

Short-sale constraints and stock returns: a systematic review

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Abstract

Purpose – This study delves into the nuanced implications of short-sale constraints on stock prices within the context of stock market efficiency. While existing research has explored this relationship, inconsistencies persist in their findings. The purpose of this study is to conduct a comprehensive review of literature to elucidate the reasons behind these disparities.

Design/methodology/approach – A systematic review of existing theoretical and empirical studies was conducted following the PRISMA method. The analysis centered on discerning the factors contributing to the divergence in projected stock prices due to these constraints. Key areas explored included assumptions related to expectations homogeneity, revisions, information uncertainty, trading motivations and fluctuations in supply and demand of risky assets.

Findings – The review uncovered multifaceted reasons for the disparities in findings regarding the influence of short-sale constraints on stock prices. Variations in assumptions related to market expectations, coupled with fluctuations in perceived information uncertainty and trading motivations, were identified as pivotal factors contributing to differing projections. Empirical evidence disparities stemmed from the use of proxies for short-sale constraints, varied sample periods, market structure nuances, regulatory changes and the presence of option trading.

Originality/value – This study emphasizes the significance of not oversimplifying the impact of short-sale constraints on stock prices. It highlights the need to understand these effects within the broader context of market structure and methodological considerations. By delineating the intricate interplay of factors affecting stock prices under short-sale constraints, this review provides a nuanced perspective, contributing to a more comprehensive understanding in the field.

Keywords Short-sale constraints, Stock returns, Overvaluation, Market efficiency

Paper type Literature review

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1. Introduction

Short-sale constraint and its impact on stock prices have been extensively examined in both theoretical and empirical finance over the past few decades. Numerous theoretical and empirical studies support the assertion that short-sale constraints lead to stock overvaluation, thereby introducing informational inefficiencies in stock markets (Miller, 1977; Asquith *et al.*, 2005; Lamont, 2012; Li *et al.*, 2022; Atmaz *et al.*, 2023). However, this perspective is not entirely unanimous, as competing theories and empirical evidence suggest that short-sale constraints can also exert downward pressure on stock prices (Jarrow, 1980; Bai *et al.*, 2006). Various underlying factors determine the manner in which short-sale

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constraints influence stock returns. The inability to precisely discern the actual effect of short-sale constraints renders the implications of these constraints less certain. Nonetheless, there is a paucity of studies that systematically compare existing theoretical and empirical research, offering a comprehensive explanation of the reason for such discrepancy. This study undertakes a review of existing theories and empirical studies to elucidate the diverse outcomes concerning the relationship between short-sale constraints and stock returns.

Short selling is a trading strategy wherein investors sell stocks they do not currently own. Typically, short sellers borrow these stocks from broker-dealers with the expectation of an imminent price decline. Short sellers are obligated to repurchase and return the borrowed stocks at a later date. The specific method by which brokers and dealers execute these transactions varies based on the market's structure. In a decentralized stock borrowing market, broker-dealers either lend stocks from their own inventory or acquire them from other custodians. In contrast, within a centralized stock borrowing market, broker-dealers supply the required stocks from their inventory or a central depository. It's understandable that broker-dealers in a centralized market encounter fewer search frictions compared to those in a decentralized one. Under current regulations, uncovered short selling is prohibited, necessitating broker-dealers to locate stocks before lending them to short sellers. Short sellers typically borrow stocks for either speculative or hedging purposes. Speculators engage in short selling when they anticipate a price decline and seek to cover their positions when prices fall. Hedgers, on the other hand, short sell stocks to hedge against their long positions in stocks. Internationally, short sales are often associated with speculation, leading regulatory authorities to exercise careful oversight and regulate these transactions. Several instances of speculative short selling have contributed to a negative perception of this practice.

The examination of short-sale constraints and their impact on stock returns has evolved since the seminal study by [Miller \(1977\)](#), which laid the theoretical foundation for predicting stock overvaluation resulting from these constraints. However, empirical substantiation of this projection encountered challenges, primarily related to the measurement of short-sale constraints. [Asquith and Meulbroek \(1995\)](#) made a significant effort to explore the link between stock returns and short-sale constraints, employing high short interest as a proxy. Their findings indicated that stocks with high short interest were overvalued and subsequently underperformed. Nevertheless, the use of short interest as a proxy for short-sale constraints faced criticism, leading to the development of various alternative proxies, including measures like breadth of ownership or institutional ownership ([Chen et al., 2002](#)), stocks with higher short interest and lower institutional ownership ([Asquith et al., 2005](#)), a higher cost of borrowing stocks ([D'Avolio, 2002](#)), and legal restrictions ([Bris et al., 2007](#)). Generally, these alternative proxies effectively supported the overvaluation hypothesis. However, it's important to note that the evidence was not consistently unanimous, as several other studies found the relationship to be either non-existent or conditional on other factors ([Khan et al., 2018, 2019](#); [Boehme et al., 2006](#)).

The review of the literature concerning the relationship between short-sale constraints and stock returns also reveals several gaps in the existing body of work. First, prior studies did not account for the influence of market conditions on the connection between short-sale constraints and stock returns. It is highly plausible that this relationship would vary in bear and bull markets. Second, a comprehensive investigation into the relationship between short-sale constraints and stock returns is lacking when it comes to differentiating between the motives behind short selling, whether it be for speculative or hedging purposes. Third, there is a limited availability of direct comparisons regarding the association between short-sale constraints and stock returns in centralized and decentralized lendable stock markets. Last, the measurement of short-sale constraints remains an unresolved issue. Therefore, validating the overvaluation hypothesis necessitates further efforts, utilizing innovative measures of

short-sale constraints. Although recent studies have utilized variations of traditional short-sale measures (Bao *et al.*, 2019; Purnanandam and Seyhun, 2018), additional endeavors are required to develop a comprehensive measure of short-sale constraints that can offer a robust assessment of the relationship between these constraints and subsequent stock returns. This review study aims to establish a comprehensive foundation for the understanding of the association between short-sale constraints and stock returns, from which identified research gaps can be addressed in future investigations.

The rest of the study is designed as follows: [Section 2](#) reviews theories on short-sale constraints and stock returns, [Section 3](#) reviews existing empirical evidence on short-sale constraints and stock returns, [Section 4](#) explores the factors contributing to disparities in theories and empirical evidence, and [Section 5](#) concludes.

2. Methodology

This study utilizes a systematic review methodology to investigate the underlying reasons for the disparities found in the existing literature concerning the impact of short-sale constraints on subsequent stock returns. To ensure a comprehensive and transparent review process, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework has been adhered to. The PRISMA guidelines facilitate a structured approach to the review process, enhancing transparency and mitigating bias in the selection of studies. By applying the PRISMA framework, I have aimed to provide a comprehensive and unbiased summary of the current state of knowledge in this field.

The inclusion criteria for this review are meticulously defined. Papers must be peer-reviewed, focusing on publicly traded stocks and financial markets, utilizing both qualitative and quantitative methods to assess post-short-sale constraint stock returns. To identify relevant studies, we conducted a thorough systematic search across academic databases such as Web of Science, Scopus, Google Scholar, EconLit, JSTOR, and ProQuest. This exhaustive search ensures a comprehensive coverage of studies exploring the relationship between short-sale constraints and stock returns.

A meticulous search strategy was devised, utilizing relevant keywords and controlled vocabulary related to “short-sale constraints” and “stock returns.” Terms like “short-sale,” “short sales,” “short selling,” “stock returns,” and others were combined using Boolean operators in databases like Web of Science, Scopus, and Google Scholar. The initial screening focused on titles and abstracts, excluding studies incongruent with inclusion criteria. Full texts of remaining articles underwent detailed evaluation. The selected studies underwent a qualitative synthesis adhering to PRISMA guidelines, resulting in 64 suitable articles for this systematic review. This rigorous process ensures an impartial and transparent portrayal of the literature on short-sale constraints’ impact on subsequent stock returns. [Appendix](#) provides a comprehensive summary of the selected articles encompassing their objectives, sample details, and major findings.

3. Review of theories explaining the influence of short-sale constraints on stock returns

Numerous theories have been formulated to explore the relationship between short-sale constraints and stock returns, as well as their impact on pricing efficiency. Miller (1977) can be credited with pioneering the development of a theory regarding the influence of short-sale constraints on stock returns. In his study, Miller (1977) investigated the behavior of stock returns in a market characterized by restricted short selling, where investors held differing opinions. He discovered that in the presence of market frictions like short-sale constraints, divergence of opinion was priced at a premium. This was because less optimistic investors

did not participate in the price discovery process, and negative information could not be fully reflected in prices. Consequently, stocks with high divergence of opinion were deemed to be overvalued. Building upon Miller's hypothesis, [Harrison and Kreps \(1978\)](#) argued that short-sale constraints, when coupled with investor divergence of opinion, could push stock prices beyond the valuation of the most optimistic investors based on their expectations of future earnings. In a finite-period general equilibrium model, [Allen et al. \(1993\)](#) delineated the necessary conditions for the emergence of a strong price bubble in the market. These conditions included factors such as the possession of private information and the presence of short-sale restrictions. [Duffie et al. \(2002\)](#) developed an asset pricing model that considered the impact of short-sale restrictions due to search frictions, such as the difficulties associated with finding security lenders and negotiating lending fees. They contended that the challenges in locating lendable securities led to an initial increase in security prices, followed by a subsequent decline. The extent of this price decline was associated with factors like initial public offerings and the degree of heterogeneity of beliefs regarding the future value of the security.

Nevertheless, various theories introduce uncertainty regarding the unequivocal relationship between stock price overvaluation and short-sale constraints. [Jarrow \(1980\)](#) contended that asset prices could either rise or fall due to these constraints. However, he posited that, under the assumption of homogeneous expectations regarding the covariance matrix of asset prices for the next period, restrictive short-sales would only result in an increase in risky asset prices. The rational expectation model proposed by [Diamond and Verrecchia \(1987\)](#) demonstrated that short-sale constraints might eliminate some informative trades but would not inherently bias securities prices upward. Prohibiting short-sales curtailed the speed at which prices adjusted to private information, particularly in response to negative news, but it did not necessarily lead to overvaluation. Additionally, they argued that periods of inactivity in trading created a downward bias in measured returns. The rational expectation model presented by [Bai et al. \(2006\)](#) postulated that short-sale constraints could exert either upward or downward pressure on stock prices, contingent on the types of trades being restricted. If these constraints limited trading for risk sharing, they would result in upward pressure on prices. However, if the restrictions primarily curtailed trading driven by private information speculation, they would exert downward pressure on prices. The rational expectation model by [Cao et al. \(2007\)](#) validated the existence of competing effects associated with short-sale constraints on asset prices. Such constraints could generate upward pressure on asset prices by reducing the supply of risky assets. However, they could also produce downward pressure by excluding investors with negative information from the market, thereby reducing the demand for risky assets. Consequently, the ultimate impact of short-sale constraints on asset prices would be determined by the relative strength of these competing forces. In a recent study, [Atmaz et al. \(2023\)](#) constructed a dynamic model in which disagreement among investors' beliefs results in a demand for shorting. They contended that short interest serves as a negative predictor of stock returns. Additionally, [Atmaz et al. \(2023\)](#) asserted that the costliness of short selling contributes to an augmentation in stock volatility.

Several theories have sought to establish a connection between short-sale constraints and stock market crashes, but their postulations vary widely. [Hong and Stein \(2003\)](#) developed a theory of market crashes based on the divergence of investor opinion. They contended that the bearish investors' negative information did not initially manifest in stock prices due to short-sale constraints. This hidden negative information from bearish investors surfaced when the market began to decline, intensifying the downward spiral and ultimately leading to a crash. [Harrison and Kreps \(1978\)](#) and [Scheinkman and Xiong \(2003\)](#) put forth similar arguments for market crashes. They posited that in the presence of investor heterogeneity and short-sale constraints, only the optimistic investors' views were reflected in prices, effectively sidelining pessimistic investors. This phenomenon created price bubbles and set

the stage for market crashes. Yuan (2004) contended that the presence of short-sale constraints and information asymmetry led to more pronounced large price movements, with crashes occurring much more rapidly than the formation of bubbles. In contrast, Bai *et al.* (2006) argued that crashes stemmed from sudden increases in perceived uncertainty rather than revisions of expectations, as suggested by previous studies.

Thus, we can discern a lack of uniformity among the theories elucidating the relationship between short-sale constraints and stock returns. While these theories acknowledge the influence of short-sale constraints on stock prices, the anticipated direction of change in stock prices hinges on a multitude of underlying factors.

4. Review of empirical studies providing evidence on the influence of short-sale constraints on stock returns

Existing empirical studies on the relationship between short-sale constraints and stock returns can be categorized from several perspectives. Numerous studies have approached short-sale constraints from the demand side. They have examined how short interest, often used as a proxy for the demand for short-sales of stocks, is linked to subsequent stock returns. Another set of studies has explored short-sale constraints from a supply-side perspective. These studies have investigated how the limited supply of lendable stocks, as measured by low institutional ownership or mutual funds, relates to subsequent stock returns. A relatively smaller number of studies have examined how the cost of short selling, which reflects both the demand for and supply of stocks available for short selling, is associated with subsequent stock returns. Some studies have delved into the impact of regulations on short sales, such as the imposition of an uptick rule or a ban on short selling, on the behavior of subsequent stock returns. Certain studies have investigated how the availability of option trading affects short-sale constraints and the subsequent behavior of returns. Furthermore, it is important to consider the structure of the lendable stock market when discussing short-sale constraints and stock returns, as the market structure itself can contribute significantly to the presence and impact of these constraints.

4.1 Short interests, short-sale constraints, and stock returns

The rational expectation model presented by Diamond and Verrecchia (1987) posits that the demand for short sales conveys bearish signals, and the informativeness of this signal increases with the magnitude of the demand. As short sellers are assumed to be informed and rational investors, their trades can also signal a mispricing of stocks. Short interest, often used as a proxy for the demand for short sales, is measured by the number of stocks sold short. Investors are more likely to exhibit higher demand for short sales when they possess negative information. Studies that have used short interest as a proxy for shorting demand include Senchak and Starks (1993), Asquith and Meulbroek (1995), Desai *et al.* (2002), Ackert and Athanassakos (2005), Takahashi (2010), Wang and Lee (2015), and Guo and Wu (2019), among others. Additionally, Rapach *et al.* (2016) and Lamont and Stein (2004) have employed short interest as a proxy for shorting demand at the aggregate level.

Asquith and Meulbroek (1995) discovered that stocks with high short interest exhibited a strong and significantly negative relationship with stock returns. Desai *et al.* (2002) provided supporting evidence that heavily shorted stocks experienced significantly negative abnormal returns. Senchak and Starks (1993) found that subsequent underperformance was evident with stocks featuring higher unexpected short interest and stocks with tradable options. Gopalan (2003) found that stocks with high short interest subsequently underperformed when the dispersion of analyst forecasts was greater. Ackert and Athanassakos (2005)

presented evidence of a strong negative relationship between short interest and the subsequent excess returns of stocks. [Hanauer et al. \(2023\)](#) found that surprise in short interest had a negative predictive effect on the cross-section of stock returns, both in the U.S. and internationally. [Takahashi \(2010\)](#) investigated the relationship between flow-based shorting demand and subsequent stock return behavior, concluding that the least heavily shorted stocks outperformed the most heavily shorted ones, and this effect persisted for up to three months after forming portfolios. [Wang and Lee \(2015\)](#) found that higher short interest was associated with subsequent negative returns for foreign short sellers. [Guo and Wu \(2019\)](#) reported that the predictive power of short interest for future returns was concentrated in the worst-rated stocks. However, the studies of [Brent et al. \(1990\)](#), [Woolridge and Dickinson \(1994\)](#), and [Asquith et al. \(2005\)](#) did not show a significant negative association between short interest and subsequent stock returns. [Woolridge and Dickinson \(1994\)](#) argued that short sellers played no role in driving stock prices down but instead provided liquidity to the market. [Asquith et al. \(2005\)](#) and [Desai et al. \(2002\)](#) contended that the differences in empirical findings were attributable to variations in sample selection and data sources used in the studies.

Several studies have explored the association between short interest and return performance at the aggregate level. Similar to the analysis at the stock level, the findings at the aggregate level have been mixed. [Rapach et al. \(2016\)](#) found that short interest at the aggregate level was the strongest predictor of stock returns, confirming prior findings that short sellers are informed traders capable of predicting stock returns. However, [Lamont and Stein \(2004\)](#) did not observe a significant relationship between aggregate short interest and subsequent market returns.

4.2 Supply of lendable stocks, short-sale constraints, and stock returns

[Chen et al. \(2002\)](#) argued that the use of short interest as a proxy for short-sale constraints is a debatable issue. They further argued that higher demand for short sales could only restrict short sales when there was not enough supply of lendable stock. Furthermore, a high short interest as a proxy for the amount of negative information excluded from the stock price could be misleading because variations in short interests could be caused by variations in the supply of stocks and transaction costs ([Lamont, 2012](#); [D'Avolio, 2002](#); [Chen et al., 2002](#)). In a similar vein, [Autore et al. \(2015\)](#) argued that stocks with high short interest could be less binding and easy to borrow, and stocks with low short interest could be highly constrained and difficult to borrow. Due to the ambiguity of short interest as a proxy for short-sale constraints, subsequent studies considered short-sale constraints a supply side issue and related it to the supply of lendable stocks for which breadth of ownership or institutional ownership was used as a proxy ([Nagel, 2005](#); [Chen et al., 2002](#)). These studies suggest that short sales are constrained when investors want to sell stocks short but cannot do so, meaning that short sales became constrained when there is high demand for short sales but the supply of lendable stocks is limited. Following this argument, [Asquith et al. \(2005\)](#) used higher short interest and lower institutional ownership as a proxy for short-sale constraints. [Prado et al. \(2016\)](#) argued that stocks with lower and more concentrated ownership were responsible for lower lending supply and higher short-sale constraints. [Aggarwal et al. \(2015\)](#) argued that institutional investors restrict supply of lendable stocks because of their preference for voting rights, which limit short sales. Furthermore, active institutional investors are less likely to lend stocks compared to passive institutional investors for the consideration of retaining fund values ([Evans et al., 2012](#)). [Lamont \(2012\)](#) argued that firms were less likely to allow their stock to be sold short anticipating that firm value would go down and, therefore, used various methods to restrict short selling, such as legal threats, investigations, lawsuits, and others.

Several studies investigated subsequent return behavior of short-sales constrained stocks proxied by limited supply of lendable stocks. For example, [Chen *et al.* \(2002\)](#) used low breadth of ownership as a proxy for short-sale constraints and found that these stocks underperformed subsequently. [Nagel \(2005\)](#) provided evidence that short-sales constrained stocks, as proxied by low institutional ownership, tended to underperform subsequently particularly among stocks with high market-to-book, analyst forecast dispersion, turnover, and volatility. [Asquith *et al.* \(2005\)](#) used low institutional ownership and high short interest to proxy for short-sale constraints and found that short-sales constrained stocks significantly underperformed subsequently. [Boehme *et al.* \(2006\)](#) used low market capitalization stocks to proxy for short-sale constraints and found that underperformance of stocks with high short interest was concentrated among stocks with low market capitalization. [Prado *et al.* \(2016\)](#), in the study of ownership structure and short-sale constraints, found that stocks with lower and more concentrated ownership were responsible for a lower lending supply and a higher shorting cost. In turn, short-sales constrained stocks exhibited subsequent negative abnormal returns. [Lamont \(2012\)](#) argued that firms, which used various methods to restrict short selling, had temporary overvaluation of stock price, but ended up with very low subsequent returns. However, few studies provided evidence that the subsequent underperformance of short-sales constrained stocks are conditional on certain assumptions. For example, [Boehme *et al.* \(2006\)](#) argued that subsequent underperformance was observed when the conditions of short-sale constraints and divergence of opinion were simultaneously satisfied. They found that stocks were not systematically overvalued when either of the conditions was not satisfied.

4.3 Cost of borrowing stocks, short-sale constraints, and stock returns

As short sellers are required to borrow stocks for short selling, several studies have utilized the cost of borrowing stocks as a proxy for short-sale constraints. The cost of borrowing stocks, often referred to as the stock borrowing fee, is determined by the interplay of demand for borrowing stocks and the supply of lendable stocks in the stock loan market. Moreover, the structure of the market for borrowing stocks also has an impact on borrowing costs. For instance, in a decentralized lendable stock market, like that in the United States, the supply of borrowing stocks is managed by individual broker-dealers. Several studies have shown that establishing a uniform and reliable stock borrowing cost in such a decentralized market is challenging for several reasons. First, the lack of market-wide data makes it impossible to obtain a comprehensive demand and supply picture, thereby complicating the determination of stock borrowing costs ([Kolasinski *et al.*, 2013](#)). Second, determining the actual stock borrowing costs is challenging because they could be associated with other services provided to brokers ([Saffi and Sigurdsson, 2011](#)). Third, higher search frictions in a decentralized lendable stock market can lead to increased stock borrowing costs ([Jones and Lamont, 2002](#)). On the other hand, in a centralized lendable stock market, like that in Japan, a central authority manages the supply of borrowing stocks and establishes a uniform borrowing cost for stock borrowers. However, a higher borrowing cost serves as a deterrent to short selling in both markets. [D'Avolio \(2002\)](#) argued that the cost of borrowing stocks appeared to be a more appropriate proxy for short-sale constraints because it genuinely determines transaction costs through market mechanisms. [Jones and Lamont \(2002\)](#), [Geczy *et al.* \(2002\)](#), [Ofek *et al.* \(2004\)](#), [Beneish *et al.* \(2015\)](#), and others also adopted the cost of borrowing stocks as a proxy for short-sale constraints.

Over the past two decades, numerous studies have examined the subsequent return behavior of stocks constrained by short sales, as measured by the cost of borrowing stocks. [D'Avolio \(2002\)](#) made a substantial contribution to the understanding of short-sale constraints from the perspective of the cost of borrowing stocks. Utilizing 18-month cost

of borrowing data from a large institutional lending intermediary, D'Avolio (2002) presented evidence that stocks with higher borrowing costs subsequently underperformed, and this underperformance was more pronounced for stocks with greater divergence of opinion. Jones and Lamont (2002) also provided corroborating evidence that hard-to-borrow stocks were overvalued and yielded lower subsequent returns. Blocher *et al.* (2013) found that hard-to-borrow stocks significantly underperformed compared to other stocks over the subsequent three-month period, and this underperformance was exacerbated for stocks with greater divergence in investor beliefs. Beneish *et al.* (2015) studied the supply of stocks available for short sales and its impact on future returns. They observed that the supply of lendable stocks typically increased with the cost of borrowing, but it could be reduced when shorting demand was high. Furthermore, they discovered that supply constraints made short sales challenging and that stocks constrained by short sales subsequently underperformed. Duong *et al.* (2017) presented evidence that expensive stocks exhibited lower future returns, even after controlling for shorting demand, suggesting that institutional investors played a significant role in the return predictability of stocks.

4.4 Regulations on short-sale, short-sale constraints, and stock returns

During the 2007–2008 financial crisis, several countries implemented short-selling bans or restrictions in an attempt to stabilize turbulent financial markets (Boehmer *et al.*, 2013). The bans were often targeted at specific financial stocks to prevent speculative attacks and curb downward pressure on stock prices. Notable instances include the United States, where the SEC imposed temporary bans on short selling for specific financial institutions. Similarly, the U.K. implemented a short-selling ban on financial stocks (Hansson and Fros, 2009). Across all regions, authorities primarily imposed restrictions on short selling activities, particularly targeting financial stocks. However, instances of a complete ban on short selling activities were also observed. While these measures were intended to restore confidence and mitigate market disruptions, they also sparked debates about their effectiveness and potential unintended consequences. Critics argued that such bans could impede price discovery and limit market efficiency, while proponents believed they were necessary to prevent excessive speculation and market manipulation during a period of heightened uncertainty. The bans were generally temporary and gradually lifted as market conditions improved. However, in various instances, authorities have imposed restrictions on short selling or enforced complete bans, regardless of prevailing financial conditions.

Regulations related to short sales, such as bans on short selling or restrictions like the uptick rule, appear to limit short selling. Previous studies have employed various regulatory measures as proxies for short-sale constraints. For instance, Khan *et al.* (2019) utilized the magnitude of regulations, Boehmer *et al.* (2008) and Diether *et al.* (2009) focused on the uptick rule, Beber and Pagano (2013), Boehmer *et al.* (2013), Brunnermeier and Oehmke (2014), and Harris *et al.* (2013) considered bans on short selling during the 2007–2009 crisis period, Bris *et al.* (2007) examined restrictions on short sales, and Chang *et al.* (2007) used an official listing of stocks permitted for short sales as proxies for short-sale constraints.

Studies investigating regulations on short sales as a measure of short-sale constraints have yielded inconclusive evidence regarding subsequent stock returns. Chang *et al.* (2007) found that short-sale constrained stocks tended to be overvalued, with the degree of overvaluation increasing in the presence of investor opinion dispersion. Harris *et al.* (2013) examined the ban on short selling of financial stocks in 2008 and observed that the banned stocks earned positive excess returns. However, Khan *et al.* (2019) analyzed the influence of short sales regulation on the relationship between stock borrowing demand and subsequent return behavior. Their results indicated that stocks with higher short interest were generally overvalued, but the degree of overvaluation did not increase

significantly in the presence of strict short-selling regulations. [Boehmer et al. \(2008\)](#) and [Diether et al. \(2009\)](#) provided similar evidence, suggesting that the elimination of the uptick price rule did not have a significant impact on prices. [Beber and Pagano \(2013\)](#) studied the impact of short-sale restrictions on liquidity, price discovery, and stock prices during the 2007–2009 crisis period, utilizing short-sale bans. Their findings indicated that the bans slowed down price discovery but were not associated with excess returns in 30 countries, except for the United States, where the association was positive and significant. The results of [Boehmer et al. \(2013\)](#) also supported the conclusion that the 2008 short selling ban did not have a significant effect on prices.

Recently, [Luu et al. \(2023\)](#) examined short selling activities during the Covid-19 period and discovered that stocks with higher foreign exposure and limited financial flexibility were more likely to be shorted. They concluded that given the significant role of short sales in the price discovery process, banning short selling during the pandemic period would not be advisable. [Deng et al. \(2020\)](#) investigated the correlation between short sales constraints and the risk of stock market crashes following the lifting of regulation SHO from multiple securities. Their findings indicated that the removal of short sales constraints reduced crash risk by limiting the hoarding of managerial bad news and enhancing corporate investment efficiency. In a study on the Chinese stock market, [Li et al. \(2022\)](#) examined the diffusion of information when regulations on short sales were partially lifted. They observed that short sales constraints significantly delayed the assimilation of information into stock prices, and such restrictions demonstrated notable return predictability. [Cao et al. \(2021\)](#) contended that short-sales constraints prompted manipulative behavior among large investors. Empirical evidence presented by [Cao et al. \(2021\)](#) suggested a substantial reduction in stock price manipulation after the relaxation of short sales constraints.

4.5 Short-sale constraints and availability of option trading

Numerous theories and empirical studies have explored how the availability of options trading impacts short-sale constraints. These studies generally suggest that allowing securities to be traded as options enables investors to make use of negative information when short-selling is restricted, thereby reducing the impact of short-sale constraints ([Diamond and Verrecchia, 1987](#); [Skinner, 1990](#); [Damodaran and Lim, 1991](#); [Figlewski and Webb, 1993](#)). The rational expectation model of [Diamond and Verrecchia \(1987\)](#) demonstrates that the introduction of option trading accelerates the adjustment to private information, thereby diminishing the informativeness of short sales. [Skinner \(1990\)](#) posited that restrictions on short sales could be partially alleviated through option trading, as investors can effectively replicate cash flows from short selling of stocks by appropriately designing call options or put options. [Damodaran and Lim \(1991\)](#) argued that even when short sales are constrained, investors can capitalize on their negative information if options markets exist. [Figlewski and Webb \(1993\)](#) provided empirical evidence that investors facing short-sale constraints turned to options as a substitute for short selling stocks, thereby reducing the impact of short-sale constraints. Similar evidence on the role of option trading in mitigating the effect of short-sale constraints was presented by [Danielsen and Sorescu \(2001\)](#), [Ofek et al. \(2004\)](#), [Blau and Wade \(2011\)](#), [Phillips \(2011\)](#), and [Grundy et al. \(2012\)](#).

In a similar vein, [Hao et al. \(2013\)](#) found that put options became more informative before the release of negative information even when short sales were allowed, suggesting that the options market attracted more informed trading. However, [Battalio and Schultz \(2011\)](#) and [Grundy et al. \(2012\)](#) discovered that trading volume in the options market did not increase when short sales were banned during the 2008 financial crisis period, indicating that options availability could not serve as a viable alternative to short sales.

4.6 Market structure and short-sale constraints

The structure of the market for lendable stocks is a critical factor in understanding the impact of short-sale constraints on stock returns. In a decentralized lendable stock market, where individual broker-dealers control the demand and supply, search frictions tend to be higher, borrowing costs tend to increase, and stocks tend to be more constrained for short sales compared to centralized markets. In contrast, a centralized market is under the control of a central authority, which manages the lending stock market and sets a uniform cost of borrowing for all lending stocks. Consequently, the involvement of a central authority reduces search frictions, borrowing costs, and short-sale constraints in a centralized lendable stock market (Khan *et al.*, 2018).

However, it can be challenging to determine which market structure contributes more to short-sale constraints, as finding an appropriate borrowing cost in decentralized markets can be difficult, if not impossible (Lamont, 2012). Khan *et al.* (2018) conducted a comparison of short-sale constraints on a few stocks traded simultaneously in both a centralized market (e.g. Tokyo Stock Exchange) and a decentralized lendable stock market (e.g. New York Stock Exchange). They found that the cost of borrowing is lower in a centralized lendable stock market, implying that short-sale constraints are less severe in centralized markets. Huszár and Prado (2019) examined short sales activities in the presence of both centralized and decentralized lendable stock markets in Japan. They revealed that retail traders dominated the centralized market, while institutional traders dominated the decentralized market with tailored and non-transparent contracts. The short-selling activities of retail and institutional traders through the alternative lending channel showcased different trading strategies and contributed to different aspects of the pricing strategy. Huszár and Prado (2019) argued that short-selling activities in the decentralized market aided in the price discovery process, which was not documented for the centralized market.

4.7 An evaluation of short-sales constraints measurement

Traditional demand-side measures of short-sale constraints have not been unanimously convincing in recent studies. To address this, several variants of existing measures have been explored. For instance, Bao *et al.* (2019) used residual short interest instead of traditional short interest and found support for the overvaluation hypothesis. This measure captures some aspects of the informativeness of short sellers but doesn't consider supply-side impediments to short-sale constraints. Purnanandam and Seyhun (2018) used insider-trading activities as a proxy for private information in stocks and observed that short selling constraints, measured by standardized short interest ratio, provided significant information about future stock returns. However, insider trading doesn't encompass all the information that short sellers bring to the market. Other variations of short interest measures are also found in the literature, such as the ratio between short selling volume and overall trading volume (Christensen *et al.*, 2014) and abnormal short turnover (Chen *et al.*, 2002).

Similarly, variations exist for supply-side measures of short-sale constraints. For example, Nagel (2005) and Chen *et al.* (2002) used institutional ownership of stock as a measure of short-sale constraints, while Asquith *et al.* (2005) used both higher short interest and lower institutional ownership. Prado *et al.* (2016) employed the concept of lower and more concentrated ownership, and Evans *et al.* (2012) utilized the activism of institutional owners as measures for short-sale constraints. Moreover, Lamont (2012) argued that the use of supply-side measures to denote short-sale constraints often depends on other institutional characteristics, such as voting rights.

The availability and frequency of short selling data can also impact the measures of short-sale constraints. Most previous studies have relied on monthly data to capture short-sale constraints, which inherently limits their ability to account for daily fluctuations and

short-term short selling strategies (Diether *et al.*, 2009). The lack of market-wide data is particularly observed when measuring short-sale constraints using the cost of borrowing or lending stocks (Kolasinski *et al.*, 2013). Differences in the sample period and the data provider often make it challenging to evaluate the performance of these measures for short-sale constraints.

In conclusion, the assessment of measures for short-sale constraints reveals that a complete and unique measure is rare and difficult to achieve. Therefore, measures for short-sale constraints should be considered within specific assumptions and methodological contexts, rather than overgeneralized.

5. Discussion

There is a general consensus that short-sale constraints can disrupt pricing efficiency by limiting the incorporation of negative information into stock prices, potentially causing overvaluation. However, as discussed in the previous sections, several theories and empirical studies have shown that short-sale constraints do not consistently lead to stock price overvaluation. The influence of short-sale constraints on stock prices depends on various factors. Existing theories propose that short-sale constraints can result in either overvalued or undervalued stock prices, depending on assumptions about expectations homogeneity, expectations revisions, perceived information uncertainty, trading motivations, and changes in the demand and supply of risky assets. Empirical studies offer diverse evidence on the impact of short-sale constraints on stock returns, and the discrepancies in findings can be attributed to several factors. The use of various proxies to define short-sale constraints contributes to differing outcomes in empirical studies. Short-sale constraints have been proxied using measures such as the short interest ratio, the supply of lendable stocks represented by institutional ownership, a combination of the short interest ratio and institutional ownership, the cost of borrowing stocks, and the availability of securities for option trading. The choice of proxy affects the selection of short-sale constrained stocks, leading to variations in their subsequent return behavior. Differences in study samples are another reason for varying findings, even when the same proxy is employed for short-sale constraints. Changing market conditions and regulations can lead to distinct implications of short-sale constraints over time. The structure of the market for lendable stocks can influence how short-sale constraints impact stock returns. Centralized and decentralized lending markets have different characteristics, affecting borrowing costs and short-sale constraints. The degree of regulations related to short sales can also affect the influence of short-sale constraints on stock returns. Short-sale regulations can vary in stringency, making it challenging to determine how market-determined short-sale constraints affect stock prices. The availability of option trading introduces complexity to the impact of short-sale constraints on stock returns. Option listings provide opportunities to leverage negative information, potentially reducing short-sale constraints. However, when both short-sale and option trading opportunities exist simultaneously, it can obscure the effect of short-sale constraints on stock returns.

In summary, the relationship between short-sale constraints and stock returns is multifaceted, with a range of factors contributing to variations in findings. Researchers must consider these factors and their interplay to comprehensively understand the influence of short-sale constraints on stock prices.

6. Conclusions

According to the efficient market hypothesis, short-sale constraints are among the factors that hinder the efficient pricing of stocks. While many theories and empirical studies

generally support the view that short-sale constraints restrict the reflection of negative information and lead to overvalued stock prices, it's important to note that not all evidence aligns with this perspective. There are differences in both theoretical postulations and empirical findings regarding the impact of short-sale constraints on stock prices. This study reviews existing research and identifies that the factors such as assumptions about the homogeneity of expectations, revisions of expectations, perceived information uncertainty, trading motivations, and changes in the demand and supply of risky assets all contribute to whether short-sale constrained stocks are overvalued or undervalued. While empirical evidence of overvaluation due to short-sale constraints is more prevalent, instances of insignificance of short-sale constraints are not rare.

This study finds that the choice of proxy for short-sale constraints, the selection of the sample period, the market structure for lendable stocks, the extent of short-sale-related regulations, and the availability of option trading all play a role in shaping different outcomes in research studies. This study has implications for regulators, policymakers, investors, and academics in the realm of stock markets. It underscores the importance of balancing the price-distorting and price-discovery roles of short-sale constraints when implementing regulations on short sales. Strict regulation on short selling aims to mitigate its potential to disrupt stock markets, but it should be carefully considered alongside the role short selling plays in price discovery.

In conclusion, this study suggests that overvaluation and subsequent reduction of stock prices are not solely the result of short-sale constraints; various factors, including market structure and investor expectations, also come into play. It emphasizes that the impact of short-sale constraints should be assessed in light of specific assumptions and market conditions. Considering that the influence of short-sale constraints on stock returns can be context-dependent, future studies should explore the relationship during extraordinary circumstances, such as the COVID-19 pandemic, which witnessed significant market turmoil and changes in short-selling regulations. Furthermore, the ban on short selling prompted by the fear of stock market turmoil requires further investigation, as there is no conclusive evidence supporting this perspective. Lastly, additional studies should be conducted to compare short selling activities in centralized and decentralized lending markets, aiming to determine whether a central supply system reduces market frictions. Nevertheless, this unique background offers an opportunity to study the overvaluation hypothesis in a distinctive setting.

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Appendix

Short-sale constraints and stock returns

Authors (Year)	Research topic	Sample period/ country	Major findings
Aggarwal et al. (2015)	Institutional investors and supply of lendable stock	USA: 2007–2009	Institutional investors limit the supply of lendable stocks due to their preference for voting rights, thereby constraining short sales
Allen et al. (1993)	Short sales constraints and asymmetric information	Theoretical study	Short sales constraints create bubbles in stock prices
Asquith et al. (2005)	Institutional ownership, short interest, and stock returns	USA: 1980–2002	Stocks with high short interest exhibit a strong and significantly negative relationship with stock returns
Atmaz et al. (2023)	Costly short selling and lending market	Theoretical study	A dynamic model where investors' belief disagreement leads to higher shorting demand and predicts stock returns negatively
Autore et al. (2015)	Short sales constraints and stock overvaluation	USA: 2005–2008	The authors report extreme overpricing and subsequent reversals where short sales are specially binding
Bai et al. (2006)	Asset prices under short-sale constraints	Theoretical study	Short-sale constraints could exert either upward or downward pressure on stock prices, contingent on the types of trades being restricted
Bao et al. (2019)	Short interest and disclosure of information	USA: 2001–2010	Stocks with high residual short interest were significantly overvalued. Managers had a tendency to withhold bad news
Battalio and Schultz (2011)	Short sales ban and equity options market	USA: August 1, 2008–October 21, 2008	Trading volume in the options market did not increase when short sales were banned, indicating that options availability was not a good proxy for short sales
Beber and Pagano (2013)	Short sales ban and stock prices	Global: January, 2008–June, 2009	Ban on short selling reduces liquidity and slows price discovery process, but was not associated with stock returns except in the US
Beneish et al. (2015)	Short sellers and stock returns	USA: July, 2004–December, 2013	Supply constraints made short sales challenging and stocks constrained by short sales subsequently underperformed
Boehme et al. (2006)	Short sale constraints, differences of opinion, and overvaluation	USA: January, 1988–December, 2002	The authors used low market capitalization stocks to proxy for short-sale constraints and found that underperformance of stocks with high short interest was concentrated among stocks with low market capitalization
Boehmer et al. (2008)	Elimination of the uptick rule and stock prices	USA: January, 2007–August 2007	Elimination of uptick rule increased shorting activities but did not have impact on stock prices

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Table A1.
Summary of studies on short sales constraints and stock returns

Authors (Year)	Research topic	Sample period/ country	Major findings
Boehmer et al. (2013)	Ban on short selling and stock returns	USA: August 1, 2008–October 31, 2008	Although shorting activities dropped significantly there was no impact on stock prices due to the ban on short selling
Blau and Wade (2011)	Comparison of return predictability in short selling and in put options	USA: Risk adjusted returns of 1,186 stocks	Underperformance of short sale constrained stocks are evident but the availability of option trading reduces the impact of short sales constraints
Blocher et al. (2013)	Impact of equity loan market on stock prices	Theoretical study	Hard-to-borrow stocks have lower subsequent returns than other stocks, with negative returns concentrated in stocks with high heterogeneity in investor beliefs
Brent et al. (1990)	Short interest and subsequent stock returns	USA: January, 1974–January, 1986	Changes in short interest and subsequent stock returns are not related
Bris et al. (2007)	Legal restrictions on short sales and market efficiency	Global: 1990–2001	Markets where short selling is prohibited, returns display significantly less negative skewness, and the frequency of extreme negative returns is lower
Brunnermeier and Oehmke (2014)	Ban on short selling of vulnerable institutions	Theoretical study	Findings supports potential justification for temporary restrictions on short selling of vulnerable institutions
Cao et al. (2007)	Short-sale constraint, informational efficiency, and asset price bias	Theoretical study	Short sales constraints could produce both upward and downward pressure on stock prices. The ultimate effect depends on which effect dominates
Cao et al. (2021)	Short sales constraints and stock price manipulation	China: 2003–2019	Short-sales constraints induced manipulative behavior of large investors and empirical showed that stock price manipulation significantly reduced after relaxing short sales constraints
Chang et al. (2007)	Short sales constraints and stock returns	Hong Kong: 1994–2003	Short-sale constrained stocks tended to be overvalued, with the degree of overvaluation increasing in the presence of investor opinion dispersion
Chen et al. (2002)	Breadth of ownership and stock returns	USA: 1979–1998	The authors used low breadth of ownership as a proxy for short-sale constraints and found that these stocks underperformed subsequently

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Authors (Year)	Research topic	Sample period/ country	Major findings
Damodaran and Lim (1991)	Option listing and stock returns	USA: 1973–1983	The authors found that the listing of options leads to significantly lower variance in the daily returns or the underlying stocks. They also found that prices adjust much more quickly to new information after the listing of options.
Danielsen and Sorescu (2001)	Availability of option trading and stock prices	USA: 1973–1995	The authors provide evidence that the negative abnormal returns and increased short interest are consistent with the mitigation of short-sale constraints resulting from the option introduction
D'avolio (2002)	The market for borrowing stock	USA: April, 2000–September, 2001	The authors provided evidence that stocks with higher borrowing costs subsequently underperformed, and this underperformance was more pronounced for stocks with greater divergence of opinion
Deng <i>et al.</i> (2020)	Short-sale constraints and stock price crash risk	USA: 2001–2010	The authors found that lifting of short sales constraints reduced crash risk by constraining managerial bad news hoarding and improving corporate investment efficiency
Desai <i>et al.</i> (2002)	Short interest and stock returns	USA: June, 1988–December, 1994	the authors provided evidence that heavily shorted stocks experienced significantly negative abnormal returns
Diamond and Verrecchia (1987)	Short sales constraints and asset price adjustment to private information	Theoretical study	The demand for short sales conveys bearish signals. As short sellers are assumed to be informed and rational investors, their trades can also signal a mispricing of stocks
Diether <i>et al.</i> (2009)	Regulation on short selling and stock returns	USA: February, 2005–July, 2005	Short-selling activity increased both for NYSE- and Nasdaq-listed Pilot stocks, but returns and volatility at the daily level remained unaffected
Duffie <i>et al.</i> (2002)	Securities lending, shorting, and pricing	Theoretical study	The authors argued that the challenges in locating lendable securities led to an initial increase in security prices, followed by a subsequent decline
Duong <i>et al.</i> (2017)	The information value of stock lending	USA: 2007–2010	Expensive stocks exhibited lower future returns, even after controlling for shorting demand, suggesting that institutional investors played a significant role in the return predictability of stocks

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Table A1.

Authors (Year)	Research topic	Sample period/ country	Major findings
Evans <i>et al.</i> (2012)	Equity lending, investment restrictions, and fund performance	USA: 1996–2009	Active institutional investors are less likely to lend stocks compared to passive institutional investors for the consideration of retaining fund values
Figlewski and Webb (1993)	Options, short sales, and market completeness	January, 1973– June, 1979	The authors provided empirical evidence that investors facing short-sale constraints turned to options as a substitute for short selling stocks, thereby reducing the impact of short-sale constraints
Gopalan (2003)	Short sales constraints, difference of opinion and stock returns	USA: 1992–2000	The author found that stocks with high short interest subsequently underperformed when the dispersion of analyst forecasts was greater
Geczy <i>et al.</i> (2002)	Cost of borrowing and short sales constraints	USA: November, 1998–October, 1999	The authors found that the loans of initial public offering, DotCom, large-cap, growth and low-momentum stocks to be cheap relative to the strategies' documented profits and that investors who can short only stocks that are cheap and easy to borrow can enjoy at least some of the profits of unconstrained investors
Grundy <i>et al.</i> (2012)	Options market and short sales constraints	USA: 2008–2009	The authors found that trading volume in the options market did not increase when short sales were banned during the 2008 financial crisis period, indicating that options availability could not serve as a viable alternative to short sales
Guo and Wu (2019)	Short interest, stock returns and credit ratings	USA: January, 1986–February, 2017	The authors reported that the predictive power of short interest for future returns was concentrated in the worst-rated stocks
Hanauer <i>et al.</i> (2023)	Surprise in short interest and stock returns	USA: May 1980– December, 2018	The authors found that surprise in short interest negatively predicted the cross section of both U.S. and international stock returns
Hao <i>et al.</i> (2013)	Short sales and put options	USA: March, 2005–June, 2007	The authors found that put options became more informative before the release of negative information even when short sales were allowed, suggesting that the options market attracted more informed trading

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Authors (Year)	Research topic	Sample period/ country	Major findings
Hansson and Fros (2009)	Market impact of short sales ban in the UK	UK: 2008–2009	During the financial crisis period of 2008–2009, the UK authority restricted short selling activities substantially. However, the authors did not find a significant effect of such restrictions on abnormal returns and volatility of stocks
Harris <i>et al.</i> (2013)	Price inflation and wealth transfer during the 2008 SEC short-sale ban	USA: Short selling ban imposed on September, 2008	The authors examined the ban on short selling of financial stocks in 2008 and observed that the banned stocks earned positive excess returns
Harrison and Kreps (1978)	Short sales constraints, divergence of opinion, and stock prices	Theoretical study	The authors argued that short-sale constraints, when coupled with investor divergence of opinion, could push stock prices beyond the valuation of the most optimistic investors based on their expectations of future earnings
Hong and Stein (2003)	Short sales constraints, divergence of opinion, and market crashes	Theoretical study	The authors contended that the bearish investors' negative information did not initially manifest in stock prices due to short-sale constraints. When surfaced, the market began to decline, intensifying the downward spiral and ultimately leading to a crash
Huszár and Prado (2019)	Comparing the over-the-counter and centralized stock lending markets	Japan: July, 2006–December, 2009	The author argued that short-selling activities in the decentralized market aided in the price discovery process, which was not documented for the centralized market
Jarrow (1980)	Heterogeneous expectations, restrictions on short sales, and equilibrium asset prices	Theoretical study	The author contended that asset prices could either rise or fall due to short sales constraints. However, under homogeneous expectations regarding the asset prices for the next period, restrictive short-sales would only result in an increase in risky asset prices
Jones and Lamont (2002)	Short-sale constraints and stock returns	USA: 1926–1933	The authors provided evidence that hard-to-borrow stocks were overvalued and yielded lower subsequent returns

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Table A1.

Authors (Year)	Research topic	Sample period/ country	Major findings
Khan <i>et al.</i> (2019)	Short sales constraints, regulations, and stock returns	Japan: January, 2012–July, 2016	The authors found that stocks with higher short interest were generally overvalued, but the degree of overvaluation did not increase significantly in the presence of strict short-selling regulations
Khan <i>et al.</i> (2018)	Short sales constraints in a centralized lending market	Japan: November, 2015–May, 2016	The authors compared short-sale constraints in a centralized market (e.g. Tokyo Stock Exchange) and a decentralized lendable stock market (e.g. New York Stock Exchange). They found that the cost of borrowing is lower in a centralized lendable stock market, implying that short-sale constraints are less severe in centralized markets
Kolasinski <i>et al.</i> (2013)	Supply and search in the equity lending market	USA: September, 2003–December, 2007	When demand is moderate, lending fees are largely insensitive to demand shocks. However, when demand is high, lending fees increase significantly and the extent to which demand shocks impact fees is also related to search frictions in the loan market
Lamont and Stein (2004)	Aggregate short interest and market valuations	USA: 1960–2002	The authors did not observe a significant relationship between aggregate short interest and subsequent market returns
Lamont (2012)	Firm’s initiative to influence short sales and stock returns	USA: 1977–2002	The author argued that firms were less likely to allow their stock to be sold short anticipating that firm value would go down and, therefore, used various methods to restrict short selling, such as legal threats, investigations, lawsuits, and others
Li <i>et al.</i> (2022)	Short sales constraints and diffusion of information	China: January, 2001–February, 2019	The authors found that short sales constraints significantly delayed the incorporation of information in stock prices and such restriction had significant return predictability
Luu <i>et al.</i> (2023)	Short selling during the Covid-19 pandemic	USA: January, 2019–April, 2020	The authors found that stocks with higher foreign exposure and limited financial flexibility were more likely to be shorted. They concluded that given the significant role of short sales in the price discovery process, banning short selling during the pandemic period would not be advisable

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Authors (Year)	Research topic	Sample period/ country	Major findings
Miller (1977)	Risk, uncertainty, and divergence of opinion	Theoretical study	The author argued that in the presence of market frictions like short-sale constraints, divergence of opinion was priced at a premium, i.e. stocks price became higher in the presence of short sales constraints and divergence of opinion
Nagel (2005)	Short sales, institutional investors, and stock returns	USA: 1980–2003	The author found that short-sales constrained stocks, as proxied by low institutional ownership, tended to underperform subsequently particularly among stocks with high market-to-book, analyst forecast dispersion, turnover, and volatility
Ofek <i>et al.</i> (2004)	Limited arbitrage, option market, and short sales constraints	USA: July, 1999–November, 2001	The availability of option trading mitigates the effect of short-sale constraints on stock prices
Phillips (2011)	Options, short-sale constraints, and market efficiency	USA: 1980–2005	The availability of option trading significantly reduces the effect of short-sale constraints on stock prices in relation to negative news
Prado <i>et al.</i> (2016)	Ownership structure, limits to arbitrage, and stock returns	USA: 2006–2010	The authors argued that stocks with lower and more concentrated ownership were responsible for lower lending supply and higher short-sale constraints
Purnanandam and Seyhun (2018)	Private information, short sales constraints and stock returns	USA: 1991–2011	The authors used insider-trading activities as a proxy for private information and observed that short selling constraints, measured by standardized short interest ratio, provided significant information about future stock returns
Rapach <i>et al.</i> (2016)	Short interest and aggregate stock returns	USA: 1990–1998	The authors found that short interest at the aggregate level was the strongest predictor of stock returns, confirming prior findings that short sellers are informed traders capable of predicting stock returns
Saffi and Sigurdsson (2011)	Price efficiency and short selling	Global: 2005–2008	The authors found that stocks with higher short-sale constraints, measured as low lending supply, have lower price efficiency. Moreover, relaxing short-sales constraints is not associated with an increase in either price instability

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Authors (Year)	Research topic	Sample period/ country	Major findings
Scheinkman and Xiong (2003)	Overconfidence and speculative bubbles	Theoretical study	The authors argued that in the presence of investor heterogeneity and short-sale constraints, only the optimistic investors' views were reflected in prices, effectively sidelining pessimistic investors. This phenomenon created price bubbles and set the stage for market crashes
Senchak and Starks (1993)	Short-sale constraints and market reaction to short interest	USA: January, 1980–December, 1986	The authors found that subsequent underperformance was evident with stocks featuring higher unexpected short interest and stocks with tradable options
Skinner (1990)	Options markets and the information content earnings releases	USA: April, 1973–December, 1986	The author found that restrictions on short sales could be partially alleviated through option trading, as investors can effectively replicate cash flows from short selling of stocks by appropriately designing call options or put options
Takahashi (2010)	Short-sale inflow and stock returns	Japan: December, 1997–March, 2008	The author investigated the relationship between flow-based shorting demand and subsequent stock return behavior, concluding that the least heavily shorted stocks outperformed the most heavily shorted ones
Wang and Lee (2015)	Foreign short sellers and stock returns	Korea: January, 2006–May, 2010	The authors found that higher short interest was associated with subsequent negative returns for foreign short sellers
Woolridge and Dickinson (1994)	Short selling and common stock prices	USA: 1986–1991	The authors argued that short sellers played no role in driving stock prices down but instead provided liquidity to the market
Yuan (2004)	Asymmetric information, trading constraints, and asset pricing	Theoretical study	The authors found that the presence of short-sale constraints and information asymmetry led to more pronounced large price movements, with crashes occurring much more rapidly than the formation of bubbles

Table A1. Source: table created by the author