daily time frame for the four stocks and three major market indexes retrieved from Thomson Reuters Eikon financial platform. The pre-saga period is represented by the time horizon from 30 June 2020 up to 08 January 2021 while the saga period is represented by the period ranging from, 11 January 2021 up to 29 June 2021. The prices are converted into natural log returns to conduct the analysis and reach robust results and conclusions. The four stocks are GameStop Corporation, AMC Entertainment Holding Inc., NAKD Brand Group LTD, and KOSS Corporation with the symbols GME, AMC, NAKD and KOSS for each stock respectively. The indexes are S&P 500, RUSSEL 2000, and NASDAQ.

3.2. Methodology

Running an OLS would impose a restriction in the model where a number of variables affect a single variable as they are the independent variables while the other is the dependent variable. Consequently, the root of correlation would be from AMC, NAKD, and KOSS to GME if it is the dependent variable. However, it is not suitable for us to impose a definite structure on the model. For robust econometric modelling, allowing the time series to speak for themselves is more appropriate and this can be achieved by deploying the Vector Autoregressive Regression (VAR). The main idea and philosophy of the VAR is that it lets the data determine the train of the causality rather than specifying how the variables should be arranged. Granger-causality test and the Wald-type test are implemented to find whether causality exists among the four stocks. The Impulse Response and the Forecast Error Variance Decomposition

functions, which are the most widely known structural analysis tools are found and plotted. All the Econometrical Models and Results are generated by utilizing the power of RStudio.

3.2.1. Unit Root and Stationarity Tests

One of the major analyses of a time series is to analyse whether a time series possesses a unit root as the assumption of statistical equilibrium must hold to conduct most of the econometric modelling. However, it will not suffix if the long-run linear equilibrium assumption is satisfied and the mean is equal to zero. The displacement should also be constant and equal to zero. In other words, the wavelets do not have many discrepancies and keep spanning around a fixed position. If such a position does not exist, then it is possible that the acceleration or the velocity is stationary Anindya et al. (1993). Several tests have been developed to measure the discrepancy in time series and to increase the robustness of the model and the confidence of the stationarity of the datasets, four unit root tests are conducted. Augmented Dickey-Fuller (ADF,1979), Phillips & Perron (PP, 1988), Kwiatkowski et al. (KPSS, 1992), and Elliott, Rothenberg & Stock (ER, 1996). Each of the mentioned above approaches applies different methods for the sake of the improvement of the power of results. The below sections will detail the methods of the six tests.

3.2.1.1. Augmented Dickey-Fuller

The study applies the three regression models of the ADF, which are the models neither constant nor trend, drift no trend and drift and trend. The lag determination is according to the Akaika (AIC) criteria, which is an argument embedded in the R code for the test and is computed automatically in the model results. The critical values in the regression models are taken from Hamilton (1994), and Dickey and Fuller (1981). The ADF unit root test has its roots built on the first-order autoregressive process (Box et al., 2015):

$$y_t = \phi_1 y_{t-1} + \varepsilon_t, \qquad t = 1, \dots, T$$

Where y_{t-1} which is the lagged value has ϕ_t as its autoregression parameter, ε_t represents the random process of stationarity that is the white noise process. The hypotheses statement of the test is as follows:

$$H_0: \phi_1 = 1,$$

$$H_1: \phi_1 < 1,$$

As nonstationary is indicated by the Null hypothesis and contains a unit root at $I(1)$. The alternative hypothesis however suggests that the time series has no unit root and is stationary at $I(0)$.

The t-statistic is computed by rearranging the equation mentioned earlier to appear as follows:

$$y_t - y_{t-1} = \phi_1 y_{t-1} - y_{t-1} + \varepsilon_t$$

$$\Delta y_t = (\phi_t - 1) y_{t-1} + \varepsilon_t$$

Deriving from this equation the t-statistic is then:

$$t_{DF} \frac{\widehat{\phi_1} - 1}{se_{\widehat{\phi_1}}}$$

Where the estimate of the errors is represented by $se_{\widehat{\phi_1}}$, $se_{\widehat{\phi_1}}$ is the OLS estimate of ϕ_t. This test statistic follows a Dickey-Fuller distribution under the null hypothesis and the critical values obtained by simulation, are tabulated in D. Dickey (1976) and Fuller (1976).

As the study is going to apply in addition to none method both the drift and trend methods, the model is extended:

$$y_t = \delta_0 + \phi_1 y_{t-1} + \varepsilon_t,$$

$$y_t = \delta_0 + \delta_1 t + \phi_1 y_{t-1} + \varepsilon_t,$$

The equation for the test when the type is neither drift nor trend (none):

$$\Delta y_t = \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi i y_{t-1} + \mu_t$$

The equation for the test when the type is drift:

$$\Delta y_t = \beta_0 + \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi i y_{t-1} + \mu_t$$

The equation for the test when the type is drift and trend:

$$\Delta y_t = \beta_0 + \beta_1 t + \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi i y_{t-1} + \mu_t$$

Where the values of the variables are defined by y_t at time period t, the constant is denoted by β_0 while the trend is denoted by $\beta_1 t$ and the error term μ_t.

3.2.1.2. Phillips-Perron

Phillips and Perron (1988) worked on some unit root tests that are commonly used in time series econometric analysis nowadays. The PP is similar to the ADF test but mainly differs in the way autocorrelation and heteroscedasticity are dealt with. The test is implemented with type Z-tau and two models; constant and trend with a lag type set to short to accommodate the data. While the lag specification in the ADF test is for the number of lags of the endogens variable to be included, the number of lags in the PP test is mainly for the correction of error terms. The ADF test focuses on parametric autoregression while the PP test does not count for that in the regression. The model for the PP test is as follows

$$\Delta y_t = \beta' \mathrm{D}_t + \pi y_{t-1} + u_t$$

Where u_t represents the value *I(0)*. The Phillips-Perron test looks at the error terms identifying any serial correlation in the regression. The purpose of the process is to correcting that by manipulating the $t_{\pi=0}$ and $T\hat{\pi}$ which are both t-statistics. The modified versions denoted Z_t and Z_π are shown below

$$Z_t = \left(\frac{\hat{\sigma}^2}{\hat{\lambda}^2}\right)^{1/2} \cdot t_{\pi=0} - \frac{1}{2}\left(\frac{\hat{\lambda}^2 - \hat{\sigma}^2}{\hat{\lambda}^2}\right) \cdot \left(\frac{T \cdot SE(\hat{\pi})}{\hat{\sigma}^2}\right)$$

$$Z_\pi = T\hat{\pi} - \frac{1}{2}\frac{T^2 \cdot SE(\hat{\pi})}{\hat{\sigma}^2}\left(\hat{\lambda}^2 - \hat{\sigma}^2\right)$$

The parameters of the variance have consistent estimates in the model which are $\hat{\sigma}^2$ and $\hat{\lambda}^2$.

$$\sigma^2 = \lim_{T\to\infty} T^{-1} \sum_{t=1}^{T} E[u_t^2]$$

$$\lambda^2 = \lim_{T\to\infty} \sum_{t=1}^{T} E[T^{-1} S_T^2]$$

The $\hat{u}_t$ is an invariable gauge of the variance σ^2 while the Newey-West value of the estimate u_t utilizing $\hat{u}_t$ is a consistent gauge of λ^2. Compared to the ADF, the Z-statistics of the PP test are identical in terms of asymptotic distribution to the t-statistics of the ADF test. The tests overcomes the ADF test as they are robust in dealing with heteroscedasticity in the standard error u_t. Another advantage of the PP test is that the lag selection does not require the user to specify its length.

3.2.1.3. Kwiatkowski, Phillips, Schmidt, and Shin

The two previous tests, the ADF and the PP, are unit root tests with the same hypothesise statement that the null hypothesise is the presence of a unit root in the dataset meaning an integration of order one *I(1)* while the alternative hypothesis states that the time series has no unit root *I(0)*. In contrast, stationary tests such as KPSS states the opposite where the null is that the time series is stationary while the alternative hypothesis mentions that the time series is nonstationary. The widely implemented is the KPSS approach due to Kwiatkowski, Phillips, Schmidt, and Shin (1992).

$$y_t = d_t + r_t + \varepsilon_t,$$

$$r_t = r_{t-1} + u_t,$$

Where d_t represents the deterministic component of the model, it could be either constant or trend.

The Lagrange Multiplier (ML) is the base of the KPSS test and is structured upon the null hypothesis that the squared standard deviation of the random walk equals zero; $H_0: \sigma_u^2 = 0$, implying that r_t is constant contrary to the alternative stating that; $H_1: \sigma_u^2 > 0$. The test statistic is defined as:

$$\text{KPSS } LM = \sum_{t=1}^{T} \frac{se_t^2}{\widehat{\sigma_t^2}}$$

3.2.1.4. Elliot, Rothenberg and Stock

The unit root tests have suffered some limitations and problems related to the extent they have the power against the alternative hypothesis when the coefficients are close to one where the stationarity cannot be identified and the gap for error reveals. When deterministic terms are added to the model, the power of these tests is also mitigated. In other words, when a drift and a trend are established in the regression, the outcomes of the tests are less accurate than those including only a constant. In an attempt to work on the improvement of the unit root test, Elliot, Rothenberg & Stock suggested two other tests; DF-GLS and P-test. Bernhard's (2008) pinpoints the following

> To improve the power of the unit root test, Elliot, Rothenberg \& Stock proposed a local to unity detrending of the time series. ERS developed a feasible point optimal test, "P-test", which takes serial correlation of the error term into account. The second test type is the "DF-GLS" test, which is an ADF-type test applied to the detrended data without intercept. Critical values for this test are taken from MacKinnon in case of model="constant" and else from Table 1 of Elliot, Rothenberg \& Stock. (p.98)

The model for the data series generating process is provided below

$$y_t = d_t + u_t$$
$$u_t = au_{t-1} + v_t$$

Where the constant or trend deterministic component is represented by d_t. If $a = 1$, the two equations above suggest an order one integration for y_t whereas the absolute value of a less than one implies stationarity of the time series.

The feasible point-optimal test statistic is defined as:

$$P_T = \frac{S(a = \bar{a}) - \bar{a}S(a = 1)}{\widehat{\omega}^2}$$

Where $S(a = \bar{a})$ and $S(a = 1)$ in the numerator are the squared residuals when summed from a regression of $y_a$on Z_a with

$$y_a = (y_1, y_2 - ay_1, \dots, y_T - ay_{T-1})$$
$$Z_a = (z_1, z_2 - az_1, \dots, z_T - az_{T-1})$$

Therefore, y_a is a T-dimensional column vector and Z_a represents matrix of $(\mathrm{T} \times \mathrm{q})$. The v_t has squeared standard deviation which is gauged with

$$\widehat{\omega} = \frac{\hat{\sigma}_v^2}{\left(1 - \sum_{i=1}^{p} \hat{\alpha}_i\right)^2}$$

Hence, $\hat{\sigma}_v^2$ and $\hat{\alpha}_i$for i = 1,…, p are extracted from the auxiliary OLS regression model

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + \cdots + \Delta y_{t-p} + \alpha_{p+1} + \varepsilon_t$$

The suggested DF-GLS approch which is the t statistic for testing $\alpha_0 = 0$ in the homogeneous regression

$$\Delta y_t^d = \alpha_0 y_{t-1}^d + \alpha_1 \Delta y_{t-1}^d + \cdots + \alpha_p \Delta y_{t-p}^d + \varepsilon_t$$

Hence, the residuals are the y_t^d. The critical values can be taken from the DF-type t test in case intercept does not exist while in other scenarios the values are taken from Table 1 of Elliott et al. (1996).

3.2.2. Vector Autoregression Model (VAR)

In its basic form, the Vector Autoregression Model process of p lags is as entertained below:

$$\mathrm{y}_t = A_1 \mathrm{y}_{t-1} + \cdots + A_p \mathrm{y}_{t-p} + CD_t + \mathrm{u}_t$$

Where $\mathrm{i} = 1, \ldots, \mathrm{p}$ is represented by $\mathrm{A_i}$ which in turn is $k \times k$ coefficient matrices. $\mathbf{u}_t$ is a K-dimensional white noise process which is not a direct function of time non-negative definite covariance matrix $\mathrm{E}(\mathrm{u_t u_t'}) = \Sigma_\mathrm{u}$. The coefficient matrix of the potential deterministic components with $(k \times m)$ as its dimension is C matrix in the equation above. For the holding of the right deterministic components including drift, trend and dummy variable is represented by D_t which is in turn an $(M \times 1)$ vector. The above equation is sometimes written in a form of a lag polynomial defined as:

$$A(L)\mathrm{y}_t = CD_t + \mathrm{u}_t$$

One distinguishing feature of VAR(p)-process is the stability of the model. In other words, time series are generated with no unit roots with means, squared deviations and

covariance structures so long as the starting values suffix. This could be checked by looking into the characteristic polynomial reversed,

$$\det\left(I_K - A_1 z - \cdots - A_p z^p\right) \neq 0 \text{ for } |z| \leq 1$$

If the result of the equation possesses a root for $z = 1$ then either some or all variables in the VAR (p)-process possess an integration of $I(1)$. The analysis of the stability can be done with the companion form and checking the eigenvalues of the coefficient matrix (Helmut, 2005). The VAR(1)-process is defined as

$$\xi_t = A\xi_{t-1} + \mathrm{v}_t$$

With

$$\xi_t = \begin{bmatrix} \mathrm{y}_t \\ \vdots \\ \mathrm{y}_{t-p+1} \end{bmatrix}, A = \begin{bmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{bmatrix}, \mathrm{v}_t = \begin{bmatrix} \mathrm{u}_t \\ 0 \\ \vdots \\ 0 \end{bmatrix},$$

If the values are less than one then the model is said to be stable. In other words, if the eigenvalues are less than one then the VAR process is stable. Before running a VAR model, it is of great importance to touch upon the selection of lags.

3.2.2.1. Information Criteria

The empirical selection of the lag order is vital to have a robust model outcome based on which other structural analysis tools will be computed. The lag specification approaches are four and entertained as

$$\begin{aligned}
\mathrm{AIC}(p)\& &= \log\det\left(\tilde{\Sigma}_u(p)\right) + \frac{2}{T}pK^2 \\
\mathrm{HQ}(p)\& &= \log\det\left(\tilde{\Sigma}_u(p)\right) + \frac{2\log(\log(T))}{T}pK^2 \\
\mathrm{SC}(p)\& &= \log\det\left(\tilde{\Sigma}_u(p)\right) + \frac{\log(T)}{T}pK^2, \text{ or} \\
\mathrm{FPE}(p) &= \left(\frac{T+p^*}{T-p^*}\right)^K \det\left(\tilde{\Sigma}_u(p)\right)
\end{aligned}$$

With $\tilde{\Sigma}_u(p) = T^{-1}\sum_{t=1}^{T} \hat{\mathbf{u}}_t\hat{\mathbf{u}}_t'$, and p^* indicates all parameters in every formula and p allocates the number of the lags. (Helmut, 2005) argues that the log of the FPE test and the AIC information criteria will have an identical lag selection for moderate and large datasets.

The equations may take the form as

$$\begin{array}{ll} \hat{p}(\text{SC}) <= \hat{p}(\text{AIC}) & \text{if } T >= 8 \\ \hat{p}(\text{SC}) <= \hat{p}(\text{HQ}) & \text{for all } T \\ \hat{p}(\text{HQ}) <= \hat{p}(\text{AIC}) & \text{if } T >= 16 \end{array}$$

3.2.2.2. Causality Analysis

The main objective of the study is to detect whether causation exists amongst the variables. In other words, if a variable contains information that is helpful in predicting the wavelets of the other one then it is common practice to state that variable X G-causes variable Y. One of the most common tests to measure causality is Granger causality (Granger, 1969). The test is not well suited for measuring causal associations in a strict form as the feasibility of a post hoc fallacy is not uncommon to be considered which is also true for any similar tests. Another test is an approach that checks for non-zero association in the error processes between the cause and the impulse (Helmut, 2005).

The two causality tests have the vector of endogenous variables $\mathbf{y}_t$ divided into two sub-vectors $\mathbf{y}_{1t}$ and $\mathbf{y}_{2t}$ with dimensions $(\mathrm{k}_1 \times \mathrm{I})$ and $(\mathrm{k}_2 \times \mathrm{I})$ with $\mathrm{k} = \mathrm{k}_1 + \mathrm{k}_2$. For the redefined VAR(p)-process,

$$\begin{bmatrix} \mathrm{y}_{1t} \\ \mathrm{y}_{2t} \end{bmatrix} = \sum_{i=1}^{p} \begin{bmatrix} \alpha_{11,i} & \alpha_{12,i} \\ \alpha_{21,i} & \alpha_{22,i} \end{bmatrix} \begin{bmatrix} \mathrm{y}_{1,t-i} \\ \mathrm{y}_{2,t-i} \end{bmatrix} + CD_t + \begin{bmatrix} \mathrm{u}_{1t} \\ \mathrm{u}_{2t} \end{bmatrix}$$

The null hypothesis states that the sub-vector $\mathbf{y}_{1t}$ does not G-cause the sub-vector $\mathbf{y}_{2t}$ stated as $\alpha_{21,i} = 0$ for $i = 1,2,\dots,p$. In contrast, the alternative hypothesis states is $\exists\alpha_{21,i} \neq 0$ for $i = 1,2,\dots,p$. The distribution of the test statistic is defined as $F(pK_1K_2, KT - n^*)$, where n^* is the sum of the parameters in the VAR(p) mentioned previously.

The null hypothesis however for the other test (non-instantons) test is written as $\mathrm{H}_0: \mathrm{C}\sigma = 0$. The Wald statistic is then written as

$$\lambda_W = T\tilde{\sigma}'C'\left[2CD_K^{+}\left(\tilde{\Sigma}_u \otimes \tilde{\Sigma}_u\right)D_K^{+}C'\right]^{-1}C\tilde{\sigma}$$

Where D_K that is the inversed Moore-Penrose of the "duplication matrix" is represented by D_K^{+} and $\tilde{\Sigma}_u = \frac{1}{T}\Sigma_{t=1}^{T}\hat{u}_t\hat{u}_t'$. The test statistic that is λ_W is arranged as $x^2(N)$.

3.2.2.3. Impulse Response Function

In the previous subsection, two causality tests were detailed which are help suggest if a time series contributes to the prediction of another. Though these tests are widely used, they fall short in measuring the impulse-response impact over time. An advantage of the IRF is its capability in investigating such dynamic interactions between the variables with the Wold MA of a VAR(P) introduced earlier as its basis. The coefficients of the matrices are therefore referred to as the expected reaction of variable $\mathbf{y}_{i,t+s}$ to a unit change in variable $\mathbf{y}_{jt}$. The contribution from the variable can be cumulated over time and accordingly it would be possible to have the cumulated effect of a shock in one variable from another at time s. In the Econometrics world, it is more conceivable to apply the orthogonal IRs rather than the IR coefficients. This is particularly common if a shock is mostly not taking place in isolation instead simultaneous relationship between the components of the error terms defied as $\mathbf{u}_t$ prevails. Those responses are taken from (Choleski decomposition of the error variance-covariance matrix) another matrix. The MA representation can be rewritten as

$$\mathbf{y}_t = \Psi_0\varepsilon_t + \Psi_1\varepsilon_{t-1} + \cdots$$

The equation functions so that if we shock the first variable it will exerts an impact on the remaining variables. The following and the rest of the variables cannot possess a direct influence on y_{It}. In essence, with respect to the IR the setting of the variables in the VAR(p) model may produce different results.

3.2.2.4. Forecast Error Variance Decomposition

The forecast Variance Decomposition gets its roots from the orthogonal IR coefficient matrices. What distinguishes this structural analysis tool is its power in measuring the contribution of one variable to the FEV of the variable k. The outcomes can be

obtained as percentage points by dividing the element-wise squared orthogonal IRs enclosed in the equation below by the variance of the FEV. Kling and Bessler (1985) states that variance decomposition can be considered as causality tests outside the time span of the estimation. The forecast error variance's equation is defined as

$$\sigma_k^2(h) = \sum_{n=0}^{h-1} \left(\psi_{k1,n}^2 + \cdots + \psi_{kK,n}^2\right)$$

Redefined as

$$\sigma_k^2(h) = \sum_{j=1}^{K} \left(\psi_{kj,0}^2 + \cdots + \psi_{kj,h-1}^2\right)$$

Dividing the term in the brackets on the right side of the equation by the term on the left yields the FEVD in % terms:

$$\omega_{\mathrm{kj}}(\mathrm{h}) = \left(\psi_{kj,0}^2 + \cdots + \psi_{kj,h-1}^2\right)/\sigma_k^2(h)$$

3.2.3. Interconnectedness Index

The Interconnectedness index suggested by Diebold and Yilmaz (2012) is computed based on the Generalized Forecast Error Variance Decomposition as put forth by Pesaran and Shin (1998). Utilizing the contributions generated by the model the total volatility spillover index formula is written as

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{i,j=1 \\ ij}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100$$

The index calculates the spillovers of fluctuation shocks all along the four tickers under investigation to the overall FEV. The equation to compute the explained error variance of a variable received by a variable from all other variables is defined as

$$S_{i.}^g(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100$$

Similarly, the spillovers transmitted from a ticker to the rest of the variables computed based on the formula bellow

$$S_{\cdot i}^{g}(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^{g}(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{N} \cdot 100$$

To find out whether a variable is transmitter or not, the net spillovers is found which is simply the difference between the caused and received gross volatility shocks and is found according to the equation

$$S_{i}^{g}(H) = S_{\cdot i}^{g}(H) - S_{i}^{g}(H)$$

3.2.4. Impact of Reddit Frenzy

3.2.4.1. VAR (1)-process: Four Stocks Pre-Reddit Frenzy Period Model

$$GME_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + CD_t + u_t$$
$$AMC_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + CD_t + u_t$$
$$NAKD_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + CD_t + u_t$$
$$KOSS_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + CD_t + u_t$$

3.2.4.2. VAR (7)-process: Four Stocks Reddit Frenzy Period Model

$$\begin{aligned} GME_t = {} & A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + A_5 GME_{t-2} \\ & + A_6 AMC_{t-2} + A_7 NAKD_{t-2} + A_8 KOSS_{t-2} + A_9 GME_{t-3} + A_{10} AMC_{t-3} \\ & + A_{11} NAKD_{t-3} + A_{12} KOSS_{t-3} + A_{13} GME_{t-4} + A_{14} AMC_{t-4} \\ & + A_{15} NAKD_{t-4} + A_{16} KOSS_{t-4} + A_{17} GME_{t-5} + A_{18} AMC_{t-5} \\ & + A_{19} NAKD_{t-5} + A_{20} KOSS_{t-5} + A_{21} GME_{t-6} + A_{22} AMC_{t-6} \\ & + A_{23} NAKD_{t-6} + A_{24} KOSS_{t-6} + A_{25} GME_{t-7} + A_{26} AMC_{t-7} \\ & + A_{27} NAKD_{t-7} + A_{28} KOSS_{t-7} + CD_t + u_t \end{aligned}$$

$$\begin{aligned} AMC_t = {} & A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + A_5 GME_{t-2} \\ & + A_6 AMC_{t-2} + A_7 NAKD_{t-2} + A_8 KOSS_{t-2} + A_9 GME_{t-3} + A_{10} AMC_{t-3} \\ & + A_{11} NAKD_{t-3} + A_{12} KOSS_{t-3} + A_{13} GME_{t-4} + A_{14} AMC_{t-4} \\ & + A_{15} NAKD_{t-4} + A_{16} KOSS_{t-4} + A_{17} GME_{t-5} + A_{18} AMC_{t-5} \\ & + A_{19} NAKD_{t-5} + A_{20} KOSS_{t-5} + A_{21} GME_{t-6} + A_{22} AMC_{t-6} \\ & + A_{23} NAKD_{t-6} + A_{24} KOSS_{t-6} + A_{25} GME_{t-7} + A_{26} AMC_{t-7} \\ & + A_{27} NAKD_{t-7} + A_{28} KOSS_{t-7} + CD_t + u_t \end{aligned}$$

$$NAKD_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + A_5 GME_{t-2} + A_6 AMC_{t-2} + A_7 NAKD_{t-2} + A_8 KOSS_{t-2} + A_9 GME_{t-3} + A_{10} AMC_{t-3} + A_{11} NAKD_{t-3} + A_{12} KOSS_{t-3} + A_{13} GME_{t-4} + A_{14} AMC_{t-4} + A_{15} NAKD_{t-4} + A_{16} KOSS_{t-4} + A_{17} GME_{t-5} + A_{18} AMC_{t-5} + A_{19} NAKD_{t-5} + A_{20} KOSS_{t-5} + A_{21} GME_{t-6} + A_{22} AMC_{t-6} + A_{23} NAKD_{t-6} + A_{24} KOSS_{t-6} + A_{25} GME_{t-7} + A_{26} AMC_{t-7} + A_{27} NAKD_{t-7} + A_{28} KOSS_{t-7} + CD_t + u_t$$

$$KOSS_t = A_1 GME_{t-1} + A_2 AMC_{t-1} + A_3 NAKD_{t-1} + A_4 KOSS_{t-1} + A_5 GME_{t-2} + A_6 AMC_{t-2} + A_7 NAKD_{t-2} + A_8 KOSS_{t-2} + A_9 GME_{t-3} + A_{10} AMC_{t-3} + A_{11} NAKD_{t-3} + A_{12} KOSS_{t-3} + A_{13} GME_{t-4} + A_{14} AMC_{t-4} + A_{15} NAKD_{t-4} + A_{16} KOSS_{t-4} + A_{17} GME_{t-5} + A_{18} AMC_{t-5} + A_{19} NAKD_{t-5} + A_{20} KOSS_{t-5} + A_{21} GME_{t-6} + A_{22} AMC_{t-6} + A_{23} NAKD_{t-6} + A_{24} KOSS_{t-6} + A_{25} GME_{t-7} + A_{26} AMC_{t-7} + A_{27} NAKD_{t-7} + A_{28} KOSS_{t-7} + CD_t + u_t$$

3.2.4.3. GME and Market Interconnectedness Pre-Frenzy Period VAR Model

$$GME_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$SPX_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$RUT_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$NASDAQ_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

3.2.4.4. GME and Market Interconnectedness Frenzy Period VAR Model

$$GME_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$SPX_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$RUT_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

$$NASDAQ_t = A_1 GME_{t-1} + A_2 SPX_{t-1} + A_3 RUT_{t-1} + A_4 NASDAQ_{t-1} + CD_t + u_t$$

CHAPTER IV

RESULTS

4.1. Descriptive Statistics

In this section, the study focuses on the descriptive statistics for the periods of the four selected stocks under investigation besides eight other stocks that were restricted by Robinood during the trading frenzy. The analysis give a brief explanation about the stocks and their association with one another. Figure 4.1 and Figure 4.2 display the correlation matrix visualizations of the two periods for AMC, CRIS, AAL, GME, BB, NAKD, BYND, CTRM, BBBY, AG, AMD and KOSS respectfully. The variables are recorded automatically according to the eigenvectors in an angular order style for the purpose of detecting any unobserved patterns among the time series.

By looking into the first visual graph, we observe that the correlation amongst the stocks is very low with the highest value of 0.22 between KOSS and AG. However, when we look at the second graph, we see that there is a drastic change in the values and colours which indicates a high degree of positive linear correlation as it gets bluer while a low degree of negative correlation when the intensity of the red colour is higher. Unlike in the pre frenzy period, the frenzy period graph depicts a high degree of association among the targeted tickers by the trading saga with the highest values observed in the square area at the bottom right of the graph between KOSS, AMC, BBBY, GME, BB and NAKD. The highest value recorded is between AMC and KOSS followed by GME and KOSS, AMC and BB, NAKD and KOSS, AMC and BBBY with values of 0.79, 0.73, 0.73, 0.72, and 0.72 respectively. Comparing and contrasting the results of the two visualizations, we see that there is a noticeable change in the degree to which those targeted stocks correlate with one another. The exploratory tool also reorders the values to accommodate changing eigenvalues to allocate the stocks with the highest values to the right of the graph. We also see more blue values in the second graph comparing to very few ones in the first graph. To understand the dynamics and get a clearer picture of the behaviour of the stocks, tables of the mean, range and other values is constructed. Table 4.1 and Table 4.2 show the summary

statistics for the two periods that emphasize the trading frenzy thesis. Detailed information is provided on the following page.

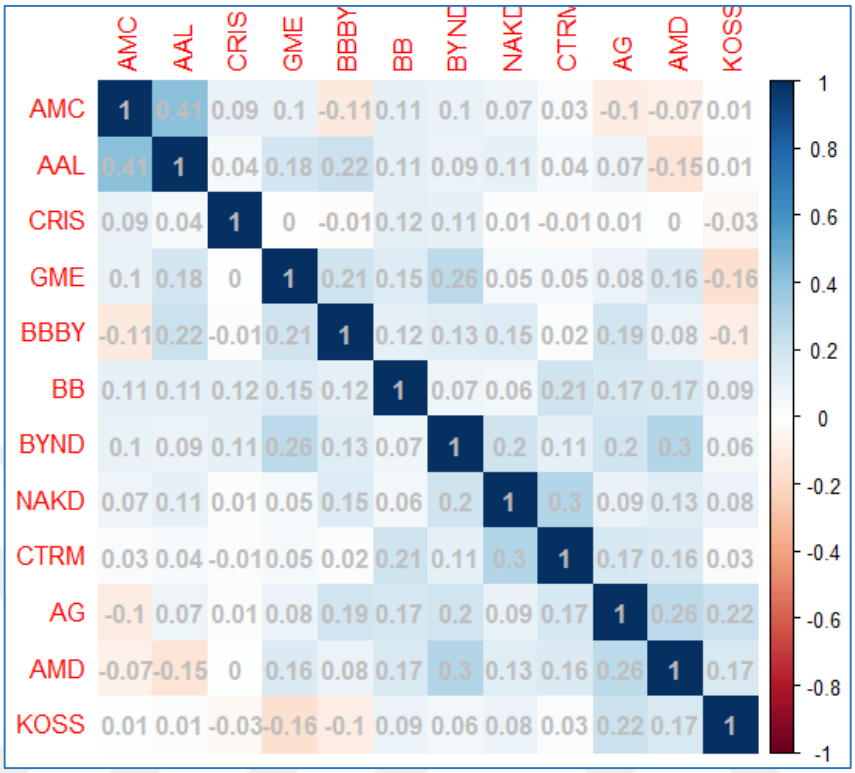

Figure 4.1. Pre-Frenzy Time Horizon Correlation Matrix Visualization, 30 June 2020 - 08 January 2021

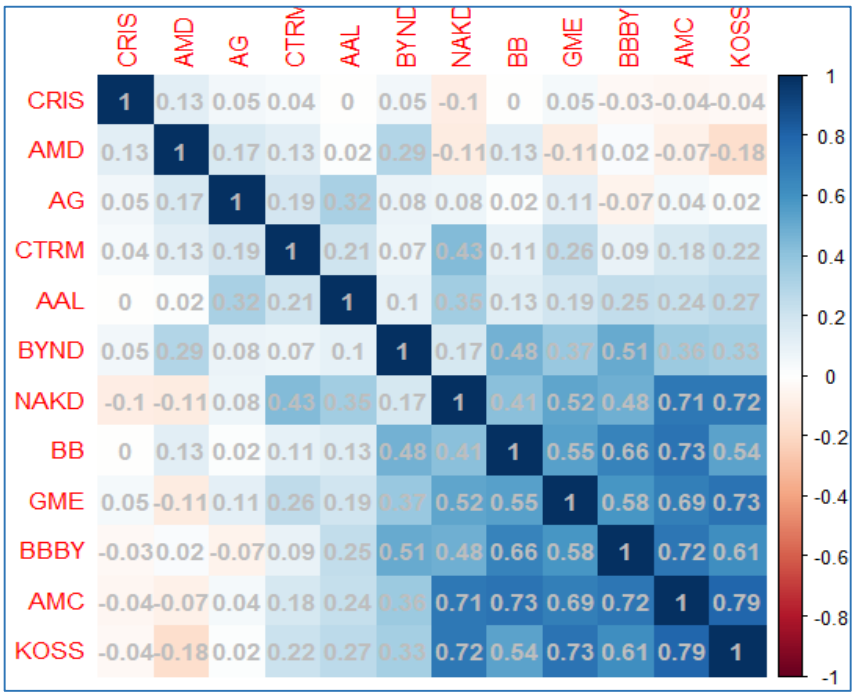

Figure 4.2. Frenzy Time Horizon Correlation Matrix Visualization, 11 January 2021 - 29 June 2021

Looking at Table 4.1 in the following page, the ranges obtained are 0.58, 0.62, 1.34 and 0.51 for GME, AMC, NAKD, and KOSS respectively while the values for the same variables in Table 4.2 are 1.77, 2.22, 1.70, 2.36. The standard deviation also differs in the two periods with values of 0.07, 0.08, 0.14, 0.06 for the pre saga period and 0.21, 0.20, 0.15, 0.23 for the saga period for GME, AMC, NAKD and KOSS respectfully. Those two measures of dispersion show that the volatility is higher in the second period while it was relatively lower in the initial period. To measure the symmetry and skewness of the data, skew and kurtosis values recorded in the table are compared. The skew for GME, AMC, NAKD and KOSS are 1.04, 1.35, 2.13, and 2.12 while the values in the second period are 0.12, 2.24, 4.68, and 3.6 respectively. The values of the kurtosis also got higher in Table 4.2 compared to table 4.1 indicating an extreme peakedness during the period.

Table 4.1. Pre-Frenzy Daily Data Time Horizon Descriptive Statistics, 30 June 2020 - 08 January 2021

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
GME	1	118	0.01	0.07	0.01	0.01	0.05	-0.22	0.37	0.58	1.04	4.42	0.01
KOSS	2	118	0.01	0.06	0.00	0.00	0.04	-0.15	0.36	0.51	2.12	9.53	0.01
NAKD	3	118	0.00	0.14	-0.03	-0.02	0.07	-0.54	0.80	1.34	2.13	11.86	0.01
AMC	4	118	-0.01	0.08	-0.01	-0.01	0.05	-0.21	0.41	0.62	1.35	6.46	0.01
AAL	5	118	0.00	0.04	0.00	0.00	0.03	-0.08	0.14	0.22	0.72	1.24	0.00
AMD	6	118	0.00	0.03	0.00	0.00	0.03	-0.09	0.15	0.24	1.01	3.54	0.00
AG	7	118	0.00	0.04	0.00	0.00	0.03	-0.13	0.11	0.23	-0.29	0.59	0.00
BB	8	118	0.00	0.04	0.00	0.00	0.02	-0.17	0.18	0.35	0.41	7.55	0.00
BBBY	9	118	0.01	0.04	0.00	0.01	0.03	-0.14	0.22	0.36	0.55	5.65	0.00
BYND	10	118	0.00	0.03	0.00	0.00	0.03	-0.19	0.09	0.28	-1.09	5.52	0.00
CRIS	11	118	0.02	0.15	0.00	0.00	0.04	-0.27	1.51	1.78	8.68	85.25	0.01
CTRM	12	118	0.00	0.08	-0.01	-0.01	0.05	-0.23	0.34	0.57	1.28	5.19	0.01

Table 4.2. Frenzy Daily Data Time Horizon Descriptive Statistics, 11 January 2021 - 29 June 2021

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
GME	1	118	0.02	0.21	0.00	0.01	0.08	-0.92	0.85	1.77	0.12	6.31	0.02
KOSS	2	118	0.02	0.23	-0.01	-0.01	0.07	-0.60	1.76	2.36	3.60	24.56	0.02
NAKD	3	118	0.01	0.15	-0.02	-0.01	0.07	-0.44	1.26	1.70	4.68	36.47	0.01
AMC	4	118	0.03	0.20	0.00	0.02	0.08	-0.84	1.39	2.22	2.24	20.83	0.02
AAL	5	118	0.00	0.03	0.00	0.00	0.03	-0.07	0.09	0.16	0.50	0.20	0.00
AMD	6	118	0.00	0.02	0.00	0.00	0.02	-0.06	0.06	0.12	-0.19	0.10	0.00
AG	7	118	0.00	0.05	0.00	0.00	0.03	-0.28	0.20	0.48	-0.32	9.38	0.00
BB	8	118	0.00	0.09	0.00	0.00	0.05	-0.54	0.28	0.82	-1.19	12.46	0.01
BBBY	9	118	0.00	0.09	0.00	0.00	0.04	-0.45	0.48	0.94	0.28	11.93	0.01
BYND	10	118	0.00	0.04	0.00	0.00	0.03	-0.07	0.16	0.24	1.16	2.93	0.00
CRIS	11	118	0.00	0.08	0.00	0.00	0.04	-0.46	0.50	0.96	0.48	19.63	0.01
CTRM	12	118	0.00	0.10	-0.01	0.00	0.06	-0.24	0.37	0.61	1.10	2.73	0.01

4.2. Unit Root and Stationarity Tests

Table 4.1 and 4.2 depicts the outcomes of the ADF, PP, KPSS, and ERS tests for the pre-mania and mania time horizons respectfully after getting the best out of the flexible *urca* package in Rstudio with its various test types and deterministic components for each approach. The four tests are applied as a pragmatic approach that is not uncommon to follow in practice since there is no clear-cut answer to respond to the question of an appropriate test to deploy and to arrive at a robust result. ADF and PP tests are almost identical with a key difference that is the utilization of non-parametric correction by the latter in order to detect the heterogeneity of the error terms and weakness of dependence. The implementation of the ERS test is aimed at ameliorating the low power of the ADF and the PP tests when it comes to having a process of data generation of AR(1) where the coefficient is near 1. Likewise, to avoid any errors in the test for integration of orders the KPSS deployed as a stationarity test with its advantage in dealing with the hypothesis statements structure from the angle of being conservative when testing for stationarity.

The ADF test lags are selected automatically according to the AIC criteria by setting the lag selection argument in the R code to "AIC". The appropriate lag selected is one lag for all the stocks and 4 lags for the mania period and the model is run for the three deterministic parts secretly, *none*, *drift* and *both*.

For the PP approach, the test offers two types of lag selections, *long* and *short* where the first is selected when the data set is large enough while the second is selected when the data set is small. It also provides two test types, *Z-alpha* and *Z-tau*. In our case, the lag argument is set to *short* and the test type is set to *Z-tau* for both time horizons.

The KPSS provides three types of lag selection, *short, long* and *nil* which sets no error correction. The model is run based on the *constant&trend* deterministic component with a *short* lag type automatically set to 4 lags for the pre-mania and mania period as the appropriate specification for the model.

The ERS test has two types of tests that are the *DF-GLS* and the *P-test* and two different types of deterministic models; *constant* and *trend.* The test specification

within the account for the DF-GLS test and the two deterministic components with a maximum lag specification set to 4 as defaulted in the test model.

Checking out the values and the critical values of the tests for the pre-mania period, the results provide sufficient information to reject the null hypothesis for the ADF, PP, and ERS tests, and conclude that the data series is stationary or does not have a unit root. For the KPSS test, the information provided does not suffix to reject the null and conclude that the data series is stationary.

Table 4.3. Daily Data Unit Root and Stationarity Tests, Pre-Frenzy Time Horizon, 30 June 2020 - 08 January 2021

Test	Stock	Deterministic terms	Lags	Test value	Critical Value		
					1%	5%	10%
ADF	GME	none	1	-7.35	-2.58	-1.95	-1.62
		drift	1	-7.64	-3.46	-2.88	-2.57
		drift, trend	1	-7.65	-3.99	-3.43	-3.13
	AMC	none	1	-7.53	-2.58	-1.95	-1.62
		drift	1	-7.54	-3.46	-2.88	-2.57
		drift, trend	1	-7.62	-3.99	-3.43	-3.13
	NAKD	none	1	-8.32	-2.58	-1.95	-1.62
		drift	1	-8.30	-3.46	-2.88	-2.57
		drift, trend	1	-8.89	-3.99	-3.43	-3.13
	KOSS	none	1	-7.73	-2.58	-1.95	-1.62
		drift	1	-7.78	-3.46	-2.88	-2.57
		drift, trend	1	-7.77	-3.99	-3.43	-3.13
PP	GME	constant	S	-11.15	-3.49	-2.89	-2.58
		trend	S	-11.13	-4.00	-3.45	-3.15
	AMC	constant	S	-9.88	-3.49	-2.89	-2.58
		trend	S	-9.93	-4.03	-3.45	-3.15
	NAKD	constant	S	-12.47	-3.49	-2.89	-2.58
		trend	S	-13.19	-4.04	-3.44	-3.15
	KOSS	constant	S	-13.30	-3.49	-2.89	-2.58
		trend	S	-13.26	-4.03	-3.45	-3.15
KPSS	GME	tau	4	0.03	0.22	0.15	0.12
	AMC	tau	4	0.08	0.22	0.15	0.12
	NAKD	tau	4	0.05	0.22	0.15	0.12
	KOSS	Tau	4	0.07	0.22	0.15	0.12

Table 4.3. (cont.)

ERS	**GME**	**constant**	**4**	**-4.81**	**-2.58**	**-1.94**	**-1.62**
		trend	4	-4.97	-3.46	-2.93	-2.64
	AMC	constant	4	-4.66	-2.58	-1.94	-1.62
		trend	4	-4.97	-3.46	-2.93	-2.64
	NAKD	constant	4	-4.18	-2.58	-1.94	-1.62
		trend	4	-4.84	-3.46	-2.93	-2.64
	KOSS	constant	4	-5.32	-2.58	-1.94	-1.62
		trend	4	-6.02	-3.46	-2.93	-2.64

The results in Table 4.4 of the ADF, PP, KPSS, and ZA tests for the mania time span series show the same outcomes as in the previous table. Looking into the values and the critical values of the tests, it is concluded that we have sufficient information to reject the null hypothesises for the ADF, PP, and ERS tests and accept the alternative hypothesis stating that the data series does not possess a unit root. For the KPSS test, the information provided does not offer sufficient information to reject the null and we conclude that the data series is stationary. Considering the four approaches, all the tests suggest that the data series of the four securities do not suffer from a unit root.

Table 4.4. Daily Data Unit Root and Stationarity Tests, Frenzy Time Horizon, 11 January 2021 - 29 June 2021

Test	**Stock**	**Deterministic terms**	**Lags**	**Test value**	**Critical Value**		
					1%	**5%**	**10%**
ADF	GME	none	1	-6.41	-2.58	-1.95	-1.62
		drift	1	-6.46	-3.46	-2.88	-2.57
		drift, trend	1	-6.54	-3.99	-3.43	-3.13
	AMC	none	1	-7.78	-2.58	-1.95	-1.62
		drift	1	-8.07	-3.46	-2.88	-2.57
		drift, trend	1	-8.03	-3.99	-3.43	-3.13
	NAKD	none	1	-8.40	-2.58	-1.95	-1.62
		drift	1	-8.37	-3.46	-2.88	-2.57
		drift, trend	1	-8.36	-3.99	-3.43	-3.13
	KOSS	none	1	-5.91	-2.58	-1.95	-1.62
		drift	1	-5.92	-3.46	-2.88	-2.57
		drift, trend	1	-5.98	-3.99	-3.43	-3.13

Table 4.4. (cont.)

PP	GME	**constant**	**S**	**-10.70**	**-3.49**	**-2.89**	**-2.58**
		trend	S	-10.77	-4.04	-3.45	-3.15
	AMC	constant	S	-28.05	-3.43	-2.86	-2.56
		trend	S	-28.29	-3.96	-3.41	-3.13
	NAKD	constant	S	-63.67	-3.43	-2.86	-2.56
		trend	S	-63.88	-3.96	-3.41	-3.12
	KOSS	constant	S	-108.65	-3.43	-2.86	-2.56
		trend	S	-108.71	-3.96	-3.41	-3.13
KPSS	GME	tau	4	0.05	0.22	0.15	0.12
	AMC	tau	4	0.07	0.22	0.15	0.12
	NAKD	tau	4	0.11	0.22	0.15	0.12
	KOSS	tau	4	0.05	0.22	0.15	0.12
ERS	GME	constant	4	-4.07	-2.58	-1.94	-1.62
		trend	4	-4.99	-3.46	-2.93	-2.64
	AMC	constant	4	-4.44	-2.58	-1.94	-1.62
		trend	4	-4.44	-3.46	-2.93	-2.64
	NAKD	constant	4	-2.03	-2.58	-1.94	-1.62
		trend	4	-3.62	-3.46	-2.93	-2.64
	KOSS	constant	4	-4.99	-2.58	-1.94	-1.62
		trend	4	-5.15	-3.46	-2.93	-2.64

4.3. Vector Autoregression (VAR) Results

The VAR model is deployed for empirical analysis purposes and to see whether knowing the value of a stock at a specified lag could help forecast the movement of other stocks at a later date and to investigate the dynamic relationship between the stocks in the model. The VAR results are obtained for the pre saga and saga period separately in order to conduct a comparative analysis to find whether the significant impact amongst the stocks differs in the two periods indicating a significant herding effect. Before establishing the VAR process, a model to select the optimal lags is conducted by using the *VARselect* function which examines the four widely known approaches of lag specification; AIC, HQ, SC and FPE and reports the appropriate lag number according to each criterium after checking all possible values of the criteria. Table 4.5 and Table 4.6 display the optimal selections obtained from the models and the lag values for each approach. For the study, the VAR model is built upon the Akaike Information Criterion as it is the most commonly used approach in practice. The method suggests a VAR(1)-process and a VAR(7)-process for the two periods.

Table 4.5. Daily Data Lag Specification, Pre-saga Time Horizon, 30 June 2020 - 08 January 2021

		Selection		
	AIC(n)	**HQ(n)**	**SC(n)**	**FPE(n)**
	1	1	1	1
		Criteria		
	1	**2**	**3**	**4**
AIC(n)	-1.93E+01	-1.92E+01	-1.91E+01	-1.89E+01
HQ(n)	-1.91E+01	-1.88E+01	-1.85E+01	-1.83E+01
SC(n)	-1.89E+01	-1.83E+01	-1.78E+01	-1.73E+01
FPE(n)	3.96E-09	4.56E-09	5.33E-09	5.97E-09
	5	**6**	**7**	**8**
AIC(n)	-1.89E+01	-1.87E+01	-1.88E+01	-1.87E+01
HQ(n)	-1.80E+01	-1.77E+01	-1.76E+01	-1.74E+01
SC(n)	-1.68E+01	-1.62E+01	-1.59E+01	-1.55E+01
FPE(n)	6.62E-09	7.85E-09	7.33E-09	8.01E-09

Table 4.6. Daily Data Lag Specification, Saga Time Horizon, 11 January 2021 - 29 June 2021

		Selection		
	AIC(n)	**HQ(n)**	**SC(n)**	**FPE(n)**
	7	2	1	5
		Criteria		
	1	**2**	**3**	**4**
AIC(n)	-1.60E+01	-1.63E+01	-1.63E+01	-1.64E+01
HQ(n)	-1.58E+01	-1.59E+01	-1.58E+01	-1.57E+01
SC(n)	-1.55E+01	-1.54E+01	-1.50E+01	-1.47E+01
FPE(n)	1.09E-07	8.55E-08	8.60E-08	7.98E-08
	5	**6**	**7**	**8**
AIC(n)	-1.64E+01	-1.64E+01	-1.64E+01	-1.63E+01
HQ(n)	-1.56E+01	-1.54E+01	-1.52E+01	-1.50E+01
SC(n)	-1.43E+01	-1.39E+01	-1.36E+01	-1.30E+01
FPE(n)	7.78E-08	8.13E-08	7.94E-08	9.08E-08

Running the models, the roots show that the models are stable as all of the roots are inside the unit circle suggesting the absence of stratus roots. When it comes to the stability of the VAR model, a process of VAR(p) is considered to be stable when the modulus of the eigenvalues are less than one. In other words, if the reverse characteristic polynomial does not have any of the roots in the complex circle (Pfaff & Stigler, 2021, p.31). To check for the structural stability of the model, it is pivotal to examine the empirical fluctuation process. In our models, all the roots in the system possess a value of less than one. However, another test is conducted for a more robust

result. The structural break visuals in Figures 4.3 and 4.4 show the graphical outcomes of the OLS-CUSUM test based on an ordinary least square which suggest the absence of structural instability for the two models. This was expected as the impacts from the shocks eventually died out as presented in the IRFs visualizations. After conducting the appropriate tests for the lag length and the structural break test, the study now focuses on the results of the models and their analysis.

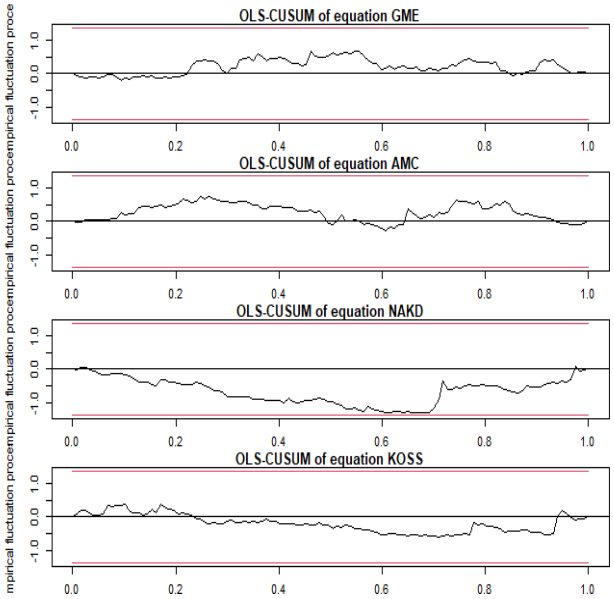

Figure 4.3. Daily Data Structural Break Test, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

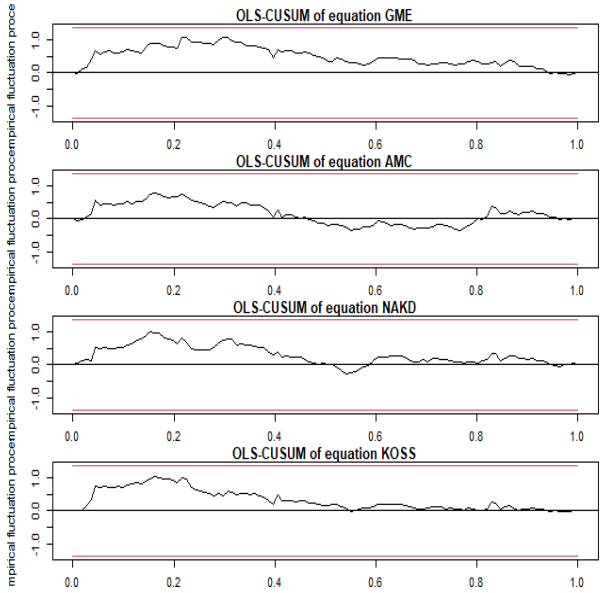

Figure 4.4. Daily Data Structural Break Test, Saga Time Horizon, 11 January 2021 - 29 June 2021

Table 4.7 and table 4.8 depict the outcomes of the two VAR models. Comparing and contrasting the two models, a significant difference is detected. In VAR(1) model, the four equations see no lag significance except for equation four (KOSS) whose influence is coming from its own lag at 0.05 level indicating a weak intertwined correlation amongst the securities. The four equations also show poor explanatory variation values of 0.024, 0.013, 0.051, 0.055 for GME, AMC, NAKD and KOSS.

In contrast, table 4.8 reports VAR(7)-process results which turns out to be tremendous as there are twenty-two significant values in the model. Starting by looking at the GME equation, it is observed that three values help explain the variation in the price of GME. Out of the three values, two are attributed to NAKD at lag one and two with a significant negative association at 5% and 10% level. The third significant value is positive and is attributed to GME.l3 at a 10% level of significance. Equation two (AMC) shows five significant values for GME.l1, NAKD.l1(-), GME.l2(-), KOSS.l2 and NAKD.l3(-) at significance level of 10%, 1%, 1%, 1% and 10% respectively. Equation three (NAKD) possesses ten significant values; NAKD.l1(-), KOSS.l1, GME.l2(-), NAKD.l2(-), KOSS.l2, NAKD.l3(-), NAKD.l5, GME.l7(-), AMC.l7, NAKD.l7(-) at significance level of 1%, 1%, 1%, 5%, 5%, 1%, 10%, 5%, 10% and 10% respectfully. The fourth equation (KOSS) possesses four values; GME.l1, NAKD.l1(-), KOSS.l2, GME.l3 at an alpha value of 5%, 1%, 1% and 10%. The stock with the highest number of significant values is NAKD with ten significant lags followed by AMC and KOSS with five lags and four lags respectively. GME ranks the least with the lowest significant values emphasizing the GameStop frenzy thesis. The R squares of the equations are also significant relative to the period before the frenzy with values of 0.498, 0.504, 0.547 and 0.438 respectively. GME has the lowest variation explanation by its own equation after KOSS followed by AMC and NKAD with all equations having a significant F-statistic at a significance level of 1%.

Table 4.7. Daily Data VAR (1)-process, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

	Dependent variable:			
	y			
	(1)	(2)	(3)	(4)
GME.l1	-0.012	0.075	-0.238	-0.030
	(0.096)	(0.100)	(0.180)	(0.080)
AMC.l1	-0.065	0.069	-0.006	0.023
	(0.091)	(0.095)	(0.171)	(0.076)
NAKD.l1	0.018	0.003	-0.134	-0.057
	(0.049)	(0.051)	(0.093)	(0.041)
KOSS.l1	0.151	-0.033	-0.310	**-0.187****
	(0.112)	(0.117)	(0.212)	(0.094)
const	0.012	-0.006	-0.0002	0.006
	(0.007)	(0.007)	(0.014)	(0.006)
Observations	117	117	117	117
R2	0.024	0.013	0.051	0.055
Adjusted R2	-0.011	-0.023	0.017	0.021
Residual Std. Error (df = 112)	0.076	0.079	0.142	0.063
F Statistic (df = 4; 112)	0.691	0.355	1.496	1.635
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4.8. Daily Data VAR (7)-process, Saga Time Horizon, 11 January 2021 - 29 June 2021

	Dependent variable:			
	y			
	(1)	(2)	(3)	(4)
GME.l1	0.137	**0.276***	0.081	**0.451****
	(0.164)	(0.157)	(0.114)	(0.199)
AMC.l1	-0.119	0.015	0.088	0.096
	(0.210)	(0.201)	(0.146)	(0.254)
NAKD.l1	**-0.493****	**-1.050*****	**-0.794*****	**-0.781*****
	(0.228)	(0.218)	(0.159)	(0.276)
KOSS.l1	0.133	0.128	**0.362*****	-0.036
	(0.168)	(0.160)	(0.117)	(0.203)
GME.l2	-0.065	**-0.565*****	**-0.402*****	-0.136
	(0.166)	(0.159)	(0.116)	(0.202)
AMC.l2	0.202	0.125	0.052	0.085
	(0.201)	(0.192)	(0.140)	(0.244)
NAKD.l2	-0.259	-0.289	**-0.398****	-0.469
	(0.242)	(0.231)	(0.168)	(0.293)
KOSS.l2	0.115	**0.633*****	**0.635*****	**0.607*****
	(0.179)	(0.172)	(0.125)	(0.218)
GME.l3	**0.314***	0.130	0.090	**0.402***
	(0.177)	(0.170)	(0.124)	(0.215)
AMC.l3	0.262	0.262	0.141	0.007
	(0.196)	(0.188)	(0.137)	(0.238)
NAKD.l3	-0.382	**-0.413***	**-0.316***	-0.478
	(0.245)	(0.235)	(0.171)	(0.298)
KOSS.l3	-0.225	0.041	0.110	-0.058
	(0.205)	(0.196)	(0.143)	(0.249)
GME.l4	-0.129	0.063	-0.121	-0.147
	(0.164)	(0.157)	(0.114)	(0.199)
AMC.l4	0.055	0.147	-0.026	0.001
	(0.189)	(0.181)	(0.132)	(0.229)
NAKD.l4	**-0.393***	-0.027	0.127	-0.177
	(0.234)	(0.224)	(0.163)	(0.284)
KOSS.l4	0.107	-0.085	0.006	0.035
	(0.206)	(0.198)	(0.144)	(0.250)

Table 4.8. (cont.)

GME.l5	0.025	-0.021	-0.039	-0.127
	(0.157)	(0.151)	(0.110)	(0.191)
AMC.l5	0.251	0.033	-0.093	0.082
	(0.184)	(0.176)	(0.128)	(0.223)
NAKD.l5	-0.167	0.203	**0.312***	0.228
	(0.243)	(0.232)	(0.169)	(0.295)
KOSS.l5	-0.124	-0.129	-0.057	0.006
	(0.188)	(0.180)	(0.131)	(0.229)
GME.l6	0.091	0.058	-0.172	-0.067
	(0.150)	(0.143)	(0.104)	(0.182)
AMC.l6	-0.133	-0.131	0.086	0.009
	(0.177)	(0.170)	(0.124)	(0.215)
NAKD.l6	0.186	0.043	-0.079	0.167
	(0.239)	(0.229)	(0.167)	(0.290)
KOSS.l6	-0.241	-0.094	0.046	-0.068
	(0.178)	(0.170)	(0.124)	(0.215)
GME.l7	0.053	-0.128	**-0.237****	0.011
	(0.150)	(0.144)	(0.105)	(0.183)
AMC.l7	0.086	0.193	**0.223***	0.080
	(0.175)	(0.167)	(0.122)	(0.212)
NAKD.l7	-0.019	-0.186	**-0.264***	-0.207
	(0.225)	(0.215)	(0.157)	(0.273)
KOSS.l7	-0.078	-0.012	0.166	0.136
	(0.172)	(0.165)	(0.120)	(0.209)
const	0.0005	0.009	-0.011	-0.002
	(0.019)	(0.018)	(0.013)	(0.023)
Observations	111	111	111	111
R2	0.498	0.504	0.547	0.438
Adjusted R2	0.327	0.335	0.392	0.246
Residual Std. Error (df = 82)	0.173	0.165	0.120	0.209
F Statistic (df = 28; 82)	**2.911*****	**2.978*****	**3.537*****	**2.279*****
Note:				*p<0.1; **p<0.05; ***p<0.01

4.4. Causality Analysis

The analysis is deployed using causality function of *vars* package to test whether a time series of a stock can be used to predict the movement of the other. To reach to a robust result, two tests are implemented. Table 4.9 and Table 4.10 show the results of the two tests for the two periods. The Granger-causality test and the Wald-type test. Comparing the period before the herding effect ignited by discussions and content sharing on forums in the Reddit social platform, with the period after, it is arguably clear that the saga had an effect on the targeted company shares causing them to move in either direction. The evidence provided by both Granger's Causality test and Wald-type test show that there is neither causation nor instantaneous causality between the time series in the first period. While the null hypotheses for the two tests says that there is not causality, all the p-values are greater than 0.05 concluding that the coefficients of the time series in the regression have a value of zero. However, the second period shows a drastic change in the outcomes and the information suffix to reject the null hypotheses. All the values for the time series except for AMC are significant indicating the presence of granger causality and concluding that the cause and effect variables have a nonzero association.

Table 4.9. Daily Data Causality Tests, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

Single & Joint Causality					
		Granger		Instantaneous	
Impulse	**Response**	**F-Test**	**P-value**	**Chi-squared**	**P-value**
GME AMC	NAKD KOSS	0.48967	0.7433	4.1513	0.3859
GME NAKD	AMC KOSS	0.66453	0.6169	4.7695	0.3118
GME KOSS	AMC NAKD	1.0312	0.3906	1.8386	0.7654
AMC NAKD	GME KOSS	0.60428	0.6597	1.8386	0.7654
AMC KOSS	GME NAKD	1.1939	0.3127	4.7695	0.3127
NAKD KOSS	GME AMC	0.55445	0.6959	4.1513	0.3859
GME	AMC NAKD KOSS	0.85561	0.4641	4.2784	0.2329
AMC	GME NAKD KOSS	0.18374	0.9074	1.6915	0.6388
NAKD	GME AMC KOSS	0.64094	0.589	1.3351	0.7208
KOSS	GME AMC NAKD	1.4311	0.233	3.422	0.331

Table 4.10. Daily Data Causality Tests, Saga Time Horizon, 11 January 2021 - 29 June 2021

Single & Joint Causality					
		Granger		Instantaneous	
Impulse	**Response**	**F-Test**	**P-value**	**Chi-squared**	**P-value**
GME AMC	NAKD KOSS	2.2416	0.0004505	49.054	5.69e-10
GME NAKD	AMC KOSS	2.916	2.843e-06	46.934	1.574e-09
GME KOSS	AMC NAKD	3.0704	8.49e-07	46.72	1.744e-09
AMC NAKD	GME KOSS	1.3499	0.1152	46.72	1.744e-09
AMC KOSS	GME NAKD	3.0052	1.416e-06	46.934	1.574e-09
NAKD KOSS	GME AMC	2.4488	9.963e-05	49.054	5.69e-10
GME	AMC NAKD KOSS	3.5811	4.037e-07	39.771	1.191e-08
AMC	GME NAKD KOSS	1.1104	0.3349	46.466	4.514e-10
NAKD	GME AMC KOSS	2.1531	0.00266	40.789	7.249e-09
KOSS	GME AMC NAKD	3.0118	1.532e-05	46.994	3.487e-10

4.5. Impulse Responses

There are a number of structural analysis tools but the impulse response function is one of the most vital and most widely used tool when it comes to measuring the impact of a shock in a systematic manner. The analysis is conducted after having estimated the VAR model and generated the predicted response functions The IRFs plots in the following pages clarify the outcomes of the causality tests as it measures the magnitude of the effect of the variable itself and for the rest of the time series. Figure 4.5 compares the IFRs of the two time horizons when there is an increase in GME. The top four graphs are for the pre-saga period while the bottom four are for the saga period. The plots show the response of AMC NAKD and KOSS when there is a shock to GME. In the first period, an increase in GME share price has little effect on all the other three stocks and its own as well.

GME to GME responses positively in the initial shock before convergence to zero occurs in the subsequent periods. AMC responds positively in the first period, but the impact fades away in the third period. NAKD movement to a positive shock from GME starts positive is downward initially before recovering in the second period and being steady around zero thereafter. Unlike AMC and NAKD, KOSS reacts differently

as it leaves the negative early to touch the zero line in the second period where it settles for the next periods. Summarizing the four responses, we can see that the impact completely dies at or before the fourth period indicating a sort of indecisive association between the four stocks. This is also a reference from the outcomes of the Granger and Instantaneous tests that those four shares are not related to each other.

On the other hand, tracing the plots of GME positive shock to itself and other stocks in the saga period, the IRFs appear to differ from the period before GME became a meme stock and grabbed the interest of retail investors. GME impact to itself shows a positive impact initially before returning to the zero zone in the second period. A slight increase is witnessed in periods 3-4 with a lower high in period four before recording a post-shock low point in period five. The wavelets climb gradually in the following periods before reaching and staying around the no-impact-red-line zone in period nine. AMC and NAKD responses are identical as the shares respond positively initially before returning to the zero area in the third period. The shares see a post-shock peak in period four. This second spike is apparently a lagging response to the price increase of GME. The shares then move on the downward side and start to fluctuate in the following periods until it sees another post-shock lower high around the red line in period nine as the impact diminishes back to zero. KOSS follows a similar pattern as well, however, its post-shock peak is below that of AMC and NAKD and is somehow near zero. All the four responses dynamic movement over the subsequent periods until the shock impact seizes to exists in period ten. This leads to the conclusion that the evidence provided by the IRFs chimes with the evidence already generated by the causality tests that the four stocks during the saga period possess some sort of association. On top of that, a quick jump is observed in all stocks simultaneously as GME surges. This arguably suggests that GME was leading in terms of share price changes while AMC NAKD and KOSS were lagging.

Figure 4.6 show the IRFs tracing the shock from AMC. The plots for the non-saga period shows little interconnectedness between the stocks. There appears to be some impact in the first periods before vanishing at or before the fourth period for all the stocks. However, the dotted lines, which construct the confidence interval, appear to be wide increasing the probability of an error. The bottom plot graphs suggest otherwise. The impact of AMC increase on the other securities appears to last for

several periods before starting to fade away in period eleven. What is interesting is the GME response. AMC negatively influences GME initially before causing it to move up and down in subsequent periods shaping a flat pattern with an upper level touched three consecutive spikes and a lower level touched three times as well.

Figure 4.7 and Figure 4.8 tracks the impact of NAKD and KOSS on the other variables respectfully. As with previous shocks, the impact is likely imperceptible in the first time horizon. The confidence bands also appear to create a wide gap for undesirable outcomes. However, the positive shock from NAKD is not perceived, while the shock initially affects KOSS positively and then shapes an upward trend in the negative territory. It impacts GME and AMC negatively before both spiked in period three and then bounce back and climb again from period 4-12 constructing an upward trend till it rests at the zero zone in period twelve. Unlike NAKD, KOSS's increase does not show any impact on the variables at the time of the shock and little influence in the following period before its negative effect and then resting below the zero line. Overall, all the graphs show a convergence back to zero some periods ahead and that is due to the stationarity of the time series. It could also be observed that the confidence bands are overall wide raising concerns about the robustness of the outcomes. However, the analysis is based on the basis of how the IRFs look and what the point estimate is.

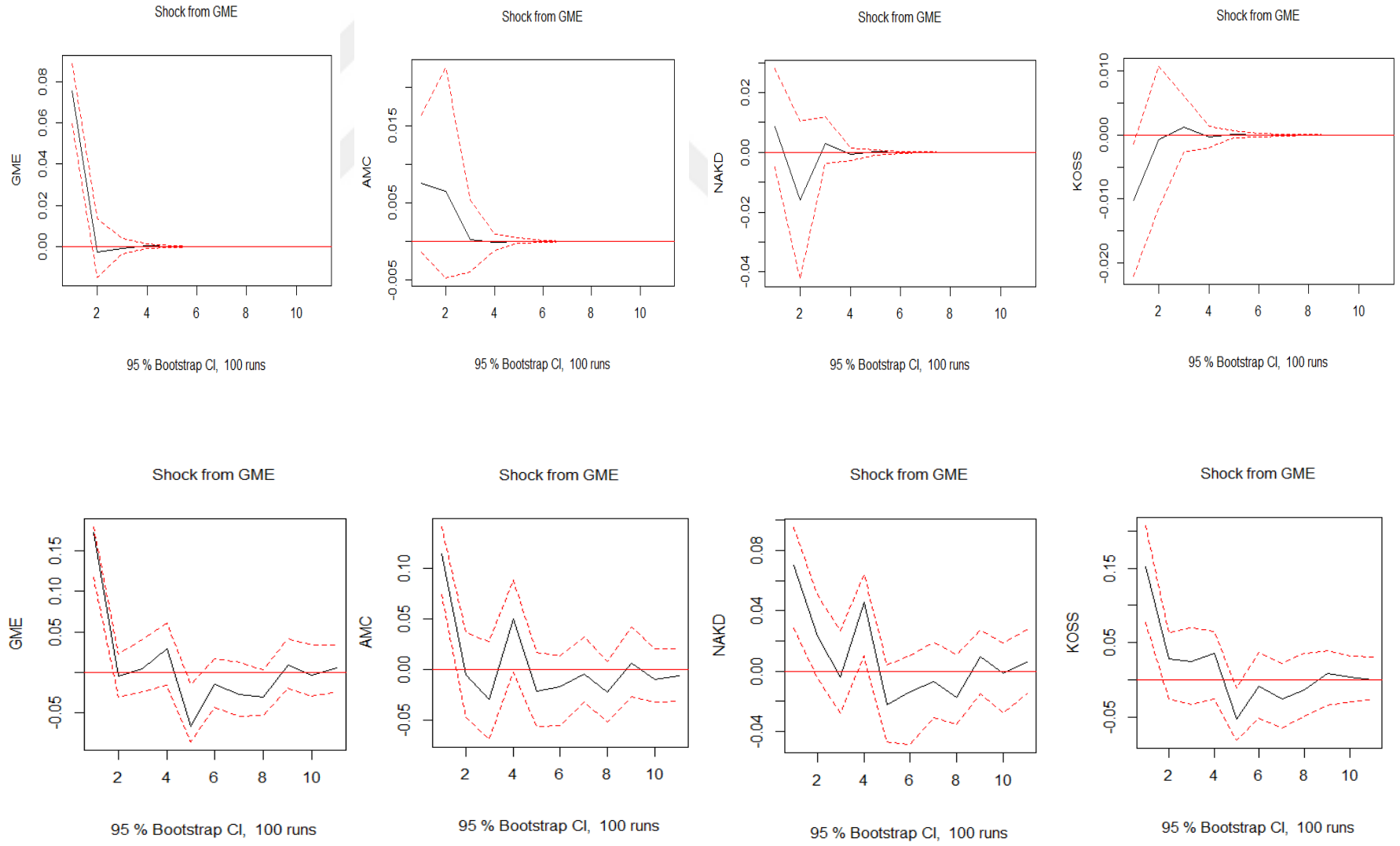

Figure 4.5. Daily Orthogonal Impulse Response from GME

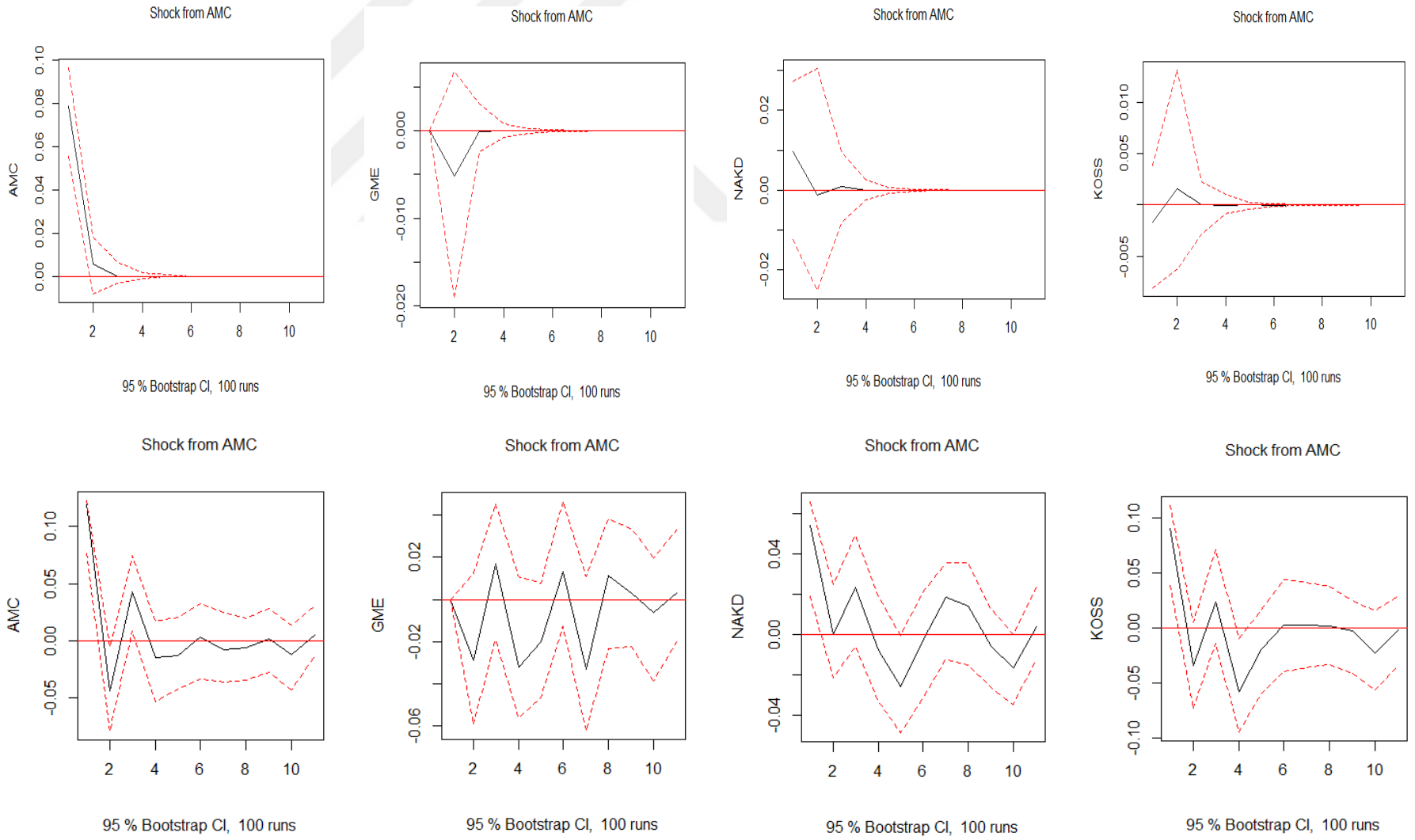

Figure 4.6. Daily Orthogonal Impulse Response from AMC

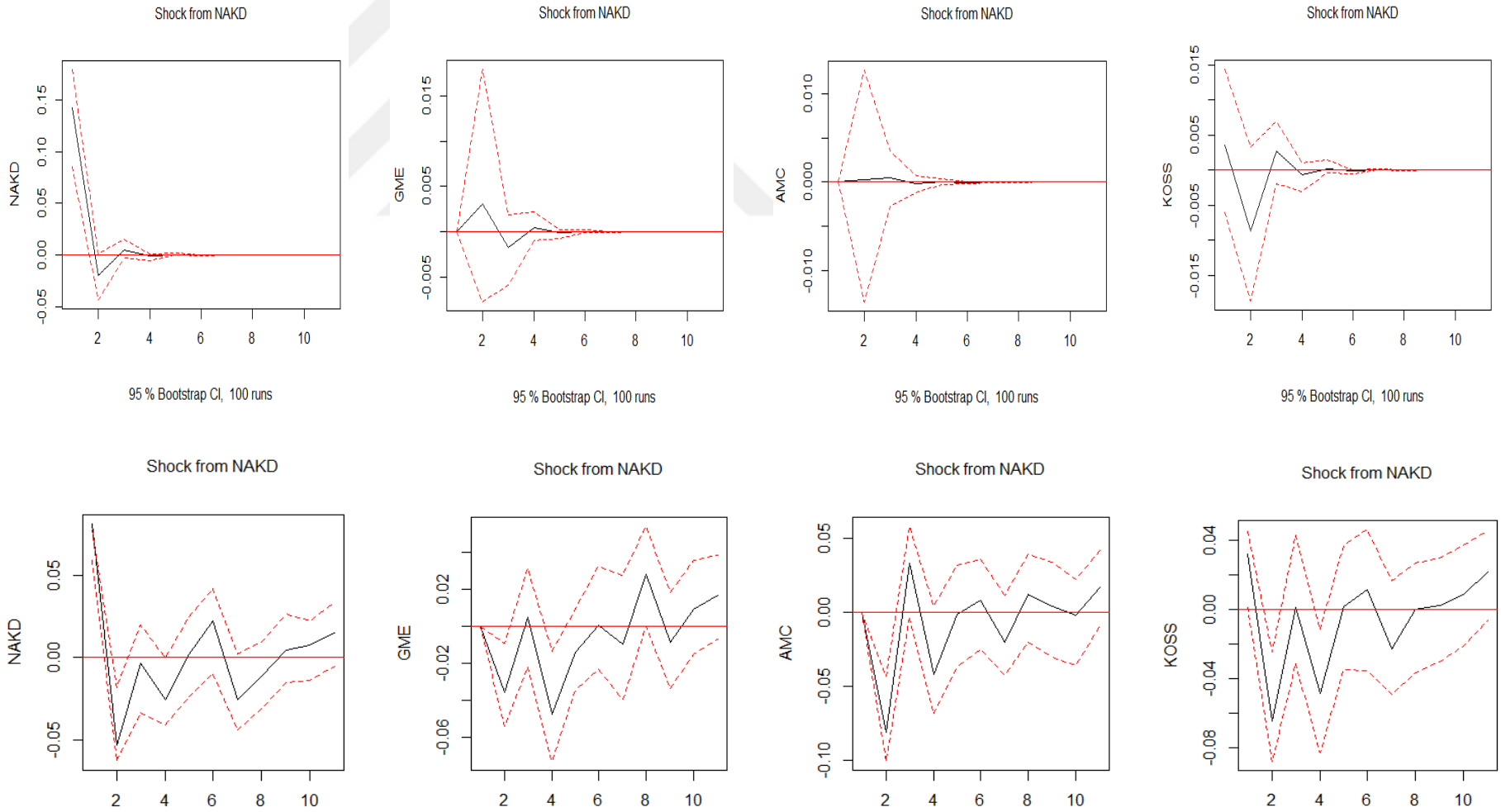

Figure 4.7. Daily Orthogonal Impulse Response from NAKD

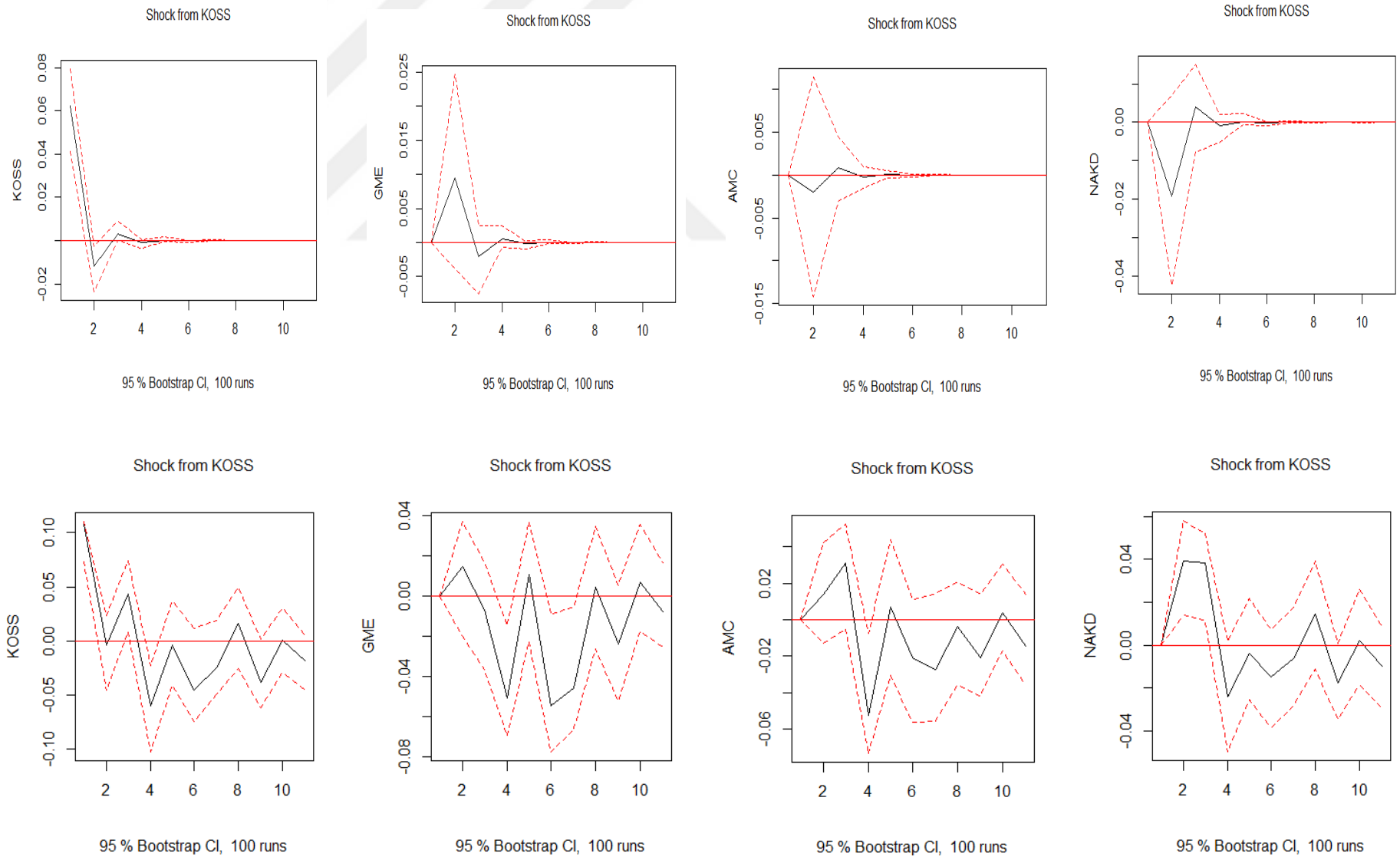

Figure 4.8. Daily Orthogonal Impulse Response from KOSS

4.6. Forecast Error Variance Decomposition FEVD

The second widely used structural analysis tool is the Forecast Error Variance Decomposition tool (FEVD). The tool tries to compose the forecast error's variance into impacts caused by exogenous shocks and measure its magnitude in percentage. Figure 4.9 demonstrate the visual graph of the FEVDs for the non-saga and saga data sets respectfully. Looking into the first graph, it is noticed that GME, AMC, NAKD, and KOSS are relatively influenced by their own shocks. If we are going to look at the graph as if someone is looking at a city from a helicopter, we realize that the shocks show hardly any variation explanation of the securities in the model. Unlike Figure 4.9, Figure 4.10 offers a drastically different decomposed variance of the forecast error. The contribution from the stocks to the variation of one another has overall changed since the start of the GameStop frenzy. Among the four stocks, the shock from GME significantly contributes to the variation of the other stocks while it shows zero response in the first period. All the stocks appear to be irresponsible for the variation of GME in the short-run. Analysing GME variation, we see that it is the only variable whose change in the first period ahead is entirely due to GME itself. This is the case due to having GME placed as the first variable in the system while the other stocks explain zero of the variation contemporaneously. In the longer horizons however, for instance, on the 11^{th} day, we see that AMC, NAKD and KOSS account for 7%, 9.2% and 15.8% respectively. The contributions from the shocks increases fairly rapidly over the periods ahead with KOSS contribution rising faster than AMC and NAKD to eventually converge in period twelve at around 15.8%, 7.5%, and 9.3% respectively. KOSS effect is also evident in the variation of AMC as AMC loses its proportion rapidly to KOSS spiking from 0% in the first period to level off at around 11%. Eleven folds over 12 periods. While KOSS contributes the most to GME and rises its proportion rapidly in AMC, it shows the least influence on AMC and NAKD while accounting for a minimum of 26% to itself - the least among the responses to its own effect - before settling at roughly 29%. GME seems to explain much of the variation in KOSS, AMC, and NAKD, with around 53%, 48%, and 34% initially and reduces in the periods ahead until it becomes fairly stable at around 40%, 34% and 29% eventually. The shock from GME to the other stocks in the earlier periods appears to be stronger than in the later periods. In the big picture, a big portion of the variation

in the FEVDs is mainly explained by the contribution of GME with roughly 67%, 34%, 29%, and 40% respectively.

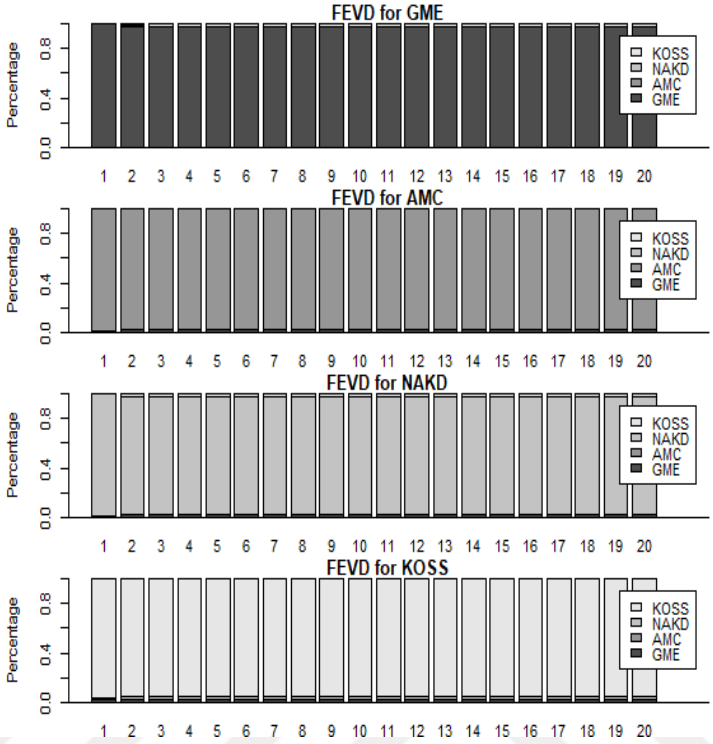

Figure 4.9. Daily FEVD, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

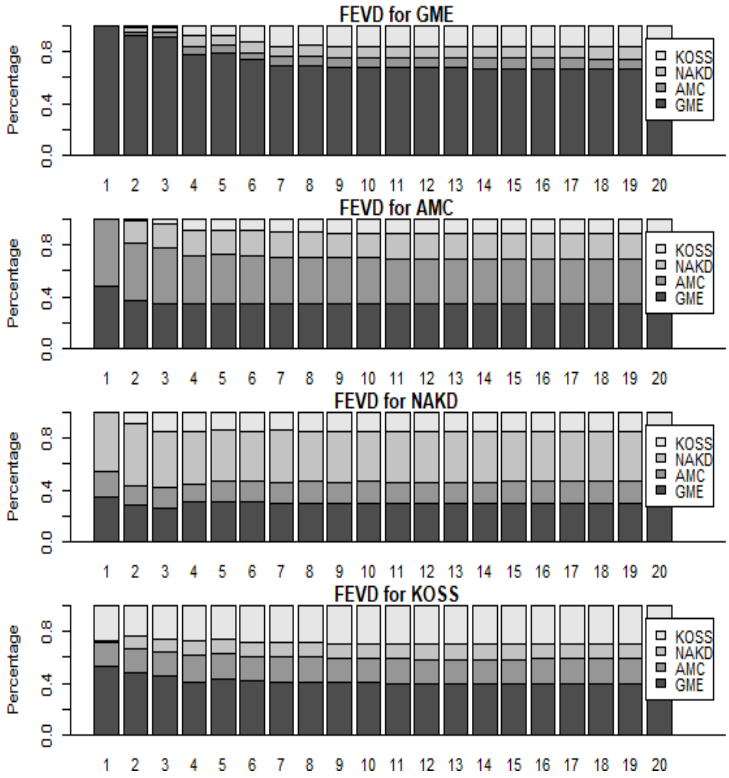

Figure 4.10. Daily FEVD, Saga Time Horizon, 11 January 2021 - 29 June 2021

4.7. GameStop and Market Indexes Interconnectedness Index

This section examines the daily return volatility spillovers across GameStop, S&P 500 Index, RUSSEL 2000, and NASDAQ. The data span the two periods under study. To avoid VAR variables ordering, the spillover index and net spillovers are based on the generalised forecast variance decomposition, which is invariant to the ordering of the tickers in the model as suggested by Pesaran and Shin (1998).

Table 11 and Table 12 below are the volatility spillover tables of the tickers. Its records are the estimated contribution to FEV of ticker i coming from a shock/innovations to ticker j.

Table 4.11. Daily Data Based Interconnectedness Index, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

	GME	SPX	RUT	NASDAQ	Spillover FROM others
GME	87.64	3.01	6.74	2.62	12.36
SPX	0.96	31.99	41.18	25.87	68.01
RUT	0.98	2.23	92.65	4.14	7.35
NASDAQ	0.17	34.73	20.38	44.71	55.29
Spillover TO others	2.11	39.97	68.30	32.63	35.75
Spillover including own	89.75	71.97	160.94	77.34	Interconnectednessd Index (178.8/400): 44.7%

Table 4.12. Daily Data Based Interconnectedness Index, Saga Time Horizon, 11 January 2021 - 29 June 2021

	GME	SPX	RUT	NASDAQ	Spillover FROM others
GME	79.63	13.74	0.84	5.79	20.37
SPX	6.64	34.84	38.75	19.77	65.16
RUT	2.60	0.89	96.38	0.13	3.62
NASDAQ	3.55	21.90	38.00	36.54	63.46
Spillover TO others	12.79	36.53	77.59	25.70	38.15
Spillover including own	92.42	71.37	173.97	62.24	Interconnectedness Index (190.8/400): 47.7%

Accordingly, the results on the off-diagonal column labelled spillover to others and the sums labelled spillover from others are to-from directional spillover. To achieve a

solid outcome, the total volatility spillover index, which is placed on the lower right part of the two tables (the Interconnectedness tables) is computed. It is expressed in percentage points by taking the sum of the off-diagonal column relative to the sum of the grand column, which includes the diagonals. The net volatility spillovers are hence computed by taking the difference between the from-to results as it appears in Table 14 and Table 15.

Table 4.13. Daily Data Based Interconnectedness Index Period-to-Period Percentage Change

	GME	SPX	RUT	NASDAQ	Spillover FROM others
GME	-9%	357%	-88%	121%	65%
SPX	593%	9%	-6%	-24%	-4%
RUT	166%	-60%	4%	-97%	-51%
NASDAQ	1935%	-37%	86%	-18%	1s5%
Spillover TO others	506%	-9%	14%	-21%	7%
Spillover including own	3%	-1%	8%	-20%	7%

Table 4.14. Daily Data Based Net Spillover Index, Pre-Saga Time Horizon, 30 June 2020 - 08 January 2021

	To	From	Net	Transmitter
GME	2.11	12.36	-10.25	FALSE
SPX	39.97	68.01	-28.03	FALSE
RUT	68.30	7.35	60.94	TRUE
NASDAQ	32.63	55.29	-22.66	FALSE

Table 4.15. Daily Data Based Net Spillover Index, Saga Time Horizon, 11 January 2021 - 29 June 2021

	To	From	Net	Transmitter
GME	12.79	20.37	-7.58	FALSE
SPX	36.53	65.16	-28.63	FALSE
RUT	77.59	3.62	73.97	TRUE
NASDAQ	25.70	63.46	-37.76	FALSE

Considering first the gross and net directional spillovers tables for the pre trading saga time horizon, from the spillovers to others we can see that the gross directional spillovers are not very different but for GME causes 2.11% while the contribution received from others sets at 12.36% mostly from RUT Index at around 6.7%. This is arguably due to its relatively small size and its influence on the broader market. Contrarily, the period since the frenzy started shows otherwise. As the data, reveals the stock is still a net receiver rather than a transmitter with significant share change of contribution to the forecast error variance composition of others by a change from 211 bps to 1279 bps, a drastic surge of 506%.

The biggest receiver of the share percentage change of the spillovers is NASDAQ followed by SPX and RUT respectively. It is not merely spillovers from GME that saw a surge, but the variance explanation from others to GME also increased by 65%: a relatively modest increase. Most of the share explanation is caused by SPX, where the stock is indexed. This concludes that the influence of GME on the broad market is not as it was before the mania while the total interconnectedness remains pretty much the same with little insignificant increase from 44.7% to 47.7% in the saga period.

CHAPTER V

CONCLUSION

The study was conducted to find out whether a trading frenzy does significantly impact the association of targeted stocks in either directions by focusing on the controversial event of GameStop taking place on January 2021 caused by the herding effect of retail investors gathering in a sub-Reddit forum. The empirical analysis of GME, AMC, NAKD and KOSS results suggest that the trading saga had a significant effect on the targeted stocks exhibiting an intertwined association opposite to the pre mania period.

Unlike the pre mania period, the structural analyses based on the-out-of-four-stocks built VAR models reveal a significant lead-lag effect amongst all the securities. The significant variation attributed to the other stocks in the model reveal that GME receives the least effect from the other variables, NAKD the highest, while KOSS possessed the lowest variation explanation by its equation while AMC appears to be the most influenced. Concerning the broad market, as evident from the interconnectedness analysis, it is observed that the index is not significant relative to GME remaining a non-transmitter stock though its contribution in the explanation of the return volatility of the broad market surged significantly.

The potential to dig deeper into the topic is feasible to further comprehend the phenomena of frenzy trading where research might be examining the contribution from of the to-become-meme stocks to the overall market volatility measured by the VIX index. It is also of great importance to test for the existence of such activity and its significance in the commodity markets and other markets. Another study could incorporate the effect of trading limitations imposed on the restricted stocks by some broker-dealers during the January mania peak.

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