Disruptions in the Securities Lending Market: Evidence From the 2021 Short Squeeze

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Abstract

The smooth functioning of the stock lending market is essential for enabling short selling and maintaining effective arbitrage. Yet, little is known about how this low-transparency market responds to acute disruptions such as short squeezes. Short selling plays a central role in price efficiency, without which prices would disproportionately reflect the beliefs of the optimist. Cheap access to shares from lending institutions facilitates this process. The January 2021 short squeeze – centered around GameStop but involving a wider array of highly shorted equities – created extreme market conditions. While regulatory and academic attention has largely been focused on the squeeze's effect on price volatility and more visible metrics of market quality, the squeeze's effects on the stock lending market have not been thoroughly explored. Through an OLS regression framework, this paper analyzes how borrowing costs behaved across the highly shorted segment of the market, as compared to the non-shorted, broader market segment. The results show that during the squeeze, borrow fees increased, but only in the highly shorted group. In the post-squeeze period, borrow fees fell significantly, but again only within the highly shorted group. The stability of control group metrics supports the idea that the observed effects were concentrated solely within highly shorted equities. These results contribute to the literature on short sale constraints, bringing further implications for inefficiencies beyond what the existing literature had shown. Furthermore, this paper provides evidence that the lending market distortions brought on by a short squeeze may persist beyond the event window, interfering with effective arbitrage.

Table of Contents

Introduction……1

Motivation…….. 6

Literature Review.....10

Data……21

Methodology……...23

Results……27

Robustness Checks……33

Conclusion……..38

Appendix……..…41

References……...42

1. Introduction

Four years ago, the subjects of short selling and short squeezes were thrust into the forefront of the finance world with the short squeeze of GameStop. The origins of this key event date back to the pandemic, where, due to lockdowns and economic restrictions, many businesses that depended on traffic to their physical locations encountered significant economic challenges. Such companies became an ideal target for short sellers, who foresaw vulnerability and probable bankruptcy. Notably, bankruptcy is the best-case scenario for short sellers: if the shares they borrowed and sold short become worthless or near worthless, then their position becomes pure profit. This strategy seemed to be working. Stock prices of select companies plummeted to record lows, while short interest levels reached extraordinary levels. This perfect play seemed to be nearing a resounding success. However, retail investors became cognizant of the situation, originating in a series of posts and livestreams from Reddit user Keith Gill. Gill expressed his bullish perspective on GameStop, arguing that the short interest was unjustified by the company fundamentals. Shocked to learn these unprecedented short interest levels (in the case of GameStop, 140% of the public float [Bloomberg, 2021]) these online traders rallied around heavily shorted companies in an attempt to simultaneously incite a short squeeze, take down what they saw as predatory hedge funds, and make a fortune in the process. A David versus Goliath narrative was born as more and more retail investors piled on, joining what they deemed to be both a meaningful cause and a once-in-a-lifetime money-making opportunity. Echoes of the 2011 Occupy Wall Street movement reemerged. In January of 2021, many of these high short interest stocks experienced dramatic price surges as short squeezes unfolded all throughout the equity markets. Table 1, below, illustrates the event through highlighting the daily returns of several high short interest securities during the height of the squeeze period.

Table 1: Daily Returns for Select Stocks, 1/21/2021–2/2/2021

Stock	21-Jan	22-Jan	25-Jan	26-Jan	27-Jan	28-Jan*	29-Jan	1-Feb	2-Feb
$GME	10.0%	**51.1%**	**18.1%**	**92.7%**	**134.8%**	-44.3%	67.9%	-30.8%	-60.0%
$AMC	0.3%	**17.8%**	**25.9%**	**12.2%**	**301.2%**	-56.6%	53.7%	0.3%	-41.2%
$BBBY	7.6%	**12.4%**	1.6%	**20.2%**	**43.5%**	-36.4%	5.0%	-14.4%	-16.1%
$KOSS	-3.2%	-5.7%	**79.6%**	**66.7%**	**480.0%**	-27.7%	52.5%	-45.3%	-42.9%
$BB	0.5%	9.3%	**28.4%**	4.9%	**32.7%**	-41.6%	-3.8%	3.8%	-21.1%
$EXPR	0.9%	**53.0%**	**131.8%**	-26.7%	**214.1%**	-50.8%	27.7%	-16.7%	-32.4%
S&P 500	0.1%	-0.4%	0.4%	-0.2%	-2.4%	0.9%	-2.0%	1.7%	1.4%

*Retail brokerage platforms suspended buy orders on January 28.

Word spread rapidly across the internet causing more speculators to jump in, further fueling the price movements. During the last week of January, GameStop and the cascading short squeeze phenomenon was the number one story in the financial news. The event came to an end when several of the top retail investor brokerage platforms restricted the ability to buy several high short interest securities. In Table 1, we can observe extraordinary returns from January 21 through January 27, abruptly halted by the January 28 brokerage restrictions. With the removal of buy-side demand, prices of the stocks involved plummeted, and the short squeeze momentum evaporated. While there have been subsequent revivals in abnormal price volatility for some of these highly shorted stocks, nothing has come close to the volume magnitude and valuations of that month (it is noteworthy that while prices fell from their January 2021 levels, many of the stocks involved in the squeeze have maintained valuations much higher than their pre-squeeze valuations). The immediately observable consequences of the event were significant. Hedge funds with large short positions on stocks that squeezed incurred significant losses. Melvin Capital, a prominent hedge fund with investors such as Citadel and Point72, lost 53% of their fund's value during the squeeze period (Chung, 2021). Melvin would eventually shut down in May of 2022, never able to fully recover from the event. White Square Capital, a London-based hedge fund, announced its closure in June of 2021 after also suffering severe losses betting against GameStop (Fletcher, 2021). D1

Capital Partners, another investment firm, lost 20% of its capital due to related short sales (Karsh et al., 2021).

Losses were not limited to Wall Street. Hordes of informed retail investors speculated on the share prices of many of these stocks during the late January peak, losing big when the squeeze fizzled out. Salvador Vergara, a 25-year-old security guard living in Virginia, took out a $20,000 loan to invest in GameStop after following discussions on Reddit (Ensign, 2021). The stock plunged 80% after his purchase. Countless stories – like Mr. Vergara's – unfolded throughout the world in the aftermath of the squeeze event. It is worthwhile to acknowledge that the squeeze did lead to some material benefits for the companies whose ticker symbols got caught up in the trading mania. In January of 2021, AMC Theatres, whose stock price rose over 500% during the squeeze period, announced a $579.8 million equity raise from the issuance of 50 million new common shares (AMC Entertainment Holdings, Inc., 2021). They've since completed multiple additional share offerings, raising hundreds of millions of dollars in cash to be put towards operational use. GameStop also took advantage of their elevated share price in April of 2021, selling 3.5 million shares that generated proceeds of $551 million (GameStop Corp., 2021). In the following years, GameStop has also issued new shares several more times, bringing their total cash raise into the billions as a direct result of the short squeeze. The event sparked regulatory debate as well. The U.S. House Committee on Financial Services held a hearing in February of 2021, titled "*Game Stopped? Who Wins and Loses When Short Sellers, Social Media, and Retail Investors Collide.*" The hearing covered topics such as Robinhood's decision to halt trading, the role that online chat forums play in the financial markets, and the fairness of aggressive short selling practices. In October of 2021, the Securities and Exchange Commission (SEC) released a report titled *Staff Report on Equity and Options Market Structure Conditions in Early 2021*, analyzing the events

and presenting their findings (U.S. Securities and Exchange Commission, 2021). The SEC found that the surge in retail investor participation, combined with short squeezes and options trading, led to extreme price volatility. The reports concluding takeaways included suggesting improved reporting on short sales, supporting thinly capitalized broker-dealers, and reviewing payment for order flow practices and the incentive structure that it creates. Notably, a key element of short selling was absent from the congressional hearing and subsequent SEC report: the impacts of the squeeze on the market for borrowing stock (also known as the stock lending market or securities lending market) and how that may have impeded upon market efficiency both during and after the event.

In this market, institutions looking to generate incremental income from their large stock holdings are paired with other financial entities (primarily hedge funds) that want to bet against securities that they deem to be weak or overvalued. Lenders charge a cost (known as a borrow fee) in order to compensate them for the risks and opportunity costs associated with loaning out their shares to short sellers. These risks include the loss of voting rights, counterparty insolvency risk, and stock sale timing inflexibility. The equilibrium borrow fee is determined as a function of loan supply, short demand, and lender risk premium. While the smooth functioning of the stock lending market plays an instrumental role in the efficiency of the financial markets, it did not receive mainstream attention during and after the 2021 short squeeze event. The extent to which the event affected the stock lending market, and consequently how distortions in the stock lending market may have impeded stock market efficiency, remain largely unexplored. This paper focuses on how the short squeeze impacted the market for borrowing stock, both during and after the event.

1.1. Motivation

The motivation for this research question can be sourced to the borrow fee behavior for the primary actor in the January 2021 short squeeze: GameStop. Its borrow fee seemingly mimics the share price, skyrocketing alongside it during the last week of January. On January 26, the borrow fee reached an astounding 83.62%. To put this figure into context, we must understand the nature in which borrow fees are paid, as well as the standard borrow fee rate. The aggregate market is easy to borrow, with less than 10% of all stocks having borrow costs above 1% (D'Avolio, 2002). Borrow fees are expressed as an annualized interest rate on the market value of the short position, and the borrowers pay on a daily basis. At a borrow fee of 83.63%, a $1 billion short position would require a daily payment of $2.29 million. The average borrow fee on GameStop for the month of January was 31.02%, or a daily payment of $850,000 on a $1 billion short position. Following the retail trading restrictions on January 28 – and the following price collapse – the borrow fee returns to a much more standard level, at approximately 1%. GameStop's trend of an exceptionally high borrow cost leading up to and during the squeeze, followed by a sharp decline, can be observed for many other high short interest stocks as well. Observe Figure 1, below, detailing the borrow fees for six highly shorted securities from December 31, 2020, through February 19, 2021. Throughout each of the six charts, the general trend is high borrow fees leading up to the squeeze period, a peak near or during the squeeze, and lower fees afterwards. High borrowing costs indicate a high demand to short, a low availability of shares to borrow, and high perceived borrower default risk – any one or a combination of these factors can be at play. It follows that low borrow fees suggest some combination of a low demand to short, high stock loan availability, and low perceived borrower default risk. Understanding the extent to which the squeeze altered the stock lending market (and where and when the impacts were felt) can provide

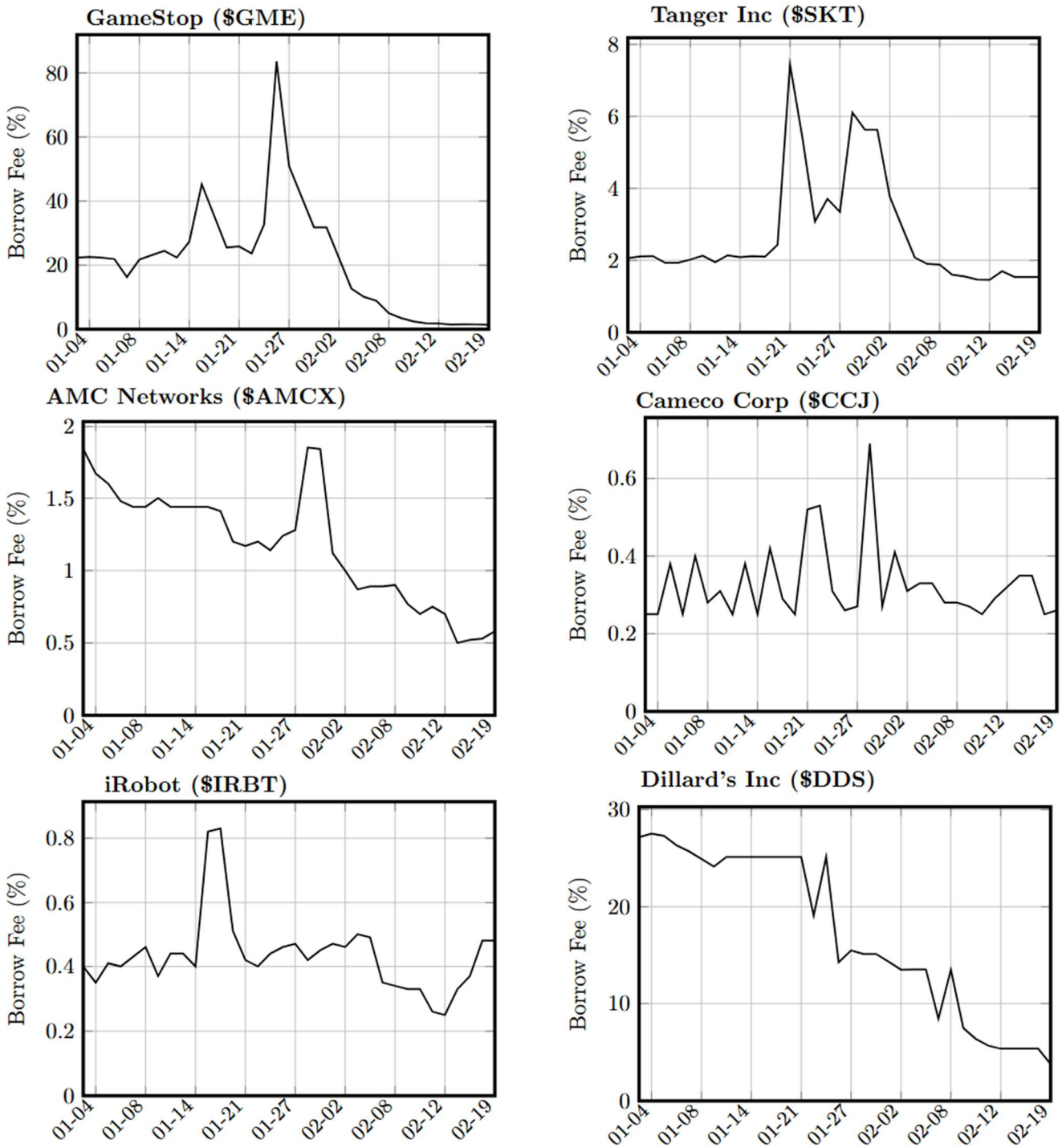
a richer understanding of the narrative throughout the event, as well as the implications on market efficiency. It is thought-provoking that borrow fees dropped for many of these securities, especially given their valuations. Although lower than their peak share price at the height of the squeeze, many stocks with previously high short interest levels maintained valuations significantly higher than their pandemic lows, even after the short squeeze hype collapsed. In February 2021, GameStop shares traded nearly ten times higher than they did during the summer and fall of 2020 (the months before the squeeze), during which short demand was exceptionally high. The same dynamic can be observed for other highly shorted stocks caught up in the event, including AMC Entertainment Holdings Inc ($AMC), Blackberry Ltd ($BB), and Koss Corp ($KOSS). After the squeeze, these companies' earnings prospects are largely unchanged, *and* they are valued even higher for non-fundamental reasons. Seemingly, short sellers would be jumping at the opportunity to profit on the difference between current value and future value. Yet, the decline in both borrow fees and (short interest levels) appears to suggest a different picture – at least in the few highlighted securities we've looked at thus far. This paper will analyze a larger sample of securities to determine answers to the following questions:

1. *Did borrowing costs generally rise for highly shorted stocks during the squeeze period?*
2. *Did borrowing costs generally decrease for highly shorted stocks after the squeeze period?*
3. *What are the implications of the results generated from the above questions?*

By testing several simple regression models against a manually constructed dataset, I find significant evidence that borrow fees increased dramatically during the squeeze period, but just for

a high short interest sample group. This relationship was not observed in the broader market. On the supply side, my regression output shows loan supply decreased during the squeeze period, potentially highlighting the lack of supply elasticity in the stock loan market. If true, this reaffirms the findings of Blocher & Zhang (2022), who studied the counterintuitive behavior of stock lenders. My research additionally finds that borrow fees decreased after the squeeze period, but again *only* for the high short interest sample. Put together, these takeaways imply several important points. First, borrow fees rose during the squeeze period for high short interest stocks due to excessive short demand to fight price increases and/or a loan supply contraction due to lender strategy. Second, in the post period, even though no "tangible" short sale constraints existed, the prior experience of getting burned by the squeeze significantly curtailed short activity, as evidenced by the plummeting stock loan borrow fees.

Figure 1: Borrow Fee Behavior for Select High SI Stocks, 12/31/2020 - 02/19/2021



2. Literature Review

My findings contribute to the literature on stock lending market behavior, short sale constraints, and short squeezes. D'Avolio (2002) provides an influential comprehensive analysis of the stock lending market. He finds that the aggregate market is easy to borrow, as determined by low borrow costs and just a fraction of the available stock supply to be on loan at any given time. Using a sample loan portfolio, D'Avolio finds a value-weighted cost to borrow of just 25 bps per annum and only 7% of loan supply (by value) currently borrowed. 91% of the stocks in his sample had borrow fees under 1%. Furthermore, while most stocks can be easily borrowed, some stocks never shorted at all despite being freely available. These such examples comprise 10% of all public equities, yet importantly less than 1% of the U.S. stock market value. The stocks that are hard to borrow, (classified as being "on special") are characterized by high investor disagreement and make up 9% of all stocks. Loan fees above 1% are labelled in this "specials" category. He uses high turnover, high analyst forecast dispersion, low cash flows, and increased message board activity as proxies for high disagreement. Within this group, the mean borrow fee was 4.3%. The probability of being "on special" decreases with market capitalization and institutional ownership. Recalls (the forced reclaiming of shares by a stock lender) are rare, with 2% of stocks on loan experiencing a recall. However, the possibility of recall poses a significant risk to short sellers due to the implication that they could be forced to exit a position at an inopportune moment. One of D'Avolio's key implications was that the ease of short selling is crucial for effective arbitrage, defining "ease" as low borrow costs and low recall risk. Recall risk is further explored in Chuprinin & Ruf (2017) where they study stock loan agreements. Notably, Chuprinin & Ruf find that high recall activity coincides with institutional selling and precedes stock declines (standard loan agreements allow for lender termination at any time without penalty). This dynamic can prevent

otherwise profitable opportunities for short sellers and is one of the greatest risks in short investments. Engelberg et al. (2018) also emphasize the importance of considering recall risk as one of the greatest threats to a short sale.

Prado (2015) and Blocher & Zhang (2022) study the supply side behavior of the stock lending market. Prado shows that institutional lenders buy shares in response to higher lending fees. However, this relationship dissipates when higher lending fees are accompanied by negative company news. This illustrates an interesting paradox within the supply side of the stock lending market: higher anticipated lending income is both a positive sign (more revenue) and a negative sign (short sellers are acting on negative information). Prado also determines that while expected future lending income is priced into equity valuations, the effect is minimized by the negative information that arises from short selling. Blocher & Zhang elaborate further on this subject, challenging the elasticity assumption of stock loan supply. Their results suggest that loan supply *contracts* during periods of high short-selling demand. Their sample ran from July 2006 to December 2016, with a daily frequency on loan market data. What they found was staggering: a one standard deviation increase in predicted demand resulted in a 9.4%-13.4% decrease in loan supply. This runs contrary to traditional economic assumptions on supply-demand elasticity, as we would expect that when demand for stock loans increases, more lenders will meet the opportunity. Blocher & Zhang theorize that this peculiar nonlending behavior may be due to the belief that withholding shares from short sellers would enhance expected returns, even despite the loss of lending fee income. This strategy is predicated on the idea that facilitating short sales on one's own investment will push down prices and harm the investment value. Blocher & Zhang also show that the supply contraction effect is increasing in investor disagreement and return skewness, traits that they characterize as "lottery like." Connecting their results to short squeezes, they also note that

during a squeeze, nonlending buyers remove stock loans from the marginal short investor, which further drives up prices.

The second area my research relates to is short selling constraints and the connection to efficiency. Miller's (1977) foundational paper on opinion divergencies in equities discusses the importance of short sellers. Even just a small number of badly informed investors can bid up the price of a given stock to an unreasonable value. Miller explains how short sales moderate this tendency for riskier stocks to be bid up to higher prices, thus maintaining efficiency in the equity markets. When short sellers are unable to act upon their beliefs, overpricing develops, as pessimists wish to hold a negative position (shorting) but are instead forced to hold zero. As such, the price reflects the optimist's viewpoint disproportionately. Miller's work has been immensely influential, and his ideas have been represented in a wide body of literature since his publishing. Harrison & Kreps (1978) show that when short selling is not possible, asset prices may exceed their fundamental value and speculation can spread. Figlewski (1981) states that short sale restrictions have an asymmetrical impact on investors with favorable and unfavorable market opinions. Namely, a market in which short selling is prohibited gives disproportionate weight to optimistic investors over pessimistic ones. More recently, Boehme et al. (2006) examine the interaction between high differences of opinion and short sale constraints. They found robust evidence of overvaluation for stocks that fall in both of the aforementioned categories. Adding to Miller's hypothesis, they conclude that high investor disagreement and shorting constraints are not enough to systematically cause overvaluation when each is considered *alone.* Rather, it is the combination of these two requisite conditions in a given security that leads to overpricing. Another body of literature considers constraints from the supply side specifically. Asquith et al. (2005) defines short sale constraints, characterizing it as the conditions that arise when high demand to short combines

with limited loan supply. They affirm Miller's original hypothesis, that constrained stocks underperform due to overvaluation. Their research also notes that most lendable shares originate from institutions rather than individuals. Therefore, lower institutional ownership is often accompanied by short sale constraints – short sellers want to short but are unable to borrow, thus preventing their beliefs from being priced into the market. Chen et al. (2002) also show that breadth of ownership is a reliable proxy for how tightly short sale constraints bind, supporting Asquith et al.'s work. Saffi & Sigurdsson (2011) show that the quantity of stock available for loan (lending supply) has a significant impact on price efficiency. Securities with a large pool for short sellers to borrow from have better price accuracy and are less prone to negative abnormal returns. Notably, they show that a large lending supply is not associated with negative abnormal returns, countering the widely held concern that shorting destabilizes markets.

Not all of the research concedes this point, however. Bris et al. (2007), for example, analyze 46 equity markets around the world to study how short sale restrictions affect efficiency and returns. They observe that prices incorporate negative information more quickly in countries where short sales are allowed and frequent, which may be a sign of greater efficiency. On the other hand, they also find strong evidence that in markets in which short selling is either prohibited or not practiced, markets display significantly less negative skewness. In another contradiction to Saffi & Sigurdsson. Kaplan et al. (2013) find that shocks to loan supply (both negative and positive) have little influence on efficiency. Conducting an experiment through partnering with a large money manager, Kaplan et al. instigated exogenous shocks to the lendable share supply. While both negative and positive supply shocks caused borrowing costs to rise and fall as we would intuitively expect, they found no evidence of consequences to efficiency. The claim that shorting constraints does not impact efficiency is unsupportive of Miller, but does not invalidate Boehme

et al., who argued that it is the *combination* of constraints and high opinion divergence that sprouts inefficiency. Kaplan et al. did acknowledge some potentially significant limitations to their study – their observation period included the 2008 financial crisis, which upended their experiment and required some improvisation to complete it. Furthermore, they admit that their supply shocks may have been too small to have an impact on equity pricing (in a short squeeze, for instance, supply shocks are extreme in magnitude). While "current" constraints can limit short selling (low loan supply, high shorting costs), there are other intangible risks facing any short sale. In addition to the risk of forced recall, further overvaluation threatens short sellers. Brunnermeier (2010) explains this key limitation to arbitrage – asset prices can drift even further from their fundamental value. In such a case, the short seller could be totally correct in their overvaluation belief and still lose money due to the timing of their short investment. Brunnermeier articulates how it is immensely difficult to predict the timing of a bubble collapse. As a result, it can be extremely profitable ride a bubble and dangerous to bet against it. Atmaz et al. (2024) connects the ideas of Brunnermeier to the 2021 short squeeze event. The authors find that GameStop's borrow fee increased dramatically due to a total collapse in lending supply, which contributed to the significant price increase. This was because short sellers were suddenly unable to roll their old positions into new ones with newly borrowed shares, forcing them to buy shares on the open market to close their position. Another one of Atmaz et al.'s key findings was that short interest has powerful predictive power on future negative returns, although only in the presence of a costly-to-short stock. Observing short interest during the GameStop episode, they note that short interest declined severely, due to expectation of continued demand – a phenomenon in direct accordance with Brunnermeier's point that the threat of further bubble growth limits arbitrage opportunities. The predictive power of short interest is further explored in Desai et al. (2002) and Cohen et al. (2007)

who both show that high short interest is significantly associated with low future returns and delisting. On a related note, Hanson & Sunderam (2014) observe a major increase in short selling activity in the 21st century. Specifically, they show that average short interest ratios for NYSE and AMEX stocks have more than quadrupled from 1988 to 2011. Given the recent surge in short volume, it is no surprise that U.S. markets have experienced several monumental short squeezes over the past two decades.

The interaction between stock borrowing dynamics, short selling constraints, and unprecedented short interest levels highlights the frictions that can arise in short selling markets. Short squeezes are arguably the greatest distortion that can take place in such short selling markets. In a short squeeze, forced purchases from short sellers drive upward price spirals, pushing valuations even further from their fundamental value – the dangerous risk that Brunnermeier cautioned against. The literature, both on short squeezes and specifically on the 2021 squeeze event, provides the necessary background to contextualize my research and show what gaps it seeks to address. Schultz (2024) characterizes short squeezes through a concrete sequence of events. Borrowed shares are recalled, and the short seller is unable to locate readily available shares. This requires the short seller to close their position early, through a forced buy-in. Recall can occur for a number of reasons, including but not limited to the inability of the short seller to meet increased collateral requirements and the risk tolerance of the lending institutions. These buy-ins exacerbate the price run ups, causing more forced positions closures as other short sellers become unable to meet collateral requirements (buy-ins can also be voluntary during a squeeze if the short seller determines it to be unwise to continue to hold their position). Schultz identifies an interesting paradox within the short selling market: the single best predictor of a short squeeze is the utilization rate (the proportion of shares available to lend that are on loan to short sellers), but

simultaneously high utilization also predicts lower returns. This dynamic highlights the inherent high-risk nature of shorting, particularly when many parties are shorting the same security all at once in high volumes (as seen with GameStop in 2021). Schultz also finds that squeezes for hard-to-borrow stocks are common (with varying degrees of magnitude) and prevent short sellers from capitalizing on significant gains.

Allen et al. (2006) show that market corners and short squeezes are not a modern phenomenon, being highly common in the nineteenth century and twentieth century. They studied several well-known stock and commodity corners that took place between 1863 and 1980, finding evidence of large investors and corporate insiders abusing their market power to manipulate prices. Importantly they discovered that such manipulation leading to a corner created an adverse price impact on *other* assets. Pirrong (1993) found a similar conclusion when applying Allen et al.'s framework specifically to short squeezes, determining that they cause both a distortion of prices and deadweight losses in the market. The first significant case study examining the detrimental effects of a major short squeeze in the twenty first century was conducted by Allen et al. (2021). They analyzed the 2008 Volkswagen short squeeze, during which the German automobile manufacturer temporarily became the most valuable company in the world by market capitalization. The authors found that the squeeze significantly impeded market efficiency and worsened price discovery. For Volkswagen stock, bid-ask spreads, volatility, and volume all increased during the squeeze, proxies that the authors used to measure efficiency. Furthermore, a "contagion effect" of sorts occurred with Volkswagen's public competitors: for those stocks, spreads and volatility increased as well, *even though* no such squeeze was taking place. This finding corroborates the work of Allen et al. (2006), who also showed an adverse efficiency impact on other assets. Allen et al. (2021) explain the efficiency loss through the lens of limits to arbitrage.

They first outline how arbitrage improves price efficiency. When prices are too low, arbitrageurs will buy and drive the price up. When prices are high, arbitrageurs will short sell and drive the price back down. In the case of the Volkswagen short squeeze, it was damaging to market efficiency because it signaled to potential short sellers that they bear the risk of being caught in a short squeeze. This intangible risk discouraged would be short sellers, consequently weakening market efficiency.

Another body of literature has specifically focused on the GameStop short squeeze and its repercussions, applying the framework from prior short squeeze studies to the event. Vasileiou (2022) provides evidence that an exceptional time series feature emerged during the examined period: the anti-leverage effect. A normal characteristic of the financial time series, the leverage effect states that there is a tendency for volatility to rise more when previous returns are negative than the respective volatility of a price increase of the same magnitude (explained in concrete terms, market volatility will generally be higher following a 5% drop in equity prices than it would be after a 5% rise). During the GameStop short squeeze, Vasileiou shows that the opposite occurs. As stock prices of several highly shorted stocks rose, volatility increased dramatically – to such a degree that Vasileiou labels it as quantitative proof of a market abnormality. As both Allen et al. (2021) and Pirrong (1993) predict, several studies on the GameStop episode identify impediments to market quality. Allen et al. (2021) examines the impact of the GameStop short squeeze on market dynamics. The authors find that short squeezes not only disrupted market quality (using the same market quality metrics as the Volkswagen study), but also negatively affected their industry competitors. Squeezed stocks saw a sharp decline in short interest and a supply contraction in the lending market – theoretically also causing an efficiency loss due to the decrease in arbitrage activity. Umar et al. (2021) highlight movements between stock prices of highly shorted stocks

during the squeeze, employing wavelet coherence analyses to determine the link in price activity. They found a positive association between GameStop prices and the performance of high short interest indices, suggesting that the bubble behavior is transmitted freely between different stocks, regardless of sector. It is also important to recognize that some research has identified certain benefits to market dynamics resulting from the 2021 short squeeze, complicating the narrative that it was a purely destructive event. Jarrow & Li (2023) develop a model that shows how as long as social media groups (such as the trading forums involved in the GameStop event) are not overly optimistic, they can provide an important deterrent to short sellers "bear raids" and thus enhance market efficiency. However, the authors did clarify that whether media groups increase or decrease efficiency depends on the situation. If they impede short sellers from correcting a security's overpricing, then they damage efficiency. Yet, if the stock is already undervalued and further shorting suppresses the price, media groups can increase efficiency. In other words, media groups are only damaging to market quality if they are overly optimistic in their beliefs. It is unclear whether retail traders exhibited such behavior during the 2021 episode. Klein (2021) explores another unexpected positive outcome of the GameStop short squeeze, finding evidence of increased autodidacticism and keyword searches concerning financial literacy. The paper shows how the market event forced an educational component in social networks, generating self-driven search queries on complex financial topics. An increase in financial literacy amongst retail traders would generally be thought of as beneficial, although the effects of this development have yet to be studied.

This paper extends the existing literature through quantifying squeeze-period distortions in the stock lending market for highly shorted stocks, an abnormality which has been studied specifically in GameStop stock but not yet with a broader scope. This feature of short squeezes

has implications for market efficiency and limits to arbitrage, as studied extensively in existing literature. Using this body of work that discerns the problems that arise when short selling is restricted, my results provide important implications for market quality – particularly in the post period. The short squeezes that unfolded throughout the market in January of 2021 were an instance of an extreme market abnormality. Valuations for highly shorted companies increased severalfold, accompanied by unprecedented trading volume, social media frenzy, and brokerage restrictions.

The impacts of a short squeeze on market efficiency and abnormality have been thoroughly researched throughout history. Notably in the twenty-first century, the GameStop and Volkswagen squeezes have been studied extensively. The literature has almost unanimously argued that squeezes and/or limits to short selling are detrimental to market efficiency. As demonstrated in D'Avolio (2002), Miller (1978), Figlewski (1981), Boehme et al. (2006), and Asquith et al. (2005), when short sellers are unable to act on their beliefs, market inefficiency and equity overvaluation tend to occur as optimists are disproportionately represented. The squeeze and post-squeeze period are integral examples of times when short sellers are constrained and thus unable to confidently act on their beliefs. These constraints unfold both tangibly and intangibly. In a literal sense, the liquidity crunch due to a lack of shares to borrow, heightened collateral demands, and forced recalls impose dramatic restrictions on short seller strategies. Yet, even in the post period, when many of these conditions are lifted, there are further constraints to short selling that do not manifest in the same literal sense. Namely, the psychological experience of incurring severe losses in a short squeeze would seem to discourage a return to aggressive short selling tactics. If this is the case (as the results will explore), then there are implications for decreased market efficiency in the post period. It is worth noting that forced recalls are a prominent feature of the stock lending market –

as shown in D'Avolio (2002), Chuprinin & Ruf (2017), Engelberg et al. (2018), and Schultz (2023). However, for the research in this paper I did not have access to recall data, so the work focuses on borrow fees as the main metric for costs imposed on short sellers. While Atmaz et al. (2024) do study the borrow fee behavior of GameStop stock throughout the squeeze, they did not conduct research on the broader group of highly shorted stocks. The reason that my paper gives particular attention to this wider lens is due to how many other studies demonstrate that abnormalities tend to creep throughout the market. As discussed previously in this section, this "contagion effect" is observed in Allen et al. (2006), Pirrong (1993), Umar (2021), and Allen et al. (2021). In summary, price movements, inefficiencies, and other abnormalities originating from one stock have been shown to move to others during a short squeeze period. Yet, the contagion effect for stock lending market distortions has not been researched.

It cannot be emphasized enough that the ease of short selling has been shown to be crucial for effective arbitrage. With this in mind, a widespread increase in borrow fees during the squeeze (as displayed in figure 1 for several select stocks) would be indicative of a period where the ease of arbitrage is impeded. Furthermore, a significant drop in fees in the post period (as displayed in figure 1 for several select stocks) would suggest a period with a lack of short demand – providing additional implications for reduced market efficiency. An additional, supplementary contribution of this paper is taking note of loan supply behavior during and after the squeeze, with the analysis of Blocher & Zhang (2022) in mind. Saffi & Sigurdsson (2011) say that a smaller supply of lendable shares leads to lower efficiency. Yet, Kaplan et al. (2013) show that loan supply change has ambiguous effects. This paper will include a model, in addition to the borrow fee model, that looks at loan supply behavior during the squeeze to gain further insight into the possible abnormalities. The key focus though will remain determining the extent of borrow fee distortions

during and after the short squeeze and uncovering whether abnormal fee behavior spread from GameStop onto other highly shorted stocks.

3. Data

The majority of academic research concerning the stock lending market gets its data from IHS Markit, which is now a part of S&P Global. However, for the purposes of my research I did not have access to this "master data set," due to cost barriers. As a result, I looked at multiple alternative sources to piece together the necessary data. The two sources I pulled time series data from were Refinitiv and ChartExchange. From Refinitiv I pulled individual stock data on short interest, prices, daily returns, volume, market capitalization, as well as market volatility (as measured by VIX closing values). From ChartExchange, I pulled individual stock data on borrow fees and loan supply. The observation period runs from December 31, 2020, through February 19, 2021. In order to quantify the different behavior between highly shorted stocks and the broader market – a key focus of this paper – I created two groups for observation, with 30 stocks in each group. The first group is called the "high short interest (SI)" group. This group of stocks was compiled by gathering the 30 stocks with the highest short interest on December 31, 2020. In other words, the 30 most highly shorted stocks *right before* the onset of the short squeeze event. For the few stocks in this list that had missing data, they were replaced by the next highest stock on this ranked short interest list. The next group is the control group. This group of 30 stocks was randomly generated from the bottom quintile of short interest, also pinning December 31, 2020, as the date of observation. Stocks with missing data were replaced by another random generation from the same bottom quintile of short interest. Once the 60 stocks were gathered, dummy variables were created to encapsulate the squeeze and post-squeeze period. I created a time window

that encapsulates the squeeze and post-squeeze periods. The introduction of trading restrictions on January 28 marked a concrete end to the bulk of the short squeeze momentum. While some highly shorted stocks began to squeeze at slightly different points in mid-January, the squeeze period defined in this paper precisely aligns with the timing of the GameStop squeeze, which most other squeezed stocks closely mimicked.

Table 2: Time Dummy Variable Specification

	Pre-Squeeze	Squeeze Period	Post-Squeeze
Date Range	Dec 31 – Jan 12	Jan 13 – Jan 27	Jan 28 – Feb 19

The resulting dataset thus contains 60 stocks – made up of a control group and a highly shorted group – with time series data across a seven-week period. During this seven-week period, the short squeeze event ramps up and then completely subsides. This divided nature of the period allows research into the market behavior during and after the squeeze event. The 60 stocks are shown below in Table 3, along with some relevant information.

Table 3: Experimental and Control Group Summary

High Short Interest Group				Control Group			
Company	Ticker	SI	Mkt Cap	Company	Ticker	SI	Mkt Cap
GameStop Corp.	GME	102.00%	1.31	Cango Inc	CANG	0.03%	0.79
AMC Networks Inc.	AMCX	55.00%	1.06	Byrna Technologies Inc	BYRN	0.36%	0.21
Macerich Co.	MAC	54.00%	1.59	Mastercard Inc	MA	0.39%	352.82
Fubotv Inc.	FUBO	50.00%	1.89	Skillful Craftsman Education Technology Ltd	EDTK	0.13%	0.04
Tanger Inc.	SKT	48.00%	0.93	Coffee Holding Co Inc	JVA	0.31%	0.02
Gaotu Techedu Inc.	GOTU	37.00%	7.48	Avery Dennison Corp	AVY	0.66%	12.94
iRobot Corp.	IRBT	36.00%	2.26	Natural Health Trends Corp	NHTC	0.29%	0.06
AMC Entertainment Holdings Inc.	AMC	36.00%	0.23	American Resources Corp	AREC	1.12%	0.08
Children's Place Inc.	PLCE	36.00%	0.73	Chubb Ltd	CB	0.64%	69.47
B&G Foods Inc.	BGS	36.00%	1.78	Old Republic International Corp	ORI	1.07%	5.99
Seritage Growth Properties	SRG	35.00%	0.57	Dominion Energy Inc	D	0.94%	61.35
Macy's Inc.	M	35.00%	3.49	Pionoor Bancorp Inc	PBFS	0.07%	0.27
Cameco Corp.	CCJ	34.00%	0.44	Colgate-Palmolive Co	CL	0.35%	73.30
Petmed Express Inc.	PETS	33.00%	0.65	Medallion Financial Corp	MFIN	0.92%	0.12
HUYA Inc.	HUYA	32.00%	1.66	36Kr Holdings Inc	KRKR	0.03%	0.09
Stitch Fix Inc.	SFIX	32.00%	3.69	American Express Co	AXP	0.01%	97.36
Carparts.Com Inc.	PRTS	31.00%	0.59	Taylor Devices Inc	TAYD	0.10%	0.04
Rocket Companies Inc.	RKT	31.00%	2.33	Pactiv Evergreen Inc	PTVE	0.74%	2.24
Vaxart Inc.	VXRT	31.00%	0.63	Apple Inc	AAPL	0.54%	2232.28
American Airlines Group Inc.	AAL	28.00%	9.80	JPMorgan Chase & Co	JPM	0.65%	387.34
3D Systems Corp.	DDD	27.00%	1.30	DTE Energy Co	DTE	0.55%	23.50
Cinemark Holdings Inc.	CNK	27.00%	2.06	Xcel Energy Inc	XEL	0.93%	35.03
Revolve Group Inc.	RVLV	26.00%	0.80	Intevac Inc	IVAC	0.03%	0.17
Accelerate Diagnostics Inc.	AXDX	26.00%	0.44	Investors Title Co	ITIC	0.85%	0.29
Marcus Corp.	MCS	25.00%	0.31	TransUnion	TRU	0.03%	18.88
Carvana Co.	CVNA	25.00%	16.91	Clarivate PLC	CLVT	0.37%	18.00
United Natural Foods Inc.	UNFI	25.00%	0.90	Kazia Therapeutics Ltd	KZIA	0.07%	0.11
Dillard's Inc.	DDS	25.00%	1.13	CACI International Inc	CACI	1.17%	6.29
Cheesecake Factory Inc.	CAKE	25.00%	1.69	Renaissancere Holdings Ltd	RNR	1.06%	8.43
Blink Charging Co.	BLNK	24.00%	1.54	Markel Group Inc	MKL	0.03%	14.24

Note: Short interest and market capitalization values measured as of 12/31/2020. Market capitalization shown in billions ($).

The dataset contains a diverse range of company sizes. As expected, the control group skews towards larger market capitalization. This is predictably the case, as companies that are highly shorted are disproportionally smaller sized (Asquith et al., 2004). Most importantly, there is a very significant disparity in short interest between those in the bottom quintile and those at the upper echelon. This allows the research to isolate short interest as a powerful distinguishing factor between the experience of the two groups during the squeeze event, and test how the presence of certain abnormalities might spread across one group but not the other.

4. Methodology

The model architecture for this paper draws inspiration from Allen et al. (2024). In their research of how short squeezes impede market quality, the authors design a model using time dummies. They create one for the squeeze period, but also for the post period – this allowed them

to isolate causal effects of each period onto select market efficiency metrics, which took turns serving as the dependent variable. For my own methodology, much of the model design revolves around similarly used time dummy variables, as I am interested in how the securities lending market was distorted both in the squeeze period and the post period. That being said, the methodology primarily revolves around the usage of a time dummy as the main regressor, with borrow fee as the dependent variable. With the dual-group structure of the data, this approach allows me to test how borrow fee activity varied from one group to another – specifically, whether the highly shorted group experienced borrow fee dynamics akin to GameStop's. I also borrow some of their controls. Given the shared period of observation, this seems to be an appropriate measure to best select control variables. Stock fixed effects are implemented in every model to control for time-invariant differences across firms, such as industry, baseline risk levels, or business models that could otherwise confound the relationship between short squeezes and the dependent variable. The first model seeks to uncover the answer to the question of whether borrow fee distortion activity was contained to just GameStop, or if it spread across the highly shorted segment.

$$Log(borrow\ fee)_{it} = a + \beta 1 Squeeze_t + \beta 2 Volatility_t + \beta 3 Volume_{it} + \beta 4 Returns_{it} + e \qquad \textbf{(1)}$$

A natural log transformation is applied to the dependent variable for several reasons. For one, a histogram of average borrow fees across the dataset reveals a dramatic skew towards zero – which we would expect, given the literature showing that the aggregate market is easy to borrow. Applying the natural log transformation mitigates this skew in the data. Second, the natural log transformation allows for greater ease of interpretation on the coefficients. In particular, the key

coefficient $\beta 1$ will thus inform us, "during the squeeze, borrow fees were X% higher." Volatility controls are derived from daily VIX measurements, and volume and returns are both stock and time specific (measured daily). This ensures the model focuses on within-firm variation over time. To differentiate the effect of the squeeze on the two groups in the data, this model will be run twice: once with the highly shorted group and other time with the control group. If the contagion effect in securities pricing and quality – observed by Allen et al. (2007) and Allen et al. (2024) during past short squeezes – occurs in the stock lending market too, we should anticipate a positive coefficient on $\beta 1$. More specifically, if the contagion effect occurs, the coefficient should be much more positive when the model is run with the highly shorted group. We would expect the control group to have either no significant coefficient or a negative one. The second model configures the post period study.

$$Log(borrow\ fee)_{it} = \alpha + \beta 1 PostSqueeze_t + \beta 2 Volatility_t + \beta 3 Volume_{it} + \beta 4 Returns_{it} + \beta 5 log(loan\ supply)_{it} + e \quad \textbf{(2)}$$

Model 2 looks very similar to model 1, with the main difference being that $\beta 1$ now is a time dummy representing the post-squeeze period. An additional control, log(loan supply), is also included. I include log(loan supply) in this model to account for the variation in borrow fees driven by changes in supply availability, which is especially relevant in the post-squeeze period when lending constraints ease and available shares are in large supply. This variable was excluded from the model 1 to avoid over-controlling during the squeeze itself, but its inclusion here substantially improves model fit and isolates the effects of post-squeeze dynamics more effectively. Reverse causality concern is mitigated by the fact that borrow fees are primarily

driven by demand and have sufficient supply, as demonstrated in D'Avolio (2002). Particularly in the post period, this should be the case. As seen in Figure 1, GameStop experienced a significant decrease in its borrow fee after the squeeze, due to a collapse in short demand. If the contagion effect in the lending market spreads from GameStop onto highly shorted securities, we would expect a negative coefficient on $\beta 1$ here. This effect should be most prominent in the highly shorted group, as these would be the securities that short sellers would be most averse from touching following the squeeze event where they are disconnected from their fundamental value. Models 1 and 2 serve to be this paper's primary result generators, although I do include several other models to gain potentially more complex insight into lending market dynamics amidst a short squeeze. Model 3 attempts to quantify the behavior of loan supply during the squeeze, using the same time dummy structure.

$$Log(loan\ supply)_{it} = \alpha + \beta 1 Squeeze_t + \beta 2 Volatility_t + \beta 3 Volume_{it} + \beta 4 Returns_{it} + e \qquad \textbf{(3)}$$

It is difficult to use intuition to predict the direction of this key coefficient ($\beta 1$). On the one hand, high borrow fees may incite institutions to lend, in order to capitalize on the high lending income. On the other hand, short demand during the squeeze may be so overwhelming that rising supply is immediately absorbed. An additional consideration is that institutions may act cautiously, even with the high fee possibility, due to the volatility of the event and perceived borrower default risk. In the same vein, model 4 considers loan supply changes in the post period. Overall, it is important to be cautious when gathering an economic interpretation from this coefficient, as changes in loan supply during the volatile squeeze period are driven by multiple factors. Model 4 considers loan supply following the squeeze.

$$Log(loan\ supply)_{it} = \alpha + \beta 1 PostSqueeze_t + \beta 2 Volatility_t + \beta 3 Volume_{it} + \beta 4 Returns_{it} + e \quad \textbf{(4)}$$

We would expect loan supply to increase in the post period: without even considering institutional lending behavior, short demand falls so steeply that the number of available shares should increase. Model 4 looks to measure the magnitude of this increase. Below, table 4 condenses the four key models with their characteristics.

Table 4: **Schematic Summary of Regression Models**

Model	Dependent Variable	Key Regressor	Control Variables	Expected Sign
(1)	$\log(\text{borrow fee})_{it}$	Squeeze_t	Volatility_t, Volume_{it}, Returns_{it}	+
(2)	$\log(\text{borrow fee})_{it}$	PostSqueeze_t	Volatility_t, Volume_{it}, Returns_{it}, $\log(\text{loan supply})_{it}$	−
(3)	$\log(\text{loan supply})_{it}$	Squeeze_t	Volatility_t, Volume_{it}, Returns_{it}	−
(4)	$\log(\text{loan supply})_{it}$	PostSqueeze_t	Volatility_t, Volume_{it}, Returns_{it}	+

Note: Models 1 & 2 serve as primary models of interest.

Together, these model specifications are designed to isolate both the direct effects of the squeeze and the subsequent adjustments in the lending market. By running parallel specifications across the highly shorted and control groups, the methodology aims to provide an insightful view of how short squeezes impact borrow fees, loan supply, and the broader functioning of the securities lending market.

5. Results

As discussed above, model 1 aims to provide the answer to one of this study's key questions: were increased borrow fees a phenomenon limited to GameStop, or did they spread throughout the highly shorted segment, in a contagion-effect like manner? The results from the first model can be observed below.

Table 5: Borrow Fee Behavior During Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses `log(borrow fee)` as the dependent variable.

	Experimental Group (1)	Control Group (2)
Short Squeeze Period	**0.096*** **	-0.067***
	(0.036)	(0.018)
Volatility	0.018***	-0.006*
	(0.004)	(0.002)
Daily Volume	2.19e-06***	1.17e-06
	(4.19e-07)	(1.42e-06)
Daily Returns	1.24	-0.103
	(1.07)	(0.17)
Constant	-1.340	-0.062
	(1.07)	(0.055)
R-squared	0.045	0.004

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Short Squeeze Period" is a time dummy variable, covering the period January 13, 2021 through January 27, 2021.

Beginning with column 1, the key coefficient ($\beta 1$) suggests the following: for highly shorted stocks, borrow fees were 9.6% higher during the squeeze period. This is indicative of a shortage of loan availability and/or a heightened demand to short. The latter is particularly easy to imagine, as short sellers may have been eager to aggressively short the squeezing securities in an attempt to rein in the rapidly escalating situation. The coefficient on $\beta 1$ is also highly significant with $p<0.01$. Most importantly, the same coefficient within the control group specification runs in the opposite direction. It suggests that for non-highly shorted stocks (representative of the broader market), borrow fees were 6.7% *lower* during the squeeze period. This distinction in direction illuminates the key insight into borrow fee dynamics during the short squeeze. Namely, the contagion effect of inflated borrow fees spreads throughout the highly shorted segment but does not influence the broader market whatsoever. The market in fact becomes easier to borrow during the squeeze, with so much short seller attention pulled towards the squeeze-related securities. The R-squared values are low by typical standards, although the R-squared is much stronger in the highly shorted

specification, which is the main model of interest. Nonetheless, the predictive power is still low across the board. While it initially may appear to be a significant limitation to the results, this is in fact a common occurrence for models involving the financial markets, due to the extreme complexity of the environment. Low R-squared values (less than 0.2) are common in regressions involving the financial markets. Outcomes are influenced by a seemingly infinite quantity of unobservable, random factors. In these contexts, a better goal is often to identify statistically and economically meaningful relationships, rather than perfectly predicting the dependent variable. There are several other limitations to these results, for which mitigants will be addressed in the robustness section. Namely, the residual histograms and plots are indicative of potential bias and overconfidence. All residual histograms and plots are posted in the appendix. Model 2 addresses the post period. Results for model 2 can be observed below, in table 6.

Table 6: Borrow Fee Behavior After Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses `log(borrow fee)` as the dependent variable.

	Experimental Group (1)	**Control Group** (2)
Post Squeeze Period	**-0.333*** **	0.100***
	(0.031)	(0.0167)
VIX Closing Value	0.012**	-0.006*
	(0.004)	(0.002)
Daily Volume	2.12e-06***	1.18e-06
	(3.81e-07)	(1.401-06)
Daily Returns	-0.356**	-0.147
	(0.113)	(0.160)
Log(Loan Supply)	-0.102**	-0.019
	(0.016)	(0.025)
Constant	1.562***	0.141
	(0.251)	(0.365)
R-squared	0.192	0.086

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Post Squeeze Period" is a time dummy variable, covering the period January 28, 2021 through February 19, 2021.

Starting with the key coefficient in column 1, the result indicates that for highly shorted stocks, borrow fees are 33.3% lower in the post period. This suggests a significant drop in short demand following the squeeze event. The coefficient is highly significant with $p<0.01$. Additionally, the specification in column 1 boasts an R-squared of 0.192, which, for a model involving financial markets during a particularly chaotic period of observation, is very strong. With the control group specification in column 2, we can observe the same opposite direction phenomena from the first model. For the broader market, there is an increase in borrow fees in the post period, estimated at a 10.0% increase. This could imply that short demand shifted away from the previously highly shorted segment and towards lower "squeeze-risk" securities. It is possible that the magnitude of the post-period fee drop for highly shorted securities is being overstated. However, the divergence in direction between the $\beta 1$ coefficient in columns 1 and 2 provides solid evidence that the post-squeeze borrow fee behavior of GameStop was mirrored throughout the highly shorted segment, but not at all throughout the broader market.

The next two models shift the focus onto loan supply. Model 3 considers loan supply dynamics during the short squeeze period. Results from model 3 can be seen below, in table 7.

Table 7: Loan Supply Behavior During Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses `log(loan supply)` as the dependent variable.

	Experimental Group (1)	Control Group (2)
Short Squeeze Period	**0.448*** **	0.005
	(0.0658)	(0.023)
Volatility	-0.039***	-3.65e-4
	(0.008)	(0.002)
Daily Volume	-1.15e-06	-6.61e-06
	(7.58e-07)	(1.73e-06)
Daily Returns	0.068	-0.282
	(0.224)	(0.208)
Constant	14.430***	13.989
	(0.193)	(0.068)
R-squared	0.026	0.048

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Short Squeeze Period" is a time dummy variable, covering the period January 13, 2021 through January 27, 2021.

Beginning with column 1, the key coefficient ($\beta 1$) suggests a conclusion strongly in line with the findings from borrow fee behavior in table 5. Namely, the results state that for highly shorted stocks during the squeeze, loan supply decreased by 44.8%. The coefficient is also highly significant with p<0.01. This is consistent with the notion that short demand overwhelms stock loan availability, contributing to the higher cost-to-borrow as observed in table 5, column 1. Another consideration that could have influenced this coefficient is that stock lenders may have been hesitant to lend in such a volatile environment where the perceived borrower default risk was soaring. While differentiating this causal relationship would require further research, the results from table 6 confirm that stock loan scarcity existed during the squeeze period. In column 2, there are no significant coefficients, and the magnitude of $\beta 1$ is low. This is suggestive of no statistically significant loan supply change for the broader market during the squeeze. The probability of model bias (as seen in the residual histogram) is also low here.

Model 5 considers loan supply in the post period, for which the regression results are displayed in table 8, below.

Table 8: Loan Supply Behavior After Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses `log(loan supply)` as the dependent variable.

	Experimental Group (1)	Control Group (2)
Post Squeeze Period	**0.631*** **	0.013
	(0.057)	(0.021)
Volatility	-0.037***	-0.000
	(0.008)	(0.002)
Daily Volume	-1.58e-06**	-6.55e-06
	(7.30e-07)	(1.73e-06)
Daily Returns	0.192	-0.293
	(0.217)	(0.208)
Constant	13.956***	13.981
	(0.190)	(0.069)
R-squared	0.026	0.048

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Post Squeeze Period" is a time dummy variable, covering the period January 28, 2021 through February 19, 2021.

The bolded coefficient in column 1 ($\beta 1$) shows that for the highly shorted group, loan supply increased by 63% in the post period. The coefficient is highly significant as well, with p<0.01. This change is implicative of a decreased borrowing demand, as well as possibly an increased propensity to lend in the highly shorted segment. The latter would be a contributing factor if institutions acted in a lagging manner, increasing supply after the passage of some period. If institutions responded immediately to changes in borrow fees, we would not expect to see a post-squeeze increase in supply, given that fees plummeted during this time. However, if lenders responded with a lag – adjusting behavior based on the elevated fees observed during the squeeze – then a delayed rise in supply would be consistent with that pattern. This distinction would require future research to better understand the timing and responsiveness of institutional lending behavior. The same relationship (of post-squeeze supply increase) is not observed in the control group, providing further evidence that the contagion effect is strongly contained within the experimental group. This can be seen in column 2, where the magnitude of $\beta 1$ is neither significant nor large,

suggesting that no statistically significant relationship can be found. As with the prior models, low R-squared values in column 1 pose the potential for concern. With this model though, the residuals histogram does not indicate a bias or overconfidence. The histogram resembles a normal distribution with clustering around 0.

5.1. Robustness Checks

To ensure the reliability of the results, I conducted several robustness checks to address both the explanatory power of the models and potential sources of bias or overconfidence (as shown in violations of the zero conditional mean assumption). These checks are used to assess the reliability and validity of the main results under alternative specifications or assumptions. The first robustness specification is to add clustered standard errors to each model. This ensures that the standard errors are robust to within-firm correlation of the error terms. Additionally, I create another specification for each model using Newey-West standard errors. The purpose of this adjustment is to address possible serial correlation in the time-series data – the Newey-West specification adjusts the model to account for heteroskedasticity and autocorrelation in the errors. This adjustment may lead to more reliable coefficient estimates with less overconfidence. Table 8 displays the robustness specifications for model 1.

Table 9: Robustness Specifications for Model 1: Borrow Fee Behavior During Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses log(borrow fee) as the dependent variable.

	Experimental Group			Control Group		
	(1)	(2)	(3)	(4)	(5)	(6)
Short Squeeze Period	**0.096*** **	**0.096** **	**0.048**	-0.067***	-0.067*	-0.045
	(0.036)	(0.045)	(0.210)	(0.018)	(0.037)	(0.205)
Volatility	0.018***	0.018***	0.013	-0.006*	-0.006**	3.99e-04
	(0.004)	(0.005)	(0.021)	(0.002)	(0.003)	(0.022)
Daily Volume	2.19e-06***	2.19e-06***	6.88e-06***	1.17e-06	1.17e-06**	1.14e-05***
	(4.19e-07)	(5.57e-07)	(1.09e-06)	(1.42e-06)	(5.20e-07)	(1.19e-06)
Daily Returns	1.24	-.202	-0.418	-0.103	-0.103	4.985
	(1.07)	(0.140)	(0.260)	(0.170)	(0.191)	(1.333)
Constant	-1.340	-0.134	-0.075	-0.062	-0.062	-0.188
	(1.07)	(0.142)	(0.502)	(0.055)	(0.075)	(0.533)
R-squared	0.045	0.045	0.045	0.004	0.004	0.045

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Short Squeeze Period" is a time dummy variable, covering the period January 13, 2021 through January 27, 2021. Columns 1 & 4 displays the original regression output. Columns 2 & 5 use clustered standard errors. Columns 3 & 6 use Newey-West standard errors.

There are several main features of the robustness specifications (columns 2 and 3) that stand out. With clustered standard errors in column 2, the significance of the key coefficient falls slightly from $p<0.1$ to $p<0.05$. Indeed, applying this feature to that model serves to provide a more conservative estimate of statistical significance. Importantly, this more conservative approach still yields a statistically significant coefficient – backing up the claim that inflated borrow fees spread throughout the highly shorted segment. In the Newey-West specification, shown in column 3, the magnitude and significance of the key coefficient decreases. This rather large distinction suggests that autocorrelation or heteroscedasticity is indeed present in the residuals. This issue can lead to underestimated standard errors, making the coefficients appear more significant than they actually are. It is also possible that the Newey-West adjustment could be overcorrecting. Weighing the coefficient exactly as it appears in column 3, the economic magnitude is still indicative of the studied effect, albeit a smaller one (a 4.8% increase as opposed to a 9.6% increase). This suggests that while the size of the increased borrow fee effect could be overstated in the original specification, the effect appears to exist nonetheless. Table 9 relates the robustness checks to model 2, which observes the behavior of borrow fees after the short squeeze.

Table 10: Robustness Specifications for Model 2: Borrow Fee Behavior After Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses log(borrow fee) as the dependent variable.

	Experimental Group			Control Group		
	(1)	(2)	(3)	(4)	(5)	(6)
Post Squeeze Period	**-0.333*** **	**-0.333*** **	**-0.064**	0.100***	0.100*	0.087
	(0.031)	(0.098)	(0.179)	(0.017)	(0.049)	(0.177)
Volatility	0.012**	0.012**	-0.008	-0.006*	-0.006**	-0.004
	(0.004)	(0.005)	(0.017)	(0.002)	(0.029)	(0.018)
Daily Volume	2.19e-06***	2.12e-06**	6.96e-06***	1.18e-06	1.18e-06*	-1.40e-07
	(3.81e-07)	(5.00e-07)	(1.58e-06)	(1.40-06)	(6.92e-07)	(1.14e-06)
Daily Returns	-0.356**	-0.356**	-0.499	-0.147	-0.147	3.089***
	(0.113)	(0.138)	(0.359)	(0.160)	(0.187)	(0.923)
Log(Loan Supply)	-0.102**	-0.103***	-0.505***	-0.019	-0.019	-0.451***
	(0.016)	(0.027)	(0.052)	(0.025)	(0.033)	(0.049)
Constant	1.562***	1.562***	7.223***	0.141	0.141	6.102***
	(0.251)	(0.381)	(0.819)	(0.365)	(0.430)	(0.847)
R-squared	0.192	0.192	0.192	0.086	0.086	0.086

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Post Squeeze Period" is a time dummy variable, covering the period January 28, 2021 through February 19, 2021. Columns 1 & 4 displays the original regression output. Columns 2 & 5 use clustered standard errors. Columns 3 & 6 use Newey-West standard errors.

In column 2, the model is altered to include clustered standard errors. The key coefficient maintains its significance at the 1% level. With Newey-West standard errors in column 3, the key coefficient loses its statistical significance but maintains its economic meaning, albeit a reduced magnitude. It states that in the post period, highly shorted stocks undergo a borrow fee reduction of 6.5%, compared to the original model's output showing a 33.3% drop. The extent to which column 3 is overcorrecting remains unclear. Yet, the sustained economic significance of a post-squeeze drop is supportive of the conclusion that there is indeed an observed effect. To reemphasize, model 2 presents the most compelling result, due to the size and significance of the key coefficient, the strong R-squared value, and the encouraging resistance to conservative robustness checks. Table 10 displays the robustness specifications for model 3, which observes the behavior of loan supply during the short squeeze.

Table 11: Robustness Specifications for Model 3: Loan Supply Behavior During Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses log(borrow fee) as the dependent variable.

	Experimental Group			Control Group		
	(1)	(2)	(3)	(4)	(5)	(6)
Short Squeeze Period	**-0.449*** **	**-0.471** **	**-0.019**	0.005	0.006	-0.019
	(0.117)	(0.198)	(0.245)	(0.023)	(0.049)	(0.245)
Volatility	-0.039***	-0.041**	-0.010	-3.65e-4	-0.001	-0.010
	(0.014)	(0.021)	(0.026)	(0.002)	(0.004)	(0.026)
Daily Volume	-1.15e-06*	2.89e-07	2.48e-04***	-6.61e-06	-6.61e-06	2.48e-04***
	(5.40e-07)	(1.72e-06)	(3.60e-06)	(6.90e-06)	(6.90e-06)	(3.60e-06)
Daily Returns	0.068	0.118	-4.132**	-0.282	-0.283	-4.132**
	(0.182)	(0.350)	(1.724)	(0.323)	(0.323)	(1.724)
Constant	14.430***	14.458***	14.077***	13.989***	13.989***	14.077***
	(0.350)	(0.492)	(0.639)	(0.090)	(0.090)	(0.639)
R-squared	0.026	0.026	0.026	0.048	0.048	0.048

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. " Squeeze Period" is a time dummy variable, covering the period January 13, 2021 through January 27, 2021. Columns 1 & 4 displays the original regression output. Columns 2 & 5 use clustered standard errors. Columns 3 & 6 use Newey-West standard errors.

The output from model 3 follows the intuition resulting from model 1. During the short squeeze, short demand overwhelmed a limited loan supply, as institutions displayed hesitancy to lend into a volatile environment. The corresponding outcome from this dynamic is high borrowing costs and low loan supply during the squeeze. In table 10, above, this decline in loan supply can be observed. Upon incorporating clustered standard errors, the key coefficient maintains the magnitude of the original model, and the significance is still strong at the 5% level. With the Newey-West specification in column 3, the significance decreases. However, as with the prior robustness tables, the economic meaning (direction) of the coefficient is still present. Lastly, table 11 weighs the respective robustness checks with model 4, which observes loan supply behavior after the short squeeze.

Table 12: Robustness Specifications for Model 4: Loan Supply Behavior After Short Squeeze for Highly Shorted vs. Control Group Stocks

The model uses log(borrow fee) as the dependent variable.

	Experimental Group			Control Group		
	(1)	(2)	(3)	(4)	(5)	(6)
Post Squeeze Period	**0.631*** **	**0.631*** **	**0.640*** **	0.013	0.006	-0.019
	(0.057)	(0.145)	(0.183)	(0.021)	(0.049)	(0.245)
Volatility	-0.037***	-0.037**	-0.039*	-0.000	-0.000	-0.010
	(0.008)	(0.014)	(0.020)	(0.002)	(0.004)	(0.026)
Daily Volume	-1.58e-06**	-1.58e-06***	3.72e-08	-6.55e-06	-6.61e-06	2.48e-04***
	(7.30e-07)	(4.10e-07)	(1.67e-06)	(1.73e-06)	(6.90e-06)	(3.60e-06)
Daily Returns	0.192	0.192	0.217	-0.293	-0.283	-4.132**
	(0.217)	(0.158)	(0.315)	(0.208)	(0.323)	(1.723)
Constant	13.956***	13.957***	13.976***	13.981	13.989***	14.077***
	(0.190)	(0.300)	(0.491)	(0.069)	(0.090)	(0.639)
R-squared	0.048	0.048	0.048	0.048	0.048	0.048

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. "Post Squeeze Period" is a time dummy variable, covering the period January 28, 2021 through February 19, 2021. Columns 1 & 4 displays the original regression output. Columns 2 & 5 use clustered standard errors. Columns 3 & 6 use Newey-West standard errors.

Uniquely to table 11, the key coefficient maintains its statistical significance through both robustness specifications. In both the clustered standard error and Newey-West columns, $\beta 1$ keeps its economic magnitude and significance at the 1% level. These results all confirm the conclusion that loan supply increases by around 63% in the post period for the highly shorted segment. This observation cannot be observed whatsoever in the control group, reaffirming the hypothesis that the distortive effects from the short squeeze were only felt throughout a specific corner of the market. With table 11 and table 9 providing the most robust results, it follows that the clarity of analysis is much better in the post period. Compared to the squeeze itself (perhaps one of the most volatile and chaotic periods the equity markets have ever seen), the post period has less conflicting noise and thus it is more manageable to see relationships between the variables of interest. Broadly speaking, the robustness checks confirm the economic meaning of the key findings – even with conservative estimations, the direction of the main coefficients remain intact. The use of clustered standard errors and Newey-West standard errors do produce lower significance levels, suggesting possible autocorrelation and heteroskedasticity. Yet, to restate, the economic meaning is largely preserved. Taken together, the robustness checks support the conclusion that the observed squeeze

and post-squeeze effects are genuine, even if their magnitude may be overstated in the baseline models.

6. Conclusion

The original goal of this study was to discern how a short squeeze – specifically, the 2021 event – interrupted or distorted the stock lending market. This question carries important implications, as the ease of short selling has been proven to be instrumental in facilitating efficient markets. Using four similarly structured regression models, this paper aimed to answer the above question through analysis of borrow fees (primarily) as well as loan supply figures. Two groups were constructed for observation: a group of 30 of the most heavily shorted stocks as of the month preceding the event, and another group of 30 randomly selected, low short interest stocks to represent the broader market. The results showed that the cost of borrowing highly shorted stocks jumped significantly during the squeeze period, at an estimated 9.6% gain. This finding is consistent with increased short demand and restricted loan supply. The control group saw a decrease in fees, suggesting the opposite effect. In the post period there was a dramatic drop(-33.3%) in borrow fees for highly shorted stocks, evident of severe curtailing in short-selling activity. No such relationship took place in the control group. Loan supply contracted (-44.8%) for the highly shorted group during the squeeze, while in the post period it rebounded (+63%).

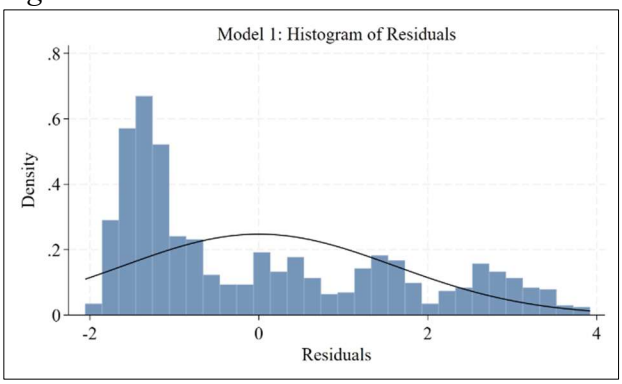
There are several important implications of these results, particularly in the post period where the results are stronger and more robust. The massive decrease in borrow fees for the highly shorted group most obviously is illustrative of short demand plummeting – this conclusion follows the simple laws of supply and demand. The connotations of this seemingly simple result are perhaps quite telling into the psyche of the short seller. In the post-squeeze period, even after falling

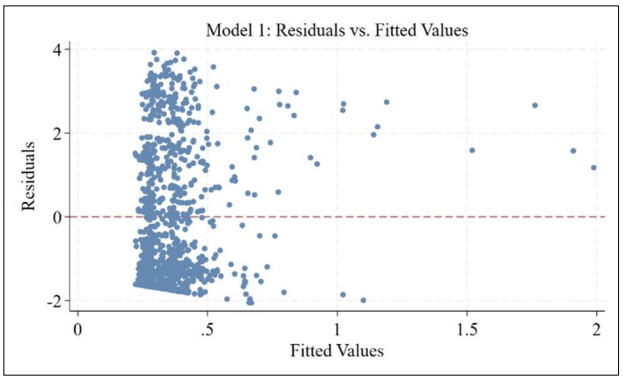
from the late January highs, most highly shorted stocks caught up in the squeeze still had valuations dramatically higher than their pre squeeze levels. Take GameStop, for example. On December 31, 2021, the share price (split-adjusted) was trading at $4.70 per share. At the peak on January 27, prices reached over $120 per share. In the three weeks immediately ensuing, shares traded between $10 and $20 per share. Notice that in this post period, the valuation is *still* more than twice that of the pre-squeeze period, during which short sellers were aggressively pursuing the stock. Furthermore, almost nothing has changed about the fundamentals of these companies within this seven-week period. The cheapness of shorting in the post period shows that even with this group of stocks being highly overvalued, demand to bet against them essentially evaporated. I determine that this demonstrates a new type of constraint on arbitrage, albeit a wholly intangible one. Short sellers seem to develop a psychological aversion to shorting in the immediate aftermath of incurring losses in a squeeze. Based in the literature, it follows that because short sellers have largely exited the shorting market in the post-squeeze period, the market should display reduced efficiency due to reduced arbitrage. While convincing, this takeaway is still speculative and would require further empirical work to determine its legitimacy. While the results can convey important takeaways, limiting factors do weaken interpretive power. First, the lack of recall data limits the depth of the analysis, particularly in assessing lender behavior. The models likely suffer from omitted variable bias as a direct result of not accounting for recalls. Second, reliance on alternative data sources instead of proprietary datasets like IHS Markit may introduce measurement error, especially given the relatively small sample size. Finally, the short observation window may not capture longer-term effects of the short squeeze. Collectively, the results and acknowledged limitations of this study point to a range of open questions for future research. In my methodology, I focused on how the short squeeze distorted borrow fees within the squeeze and post-squeeze

period. Applying this same framework to recall prominence would be an insightful study on how institutions responded to squeezes taking place within securities they owned. A study of this nature would best be approached through partnering with an institutional money manager, as done in Kaplan et al. (2013). This structure would allow a detailed study of how institutions behaved during the squeeze, weighing the trade-off inherent in holding stocks that were generating high lending income while simultaneously exposing them to elevated volatility and ownership risk. Partnering with a supply-side entity would also help disentangle supply-driven versus demand-driven forces during the squeeze and post-squeeze period, offering clearer insight into the causal forces behind large swings in borrow fees. Future research could also apply the framework of my study to historical short squeeze events – such as the Volkswagen squeeze in 2008 – to assess whether similar stock lending market dynamics occurred in the high short interest segment. Comparing this methodology across different episodes would help determine whether the observed spike in borrowing costs is a consistent feature of squeezes or unique to the 2021 case.

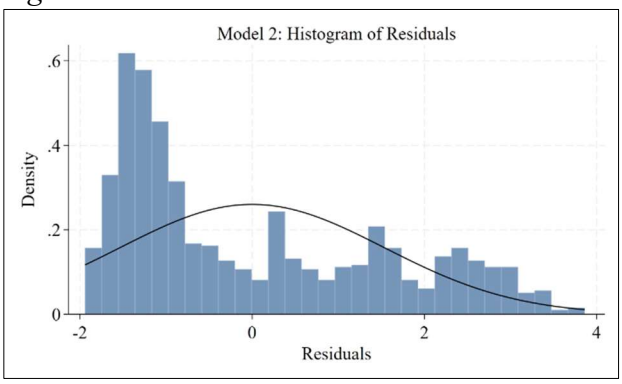
Appendix

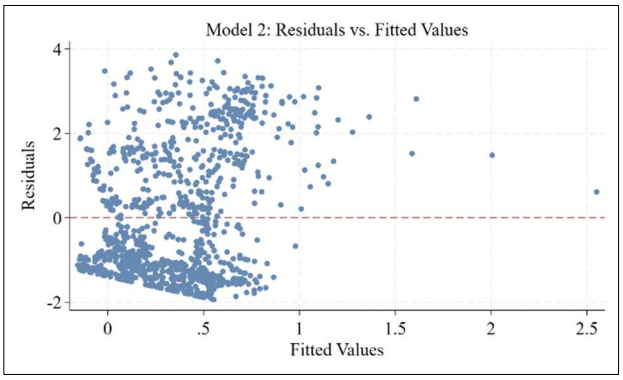
Figures 2 & 3: Model 1 Residuals



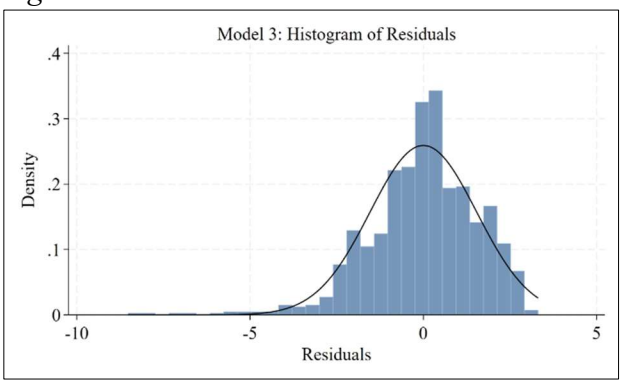


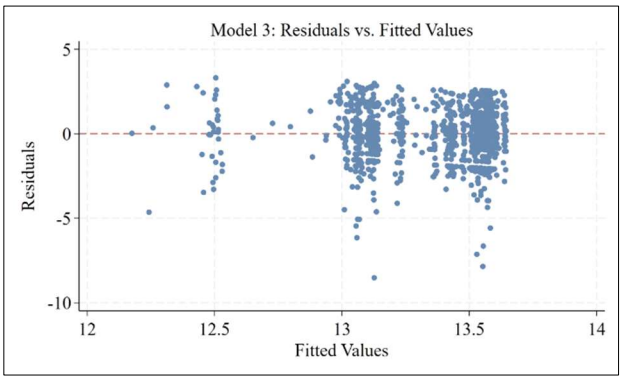
Figures 3 & 4: Model 2 Residuals



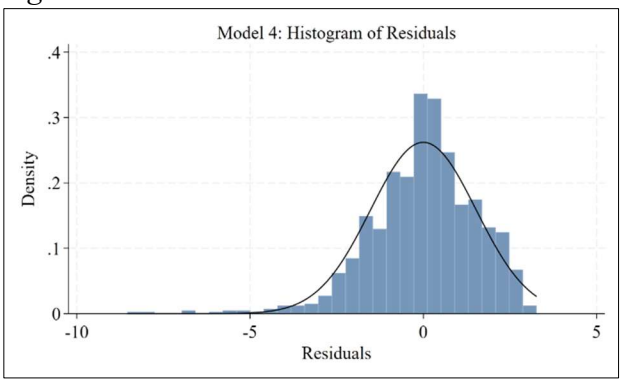


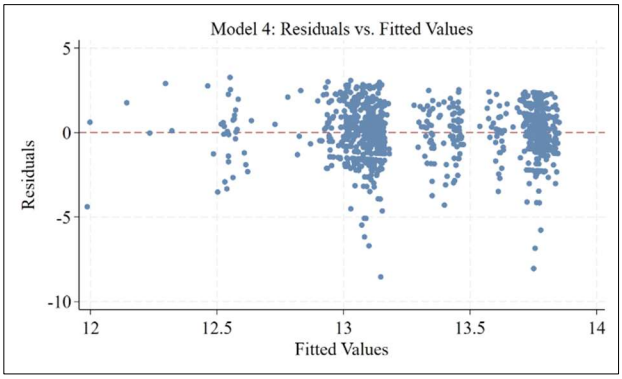
Figures 4 & 5: Model 3 Residuals





Figures 5 & 6: Model 4 Residuals





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