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Margin Rules and Margin Trading: Past, Present, and Implications

Zhuo Chen,[1] Zhiguo He,[2,3] and Wei Wei[2]

[1]PBC School of Finance, Tsinghua University, Beijing, China

[2]Graduate School of Business, Stanford University, Stanford, California, USA; email: hezhg@stanford.edu

[3]National Bureau of Economic Research, Cambridge, Massachusetts, USA

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Abstract

Margin—collateral or funds that investors deposit with their counterparties—is a crucial component of the practice of borrowing money to fund investment. While margin offers the potential for enhanced returns, it also exposes investors to the risk of escalated losses, thereby necessitating stringent regulatory oversight. Delving into the regulatory framework governing margin trading, we provide historical insights into the origins and dynamics of various margin requirements, and we review academic studies that illuminate the implications of these regulations for asset pricing, financial stability, and the design of margin rules. With an eye to the future, we also outline recent advancements in the evolving landscape of margin rules, such as portfolio margin and central clearing.

1. INTRODUCTION

Margin is a form of collateral or funds that investors deposit with their counterparties to protect against market fluctuations and defaults. Margin trading allows investors to leverage their investments but also carry the risk of magnified losses, leading to regulatory oversight in many major countries.

In this review, we start with an exploration of several critical aspects of the regulatory landscape on margin trading in Section 2. Regulation T, which was established in 1934, governs the requirements and stipulations associated with margin borrowing from brokers. In contrast, Regulation U sets guidelines and restrictions on margin lending from banking institutions. As we explore the nuances of Regulation U, we will gain insights into the unique considerations and implications of borrowing on margin from banks (and potentially from brokers concurrently).

Our approach throughout is to adopt a historical lens, elucidating the origins of these margin regulations (Section 2) while referencing various theoretical studies that delve into their implications for equilibrium asset pricing and financial stability (Section 3.1). In doing so, we also strive to consolidate a substantial corpus of empirical findings together with those theoretical discussions, by reviewing the empirical literature on the asset pricing impact of margin rules (Section 3.2). Section 3.3 then examines the research on the design of margin rules, highlighting an important financial friction arising from cross-netting that we elaborate upon in Section 4.2.

Our review also aims to take a forward-looking perspective whenever possible. For instance, at the end of Section 2 we outline the evolving landscape of margin rules and regulations, including the portfolio margin and the potential expansion of margin rule schemes after the Great Financial Crisis (GFC). Taking the ongoing reform of portfolio margin as an example, in contrast to the traditional Regulation T margin, which calculates margin requirements on the basis of the individual asset, portfolio margin takes into account the overall risk of an entire portfolio of positions, considering the potential correlations between different assets and their associated risks. We review several leading articles on this issue in Section 3.3.2.

Section 4 addresses a significant aspect of margin rule design that continues to evolve: central clearing. Central clearing is a process in which a specialized organization, known as a central clearing counterparty (CCP), intermediates between buyers and sellers in a financial transaction. Assuming the role of counterparty for both the buyer and the seller, CCPs employ a variety of methods, including margining, default funds, and netting, to manage counterparty risk and potential default losses. Among these methods, netting plays a crucial role in central clearing by combining multiple financial obligations to arrive at a net obligation amount. Our review focuses on the literature on CCP efficiency and the optimal design of margin rules for CCPs and discusses the post-GFC regulatory push within this framework.

2. MARGIN AND MARGIN RULES

Margin is the collateral or fund that an investor is required to deposit with her broker or exchange to protect against the risk of market price changes or counterparty default. Buying on margin occurs when an investor borrows from brokers to buy securities, using the securities as collateral for the purchase loan. Investors may also conduct short sales through margin accounts, involving borrowing securities from brokers to sell them in the open market. The concept of margin is also tightly linked to repurchase agreement (repo), which is a transaction combining a spot market sale of securities with a simultaneous forward agreement to buy back the securities at a later date. Effectively, margin trading is like using cash or qualifying securities as collateral for a loan, which comes with a periodic interest rate that must be repaid. Leveraging the margin, investors could boost returns on winning trades. However, this increased leverage could magnify losses in cases

in which the security's price moves in the opposite direction, with potential market-wide and macroeconomic implications.

Exactly for this reason, margin trading is subject to regulatory oversight in almost all countries. In the United States, regulatory entities include the Board of Governors of the Federal Reserve System (Fed), the Securities and Exchange Commission (SEC), specific self-regulatory organizations (SROs) under the SEC's supervision, and the Commodity Futures Trading Commission (CFTC). On specific laws, Regulation T, the first federal requirement on margin loans and established in 1934, governs lending by brokers and dealers (Section 2.1); Regulation U, adopted in 1936, imposes limits on bank and nonbank lending on margin stocks (Section 2.2); and Regulation X, adopted in 1971, restricts US citizens' ability to borrow abroad to circumvent the domestic margin rules.

2.1. Margin Requirements: Regulation T

In response to the 1929 stock market crash, the Securities Exchange Act of 1934 bestows on the Fed the authority to regulate the amount of credit that may be used to purchase and carry securities, regardless of whether the transaction involves a commercial bank. Although the Fed typically exercises regulatory authority only over banks and the SEC regulates brokers and funds, during that period, banks were the primary source of credit in the economy, and policy makers attributed the intensification of the 1929 Great Crash to a stock market frenzy driven by debt. Congress outlined three overarching objectives for margin rules: restraining excessive credit within the stock market, safeguarding investors from excessive debt, and mitigating stock market volatility stemming from forced securities trading (Moore 1966).[1]

The Fed oversees margin trading via establishing federally mandated margin requirements that restrict the extent to which securities can be acquired through borrowed funds. Besides the Fed, SROs—such as the New York Stock Exchange (NYSE) and the Financial Industry Regulatory Authority (FINRA)—can also set rules governing margin trading. Brokerage firms are also permitted to establish their own margin requirements, which are referred to as house margin requirements. House margin requirements should be at least as restrictive as the Fed and SRO rules.

We now discuss three key margin rules in practice: minimum margin requirements, initial margin (IM) requirements, and maintenance margin requirements. We also briefly discuss margin requirements in the context of short sales.

2.1.1. Minimum margin. Minimum margin is the amount required to be deposited in the margin account before margin trading or short selling. FINRA requires a minimum deposit of $2,000 or 100% of the purchase value of the margin securities (whichever is less), in either cash or securities. Some brokerage firms may impose higher thresholds. This rule still exists today, and notably it is the only margin requirement that involves a fixed-dollar amount, as opposed to a percentage.

2.1.2. Initial margin. IM refers to the percentage of equity that the investor contributes to the purchase of securities. The Fed sets the IM requirement, which determines the maximum amount that investors can borrow; for example, an x% IM requirement means that an investor can borrow up to $1 - x$% of the cost of a security purchase. A higher IM requirement implies a more stringent borrowing constraint.

From 1934 to 1974, the Fed adjusted the IM requirement on 22 occasions, either increasing to curb the excessive use of credit in financial markets or decreasing to accommodate the expanding credit demand from commerce and industry. However, the requirement has remained unchanged at 50% since 1974.

[1]The *Wall Street Journal* provides more interesting details in Tracy (2016b).

Federal regulations also dictate the eligibility of securities for margin trading, determining which can be used as collateral. Within these regulatory parameters, brokers have the discretion to establish their own requirements. Securities with lower liquidity and higher volatility are more likely to be classified as nonmarginable securities. Examples of such nonmarginable securities include certain over-the-counter (OTC) stocks, penny stocks, and recent IPO listings. Most other securities listed on the NYSE, NASDAQ, and AMEX are marginable.

2.1.3. Maintenance margin. After purchasing securities on margin, investors are required to keep a minimum amount of equity in the margin account. FINRA requires that the equity be no less than 25% of the total market value of the securities in the margin account at all times. This 25% is termed the maintenance margin requirement. In practice, many brokerage firms adopt higher maintenance margin requirements, usually between 30% and 40%.

Once the equity value falls below the maintenance margin requirement, brokerage firms typically issue a margin call to require that more cash or securities be deposited into the margin account. If an investor cannot meet the margin call, brokerage firms may liquidate securities within the account to raise the equity value to the maintenance margin requirement.[2]

2.1.4. Short-sale margin. Short sales are the inverse of margin trading. Short sellers speculate on declining security prices by selling securities that they do not own and then buying them back at a lower price. To initiate a short sale, investors must borrow shares from brokers using margin accounts and subsequently return them. Therefore, short sales are also governed by Regulation T. Under Regulation T, short sales require a deposit equal to 150% of the value of the position at the time of execution, which include the full value of the short position (100%) and the IM requirement (50%). Maintenance requirements include 100% of the current market value of the short sale and a minimum of 25% as the maintenance margin requirement. Short sale plays an important role in mitigating overpricing and improving market efficiency. For comprehensive reviews on short sales, see Duffie (2010), Gromb & Vayanos (2010), and Reed (2013).

2.2. Margin Rules on Banks and Other Nonbroker Lenders: Regulation U

Two years after the adoption of Regulation T, the Fed, recognizing that investors could circumvent Regulation T by borrowing from banks rather than brokers, adopted Regulation U in 1936. Regulation U established margin rules to limit security loans by banks. Another important goal of Regulation U was to restrict the reallocation of bank credit from legitimate business to speculative markets, since financing from banks is an important funding source for brokers to finance margin loans.

However, Regulation U has a more limited scope than Regulation T. Two specific criteria are applied. First, regarding collateral type, Regulation U only regulates loans directly or indirectly against margin securities, leaving loans unsecured or secured by nonmargin securities unregulated. In contrast, Regulation T prohibits brokers from lending against nonmargin securities. Second, regarding loan purpose, if the loan proceeds are used to purchase margin securities, such loans will be regulated by Regulation U and are termed purpose loan or purpose credit.[3]

While the Fed has the flexibility to set the IM requirement under Regulation U at any level, it has traditionally set it at the level allowed by Regulation T, currently 50%. For unregulated loans

[2] Brokerage firms are not obligated to issue margin calls; they have the discretion to sell securities at any time once the equity value falls below the requirement.

[3] To collect the purpose information, Regulation U mandates that every regulated borrower complete a purpose statement, which is Form FR U-1 for banks and Form FR G-3 for other nonbroker lenders.

such as nonpurpose loans, lenders can require any margin on a good faith basis. Unlike Regulation T, Regulation U does not contain minimum or maintenance margin requirements, implying that lenders can issue margin calls on the basis of their own credit criteria.

Although Regulation U specifically applies to purpose loans secured by margin securities, it recognizes the possibility that a lender might extend both secured and unsecured purpose loans to the same borrower. This is accomplished through the single credit rule, which requires that any purpose loans (whether secured or unsecured) extended to a borrower, as well as all collateral linked to these loans, be aggregated into a single purpose loan. The aggregated purpose loan must satisfy the margin requirements of Regulation U. The primary goal of the single credit rule is to prevent banks from initially providing a purpose loan secured by margin securities and subsequently extending another unsecured purpose loan on the basis of the equity from the initial loan (Fortune 2002). For example, under the 50% IM requirement, a borrower can buy $100 of margin securities but borrow $50 from Bank A, pledging the securities as collateral. If he then borrows an additional unsecured loan of $30 from Bank A to buy more margin securities, Bank A extends $80 of loans to the borrower in total while receiving only $100 of securities as collateral, resulting in an 80% loan-to-value ratio well above the 50% limit set by Regulation U. The single credit rule prevents this situation by requiring that the aggregated loan be no greater than 50% of the aggregated collateral.

In practice, investors may take advantage of the disparity between Regulation T and Regulation U to structure transactions aimed at circumventing the margin requirements. For instance, consider an investor who wishes to short margin securities. As explained toward the end of Section 2.1, short sales are subject to a margin requirement of 150% under Regulation T. Of the 150% margin requirement, 100% can be satisfied by selling the borrowed security, which was initially obtained from Broker I, and the investor seeks to borrow the remaining 50% from Bank A, relying on a second lien on the equity involved in this short transaction. This example, with two distinct lenders, falls outside the single credit rule, as both Regulations T and U prohibit a single lender from relying on the same collateral when extending both purpose and nonpurpose credit to the same borrower. As a result, Bank A is permitted to extend such loans under Regulation U to this investor, since legally the credit to meet a Regulation T margin requirement for a short sale is viewed as a nonpurpose credit. Through the joint arrangement between the investor, bank, and broker, the investor is able to obtain purpose and nonpurpose credit from two parties without violating the explicit language of the Fed's margin rules.[4]

The Fed adopted Regulation G to bring financial institutions other than banks or brokers under the federal margin umbrellas in 1968 but then incorporated it into Regulation U in 1998. Since then, the Fed has been able to reach across almost the entire financial system through margin requirements.

2.3. Repurchase Agreement

Margins also play a significant role in the repo markets. A repo is the sale of securities combined with a simultaneous forward agreement to repurchase the securities at a later date, often the next day (Duffie 1996, Garbade 2006, Adrian et al. 2014a). Effectively, a repo transaction resembles a collateralized loan in which the security-buying party acts as a lender of cash, where the seller acts as a borrower, using the security as collateral.

In a repo transaction, there are two primary counterparties: the security seller, who functions as the cash borrower (also known as the security lender), and the security buyer, who functions as

[4]Further details on this case can be found in Holz (1998).

the cash lender (also known as the security borrower).[5] The security exchanged for cash serves as a collateral; the most prevalent collaterals are Treasuries, followed by equities and private sector debt securities (Baklanova et al. 2019). Typically, the value of collateral is higher than the loan amount, and the difference as a percentage of the collateral value is termed the haircut. A dramatic increase in haircuts could potentially trigger a repo run, analogous to a traditional bank run (Gorton & Metrick 2012, 2010).

Repos have two unique features—collateral reuse and superseniority. Collateral reuse is the practice that allows the collateral posted by the borrower to be used again by the lender for the lender's own purposes.[6] Collateral reuse enhances the liquidity of the underlying assets, particularly when collateral is scarce. However, reuse generates the collateral multiplier or collateral chains, which may exacerbate fragility during periods of market stress (Gottardi, Maurin & Monnet 2019; Infante, Press & Saravay 2020; Infante & Vardoulakis 2021).

Regarding superseniority, in the 1980s repos received an exemption from the automatic stay, which effectively allows lenders to gain a position of superseniority in bankruptcy. This significantly reduced lenders' exposure to counterparty risk and as a result spurred the dramatic growth of this market (Garbade 2006). However, superseniority only transfers credit risk from repo lenders to other claimholders (mainly regular creditors), instead of eliminating the risk. Pointing out this issue, Bolton & Oehmke (2015) argue that the desirability of superseniority depends on whether credit risk is more efficiently borne by the junior parties, as superseniority would affect endogenous contractual frictions in different markets.

Another issue is worth noting. If the borrower defaults on the promise to repurchase the security, the lender has the right to terminate the agreement and keep or sell the security. In case of a fire sale, if the security is sold below the promised debt repayment, the lender keeps the entire proceeds, while the borrower receives nothing, and if the price exceeds the promised repayment, the lender still keeps the promised amount and returns the remaining amount to the borrower.[7] This incentivizes the lender to sell the collateral at a fire sale price, as long as it exceeds the promised repayment level.

Finally, there are two main categories of repos categorized by their settlement methods: bilateral and triparty. Bilateral repos are transactions in which settlement typically occurs directly between the two counterparties on a delivery-versus-payment basis, implying that lenders must have the capabilities to value and manage the collateral either by themselves or via their custodial banks. Triparty repos involve a third party providing a suite of collateral management and settlement services for the two transaction parties; the lender does not need to have capabilities to value and manage the collateral. The GFC highlighted the fact that the clearing banks are not only agents but also the largest creditors in the triparty market, due to a process termed unwind; see Section 4.4.2. Gorton & Metrick (2012), Copeland, Martin & Walker (2014), and Krishnamurthy,

[5]Throughout this review, the term borrower (lender) refers to the cash borrower (lender).

[6]Although reuse is often used interchangeably with the term rehypothecation in academic research, there are some legal differences between the two terms. For example, the Financial Stability Board narrowly defined rehypothecation as "any use of client assets by a financial intermediary" while defining reuse as a broader concept that includes "any use of assets delivered as collateral in a transaction by an intermediary or collateral taker." See Financ. Stab. Bd. (2017). Throughout this review, we use the term reuse to broadly refer the practice of lenders to reuse collateral received in one transaction for their own purposes.

[7]Here is an example with the current market value of the underlying security being $100. Party A sells the security to Party B for $80 and commits to repurchasing it for $88 in 1 month. In the event of a fire sale, if Party B sells the security for less than the promised repayment of $88, then it retains all the proceeds, and Party A receives nothing, and if the sale price surpasses $88—say $90—then Party B keeps the promised amount of $88 while returning the difference of $2 to Party A.

Nagel & Orlov (2014) analyze the haircut changes in the bilateral and triparty repo markets during the GFC, indicating different patterns between the two markets during that period.

2.4. Evolution of Margin Rules

The evolution of margin rules reflects the Fed's regulatory posture changes. Until 1974, the Fed was concerned about the financial risks and adjusted the margin rules regularly, even raising the IM requirement to 100% once in the 1940s. Afterward, the Fed began to deem margin rules less necessary and pushed a deregulation of the financial system. During this period a new margin methodology—portfolio margin—was proposed and implemented, decreasing the requirements significantly (Section 2.4.1). However, the GFC raised significant concerns among regulators about financial stability, leading to various regulatory reforms.

2.4.1. Portfolio margin. By the 1980s, policy makers came to view the margin requirement as obsolete, as increasingly sophisticated investors found ways to circumvent these requirements.[8] In the 1990s, then–Fed Chairman Alan Greenspan spearheaded a deregulation push at US financial regulatory institutions, including the Fed;[9] this partially contributed to the relative dovish position toward margin requirement, which remained unchanged even as the tech stock bubble grew in the late 1990s.

In the meantime, policy makers began to recognize that margin requirements based on any single security often exceed the overall portfolio risk, owing to imperfect correlations among securities within portfolios. Advances in portfolio risk management strategies made the risk-based margin rule a potential alternative. In 1998, the Fed amended Regulation T, allowing brokers to introduce portfolio margin in margin accounts. In 2005, the SEC authorized a 2-year pilot program for portfolio margin on the NYSE. In 2008, FINRA announced amendments to formalize the permanent implementation of portfolio margin.

The specific methodology for calculating portfolio margin mandated by the SEC is a type of portfolio risk–based margin system. The basic idea is that margin requirements should be based on the largest projected net loss of all positions in a group under multiple pricing scenarios, allowing gains from one class of assets to partially offset losses to a different class.[10] The margin requirements for most trading strategies are much lower under the portfolio margin than under the traditional position-based methodology. We further discuss the academic research on portfolio margin in Section 3.3.2.

2.4.2. Recent plans to craft new margin rules. During the GFC, the shadow banking system, through repos or asset-backed commercial papers, significantly destabilized the financial system (Gorton & Metrick 2012; Copeland, Martin & Walker 2014; Krishnamurthy, Nagel & Orlov 2014), leading the Fed to be concerned about whether it had enough policy tools to govern the aggregate margin in the economy. In 2016, a global agreement was signed to adopt rules similar to the federal margin rules, a united effort to prevent financial firms from moving transactions offshore to evade the Fed rules.[11] Unlike traditional margin rules largely focused on stocks, this

[8]For an example of how investors utilize the disparity between Regulation T and Regulation U to circumvent margin requirements, see Section 2.2.

[9]In 1990, then–Fed Chairman Greenspan even told a House subcommittee that Congress should move the Fed's margin-setting authority to another regulatory agency because the Fed "does not have overall prudential responsibility" for overseeing broker-dealers and other nonbank organizations. See Tracy (2016a).

[10]More details about the portfolio margin rules are at **http://www.themargininvestor.com/how-portfolio-margin-works.html**.

[11]For more details, see Financ. Stab. Bd. (2020).

agreement also proposed directions for crafting new rules to bring security financing including repos within regulatory reach.

3. MARGIN REQUIREMENTS AND ASSET PRICES

As described in Section 2.1, margin rules have historically been changed many times. Policy makers, practitioners, and academia concur as to the significant influence that margin requirements have had on asset prices, even though the precise impact remains a subject of enduring debate. This section starts by discussing the theoretical literature regarding the relation between margin constraints and equilibrium asset pricing. We then document empirical findings on margin changes and their impact on asset prices, illustrating evidence from both the United States and other countries, as well as across various asset classes. Finally, we discuss the design of margin rules, which are substantiated by a synthesis of theoretical findings and empirical evidence.

3.1. Margin and Equilibrium Asset Prices: Theories

We start with the classic literature on the flattened risk-return trade-off due to margin constraints and then discuss how margin affects equilibrium asset pricing in equilibrium. We subsequently offer a brief review on macrofinance models with leverage constraints, where margin plays a central role.

3.1.1. Borrowing constraints and flattened security line. The origin of margin-based asset pricing studies can be traced back to the seminal work of Black (1972). In that classic paper, Black explains the flattened security market line empirically documented in Black, Jensen & Scholes (1972) by relaxing the assumption of unlimited riskless borrowing in capital market equilibrium. Intuitively, shorting the riskless asset (i.e., borrowing) is more difficult than longing it (i.e., lending); this implies that the effect of beta exposure on assets' expected returns in a standard capital asset pricing model (CAPM) is weaker when we impose restrictions on borrowing such as margin requirements.

More recently, building on the work of Black, Jensen & Scholes (1972) and Black (1972), Frazzini & Pedersen (2014) introduce heterogeneous portfolio-level borrowing constraints for individual investors and derive a flattened security market line in an overlapping generation framework. Since risk-averse investors face a portfolio margin constraint, they value the embedded leverage of high-beta assets more than the benchmark setting without such constraints. This economic force pushes down the required returns of those high-beta assets, leading to the flattened security market line.

3.1.2. Failure of the law of one price and margin-based asset pricing. In a slightly more conceptual level, this flattened security line connects to the failure of the law of one price when the economy faces financial constraints. In the seminal work of Gromb & Vayanos (2002, 2018), the authors model arbitrage activities on price discrepancies between two identical assets traded, with an emphasis on collateral constraints and market segmentation. They demonstrate that asset prices and allocation efficiency are intrinsically linked to arbitrageurs' financial constraints, which in turn depend on their wealth and portfolio positions. Their work offers a mechanism through which liquidity—reflected in the margin requirements of arbitrageurs—impacts asset prices, market efficiency, and overall welfare. Many empirical papers offer strong empirical support for the margin-induced failure of the law of one price, which we review in Sections 3.2.2 and 3.2.6.

Along this line, Basak & Croitoru (2000) introduce certain portfolio constraints into an otherwise canonical continuous-time dynamic asset pricing model and establish the possibility of

mispricing—that is, diverging prices between a positive-supply underlying asset and a redundant zero-net-supply derivative asset—in equilibrium. Using a similar setting but with heterogeneous-risk-aversion investors, Garleanu & Pedersen (2011) show that asset required returns increase in both market betas and margin requirements. In their model, a standard consumption CAPM is augmented by the friction of security margin times the shadow cost of funding. A sequence of negative fundamental shocks results in binding margin constraints and thus raises the risk-adjusted performance of high-margin stocks. In contrast to the original borrowing constraint idea in Black, Jensen & Scholes (1972) and the recent extension of Frazzini & Pedersen (2014), Garleanu & Pedersen (2011) allow for asset-specific margins and show how such margins affect asset returns in the cross section.

Most literature that studies the asset pricing implications of portfolio constraint takes the constraint as given. Microfounding the financial constraint via limited commitment, Biais, Hombert & Weill (2021) show that the equilibrium price of a security is always lower than that of replicating portfolios of long positions. Relatedly, arguing that financial innovations emerge to lower the collateral requirement, Shen, Yan & Zhang (2014) derive a similar finding, showing that in general cross-netting friction implies a higher collateral requirement for the underlying asset and hence a lower price than that of its replicating portfolio. Section 3.2.2 reviews the empirical evidence on this theoretical prediction, especially the corporate bond–CDS spread (Mitchell & Pulvino 2012; Bai & Collin-Dufresne 2019; Choi, Shachar & Shin 2019).

3.1.3. Endogenous margin and leverage cycle. In practice, margin is often tied to the volatility of that particular asset (Krishnamurthy, Nagel & Orlov 2014), pointing to margins that are endogenously determined in equilibrium. This is achieved in Brunnermeier & Pedersen (2009) by imposing an exogenous value-at-risk (VaR) rule, and the rule is further microfounded by Adrian & Shin (2014) as an optimal contract in response to moral hazard issues.

In an influential literature, Geanakoplos (2010, 2018) provides a theory of endogenous leverage in collateral equilibrium models. On the basis of heterogeneous belief, this literature derives the optimal lending contract—including both margin requirement (or, equivalently, haircut) and interest rate—from first principles. In an equilibrium where optimists borrow from pessimists, the optimal haircut is set so that default never occurs along the equilibrium,[12] leading to the emergence of a leverage cycle as assets shift between optimistic and pessimistic agents. Important extensions include Fostel & Geanakoplos (2008), Simsek (2013), Shen, Yan & Zhang (2014), and Fostel & Geanakoplos (2015); for a review, see Fostel & Geanakoplos (2014).

3.1.4. Leverage constraints in dynamic general equilibrium models. Margin constraints or, broadly, portfolio constraints play a key role for us in understanding equilibrium asset pricing behaviors, especially from a dynamic angle.[13] In this subsection we review a set of papers that touch on this issue.

[12] This is true only when cashflows are binary, as shown in Simsek (2013). He & Xiong (2012a) show that, if uncertainty is spanned by a binomial tree, then short-term debt without default is an equilibrium outcome.

[13] Besides the general equilibrium literature that we are reviewing here, there is a rich literature studying the optimal consumption portfolio problem in a partial equilibrium setting—that is, investors decide how much to eat and invest by taking the price as given—in the presence of portfolio constraints. Early papers, to name a few, include Grossman & Vila (1992), who show that the borrowing constraint, even before it actually binds, will distort investors' optimal portfolio decision (relative to the benchmark model without borrowing constraint). Various techniques, such as stochastic dynamic programming (Vila & Zariphopoulou 1997), the duality method (Tepla 2000), and martingale characterization (Cuoco & Liu 2000), are developed in this literature.

3.1.4.1. Margin and aggregate volatility. While these days there is consensus that margin requirements have a definite impact on asset prices, historically academia and policy makers have had long debates on how margin requirements affect asset volatility (Fortune 2001). Supporters of margin control argue that excessive credit increases unnecessary market volatility: Unsophisticated retail investors may take too much margin debt during bull markets, but the forced sales during market downturn accelerate market fluctuations and liquidity squeeze (e.g., Hardouvelis 1990, Hardouvelis & Peristiani 1992, Hardouvelis & Theodossiou 2002). By contrast, others argue that a moderate level of margin trading improves market liquidity without causing excessive volatility (e.g., Ferris & Chance 1988, Kupiec 1989, Roll 1989, Salinger 1989, Schwert 1989, Hsieh & Miller 1990, Kahraman & Tookes 2017). Partly, as we see shortly in Section 3.2.3, this debate arises because the majority of the empirical literature does not find substantial evidence that regulating margin requirements in stock markets had an economically significant impact on market volatility.

As a result, much work has emerged to offer theoretical explanations for the inconclusive empirical findings, and we review several representative papers in this line of work.[14] In a two-agent setting with different risk-tolerance coefficients, Kupiec & Sharpe (1991) show that tightening IM requirements could increase or decrease stock price volatility, depending on whether we have stochastic risk tolerance or a stochastic proportion of risk-tolerant agents. Looking at this issue from a different perspective, Brumm et al. (2015) emphasize that the mere presence of a second asset, exempt from Regulation T, has an impact on the equilibrium relation of margin and volatility concerning the asset subject to Regulation T.

Following the literature of endogenous margin à la Geanakoplos (2010, 2018) and Brunnermeier & Pedersen (2009) reviewed in Section 3.1.3, Rytchkov (2014) introduces volatility-dependent margin requirements in the dynamic framework of Garleanu & Pedersen (2011) and demonstrates that a general equilibrium analysis may reverse the conclusions of a partial equilibrium analysis often employed in the literature. In an extension with two risky assets, Rytchkov (2014) shows that different margins on two risky assets could generate a strong cross-sectional dispersion of return volatilities.

3.1.4.2. Instability, leverage constraints, and multiplicity of equilibria. Potentially amplified aggregate return volatility is closely linked to the concept of (in)stability of financial markets, formally defined as movement in prices in a rational way even in the absence of changes in economic fundamentals as in Chowdhry & Nanda (1998). In that paper, the authors point out that margin requirement essentially links the investors' capacity to invest in risky assets and the endogenous price of the risky assets that serve as collateral. As a result, even without fundamental shocks, there could be rational price rises/falls in which the gains/losses sustained by some investors are such as to make these price changes self-fulfilling in equilibrium. Along this line, Basak et al. (2008) offer a nice theoretical analysis on equilibrium multiplicity in the standard dynamic setting with a general portfolio constraint. For more recent progress on this topic, see Zentefis (2022).

In general, it is challenging to incorporate information asymmetry in a setting with leverage constraint. One important exception is the paper of Yuan (2005) who examines a rational expectations equilibrium model involving information asymmetry and borrowing constraints, complicating analysis due to nonlinearity in debt contracts. After a negative fundamental shock, informed investors can face borrowing constraints, causing asset prices to become more volatile.

[14]If the representative agents are log investors, then since income effect exactly cancels wealth effect, the equilibrium price-dividend ratio is independent of any portfolio constraints, and all the actions are on the risk-free rate. See Coen-Pirani (2005) and He & Krishnamurthy (2013) for this result.

This can lead to a backward-bending asset demand curve for uninformed investors, making it harder for them to extract information from falling prices and potentially resulting in multiple equilibria and self-fulfilling panic selling. Endogenizing information acquisition decisions among investors further amplifies this effect, as demonstrated in Glebkin, Gondhi & Kuong (2021).

3.1.5. Intermediary asset pricing, financial crisis, and the macrofinance literature. Margin and leverage are at the center of the fast-growing literature on macrofinance after the GFC, which highlights the collateral-based amplification mechanism (Kiyotaki & Moore 1997).

3.1.5.1. Financial intermediary leverage and asset prices. The literature of intermediary asset pricing (He & Krishnamurthy 2012, 2013) argues that, because financial intermediaries—say broker-dealers and banks, rather than households—value and trade financial assets actively, they are more likely to be the marginal investors whose pricing kernels are the key to understanding asset prices. This literature was largely inspired by the GFC. This episode provided very stark evidence in favor of intermediary asset pricing, but recently there is growing recognition that the issues apply outside of such episodes (Adrian, Etula & Muir 2014b; He, Kelly & Manela 2017; Haddad & Muir 2021).

Financing constraints of financial intermediaries can be viewed as one general form of margin requirements, and their effects on capital markets could be substantial. Two lines of research are centered around how intermediaries affects asset prices. He & Krishnamurthy (2013) and Brunnermeier & Sannikov (2014) model the intermediary's optimization problem from the angle of equity capital constraint; i.e., intermediaries (endogenously) cannot raise further equity. These authors show that a nonlinear risk premium can arise during crisis. Their model implies a countercyclical leverage, which is supported by He, Kelly & Manela (2017). In contrast, as explained above, Adrian & Shin (2014) and Brunnermeier & Pedersen (2009) focus on debt constraint; i.e., intermediaries (endogenously) cannot raise further debt given a certain equity.[15] Such a setup implies a procyclical leverage (see, e.g., Adrian, Etula & Muir 2014b; Adrian, Moench & Shin 2016).

As explained in He, Kelly & Manela (2017), these two model classes describe different intermediary subsectors that interact in financial markets. During a downturn, when the marginal value of wealth is likely to be high for all investors, hedge funds (which are perhaps closer to the type of intermediary described by debt constraint models) sell their assets to commercial banks (which may be better described by equity constraint models), and so leverage of these two sectors moves in opposite directions. See Kargar (2021) for such a model.

3.1.5.2. Other review articles on the macrofinance literature. Given our focus of margin rules, we simply mention a list of excellent reviews on the vast literature of macrofinance. On the market malfunctioning during the GFC, see Brunnermeier (2009), Krishnamurthy (2010), and Adrian, Colla & Song Shin (2013); Adrian, Kiff & Shin (2018) provide a retrospective view of the GFC after a decade. Stressing short-term debt, information sensitiveness, and bank/debt runs,[16] Gorton (2018) offers an important historical perspective on financial crises, and Gertler & Kiyotaki (2010) review the literature on macroeconomic business cycles and collaterization.

3.2. Margin Rules and Asset Prices: Empirical Evidence

As we review in Section 3.1, theoretical studies suggest that (*a*) assets with different margin requirements have different price dynamics and (*b*) changes in margin requirements will affect

[15] It is worth pointing out that equity constraints are more primitive than debt constraints because intermediaries can always relax the debt (or leverage) constraint by issuing more equity.

[16] For the recent literature on dynamic runs on short-term debt rather than demandable deposits, see Acharya, Gale & Yorulmazer (2011) and He & Xiong (2012b).

variations in asset prices. In this section, we first review papers that empirically study the equilibrium risk-return trade-off when investors face borrowing constraints. We then discuss the US and international evidence on the relation between margin changes and asset prices, not only for stock markets but also for other asset classes. Finally, we review articles on the topic of asset pledgeability and asset prices.

3.2.1. Risk-return trade-off in the presence of borrowing-constrained investors. Following the seminal papers by Black (1972) and Black, Jensen & Scholes (1972) reviewed in Section 3.1.1, the literature has documented strong support of the hypothesis of a flattened security line. One notable paper is that of Frazzini & Pedersen (2014), who show that a market-beta neutral longing-low-beta and shorting-high-beta strategy delivers abnormal positive returns in various markets and asset classes. However, during the period with lower funding liquidity (proxied by a rising TED spread), Frazzini & Pedersen (2014) fail to find higher betting-against-beta returns, which is inconsistent with the main theoretical prediction of a flattened security market line when margin requirements tighten. Of course, this null result could be driven by many other confounding factors, given that the TED spread is endogenous. By exploiting historical changes in the IM requirement as quasi-experiments, Jylhä (2018) establishes a convincing causal link between the heightened margin requirements and weaker beta-return relationship. As market-wide IM increases, Jylhä (2018) shows that the security market line, i.e., the beta-return relation, becomes flatter, providing direct evidence for the causal effect of margin changes on asset prices.

Following a similar vein, researchers have explored other channels through which margin constraints distort standard risk-return trade-off, including investors' desire or aversion for leverage (Asness, Frazzini & Pedersen 2012; Boguth & Simutin 2018; Chen & Lu 2019; Frazzini & Pedersen 2022), leveraged financial products (Lu & Qin 2021), and margin debt (Asness et al. 2020). Finally, the literature acknowledges that both sophisticated institutional investors (Ang, Gorovyy & Van Inwegen 2011; Jiang 2024) and retail investors (Heimer & Simsek 2019, Bian et al. 2024) use margin borrowing to take leverage. Activities of these levered investors affect asset prices, market efficiency, and stability, especially arbitrageurs in correcting mispricing (see, e.g., Coffey, Hrung & Sarkar 2009; Acharya, Lochstoer & Ramadorai 2013; Fontana & Scheicher 2016; Hitzemann et al. 2021).

3.2.2. Violation of the law of one price. The empirical support for the violation of the law of one price (Section 3.1.2) due to leverage frictions is vast, and one notable example is the so-called CDS-bond basis, i.e., the difference between Treasury bond yield and the yield of a synthetic bond consisting of a corporate bond and its CDS.[17] This literature includes those who document a widening price gap of CDS-bond basis during the 2007–2009 GFC when liquidity provision was halted (e.g., Mitchell & Pulvino 2012; Bai & Collin-Dufresne 2019; Choi, Shachar & Shin 2019; Augustin & Schnitzler 2021). However, Siriwardane (2019) shows that capital shocks proxied by CDS margin payments to CDS sellers help explain time series variations in CDS-bond basis even outside the GFC.

3.2.3. US stock market reactions to historical margin rule changes. The very first set of empirical studies do not find any conclusive effect of margin requirements on asset volatility (Moore 1966, Officer 1973), prompting the theoretical explanations we discuss above in Section 3.1.4.

[17]For papers that document the violation of the law of one price in other markets, see papers discussing corporate bonds (Chen et al. 2023), sovereign bonds (Corradin & Rodriguez-Moreno 2016), equity futures-cash basis (Hazelkorn, Moskowitz & Vasudevan 2023), and real estate (Zevelev 2021). We review some below in Section 3.2.6 when we discuss the connection between pledgeability and asset prices.

As we mention in Section 2.1, the Fed adjusted the IM requirement 22 times from 1934 to 1974, offering interesting variations in margin requirements for empirical studies. Largay (1973), Eckardt & Rogoff (1976), and Grube, Joy & Panton (1979) find that the announcements of stocks' 100% IM requirements were associated with short-term price appreciation and volume increase, while such effects reverted or became unclear after stocks were actually under margin constraints.

A few papers argue that restrictions on margin trading curb speculation and thus reduce instability. Hardouvelis (1990) finds that, historically, more stringent margin requirements are associated with lower stock market volatility, although his methods and conclusions were criticized by several follow-up papers from the perspectives of inappropriate sample period and volatility measures (e.g., Ferris & Chance 1988, Kupiec 1989, Roll 1989, Salinger 1989, Schwert 1989, Hsieh & Miller 1990). Responding to some of these criticisms, Hardouvelis & Peristiani (1992) extend the analysis to Japan and show that a higher margin is followed by lower subsequent market volatility during normal/bull markets, while margin seems to have little impact on volatility during bear markets, and Hardouvelis & Theodossiou (2002) further investigate whether US margin requirements have an asymmetric effect by using a sophisticated method similar to the GARCH-M employed by Kupiec (1989).[18]

By exploiting the additions of OTC issues to the marginable security list, Seguin (1990) does not find any evidence for margin destabilizing price but instead shows that stocks' margin eligibility enhances market depth. Mayhew, Sarin & Shastri (1995) document that a decrease in equity-option margin leads to lower stock liquidity but that the opposite is not true when the margin increases, suggesting that uninformed traders are more sensitive to margin changes.[19] In sum, the cross-sectional relationship between assets' margins and their volatility is also inconclusive.

3.2.4. Margin rules and asset prices in other counties: China, India, and Japan. Several other papers study how margin changes affect asset prices in non-US markets. In India, every month stocks are categorized into a marginable group if they meet certain requirements (e.g., at least 80% active trading days), providing a unique setting for identification. With a regression discountinuity setup in margin eligibility, Kahraman & Tookes (2017) find that stock liquidity improves after being eligible for margin trading but that a downward liquidity spiral is observed due to deleveraging during crisis. In another closely related paper, Kahraman & Tookes (2020) show that stocks connected through common brokers saw higher pairwise return correlation, especially during times when those margin clients with the same broker experienced portfolio losses.

China introduced margin trading into its stock markets in 2010. A few papers exploit China's staggered liberalization of stock margin trading to estimate the impact on liquidity (Hu, Liu & Zhu 2019; Wan 2020), price efficiency (Chang, Luo & Ren 2014; Wang et al. 2019), volatility (Hansman et al. 2022), and violation of the law of one price (Hu et al. 2020). More strikingly, both brokerage-financed margin and shadow-financed margin have emerged in China since the introduction of margin trading in 2010. As documented in Bian et al. (2024), the shadow-financed margin system features less strict requirements for the asset level, leverage, and trading experience for margin investors. After the leverage-induced stock market crashes in 2015, Chinese regulators shut down the shadow-financed margin business, and qualified retail investors could borrow only through brokerage firms thereafter.[20] Bian et al. (2024) show that shadow margin traders played

[18] See Fortune (2001) for a comprehensive review of this debate.

[19] Various papers argue that margin functioning does little to affect market volatility/liquidity. Among them are Cohen (1966), Moore (1966), Largay & West (1973), and Officer (1973). Kupiec (1998) and Fortune (2001) provide nice reviews of old studies on this issue.

[20] For more details on China's margin trading framework, see Bian et al. (2024).

a more significant role than brokerage investors in transmitting shocks across stocks during the 2015 Chinese stock market crash, highlighting the importance of policy decisions in restricting and monitoring margin trading, especially in market turmoil.

As we discuss in Section 3.2.3, Hardouvelis & Peristiani (1992) use Japanese data to study the impact of margin requirements on stock price fluctuations and provide a comprehensive summary of the institutional details of Japanese margin regulations. Using data from Chinese, Japanese, and Taiwanese stock markets, Chen et al. (2024) show that, while short selling predicts future stock returns in the cross section, margin buying does not exhibit strong return predictability, suggesting that the latter type of investors is less sophisticated.

3.2.5. The impacts of margin changes on other asset classes. As in the stock market, margin affects other assets' prices, volatility, and liquidity in both good and bad ways. Mayhew, Sarin & Shastri (1995) find that margin decrease in equity options would attract uninformed (and likely leverage-constrained) investors to migrate from the stock market to options, resulting in a lower option spread and a higher trade informativeness. In another paper, Santa-Clara & Saretto (2009) discuss one potential drawback of restricting option market margins: Risk sharing using options is limited, as margin requirements prevent investors from writing put options. Daskalaki & Skiadopoulos (2016) and Hedegaard (2014) find a similar negative effect on risk sharing, volatility, and market liquidity in futures markets if exchanges set higher margins. Gay, Hunter & Kolb (1986) argue that margin remains an effective tool to control risk exposure for exchanges and that the effects of margin on futures trading volume/open interest/volatility are contract dependent (Fishe & Goldberg 1986).

3.2.6. Pledgeability and asset pricing. Margins are adopted for pledgeable assets when they are used in collateralized borrowing against potential default. Assets with the same cash flows but different margin requirements (levels of pledgeability) should have different values; see Garleanu & Pedersen (2011) discussed in Section 3.1.2.

The primary obstacle to empirically estimating the value of asset pledgeability is that asset margins are endogenous in practice. The following features of Chinese corporate bond markets offer a unique setting to address this endogeneity concern. There are two distinct and largely segmented bond markets in China: the OTC interbank market and the centralized exchange market, with certain corporate bonds being dual listed on both (Amstad & He 2019). The two markets employ different mechanisms for repo transactions.[21] Chen et al. (2023) exploit this unique dual-listing market structure where the very same bond can be traded on two markets with different margin rules. They also leverage a policy shock that shut down the pledgeability channel for mid-rated bonds in the exchange market while leaving lower/higher-rated bonds immune. The estimated pledgeability premia, for a haircut increase of 0 to 100%, range from 39 to 85 bps.

In a similar approach, Zevelev (2021) uses a constitutional amendment in Texas that in 1998 legalized home equity loans, i.e., the ability of a household to pledge its home in the future, to study how real estate pledgeability affects asset value. The pledgeability premium is also connected to the literature on nonconventional monetary policy tools that shows that eligibility in the central banks' collateral basket typically translates to a reduction in spreads of various securities (e.g.,

[21]The interbank market in China functions similarly to the US triparty repo market, with borrowers and lenders engaging in bilateral negotiations to reach agreements and the clearing bank settling the transaction. In contrast, the exchange market operates like the CCP-based European electronic platforms (Mancini, Ranaldo & Wrampelmeyer 2016), where the exchange not only settles transactions but also serves as the CCP for all repo participants. Consequently, interbank repos tend to be highly customized, while exchange repos are standardized and transparent.

Ashcraft, Garleanu & Pedersen 2011; Van Bekkum, Gabarro & Irani 2018; Mésonnier, O'Donnell & Toutain 2022; Pelizzon et al. 2024).

3.3. Design of Margin Rules

Although the precise directional effects of margin requirements on capital markets have been the subject of debate for several decades, there is consensus among researchers that margins exert significant influence on asset prices and market volatilities. This influence can potentially lead to market instability and inefficiencies in capital allocation, and hence it is imperative to formulate well-considered margin regulations and establish appropriate policy objectives.

3.3.1. Optimal margin rules. Luckett (1982) provides an early attempt to model the optimal margin rule, offering empirical support for the effectiveness of Regulation T as a regulatory tool. Chowdhry & Nanda (1998) show that margin constraints lead to potential price instability due to equilibrium multiplicity, and these authors propose to have a combination of margin requirements, price limits, and price continuity rules. Several other papers argue that the commonly used normality assumption may significantly underestimate the required margins; thus, they advocate margin rules that are based on the extreme value theory (Longin 1999, Cotter 2001).

It is widely acknowledged that technological advances and improved monitoring capabilities enable financial institutions to potentially reduce margin requirements or adopt more lenient loss assumptions in the event of defaults (e.g., see Raykov 2022). Researchers have also proposed several measures, including more frequent and detailed public reporting of margins (e.g., disaggregated by product class and entity), as advocated by McDonald (2014) and Brunnermeier & Krishnamurthy (2014). Furthermore, there have been suggestions for the implementation of new IM rules for noncleared OTC derivatives by O'Kane (2016) and Cont (2018) and for the adoption of central clearing for margin trading by Duffie, Scheicher & Vuillemey (2015), Biais, Heider & Hoerova (2016), and Bignon & Vuillemey (2020). We discuss the optimal margin rules for CCPs in Section 4.3.

3.3.2. Portfolio margin. The approach of portfolio margin has evolved significantly over the past three decades (Section 2.4.1). Unlike standard margin requirements that typically evaluate individual securities, portfolio margin takes into account the overall risk of the entire portfolio, allowing for potentially lower margin requirements by considering risk offsets and diversification benefits within the portfolio, i.e., cross-netting.

However, cross-netting friction remains prevalent in practice. A well-known example is that of Metallgesellschaft AG, a German conglomerate, which faced a liquidity crisis in the early 1990s despite having a hedged position in oil forwards and futures, and the company's inability to meet margin calls on its futures positions due to market volatility led to significant financial distress (Culp & Miller 1995). Motivated by this friction, Shen, Yan & Zhang (2014) show that the optimal security design is achieved by isolating the variable with disagreement.

Existing literature proposes several methods to improve netting efficiency. For example, Szabó & Váradi (2022) argue that overmargin requirements may exist without accounting for the correlation structure of the assets; they propose a stochastic correlation model to calculate the portfolio margin. Veraart (2022) shows that portfolio compression, i.e., a netting mechanism reducing gross positions of a portfolio, can help reduce systemic risk. Relatedly, Chen, Wu & Li (2023) propose an IM model for option portfolios that allow clearinghouses and regulators to gauge the tightest margin levels that are stable, emphasizing the role of netting and the upper bounds of maximum loss. Section 4.2 further discusses this issue of cross-netting friction in the framework of central clearing.

On the empirical side, Capponi et al. (2022) rely on a novel dataset of portfolios of CDS trades cleared by ICE Clear Credit (ICC), along with the required margins, to understand the cross-sectional and time series determinants of portfolio margins. They find that (*a*) margin is set much more conservatively than the standard VaR rule; (*b*) two extreme tail risk measures, i.e., maximum shortfall and aggregate short notional, account for 72% of the margin variations in their panel data; and (*c*) shocks to market-wide state variables such as VIX increase margin requirements across all portfolios. Therefore, the clearinghouse is more concerned with extreme losses than the one captured by VaR when setting portfolio margin, consistent with the theoretical prediction in Fostel & Geanakoplos (2008) and the extreme value theory studied in Longin (1999) and Cotter (2001).[22]

3.3.3. Discussion for future research. Although most of the existing theoretical studies employ only individual security margin as the collateral constraint (e.g., Gromb & Vayanos 2002; Garleanu & Pedersen 2011; Shen, Yan & Zhang 2014), most recent studies allow investors to cross-margin their positions so that the collateral constraint is equivalent to a nonnegative financial wealth constraint (e.g., Frazzini & Pedersen 2014; Chabakauri & Han 2020; Szabó & Váradi 2022; Chen, Wu & Li 2023). (This issue is closely related to the cross-netting frictions that we review in Section 3.3.2 and discuss further in Section 4.2.) In the future, researchers can advance this research direction by integrating portfolio margin practices into optimization problems with multiple assets. Besides, it is also interesting to introduce defaults into the analysis, as traditional asset pricing models with power utility typically do not have default scenarios along the equilibrium path.

4. CENTRAL CLEARING AND MARGIN REQUIREMENTS

Central clearing is a process in which a specialized organization, known as the CCP, steps in between counterparties to assume their rights and obligations by acting as the buyer to every seller and vice versa. In this so-called novation process, the CCP takes on all counterparty risk, reducing investors' exposure to each other. To mitigate risks, the CCP reallocates losses in the event of a clearing member default through methods like margining, default funds, and netting.

In this section, we first review several basic CCP margin arrangements. We then review the literature on the impacts of the CCP margin and the optimal CCP margin rules.[23] Finally, we discuss some post-GFC developments, including a reform on unwind in the US triparty repo market, which is closely related to the risks of clearing banks.

4.1. Margin Requirements Under Central Clearing

The CCP employs a variety of tools to insulate against investors' default.

4.1.1. Margining. Clearing participants must meet margin requirements and contribute to the default fund by posting collateral, which can be cash or liquid assets, to the CCP. Centrally cleared markets use two main categories of margin. IM is the collateral that clearing participants must deposit before entering a trade. If a counterparty defaults, the IM posted by the defaulting party can be used to cover the costs of replacing the defaulted positions. Variation margin (VM) covers

[22] Other studies that incorporate portfolio margin setting include Deng, Dulaney & McCann (2013), Matsypura & Pauwels (2014), Siriwardane (2019), Wang et al. (2021), and Biais, Heider & Hoerova (2021).
[23] For more details on related topics, we recommend Gregory (2014), Domanski, Gambacorta & Picillo (2015), and Menkveld & Vuillemey (2021).

current exposures due to changes in market price.[24] VM is used to closely track market movements, while IM is used to cover worst-case liquidation. They serve functions similar to the maintenance margin and IM in margin trading (Section 2.1).

4.1.2. Default fund. The CCP also holds default fund contributions from its clearing participants to cover potential losses. In extreme scenarios in which both margins and default fund contributions are depleted, additional losses could be covered by the CCP's equity contribution. Generally, the default waterfall outlines different ways in which resources will be used (Duffie 2015).

4.1.3. Netting. Netting entails combining or aggregating multiple financial obligations to arrive at a net obligation amount, which is used to reduce settlement, counterparty, and other financial risks. CCPs can provide multilateral netting, which is a payment arrangement among multiple counterparties that transactions are aggregated, rather than settled between pairs. Typically, multilateral netting can alleviate systemic risk by reducing exposures more than in bilateral markets. Netting is closely related to the portfolio margin that we discuss in Sections 2.4.1 and 3.3.2.

4.2. Cross-Netting and Central Clearing Counterparties

In perfect financial markets, central clearing that merely redistributes cash flows should not matter (Modigliani & Miller 1958). Several papers, however, find that prices of cleared assets rise after the introduction of central clearing, suggesting that investors are willing to pay more for centrally cleared assets (e.g., Loon & Zhong 2014; Bernstein, Hughson & Weidenmier 2019). Thus, financial frictions are essential to justify the existence of CCPs. Given the page limit of this article, we discuss only frictions related to cross-netting; Menkveld & Vuillemey (2021) provide an excellent review.

In practice, portfolio margin is far from perfect (see Section 3.3.2); this provides an economic rationale for central clearing. However, although joint clearing by one single CCP can reduce margin requirements and counterparty risk, multiple CCPs for various classes of derivatives could hurt netting efficiency, resulting in a higher counterparty risk (Duffie & Zhu 2011). Empirically, Duffie, Scheicher & Vuillemey (2015) exploit a proprietary dataset of bilateral CDS positions to examine how central clearing could affect collateral demand due to margin requirements. They find that the market-wide collateral demand increases with the application of dealer-to-dealer IM requirements but that netting and diversification lower the aggregate collateral demand, which outweighs the effect of increased IM requirements. Overall, central clearing has significant distributional effects on collateral requirements across various market participants.

4.3. Optimal Margin Rules for Central Clearing Counterparties

Extensive research findings of central clearing's impact on counterparty and systemic risk underscore the policy significance of optimal CCP margin rules. Capponi & Cheng (2018) model a profit-maximizing clearinghouse that sets fee and margin requirements for heterogeneous traders who may default, weighing the trade-off between better default protection and lower market liquidity. The equilibrium margin requirements are determined by price volatility, trader fundamentals, and funding costs. In a related paper, Wang, Capponi & Zhang (2022) model the default

[24]In centrally cleared derivatives markets, the CCP collects VM payments from clearing members whose positions have lost value and pays VM to those whose positions have gained value on the basis of the daily change in the market value of the contracts.

waterfall of CCPs and study the different roles that default funds and IMs play in maintaining member risk management incentives. Their model generates a positive relation between IMs and stringent capital requirements.

Extending the framework of Duffie & Zhu (2011), Menkveld (2017) find that crowded positions consititute a potential source of systemic risk in CCPs. Crowded positions occur when many investors take positions on the same side of the market, resulting in highly correlated portfolios that put the CCP at risk of simultaneous defaults. The paper then proposes measures of CCP exposure accounting for the risk from crowded positions, potentially useful for collecting more resources from those investors who contribute more to crowding. In a similar vein, Lopez et al. (2017) propose a new methodology—CoMargin—which internalizes trading externalities and takes the interdependence of profit and loss of clearing members into consideration. Using a proprietary dataset, they show that CoMargin outperforms existing margin requirements.

4.4. Recent Developments after the Global Financial Crisis

The GFC exposed significant vulnerabilities within the financial system, prompting a wave of reforms aimed at strengthening financial infrastructure and enhancing stability.

4.4.1. Reforms in the over-the-counter derivatives markets. The GFC highlighted the fragility of OTC derivatives markets. Counterparty and liquidity risks in the bilateral OTC clearing may propagate systemic risk, and nonstandard margin requirements could be insufficient to cover default risks, especially during periods of tightening liquidity. After the GFC, regulators pushed a series of initiatives aimed at making the derivatives market more stable.[25] Both the regimes in the United States and European Union aim to move most transactions to CCPs. In 2009, the G20 leaders committed to reforms in the OTC derivatives market. By 2022, 17 out of the 24 Financial Stability Board member jurisdictions had enforced comprehensive standards for mandatory central clearing.

Ghamami & Glasserman (2017) introduce a model to evaluate whether CCPs launched by the G20 countries have created enough incentive for market participants to choose CCP clearing over OTC clearing. They use OTC market data collected by the Fed to test their model predictions and find that a higher burden for OTC clearing seems insufficient to favor CCP clearing. Other studies on the effects of CCP margin include discussions of margin procyclicality (Murphy, Vasios & Vause 2014, 2016; Benos, Ferrara & Ranaldo 2022), CCPs' role in stable funding (Mancini, Ranaldo & Wrampelmeyer 2016; Bernstein, Hughson & Weidenmier 2019), mitigating fire sales (Vuillemey 2023), the cost of repo funding (Miglietta, Picillo & Pietrunti 2015), and CCP systemic risk (Boissel et al. 2017, Bignon & Vuillemey 2020).

4.4.2. Reform on unwind in triparty repo and counterparty risk on clearing banks. In the US triparty repo market, borrowers and lenders engage in bilateral negotiations to reach agreements, and clearing banks settle the transaction. Unlike the central clearing framework, the clearing banks in this market do not interpose themselves between the borrower and lender and therefore do not guarantee the associated transactions.[26]

[25] Foremost among them are the Dodd-Frank Wall Street Reform and Consumer Protection Act (Pub. L. 111–203, 124 Stat. 1376, 12 USC §5301) (**https://www.congress.gov/bill/111th-congress/house-bill/4173/text**) and the European Market Infrastructures Regulation (EU Reg. 648/2012) (**https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0648**).

[26] In contrast, the US General Collateral Finance Repo market, the European electronic platforms, and China's exchange market are CCP based.

However, the distress experienced by dealers during the GFC starkly reveals that the clearing banks serve as not only agents but also primary creditors in the US triparty repo market. This credit exposure is associated with a process termed unwind, which refers to a daily practice in which the clearing bank releases the collateral to the borrower and returns the cash to the lender each morning, before the repo transaction is settled later in the day.[27] Through this process, the clearing bank effectively extends intraday credit to the borrower, exposing itself to significant counterparty risk (Copeland, Martin & Walker 2010, Copeland et al. 2012).

While the triparty repo market benefits from the operational efficiencies provided by clearing banks, it lacks the robust risk management framework of a centrally cleared market (Section 4.1), leading to potentially significant instability. Recognizing this vulnerability, the New York Fed convened the Task Force on Tri-Party Repo Infrastructure (**https://www.newyorkfed.org/banking/tpr_infr_reform.html**) in September 2009, and considerable progress has been achieved. The share of repo volume financed through intraday credit from a clearing bank has dropped significantly, from 100% before the reform to an average ranging from 3% to 5% in 2015, well below the task force's initial target of 10%.[28]

5. CONCLUSION

Margin is collateral or funds that investors deposit with brokers to mitigate risks. Buying on margin involves borrowing money to buy securities while using those securities as collateral. This approach has the potential to enhance returns but also exposes investors to the risk of amplified losses, leading to rigorous regulatory oversight. This review delves into the regulatory landscape of margin trading. With a historical perspective, we elucidate the origins and dynamics of various margin requirements while reviewing academic studies that explore the implications of these regulations for asset pricing, financial stability, and the optimal design of margin rules. We also provide a forward-looking perspective by outlining the evolving landscape of margin rules, encompassing recent developments such as portfolio margin and central clearing.

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[27]The unwind process generally applies to all repos, not only daily rolling repos but also term repos that are not maturing that day. The primary reason for this is operational simplicity (Copeland et al. 2012).

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