Stock Options, Stock Loans, and the Law of One Price*

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First Draft: March 2017
This Draft: February 2018

ABSTRACT

Historically, option market makers were exempt from borrowing shares when short selling which allowed them to hedge their exposure in hard-to-borrow stocks. As a result, options were not redundant securities – they allowed traders to circumvent short-sale constraints. Regulators removed this exemption in 2008 and in 2013 they prohibited a workaround using 'reverse conversions'. These regulatory changes eliminated the shadow supply of hard-to-borrow shares provided by options; we find that these changes increased the redundancy of option securities and caused a significant increase in equity loan fees. Consequently, market quality has deteriorated: price efficiency is lower and stocks are more overpriced.

Keywords: Equity Options, Short Sales Constraints, Return Predictability, Price Efficiency, Equity Lending Market.

JEL Classification Numbers: G12, G14

*This paper was previously circulated as part of the paper "The Limits to (Short) Arbitrage." We are grateful for the helpful comments of Rich Evans, Adam Reed, Ngoc-Khanh Tran, and Karl Diether, and conference and seminar participants at the conference on Financial Regulation at the Atlanta Federal Reserve, Georgia Tech, Vanderbilt University, and Syracuse University. This work was conducted in part using the resources of the Advanced Computing Center for Research and Education at Vanderbilt University, Nashville, TN and Wharton Research Data Services. All errors are our own.

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I. Introduction

Options contracts are an important part of modern financial markets.[1] Well functioning markets require accurate pricing models, and option pricing models typically rely on replicating portfolios that use stocks and bonds to replicate the payoffs of an option contract (Black and Scholes, 1973, Cox, Ross, and Rubinstein, 1979). The basis of this replicating portfolio approach is the important assumption that option contracts and the underlying securities are redundant assets, which gives rise to the law of one price. However, despite the importance of the redundancy assumption to modern financial markets, empirical evidence on its validity remains mixed.

Early studies of equity markets and options markets used option introduction as an exogenous event to test the redundancy of options markets. Overall, these studies find that options provide additional information, and therefore are not redundant assets (e.g., Conrad, 1989, Skinner, 1989, Sorescu, 2000).[2] However, Mayhew and Mihov (2004) show that options listing is endogenous and after accounting for this fact, option introduction has no effect on the underlying. Similarly, a number of papers show evidence that short sale constraints in the stock market pass-through to option prices, implying that prices in the two markets are closely linked (e.g., Ofek, Richardson, and Whitelaw, 2004, Evans, Geczy, Musto, and Reed, 2009, Battalio and Schultz, 2011). In other words, recent evidence suggests that the law of one price does hold between stock and options markets (see also Bollen, 1998). As a result of this conflicting evidence, a number of important issues remain unresolved: Are options truly redundant securities? Can option contracts be used to circumvent short sale constraints in the stock market? And, finally, do regulations on options impact the formation of stock prices? We find that the answer to each of these questions is related to the presence of regulatory actions that introduce significant frictions between stock and option markets. As a result, our results help reconcile and explain the seemingly conflicting findings in the existing literature.

[1] For example, annual trading volume in equity options has exceeded $3B every year since 2008, according to the Options Clearing Corporation (OCC).

[2] Conrad (1989) notes that short selling restrictions are a key scenario where options may provide a non-redundant use. In addition to the empirical evidence, Ross (1976) shows theoretically that options might not be redundant securities when security markets are not complete.

Specifically, in this paper we examine the relation between equity options and their underlying stock in the context of short sales constraints. We find that the relation between the two is a function of the regulatory environment. In other words, options and stocks may or may not be redundant securities, depending on how the two markets are regulated. When option market makers are exempt from borrowing shares to hedge their position, we find that options are not perfectly redundant securities. Indeed, market makers can use their exemption to partially circumvent short sale constraints. In equilibrium, the ability to avoid paying high equity loan fees is valuable to short sellers, who pay a premium to option market makers to construct synthetic short sales via option contracts. The result is that options can be used to create a shadow supply of short selling when traditional short selling is costly or difficult. However, after the market maker exemption was removed in 2008 and the regulation was further strengthened in 2013, we find that option markets and stock markets are now more tightly linked than ever before. In other words, options are now redundant securities. Moreover, we find that this linkage has come with a cost: short selling constraints are higher without the option market to alleviate them and consequently, price efficiency is lower and stocks are more overpriced.

In 2005, increasing concerns about failures to deliver in the securities lending market (Boni, 2006, Evans, Geczy, Musto, and Reed, 2009) led the Securities and Exchange Commission (SEC) to implement Regulation SHO.[3] This regulation established SEC regulatory authority over the securities lending market and therefore short selling, which previously had been self-regulated by the exchanges. One key objective was to restrict so-called "naked" short selling, which is the practice of short selling a stock not owned (or borrowed). As a part of the restriction on naked short selling, the SEC established the Option Market Maker (OMM) exception, which allowed option market makers to naked short sell if they did so in the context of "bona fide" market making in options markets.

The financial crisis of 2008-2009 produced significant government action to stabilize the financial sector, and one key focus of this action was the restriction of short selling. Among the actions

[3]The regulation was established on July 28, 2004 and became effective on January 3, 2005.

taken to restrict short selling was the removal of the option market maker exception, thus requiring option market makers to locate and borrow shares to short sell when hedging option trades. Unlike other actions to stabilize markets, such as the fall 2008 short sales ban, this action was permanent.[4]

We explore whether these changes in the regulatory environment can help reconcile seemingly conflicting evidence in the existing literature. We start by investigating whether the option market maker exception (and its removal) impacts the relation between option and stock prices. We find that is does. Specifically, we find that regulation on option market maker behavior directly impacts whether stock options are redundant with regard to their underlying securities. With the option market maker exception in place, stock options provide a 'shadow supply' of synthetic shares to short when stocks loans are expensive. Therefore, in times of high short selling constraints and high short demand, the law of one price does not apply: options provide a cheaper way to short sell. This divergence between stock and options markets is due to naked short selling by the option market maker, who sells a put option to the short seller, but does not price the option to include the cost of short selling to hedge the option trade. Put differently, the ability to avoid high equity lending fees is valuable to a short seller; in equilibrium, the option market maker and short seller both share this value (Evans, Geczy, Musto, and Reed (2009)).

Empirically, we identify the relation between short sale constraints and option prices by comparing equity lending fees to the implied stock loan fees from option prices, calculated as the transaction cost necessary to derive put-call parity in the option market. If stock and option securities are perfectly redundant, we would expect equity loan fees and option implied loan fees to be the same due to the law of one price. We split our sample into three sub-samples to examine the impact of different regulatory regimes. In the early period (before August 2008) we find that options are not redundant securities; option implied loan fees are, on average, lower than equity lending fees. However, after the option market maker exception is removed, demand to short sell simply passes through the options market directly to the stock loan market in all situations, and the

[4]It was also combined with the close out requirement (rule 204T then later rule 204) and the pre-borrow penalty for violating close out rules, such that committing a fail-to-deliver had large consequences. We discuss these issues in greater detail in the Appendix.

law of one price applies more strictly. After 2008, we find that options and stocks are much more tightly linked, consistent with the idea that options are more redundant following the removal of the option market maker exception. In fact, after 2008, we find that using options to construct a synthetic short position is slightly more expensive than using the equity lending market.[5]

While the removal of the option market maker exception means the law of one price is more applicable in the context of short selling constraints, we document some important and (perhaps) unintended consequences of this regulatory change. This is our second key finding. The removal of the option market maker exception effectively reduced the supply of lendable shares in the stock loan market; as a consequence, we find that stock loan fees have increased. Moreover, because higher equity lending fees inhibit short selling, we find that price efficiency is worse and stocks are more mispriced.

In our tests, we designate three regimes of options market regulation, split on two regulatory actions by the SEC. The first action was finalized in October 2008, when the SEC removed the OMM exception for all stocks. The SEC followed with a second regulatory action: a Risk Alert issued on August 9, 2013 that identified and banned resets on a trade called a "reverse conversion."[6] Reverse conversions allowed short sellers to circumvent the loss of the option market maker exception (though at greater cost). Therefore, we find that prohibiting this trade had a substantial impact on market outcomes. Henceforth, we refer to these three periods as Early (pre-Sept 2008), Middle (Sept 2008 - August 2013) and Late (Sept 2013 - Dec 2015).

Figure 1 shows the basic patterns across these three regimes and the power of the second event in particular. We plot for each of the three regimes the distribution of two statistics summarized by the Markit Daily Cost to Borrow Score (DCBS), a 10-group ordering based on stock loan fees.[7]

[5]This result suggests that transaction costs in the option market are more significant and/or option prices contain a slight premium due to lending fee risk. As noted in Engelberg, Reed, and Ringgenberg (2017), stock loan fees can change daily. A short position established via a put option can lock-in a given lending fee and therefore avoid the risk of future loan fee changes. As a result, short sellers may be willing to pay a premium to short sell via option markets.

[6]A reverse conversion is a put-call parity trade that shorts the stock and buys a synthetic share with matched put and call options. The specific behavior banned was the quick buying and re-selling of the stock to reset the clearing clock, avoiding failures to deliver. In an abuse of terminology for the sake of brevity, we will simply refer to these trades as 'reverse conversions' by which we imply the additional reset behavior that allows naked short selling. We discuss reverse conversions in more detail in the Appendix.

[7]The DCBS is not a decile rank, it is a 1-10 bin ordering of stocks by how costly they are to borrow. Bin 1 typically

Panel A shows that failures-to-deliver declined from the early to middle regime, consistent with the stated purposed of the regulation (and as has been documented before (e.g., Stratmann and Welborn, 2013)). However, we find that from the middle to late regimes, it again drops and flattens across all DCBS bins. The drop in DCBS 10 (i.e., expensive to short stocks) is 66% from the early to middle regimes, and 52% from the middle to late regime, which shows the importance of the second action. Moreover, this pattern is not due to a secular time trend. Overall mean failures-to-deliver peaked in 2008, dropped to a low in 2013, and they have modestly increased through 2015.[8]

The cause of this further reduction is evident in Figure 1 Panel B, which plots put-call paired option volume. Specifically, paired option volume is a measure intended to capture reverse conversions, and is computed first by taking the minimum of put and call volume across strike-maturity pairs, then computing the daily average by firm across strike and maturity. Strikingly, paired put-call volume spikes in DCBS 10 during the middle period, when only reverse conversions are available to synthetically generate short sales. In other words, when naked short sales are prohibited but reverse conversions are still allowed as a work around, we find a dramatic increase in option volume in precisely the contracts that are likely to be used for reverse conversions. Finally, in the Late regime, after reverse conversions were prohibited, we find that option volume drops by 54% on average for bins 1-9 and 92% in bin 10. In other words, consistent with the intent of the regulation, the data suggests that reverse conversions effectively stopped after 2013.

Finally, the effect of these regulatory changes on loan fees is shown in Figure 2. Panel A plots equity lending fees, which come from Markit, summarized again by DCBS bin and regulatory regime. Within each DCBS bin, it is clear that stock loan fees are rising across the regimes. In other words, short selling has become more costly as option regulation has increased. Panel B shows option implied fees, which follow a hump-shaped pattern within each DCBS bin across regimes. Panel C shows the difference between the two, computed each day, then summarized.

has approximately 80% of the sample because most stocks are inexpensive to borrow. The numbers behind Figure 1 (and other similar computations, showing robustness), are the Appendix.

[8]The appendix displays a plot of these values.

The figure clearly shows the structural shift in these markets, primarily in DCBS bins 1-9. In the early regime, across all DCBS bins, loan fees on average exceed option implied fees. Intuitively, this make sense: since market makers could avoid paying high loan fees by naked short selling (Evans, Geczy, Musto, and Reed, 2009), they were able to construct synthetic short sales at a lower price. This is consistent with the view that options are a mechanism for alleviating short selling constraints. In the middle regime, the two sets of fees are very close except in DCBS bin 10, where we expect the most activity in reverse conversions. This trade operated in a murky regulatory area, and so is likely only prevalent when the benefit was extremely high. In the final regime, we see that option implied fees exceed loan fees (i.e., the differences are now negative). Again, intuitively this makes economic sense if, as noted by Engelberg, Reed, and Ringgenberg (2017), market makers are now exposed to short selling risk by selling put options that must be continually re-hedged at varying loan fees.[9] Importanlty, it is in this regime, which persists to the present, that options are redundant securities because all short demand must pass through to the stock loan market.

Overall, it is clear from these basic patterns that a structural shift has occurred in the links between these two markets. Our primary contribution is that we show *why* options have become more redundant: it is due to the removal of the option market maker exception, which results in a stronger link between option markets and the stock loan market by forcing market makers to borrow shares to hedge at all times. This linkage means that option markets could no longer provide the 'shadow supply' of shares when stocks became expensive to borrow. Importantly, we find that this has led to increased short sale constraints which in turn affect stock market efficiency.[10] To test for the impact of these regulatory changes, we examine a differences-in-differences specification around both regulatory actions. Our primary sample consists of all stocks with either a lending

[9]Muravyev, Pearson, and Pollet (2016) examine short selling risk, but do not find this risk premium. However, their data set ends in 2013. We find a premium primarily in post-2013 data because only then do OMM have to borrow the stock.

[10]Others have noted that loan fees went up around the financial crisis of 2008 (Kolasinski, Reed, and Thornock, 2013, Stratmann and Welborn, 2013), but have not identified the cause. We are the first to show that a. it is due to the removal of the option market maker exception and b. this pattern has continued and persisted as the SEC reinforced its regulatory stance in August 2013.

market or tradeable options (or both), between July 2006 and December 2015.

Our identification strategy relies on the assumption that the removal of the option market maker exception was a shock to short selling constraints that was unrelated to other factors that differentially affect asset prices. We use a difference-in-differences framework around regulatory changes to assess the impact on asset prices. In our framework, the identifying assumption is equivalent to the requirement that the average change in the price process of short sale constraints firms would have been equal to the average change in the outcomes of non-short sale constrained firms in the absence of changes to option market regulation. Of course, this is clearly not the case in October 2008, when a number of other changes impacted asset prices. To mitigate this, we compare data before the initial emergency action on July 2008 to data after the final rule was implemented in October 2008, which therefore removes (at least) the short selling ban as a confounding event (Battalio and Schultz, 2011). However, the financial crisis was cataclysmic enough that its effects certainly outlived this narrow window and so we do not solely rely on that event for identification. The second regulatory action on August 9, 2013 is more plausibly isolated, however it is smaller in scope, only applying to the very hardest to borrow stocks due to its complexity and murky legal status.

In addition to the two-event difference-in-difference analyses, we also test the early regime (pre-July 2008) versus the late regime (post-Aug 2013). This removes the crisis and its immediate aftermath as a possible source of variation and shows the persistent effect of both SEC actions, without contamination from the financial crisis or subsequent recovery. This large gap perhaps also stretches the identifying assumptions of the difference-in-differences approach. However, any alternative explanation of our results would have to show what would fundamentally alter the relation between equity options markets and stock loan markets over this period in a manner that differentially impacted hard to borrow stocks.

We show that there has been a loss of 'shadow' loan supply in the form of failures-to-deliver. This is a direct result of the loss of the option market maker exception. Our evidence of this is in two parts: (1) in our difference-in-differences framework, measured stock loan supply has

increased among hard-to-borrow stocks compared to easy-to-borrow stocks, and yet (2) for a given change in demand among hard to borrow stocks, the change in loan fees is much *greater* after the removal of the option market maker exception. Crucially, we note that the second result is only possible given a reduction in supply. Thus, if measured supply has increased, yet prices are higher for each level of demand, it must be that there is unobserved supply that has decreased, such that the supply experienced by market participants (observed plus unobserved) has decreased.

This evidence is necessarily indirect: it is difficult to measure 'shadow' supply. However, further evidence of reduced observed plus unobserved loan supply is that across the three regulatory regimes that both stock lending fees and option implied lending fees have significantly increased, while the difference between the two has decreased. This is precisely the outcome we would expect if option market makers had to, without exception, borrow in the lending market, with the ultimate effect being option implied fees exceeding loan fees due to the risk premium inherent in option implied fees as well as option market transaction costs.

Since our outcome variable is fees, we use utilization (Shares Borrowed/Shares Supplied) as a treatment variable in the difference-in-difference specification predicting fees. Across each regime change, as well as when we test the early vs. late regimes, we see statistically significant increases in the stock loan fee and option implied loan fee among high utilization stocks. We also see statistically significant decreases in the difference. This is a formal statistical test of what is easily seen in Figure 2.

Having established the loss of supply that leads to increased loan fees, we next turn to the implications. Using the price delay measure in Hou and Moskowitz (2005), we find in a differences-in-differences framework that price delay has increased (i.e. price efficiency has decreased) among hard-to-borrow stocks with traded options.[11] We further decompose the Hou and Moskowitz (2005) into a positive delay and negative delay measure, which tests the incorporation of positive and negative market information, respectively. We find that the increase in price inefficiency is due *solely* to in increases in the incorporation of negative information, which is consistent with an

[11] Boehmer and Wu (2013) showed that short selling is associated with greater price efficiency as measured by the Hou and Moskowitz (2005) delay measure.

increase in short selling constraints. This result extends the chain of causality: forcing option market makers to borrow stock generates an increase in short selling constraints, which in turn cause a reduction in price efficiency, primarily limiting the incorporation negative market information.

Finally, we examine mispricing, which we measure as the magnitude of return predictability among short-constrained stocks. We show that mispricing has increased among hard-to-borrow stocks with traded options across the two regulatory actions. In contrast, among hard-to-borrow stocks that only have stock loans possible (no traded options), mispricing has remained the same or even decreased during the same time period. This is striking given the difference in populations – stocks without options are typically smaller, less liquid stocks more prone to mispricing. This also helps eliminate the alternate explanation of a demand shift as causing the increase in fees: this alternative explanation has to explain why there has been a differential effect between stocks with options vs those without traded options.

Given the length of our data set (2006-2015), we can show these patterns outside of the financial crisis period, which allows us to expand upon the evidence in previous studies (e.g., Stratmann and Welborn, 2013, Battalio and Schultz, 2011).[12] In other words, our results are not only based on the 2008 regulatory changes, which may be confounded by the financial crisis. Since we also find significant changes with the August 2013 SEC clarification on reverse conversions, we can identify regulatory action as a decisive factor. As further evidence, we persistently find significant differences comparing the pre-July 2008 time period with the post-August 2013 time period. Because this omits July 2008 - August 2013, this removes any possible confounding due the financial crisis and subsequent recovery.

Overall, we no longer find evidence of option market dislocation as in Battalio and Schultz (2011). Instead, our findings are consistent with a tight linkage between stock loan markets and option markets post-August 2013, now that market makers are required to borrow in the stock lending market. This implies that from the perspective of a short seller facing high lending fees,

[12] Stratmann and Welborn (2013) compare Q2 2008 to Q4 2008 and find a reduction in failures to deliver and option volume and increased loan fees. Battalio and Schultz (2011) investigate the effect of the short selling ban of 2008 on option market function.

options are now redundant securities. This redundancy is in contrast to markets prior to 2008, when option market makers could naked short sell and therefore the options market provided elastic supply of shares for short selling when they were needed most, thus alleviating short constraints.

II. Background

In this section, we briefly review the existing literature and we discuss the SEC regulatory actions taken with regard to short selling and options markets. We then develop several hypotheses.

A. Related Literature

Our work is closely related to the existing literature on the link between short selling and options markets, which has two viewpoints. The first focuses on the short demand side, where an investor expecting negative returns (or implementing a long/short arbitrage) can choose to either use stock markets or options markets to establish a short position. This literature posits that the existence of options markets mitigates short selling constraints. One of the earliest studies on this topic was Figlewski and Webb (1993), who show that optionable stocks have significantly higher short interest, indicating that options seem to increase supply for short sellers. In addition, Sorescu (2000), Danielsen and Sorescu (2001), and Battalio and Schultz (2006) all find that options ease short sale constraints by expanding supply for short positions. Danielsen and Van Ness (2007) provide counter evidence.

The second viewpoint focuses on the hedging motive of options market makers (e.g., Battalio and Schultz, 2011, Jameson and Wilhelm, 1992). If an investor uses options to establish a short position, the option market maker then borrows and shorts the underlying stock to hedge the put option written (or call option bought). Of interest here is whether options markets act as additional supply or simply a pass-through for short demand to the stock loan market. If short sellers buy put options, for instance, but the market maker writing that option hedges by shorting the stocks and borrowing in the lending market, then the option market does not increase supply, but rather passes through the demand to the equity lending market. Battalio and Schultz (2011) study the 2008 short

selling ban and find strong support for this view.[13] Our findings reconcile these two literatures, by showing that there has been a structural shift. With the option market maker exception, before 2008, options did provide additional supply for short selling and so alleviated constraints. However, after 2008, with the removal of the option market maker exception, stock option availability is no longer relevant with regard to short selling constraints because option market makers have to borrow shares to short like all other market participants.

Our work is also related to the literature investigating failures-to-deliver. With pre-September 2008 data, Evans, Geczy, Musto, and Reed (2009) show that options market makers fail to deliver when expensive-to-borrow stocks are recalled and this failure passes through to options prices as violations of put-call parity. Boni (2006) provides evidence that these failures to deliver were strategic. Stratmann and Welborn (2013) show that the Evans, Geczy, Musto, and Reed (2009) effect was mitigated (i.e. FTD decreased) when the SEC revoked the options market maker exception in October 2008. However, they also show that this regulation was not fully effective, concluding "... the options market is an alternative to the securities lending market when borrowing constraints exist." (Stratmann and Welborn, 2013, p. 203), but do not explain how this happens. We provide evidence that the option market continued to provide additional supply through a reverse conversion trade (with the accompanying naked short selling), which was subsequently forbidden by the SEC in August 2013.

Our work is most closely related to recent papers investigating short selling and stock options around the 2008 crisis. Fotak, Raman, and Yadav (2014) show that higher failures to deliver lead to higher liquidity and greater pricing efficiency, and that both liquidity and price efficiency decline among banned stocks during the short sale ban of 2008. They find no negative consequences of failures to deliver. Stratmann and Welborn (2013) compared data from the second quarter of 2008 to the fourth quarter of 2008 and find that failures to deliver declined, option volume declined, and stock loan fees increased. All of these findings are consistent with the authors' hypotheses, but they cannot be differentiated from the effects of the financial crisis. Our longer time period and second

[13] Also see, in particular, the discussion in Battalio and Schultz (2011) on option market maker hedging motives and behavior.

regulatory action in August 2013 better identify regulatory action as the driving factor behind the observed changes in markets. We also investigate option market-lending market dislocation, price efficiency and mispricing due to short constraints, in addition to basic market shifts like volume, liquidity, and price.[14]

B. Timeline of SEC rule changes

As previously discussed, we divide our sample into three regimes based on two SEC actions. The split in our monthly data happens around the July-October 2008 and August 2013 events, respectively. To better provide context for these choices, we briefly summarize the timeline of events regarding relevant SEC action, short selling, and stock options during this period.[15]

Before Regulation SHO passed in 2004, short selling was self-regulated by the exchanges. Concern about rampant naked short selling led the SEC to step in and pass Regulation SHO, which became effective January 3, 2005. Regulation SHO required traders to borrow stocks, with a rule called the 'locate requirement.' Traders had to 'locate' shares they intended to borrow prior to executing a trade. Three days later, the short seller had to borrow the shares to deliver them to the buyer, which was called 'T+3' settlement. Failing to do this is called a 'failure to deliver'. The SEC also wrote a regulation called the 'close out requirement' which required firms to close out FTD within 10 days after failing to settle (or 13 days after the short sale). However, the SEC provided some exceptions to the locate requirement, the most prominent being the option market maker exception. This exception applied only to options market makers, and was intended only to allow for liquidity provision, i.e. market making, in options markets.

Therefore, before 2008, the equity options market provided a supplemental supply of shares for short sellers. Because the options market maker had an exception to the close-out requirement, she could naked short sell stocks to provide liquidity, even as the price of put options increases due to significant demand. Therefore, a short seller could simply purchase a put option rather than short the stock, and the market maker could in turn short the stock (at no cost to her) to hedge that

[14]The author thanks Rich Evans for useful conversations about failures-to-deliver.

[15]Battalio and Schultz (2011) also provide an excellent timeline of the events of Fall 2008.

sale. This is indeed liquidity provision, but one could argue that it is liquidity provision in the stock loan market as well as the stock options market. This behavior was documented by Evans, Geczy, Musto, and Reed (2009) who showed that failure was an option for the option market maker and that this behavior was mutually beneficial to both the option market maker (who kept the lending fee) and trader (who could profit from his short sale).

A downside of this behavior was a high rate of failures to deliver. Since she had sold short without buying the shares, the option market maker cannot deliver them to the buyer. While on the surface, this seems problematic, there are no documented negative effects of failures to deliver in the academic literature. Rather, Stratmann and Welborn (2013) and Fotak, Raman, and Yadav (2014) indicate that failures to deliver *enhance* market function, likely through the channel we identify: a shadow supply of stock loans for short sellers, which allows for the correction of overpriced stocks.

The first recent action regarding the option market maker exception was proposed on August 7, 2007 (Amendment to Regulation SHO, Proposed Rule Release No. 34-5613). This rule proposed the removal of the option market maker exception, which would have the effect of requiring option market maker to locate and borrow shares in order to hedge put option sales. Comments were closed on September 13, 2007 and no final action was taken by the SEC. To put this in context, this proposed rule came shortly after the announcement that two Bear Stearns hedge funds had "very little value" even after a bailout by the firm a month earlier.[16] It also corresponded with the quantitative hedge fund meltdown (Khandani and Lo, 2011).

Subsequently, the financial crisis began to unfold and Bear Stearns was taken over/bailed out in March 2008. On July 7, 2008, the SEC again proposed removing the option market maker exception, with a comment period ending August 13, 2008. However, the SEC issued an emergency order eight days later on July 15 banning short sales and eliminating the option market maker exemption only on a list of financial stocks.[17] The proximate reasoning was downward price pressure

[16] 2 Bear Stearns Funds Are Almost Worthless, July 17, 2007, New York Times, http://www.nytimes.com/2007/07/17/business/17cnd-bond.html

[17] Emergency Order Pursuant to Section 12(k)(2) of the Securities Exchange Act of 1934 Taking Temporary Action to Respond to Market Developments, SEC Rel. No. 34-58166.

on financial firms' equity, particularly Fannie Mae and Freddie Mac, as well as Lehman Brothers.[18] The SEC expanded the list of securities on September 18, 2008, but in this same Emergency Order, the SEC reversed itself and reinstated the OMM exception on banned stocks, reiterating that it was only to be used for bona fide market making.[19] A month later, the SEC reversed course again, and finalized the rule removing the option market maker exception on October 17, 2008.[20] They also strengthened the penalties for not following the close-out requirement: any broker dealer who did not close out a failures to deliver on the day after settlement (T+4) would be subject to the 'pre-borrow' rule, such that the cannot simply locate shares to borrow, but instead have to execute the transaction to borrow them prior to executing the short sale. This penalty would apply not just to proprietary trades, but to any trade the broker-dealer placed on behalf of its clients, even market makers. These actions clearly succeeded in its primary goal: to reduce the numbers of failures-to-deliver (Stratmann and Welborn, 2013, Fotak, Raman, and Yadav, 2014), though the regulatory uncertainty (and short sales ban) had large deleterious effects on options markets (Battalio and Schultz, 2011).

The timeline of SEC action on options markets and short selling does not end here because traders adapted to the new rule. After markets began recovering and the short sales ban was lifted, traders began using so-called "reverse conversions" to synthetically expand the supply of lendable shares for short selling. Reverse conversions are typically used as a put-call parity arbitrage trade, where the arbitrageur sells the stock and buys a synthetic share with put and call options, arbitraging the spread between them. However, post-2008, this trade was put to use by traders to short sell stocks. The trader would buy the entire market-neutral trade from his broker, then sell the stock, holding the synthetic short position. This trade is more expensive and more complicated than buying a put option, and also operated in a regulatory grey area since the position had to be re-established every few days to avoid a failure-to-deliver.[21] This "reverse-conversion-as-short-

[18]For a nice contemporaneous summary of market sentiment, see SEC Moves to Curb Short-Selling, July 16, 2008, The Wall Street Journal https://www.wsj.com/articles/SB121614248005255151.

[19]Emergency Order Pursuant to Section 12(k)(2) of the Securities Exchange Act of 1934 Taking Temporary Action to Respond to Market Developments, SEC Rel. No. 34-58592.

[20]Amendments to Regulation SHO, SEC Rel. No. 34-58775.

[21]If a market maker sells and re-buys the position every three days, it resets the 'clock' on clearing and thus avoids

sale" behavior ended on August 9, 2013, when the SEC issued guidance specifically identifying this trade and notifying market participants that the SEC considered it an illegal bypass of the fail-to-deliver requirements.[22]

In summary, we find that per SEC regulation since August 9, 2013, the equity options market no longer acts as an additional market for informed shorts as shown empirically by Sorescu (2000) and Danielsen and Sorescu (2001), and now simply passes demand through to the stock loan market. We will show that this regulatory change has profound implications for market function, in the form of price efficiency and mispricing.

C. Hypotheses

The existing literature shows, both theoretically and empirically, that higher equity loan supply is related to lower short selling costs, better price efficiency, and less mispricing. Accordingly, motivated by the existing literature, we posit that the removal of the option market maker exception by the SEC could have the following sequence of effects. It could:

1. reduce the (effective) supply of shares for short sellers;

2. increase short selling constraints among hard to borrow stocks (as measured by equity loan fees); and

3. decrease market efficiency.

As stated in Evans, Geczy, Musto, and Reed (2009), a failure-to-deliver is a form of zero-rebate equity loan from the buyer to the seller who fails to deliver. Since failures to deliver primarily happen among hard-to-borrow stocks, this behavior has the effect of alleviating supply constraints right as they are most likely to bind. Therefore, the removal of this exception (all else equal) should increase lending fees by restricting supply to that which is available in the equity loan

a formal failure-to-deliver. This obeys the letter of the rule but violates the intent of the rule. We provide more detail and an example of a reverse conversion in the appendix

[22] "Strengthening Practices for Preventing and Detecting Illegal Options Trading Used to Reset Reg SHO Close-out Obligations," SEC Risk Alert Volume III, Issue 2, August 9, 2013.

market alone.[23] Therefore, theory suggests that the removal of the option market maker exception generated a negative supply shock to the equity lending market. This generates our first testable hypothesis:

Hypothesis 1: *The removal of the option market maker exception caused a supply shock (reduction).*

Figure 3 provides indirect (equilibrium) evidence of the impact of the removal of the option market maker exception. This figure plots the relation between supply, demand, and lending fees in the different regimes, but not in a Price-Quantity framework. Instead, on the horizontal axis we plot utilization, which is the ratio of Quantity Demanded divided by Total Supply Quantity. This is a variable in the Markit data on stock lending. We plot ten points per regime, one pair averaged within a DCBS bin, which is a Markit proprietary ten-bin grouping of stocks by cost to borrow. Paired with each utilization observations is the average lending fee. This plot then captures the intersection of supply and demand on the horizontal axis and the lending fee on the vertical axis. The figure shows a clear shift in the curve across the three regimes, such that for a fixed utilization, the fee is increasing by regime. Thus, for a given demand and supply (i.e. utilization), the fee is higher in more recent regimes.

This pattern is consistent with the options market, via failures to deliver, providing more supply for short sellers in the early regime, then disappearing after the SEC action to revoke the OMM exception. Consider the early regime curve, in blue. Now, assume that some amount of supply is not recorded, but rather, is apparent in the quantity of failures to deliver. This means that supply, in the denominator of utilization on the horizontal axis, is understated.[24] Thus, if the hidden supply provided by option market maker failures to deliver were included, true utilization for a given fee would be lower, and the curve should be shifted leftward, thus bringing it more in line with the later regime curves where the effect of failures to deliver is minimal. The same pattern exists

[23] Blocher, Reed, and Van Wesep (2013) model such a supply shock, specifically showing that reductions in supply via loan recalls around dividend effects cause higher loan fees.

[24] Failures to deliver will not show up in the supply numbers provided by Markit, which are derived from beneficial owners of the stock providing their portfolios as potential loan inventory.

between the middle and late regimes – the middle curve, assuming inclusion of failures to deliver into supply, would shift leftward, bringing it in line with the late curve where there is minimal failures to deliver hidden supply due to SEC enforcement. Of course, this graphical evidence is inherently limited. In the Results section, we find a similar pattern in a multivariate regression setting.

C.1. Market function: price efficiency and mispricing

If the lowering of failures to deliver reduced stock loan supply and increased short selling constraints, the existing literatures suggests we should expect diminished price efficiency because it will take longer for information (particularly negative information) to be impounded into prices (Boehmer and Wu, 2013). We also expect more mispricing, in particular overpricing, since short investors are more constrained from participating in markets due to higher cost to borrow shares (e.g., Miller, 1977). These observations generate our remaining testable hypotheses:

Hypothesis 2: *The removal of the option market maker exception caused decreased price efficiency.*

Hypothesis 3: *The removal of the option market maker exception caused increased mispricing.*

To be clear, we articulate our null hypothesis. Most proponents of the rule change believed that reducing failures to deliver would smooth market function without having a negative effect. Some believed that short selling (as proxied by failures to deliver data) was *causing* mispricing due to fraudulent and manipulative short selling, so eliminating failures to deliver should improve price efficiency and reduce mispricing. However, to be conservative, our null hypothesis is simply that the rule change had no effect on market function: price efficiency and mispricing should be the same, on average, before and after.

In some cases, we include results for stocks *without* traded options for comparison. In general, we argue that these stocks are not a good baseline test or control group because stocks without

traded options are not comparable to those with traded options, because options listing is endogenous (Mayhew and Mihov, 2004). However, we include these results to provide additional information on the full impact of the regulatory changes.

III. Data

Our sample consists of all CRSP common stocks (share codes 10 or 11) from July 1, 2006 through December 31, 2015 that have stock loan data, traded options, or both, though our primary sample includes only stocks with both stock loan data and traded options. The starting date is due to data availability within the Markit/Data Explorers dataset. Prior to July 2006, the Markit data had much lower coverage of the securities lending market.

Our univariate summary statistics are primarily calculated using daily data, but these results are unchanged if we aggregate to the monthly level. For our regression analysis, we use the monthly frequency for comparability with the extant literature on short selling constraints and because the price efficiency measures we use are lower frequency measures.

A. Equity Options

We obtain option data from OptionMetrics for the period 1996 through 2015, though in most cases we only use 2006-2015. We drop options with greater than 180 days or less than 7 days to maturity and an offer price greater than ask price, both of which must be greater than zero.[25]

We also obtain the risk free rate from OptionMetrics, and linearly interpolate it for days to maturity where no rate is listed. Our sample of options is unique by firm/date/strike/expiration/put-call-flag, and where duplicates arise, we keep the option with the highest traded volume. Duplicates can arise because OptionMetrics aggregates data from multiple sources, so this choice has the effect of choosing the most liquid option.[26]

[25]We correct the lag in the open interest variable starting November 28, 2000 in Option Metrics as noted in Barraclough and Whaley (2012).

[26]For options data starting in 2006, we use the closing stock price data from OptionMetrics. As of February 13, 2006, U.S. equity option markets close at 4pm, instead of 4:02pm ET (SEC release 34-53246). Prior to this change, Battalio and Schultz (2006) note that option markets close at 4:02pm ET while equity markets close at 4:00pm ET.

We include dividend-paying stocks in our sample. Thus, we need to account for both the present value of the dividend and the early exercise premium. We obtain dividends from Option Metrics, and only keep regular dividends (distribution type = 1) that are paid annually, semi-annually, quarterly, and monthly. Because we limit the time to expiration to 180 days, we only need to keep the next six dividends for any given stock. We exclude contracts for stocks that had liquidating dividends, canceled dividends, and duplicate dividends (more than one payment in a day).

We compute the early exercise premium (EEP) using the Cox-Ross-Rubenstein (Cox, Ross, and Rubinstein, 1979) binomial option pricing model.[27] For each option, we compute both the European and American price of the option using binomial trees and take the difference, using the one year trailing daily volatility as the volatility input. The OptionMetrics implied volatility will be systematically biased for hard-to-borrow stocks due to put-call parity violations (Cremers and Weinbaum, 2010), so we cannot use it to get a precise and unbiased EEP estimate.[28]

Summary statistics for our options sample are displayed in Table I. The implied volatility is provided by OptionMetrics, and Early Exercise Premiums (EEP) are computed as just described. The Ofek-Richardson-Whitelaw measure is the ratio between the closing stock price and option implied stock price for put-call parity to hold, as computed in Ofek, Richardson, and Whitelaw (2004). This ratio is calculated as $R = 100 \times ln(S/S^i)$, where S is the observed closing stock price and S^i is the implied stock price calculated assuming put-call parity holds. If put-call parity violations are symmetric, then the distribution of R should be centered around 0.

The equity prices provided by OptionMetrics prior to 2006 are the closing (i.e., 4:00 pm ET) prices, which could lead to a bias in the calculation of implied loan fees. Accordingly, for options data before 2006, we take the last trade price on or prior to 4:02pm ET from TAQ. We make this adjustment, though it matters little since our primary sample starts in July 2006.

[27] Call options on stocks without dividends will never be exercised early and so have an EEP = 0. All other EEPs are computed.

[28] Barone-Adesi and Whaley (1987) showed how to estimate the EEP, but we are able to precisely compute the EEP by computing both the American and European option price and taking the difference. We thank the Vanderbilt ACCRE computing grid for allowing us to run dozens of 8-core parallel MATLAB jobs over a period of several weeks. The EEPs are available from the authors and will be posted online post-publication.

B. Equity Lending Data

Information on the cost of short selling comes from Markit (formerly known as Data Explorers), a leading provider of data in the equity loan market. Markit aggregates and distributes information regarding equity loan positions at the daily frequency. The data is sourced directly from a wide variety of contributing customers including beneficial owners, hedge funds, investment banks, lending agents, and prime brokers. Our sample includes all U.S. equities and exchange-traded funds in their database, from 2002 to September 2016, but we eliminate data prior to July 2006 due to its unreliability and 2016 due to the lack of options data.

The database contains a number of statistics summarizing transactions in the equity loan market at the stock-day level. The SAF is the simple average fee, which represents the buy-side (e.g. hedge funds) cost to borrow, the Daily Cost to Borrow Score (DCBS) is a 1-10 grouping of stocks, daily, by how expensive they are to borrow. We also use utilization, which is the ratio of shares supplied to shares demanded, each of which is also available alone in the data. We also use the BO Inventory Concentration Ratio for our measure of Inventory Concentration.

To measure stock loan fees, we begin with the simple average fee (SAF) provided in this dataset, but this field is not populated for every observation. Thus, we follow the procedure in Blocher and Whaley (2016), which interpolates the missing lending fees with the SAF provided and replaces missing values with the estimates back into the data using the DCBS monthly average SAF, because the DCBS is populated for every observation. They show that this estimation procedure yields a correlation coefficient very close to 1 when comparing estimated fees to known market-based fees. Unless we specifically identify the fee as the Markit SAF, when we refer to lending fees, we mean the Blocher and Whaley (2016) interpolated fee.

We measure the linkage between the stock market and options market using loan fees and option implied loan fees. Conceptually, an *Option Implied Loan Fee* is the required lending fee to eliminate the put-call parity deviations identified in Ofek, Richardson, and Whitelaw (2004).

Unfortunately, computing option implied loan fees using market quoted option data generates a very noisy dataset. This problem has been noted in the literature estimating risk neutral distribu-

tions (RND) (Breeden and Litzenberger, 1978) for individual stock options, which is why most of the literature on RNDs has focused on index options. Yet, even estimating the RND for an index option has proven difficult, such that various smoothing methods have been developed (Figlewski, 2008). To get a more precise measure of a stock's option implied fees, we follow the approach of Carr and Wu (2010) to develop a volatility surface across a grid of pre-determined strike prices and maturities. Then, focusing on the at-the-money series, we compute option implied fees for varying maturities, which we then average into a single estimate per stock-day.[29]

C. Other data

We obtain fail-to-deliver data in total shares from the SEC website.[30] Before September 16, 2008, reports of less than 10,000 were omitted from the data, after that date, all fails were reported. To ensure comparability since September 2008 corresponds to our first regulatory action, we adjust the later data to omit observations with less than 10,000 shares. This has no difference in our reported results.

Summary statistics for our combined, monthly sample are in Table II. In Panel A, we sort the data by market capitalization decile to provide a familiar ordering of the data, as observed in the summary of market capitalization, volume, volatility, and spread. The next four items are from the stock loan market, which are estimates of demand and supply (both in $M in market value), the utilization, which is Demand/Supply, and the interpolated lending fee in basis points. The remaining columns summarize data from the options market: Volume, Open Interest, and Spreads. Each of these are computed as the mean across option contracts each day, then the monthly value is the mean of that daily value. "Pair" measures are paired puts and calls by strike and expiration, with the minimum Volume and Open Interest across pairs kept and the maximum spread across pairs is kept.

Panel B presents the same data, but sorted differently. Here it is sorted by the DCBS, which is a proxy for difficulty in borrowing, with higher DCBS indicating harder to borrow stocks (by loan

[29]This procedure will be discussed in more detail soon in a new working paper.

[30]https://www.sec.gov/help/foiadocsfailsdatahtm.html

fees). Higher DCBS firms are typically smaller (though the average market capitalization in DCBS 10 is $218, which places it between market cap deciles 4 and 5) and more volatile. They also have greater option market activity by all measures, though options spreads are somewhat consistent across DCBS bins.

IV. Results

A. Identification

Our identification stems from two regulatory events: the removal of the option market maker exception in July-October 2008 and the SEC Risk Alert officially banning reverse conversions as a method of naked short selling on August 9, 2013. In our primary tests, we use a difference-in-differences regression of the form:

$$y_{i,t} = \alpha + \beta_1 \text{Special}_{i,t} + \beta_2 \text{Regime}_{i,t} + \beta_3 \text{Special} \times \text{Regime}_{i,t} + \delta_i + \delta_{I(i),t} + \epsilon_{i,t}, \qquad (1)$$

where $\text{Special}_{i,t}$ is an indicator variable that is equal to one if firm i is expensive to borrow (treated) and zero otherwise, $\text{Regime}_{i,t}$ is an indicator variable that is equal to one if date t occurs after a particular regulatory change, δ_i are firm fixed effects, $\delta_{I(i),t}$ are industry $\times$ date fixed effects, and the outcome variable $y_{i,t}$ consists of several different measures of stock price efficiency and trading behavior, as discussed in greater detail below. The treatment effect is measured by β_3, which formally tests whether short sale constrained stocks were differentially impacted relative to non-constrained stocks after a regulatory change.

As previously mentioned, our identification strategy relies on the assumption that the regulatory changes were a shock to short selling constraints that were unrelated to other factors that differentially affect asset prices. In our framework, the identifying assumption is equivalent to the requirement that the average change in the outcomes of short sale constraints firms would have been equal to the average change in the outcomes of non-short sale constrained firms in the absence of changes to option market regulation. The 2008 event is fraught with challenges. First, the

crisis itself had multiple regulatory actions and market reactions that could confound our results. Second, there is not a clear 'event' upon which to condition. Since multiple, contradictory SEC actions spanned July to October 2008, generating significant uncertainty, we drop these four months from our analysis.[31]

The second event is cleaner in the sense that arguably nothing else of note happened in August 2013 – however, it is possible that the event may not be large enough to generate a result. Put differently, the power of the test could be low. Of course, our identification assumptions could be violated if there exists a time trend in our outcomes variables that would have occurred even absent these regulatory changes. Accordingly, our identification strategy requires us to show that this second regulatory action actually changed trader behavior. This critique may be valid given the time trends in option volume shown in Figure 4. Whether measured as Open Interest or Volume, among Calls or Puts, summing or averaging, there is a clear hump-shaped pattern in option market activity. The peak is right around the financial crisis of 2008. Since then, equity option markets have shown a clear downward trend in volume and open interest. Accordingly, we stress that our identification strategy compares the outcomes of constrained stocks to the outcomes of unconstrained stocks. As such, our approach controls for general time trends as long as these time trends did not differentially impact our treatment group.

To see the impact of this second event in particular, we again examine the pattern in Figure 1. Each statistic is summarized across the Markit Daily Cost to Borrow Score (DCBS), which is a proxy for lending fees. The DCBS is not a decile grouping: approximately 80% of the observations are in DCBS 1, scores of 2 and higher typically represent stocks that are "on special" or hard-to-borrow. Each statistic is summarized separately in the three regimes just described to see the change in behavior.

Panel A plots fails-to-deliver (in millions of shares), which as already noted elsewhere (Stratmann and Welborn, 2013, Kolasinski, Reed, and Thornock, 2013), decreased significantly after the option market maker exception was removed in October 2008. However, note that in the middle

[31] An early version of this paper instead split this four months between the early and middle regimes, and found similar results. As such, our results are not sensitive to this choice.

regime, there is still a weak upward trend as stocks get more expensive to borrow, with pretty substantial fails in DCBS 10. The pattern flattens out substantially from the early to middle regimes, but again drops from the middle to final regimes, mostly among the highest DCBS stocks. To emphasize the importance of the second SEC action in 2013, FTD in the DCBS 10 bin dropped by 66% after the first regulatory action in 2008, and by 51% after the 2013 action.

The most important piece of evidence in favor of the importance of the second regulatory action is in Panel B, which plots put-call option volume.[32] We take put-call pairs daily across strike and maturity and compute the minimum volume of each pair (omitting zero open interest observations). This is intended to identify the volume of reverse conversions, which require both contracts. We then take the daily average across strike and maturity, then average across days again to get monthly averages. In the early regime, volume shows higher levels across the DCBS and a general upward trend with DCBS. In the middle regime, we see that for DCBS 1-9, volume flattens out, but in DCBS 10 it spikes up to 70, more the double the next largest observation in any DCBS, in any regime. This shows how all the options volume has moved to the most lucrative to short since the reverse conversion bypasses the stock loan market. It also shows how traders know this is a grey area, legally, since they primarily seem willing to do the trade when it is very profitable, implying an extra premium required. In the Late Regime, after August 2013, when the SEC outlawed the trade explicitly, we see all option volume drop substantially, by about half or more across all DCBS groups. This lack of volume in the options market among hard-to-borrow stocks is an indicator that (among other possible causes), the inability to short was once an important generator of option trades and no longer is possible.

In subsequent tests, we not only test differences between the early and middle, then middle and late regimes, but we also test the early versus late regimes. This has the effect of omitting the middle regime, when markets are experiencing the aftermath of the financial crisis. By any estimation, markets had recovered by August 2013 and so this test should be free of confounding effects from the financial crisis. In addition, this can be seen as a test of the combined effect of

[32]The same pattern exists in open interest, as well as if we sum volume across contracts, or take the max of min vol across daily contracts, available in the appendix

both regulations, since both events happened between the early and late regimes.

In unreported results, we also test that our difference-in-differences framework is fully identified by re-running our specifications with control variables that explain the dependent variable in an OLS specification. If the difference-in-difference is well specified, these additional variables should not affect the magnitude or statistical significance of the treatment effect. In all specifications, we find that this is the case.

B. Impact on Asset Prices

We have three main sets of results. First, we document that regulatory action is strongly related to loan fee increases among hard-to-borrow stocks. Then, we provide evidence that the mechanism is the reduced loan supply due to the limitation of failures to deliver.

Second, we implement the Delay measure of Hou and Moskowitz (2005) to measure price efficiency across the three regimes. We find that delay has increased (i.e., price efficiency has decreased). When we decompose the Delay measure into positive and negative portions, we find that there has been virtually no increase in Positive Delay and that all of our result comes from increases in Negative Delay. In other words, we find that there is an increase in the delay of incorporating negative market information, but not positive information. Third, we measure mispricing as proxied by return predictability. Among stocks with traded options, we find return predictability to be larger in the recent regime compared to pre-July 2008. In contrast, return predictability has *decreased* among stocks with only stock loans available (and no traded options).

C. Increases in Loan Fees: Fails-to-Deliver as Lost "Shadow" Loan Supply

We start by documenting the increase in loan fees and showing that it is the result of the contraction of supply available via the option market maker exception, and the resulting loss of failure-to-deliver "inventory". Of course, the loan fee increases are already clear looking at Figure 2, Panel A. We can clearly see, at least comparing the Early to Late regimes (or Early to Middle regimes) that fees have increased, and increased the most for stocks that are most costly-to-borrow

(higher DCBS groups).

There is further evidence of fee increases in Figure 5. This plots the distribution of the Simple Average Fee (SAF) from Markit, using a box-and-whisker plot for each year. Each box plots the interquartile range, and the upper and lower 'whisker' show the 5th and 95th percentile. The upper and lower panel plot the same data, but with different resolution. The upper panel ranges from 0 to 1,200 bps to show the whole distribution. The lower panel ranges from -50 to 200 bps to focus on the pattern in the mean and median. The mean of the SAF rises from about 50 bps in 2007 up to between 150-200 in the past few years. The distribution is also more skewed than before, with the mean well above the 75th percentile.

Figure 5 shows the challenges of using the October 2008 regulatory action as instrumental. Loan fees clearly fall from 2008 to 2009 by any measure: mean, median, any percentile - even the standard deviation is lower. This stands to reason after the huge drop in financial markets that there would be little demand for short selling in 2009 across all stocks. Indeed, the S&P 500 did not recover its pre-crisis level of 1,550 (Oct 2007) until February 2013. However, if we compare the period of 2013-2015 to the pre-2008 period, we see a clear difference in loan fees in Figure 5.

Table III examines these results in a regression framework that uses a difference-in-differences estimation of stock loan fees and option implied loan fees. The first difference is the regime shift, which is Early-Middle (Model 1), Middle-Late (Model 2) and Early-Late (Model 3). These transitions test the two regulatory actions (Models 1 and 2) and the cumulative effect of the two by testing the pre-July 2008 data to post-Aug 2013 data (Model 3). The treatment variable (or second difference) is 'High Utilization' defined as a utilization (demand/supply) of 60% or greater. This represents stocks that are hard to borrow without using loan fees (since fees is the outcome variable). [33] The dependent variable is the logarithm of the loan fee. The Regime indicator is omitted from the specification because it is collinear with our Time-based fixed effects, which

[33]We exclude firms with between 40% and 60% utilization, which is only 7.9% of the sample. We get weaker results when we use these Moderate Utilization observations as the treatment variable. Ideally, we would use failures-to-deliver as the treatment, but this is not possible. Post-regulation, we would need to be able to identify stocks that would have high failures-to-deliver if they were allowed, but this not measurable. Thus, we need to use proxies for hard-to-borrow, a situation where stocks are expensive to borrow and thus borrowers would prefer to failures-to-deliver if they could.

provide more granular control for time-based effects. We include Firm and Time-Industry fixed effects and clustered standard errors. Our main specification does not include additional co-variates, however, in unreported analyses (available upon request) we find that our treatment effects are largely unchanged when we add additional controls, which suggests that our identification strategy is valid.

The results in Table III confirm Figure 2, Panel A and Figure 5. There is a clear step change in fees around the financial crisis (Model 1), no effect around the August 2013 event, but a substantial effect comparing the early regime to the late regime, which measures the cumulative effect of the two regulatory actions (Model 3). It is not surprising that we do not find an effect from middle to late, because the effect of reverse conversions was likely isolated to a relatively small group of stocks, so the effect on average loan fees may not be detectable. Panels A and B show results for three and six month symmetric windows respectively, with twelve month symmetric windows showing similar results, and available upon request.

In Models 4-6, we see a similar pattern among option implied fees. Fees rise substantially around the financial crisis, drop around the second regulatory action, but when comparing the early regime to the late regime (Model 6), the upward shift is present and the same magnitude as Model 4. To compare the two, Models 7-9 repeat the analysis with the difference between the two now as the dependent variable. Here, we see a negative relationship across the regulatory events, meaning that the difference is getting smaller (or even becoming negative). The positive coefficient in Model 8 does not appear to affect the overal shift seen in Model 9 from the early to late regime.

Next, in Table IV, we show how the relationship between Demand and Loan Fees has changed due the removal of failures to deliver, which shows that it constituted a supply shock to the equity loan market. The three models are just as before, measuring the three different regime changes. This is not, however, a difference-in-difference because we interact the regime changes with Demand, a continuous variable. Instead, what we show is that the interaction term is positive in both Model 1 (Early-Middle) and Model 3 (Early-Late), which shows that a move in Demand results in an even larger move in loan fees post-regulation. While this is not irrefutable evidence, it is

indicative of the shift in equilibrium due to the lost of 'shadow' supply in failures-to-deliver, and backs up what we see in Figure 3 with statistical evidence.

As further support for the loss of failures-to-deliver, we show in Table V that there is a *positive* trend in measured supply among hard-to-borrow stocks. This is unsurprising given current results showing that more and more stock owners see lending as an important income stream (Blocher and Whaley, 2016, Evans, Ferreira, and Prado, 2017). Thus, we should expect that supply constraints have eased over time: for a given shift in demand, prices should move less if there is more supply now than in the past. Instead, we find the opposite, which backs up our hypothesis that the loss of the failures-to-deliver 'shadow supply' has played an important role in the increase in loan fees.

D. Price Efficiency measured as Delay

Both this section and the next perform tests of market function due to increased short constraints. We have already shown that lending fees rose due to the regulatory action, which we linked to the loss of stock loan supply due to lower failures-to-deliver. Blocher, Reed, and Van Wesep (2013) showed that fees can be seen as a short constraint, where a ban on short sales is simply modeled as a lending fee of infinity. Our goal in this section and the next is to quantify how much these increased fees translate into constraints that affect market function.

Therefore, we analyze price efficiency with the Delay2 measure in Hou and Moskowitz (2005).[34] This delay measure derives fundamentally from a regression of weekly firm returns on weekly market returns with lags. We use four lags as as in Hou and Moskowitz (2005):

$$Ret_{i,t} = \alpha + \sum_{n=0}^{4} \delta_n Ret_{mkt,t-n} \tag{2}$$

The Delay2 measure is

$$Delay2 = \frac{\sum_{n=1}^{4} \delta_n}{\delta_0 + \sum_{n=1}^{4} \delta_n} \tag{3}$$

where the $\delta_1 \ldots \delta_4$ represent the coefficient estimates for the four market return lags and δ_0 is the

[34] In unreported results, we also test the Delay1 measure, based on R2, with similar findings. We do not report these results because we cannot do a similar asymmetric decomposition.

estimate for the contemporaneous market return coefficient .

This measure captures the rate at which public market information is incorporated into a stock price. If information is incorporated quickly, the market return lags should be uninformative and coefficients should be statistically zero, which will produce a delay measure very close to zero. In contrast, if information takes longer to incorporate into prices, the lags become more statistically significant, and the delay measure increases, indicating lower efficiency.

Because we are investigating short sales constraints, however, we can be more precise. Specifically, short sales constraints should only affect the incorporation of negative information. Therefore, we decompose the market return into two components, a positive component and a negative component. The positive component keeps all positive market returns, and sets negative returns equal to zero. The negative component keeps all negative market returns and sets positive returns equal to zero. We can recover the original time series of market returns by summing the positive and negative components.

We estimate the following asymmetric delay model:

$$Ret_{i,t} = \alpha + \sum_{n=0}^{4} \beta_n Ret_{mkt,t-n} 1_+ + \sum_{n=0}^{4} \lambda_n Ret_{mkt,t-n} 1_-$$

Then we compute positive delay as follows:

$$PosDelay2 = \frac{\sum_{n=1}^{4} \beta_n}{\beta_0 + \sum_{n=1}^{4} \beta_n}$$

and negative delay as follows:

$$NegDelay2 = \frac{\sum_{n=1}^{4} \lambda_n}{\lambda_0 + \sum_{n=1}^{4} \lambda_n}$$

Results for the standard Delay measure are in Table VI.[35] This table uses the same differences-in-differences framework as in Tables III. The dependent variable is the Delay2 measure in Hou

[35]To be sure that the assymetric delay decomposition does not introduce a bias into the delay measure, we examine a calibration on simulated data. The results, available in the appendix, suggest our measure is unbiased.

and Moskowitz (2005). Our goal is to examine how this delay measure changes from regime to regime. The treatment variable is 'Special', which is an industry term for hard-to-borrow. We define Special as a month that has at least 19 days with a lending fee above 100 bps. To test our identification, we include multiple controls for stock liquidity, since Hou and Moskowitz (2005) showed liquidity to be a key determinant of the delay measure, and find that these do not affect the coefficient estimates, supporting the identifying assumptions of our difference-in-differences specification. Models 1-3 in each panel are for three month symmetric windows, and models 4-6 are for six month symmetric windows.

As with any difference-in-difference specification, we focus on the interaction term, Regime # Special. We see no increase in Delay2 around the financial crisis, which is Models 1 and 4 (six and twelve month windows, respectively). We choose to show the wider windows because Delay2 is measured with weekly data in a rolling regression over one year. Therefore, we need wider windows to capture changes in Delay. Our strongest result is the increase in delay from pre-2008 (early) to post-2013 (late), which is positive and significant in all Models 3, and 6. In unreported results, we get similar outcomes with a three month window. This is evidence that overall, price efficiency has decreased

Table VII shows the results for the decomposed Delay2 measure. Panel A has the Positive Delay2 measure and Panel B shows results for the Negative Delay2 measure. The results for Positive Delay2 are insignificant in most cases, though there is a moderate increase from middle to late with six month windows (model 2). This result does not obtain with a twelve month window (model 5) or a three month window (unreported), so it is not robust. However, in Panel B, we see positive and significant results for both early to middle and early to late regimes over both both the six and twelve month windows (as well as three month, unreported). This shows up models 1, 3, 4, and 6.

This result shows that the increase in inefficiency is coming primarily from short constraints: there is more delay in incorporating negative market information into prices, not positive market information. It also shows an increase in market inefficiency around the financial crisis (early

to middle), which is important since we have already shown this transition exhibits the largest increase in loan fees, and therefore the greatest increase in short selling constraints.

E. Mispricing Measured as Return Predictability

Finally, we examine the impact of these regulatory changes on stock mispricing, which is linked to short selling constraints, as in Section D. If constraints are higher when option market makers are more constrainted, then we should see greater mispricing.

Our proxy for mispricing is the subsequent measured stock return conditional on a stock being constrained. We measure constrained as being hard-to-borrow, based on lending fees. The mispricing result is in Table VIII. There, we show returns measured as (Fama and French, 1993) three factor abnormal returns, which we compute as raw return minus the matched 25 portfolio return. We use monthly data from July 2006 to December 2015, with the event dates omitted (July 2008-October 2008 and August 2013), though our results are not sensitive to this choice. We include stocks with traded options as well as those that do not have traded options for reference. We also split the sample into the same three regimes, Early, Middle, and Late, and perform a T-test of differences between the hard-to-borrow and easy-to-borrow stocks, which we define differently in each panel to show robustness.

In Panel A, we define hard-to-borrow as a stock having at least 19 trading days with daily lending fees above 100 bps, the same as in previous analyses. In Panel B, we define hard-to-borrow as 19 days per month with lending fees above 200 bps. In Panel C, we define hard to borrow as monthly average lending fee above the 95^{th} percentile, measured monthly. This accounts for the fact that the entire distribution of lending fees has been increasing with time, as shown in Figure 5 and Table III.

The result is similar regardless of how we define hard-to-borrow: in the most recent regime, we see more mispricing. In Panel A, we see this in relative terms compared to the sample of stocks without traded options. In that sample, we see less mispricing in an absolute sense: returns on hard-to-borrow stocks are -1.10%, -0.50%, and -0.38%, respectively, in the early, middle, and late

regimes. We also see it in the relative sense: in the late regimes, the difference between hard-to-borrow and easy-to-borrow is 0.84% vs 1.00%. However, among stocks with options, we see a big drop in mispricing from the early to middle regime (-2.12% to -0.34%) but then a rebound in the late regime to -1.94%. There is a similar pattern in the difference between hard-to-borrow and easy-to-borrow.

The pattern is more striking in Panel B, when we raise the bar for specialness to 200 bps instead of 100 bps. This is reasonable since stocks have become more expensive in recent time. Here, we see a similar decrease in mispricing among the stocks with Loans Only (-1.45%, -0.75%, and -0.64%, respectively for early, middle, and late) but a drop and large rebound among those with Options and Loans: -1.78% in the early period, down to -0.63%, then back up to -2.52%. Again, the differences between hard-to-borrow and easy-to-borrow follow the same pattern.

Finally, in Panel C, we use the 95th percentile of loan fees as a daily fee threshold. Specifically, we compute the 95th percentile loan fee in each regime, which is 145 bps in the early regime, 193 in the middle regime, and 540 bps in the late regime. Again, to be defined as special, a stock must exceed this threshold for 19 days or more each month. We again get the same pattern among stocks with both Options and Loans, though now the Loans Only sample is more stable, with a hard-to-borrow return of -0.60% in both the early and late regime. This final specification gives the largest effects in the late regime across all Panels, though the differences are not statistically significant.

It stands to reason that the differences would be greatest among the hardest-to-borrow stocks (i.e. the highest threshold in Panel C). If we assume that OMM borrow stocks when they can, and only fail-to-deliver (in the early or middle regimes) when they cannot find the stock, then we expect to see the biggest differences among these stocks. The less constrained stocks did not see as much of a change in supply, since they were not were most of the FTD activity was occurring.

We present multivariate results in Table IX. We use the same threshold for specialness as in Panel C of Table VIII, which is the 95th percentile loan fee in each regime. We see that the magnitude of the coefficient on the indicator variable is approximately double in Models 5 and

6 (late regime) compared to Models 1 and 2 (early regime), and all are statistically significant.

These results are suggestive, but we formally test the differences between regimes in Table X. In this table, the regime indicator turns on for the middle (Models 1 and 2) and late (Models 3 and 4) regimes, and is zero only for the early regime. This tests the coefficient difference between the early regime and the regime labeled. We use the same special measurement and controls as in Table IX. As the interaction term (first row) shows, the differences are negative and statistically significant at the 10% level, which indicates that return predictability has increased in both the middle and late regimes versus the early regime.

For reference, Models 5-8 show the same specification, but for stocks without options. Of note here is that while there is an incremental effect in the Middle vs Early specifications (Models 5-6), it disappears when comparing Late vs Early (Models 7-8). This indicates that among these stocks, there may have been some increased mispricing around the financial crisis, but that it did not persist. However, among stocks with traded options (where the option market regulation has remained), we see a persistent effect.

Together with the previous section, the results show that the removal of the OMM exception has reduced supply for short selling, and this increased short selling constraints. As a result, stocks are more overpriced and stock prices are less efficient.

V. Conclusion

Options are a crucial component of modern financial markets, yet, the existing literature is unclear on one of the fundamental assumptions underlying option pricing theory. In this paper, we examine whether options are truly redundant securities. We find that the answer depends on the regulatory regime. In 2008, the SEC eliminated the ability of traders to short sell without borrowing shares, and in 2013, they further restricted short selling by removing the ability of option market makers to short sell without borrowing shares. We find that these rule changes had significant consequences for the formation of prices in option and stock markets.

Our results suggest that prior to 2008, options were *not* redundant securities. Indeed, option

contracts could be used to synthetically construct a short position at lower cost. In particular, option market makers could naked short sell, which allowed them to avoid paying high equity loan fees, and some of this value passed through to short sellers. However, following the removal of the option market maker exception and the subsequent prohibition of reverse conversion trades, we find that options have become significantly more redundant. In particular, option prices now closely follow stock prices inclusive of security lending fees. As a consequence, short selling has become more difficult.

We find that these changes had deleterious effects on the formation of stock prices. Because short selling in high loan fee stocks is more difficult, we find that market quality in these stocks has deteriorated. Price efficiency is now lower and these stocks are now more overpriced. However, we are careful to note that our results do not provide general welfare effects. While our findings suggest that short sellers are worse off and some stocks are priced less efficiently, it is possible that other benefits exist. For example, we find that there are significantly less failures to deliver. We also document higher equity loan fees, suggesting that equity lenders may be better off. Overall, our results suggest that regulatory polices can have significant impacts on the formation of asset prices. As such, our findings have important implications for academics, practitioners, and regulators.

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Figure 1. Univariate statistics by Regulatory Regime.

The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. Data are daily, summarized by Markit's Daily Cost to Borrow Score (DCBS) which a 1-10 grouping based on how hard a stock is to borrow.

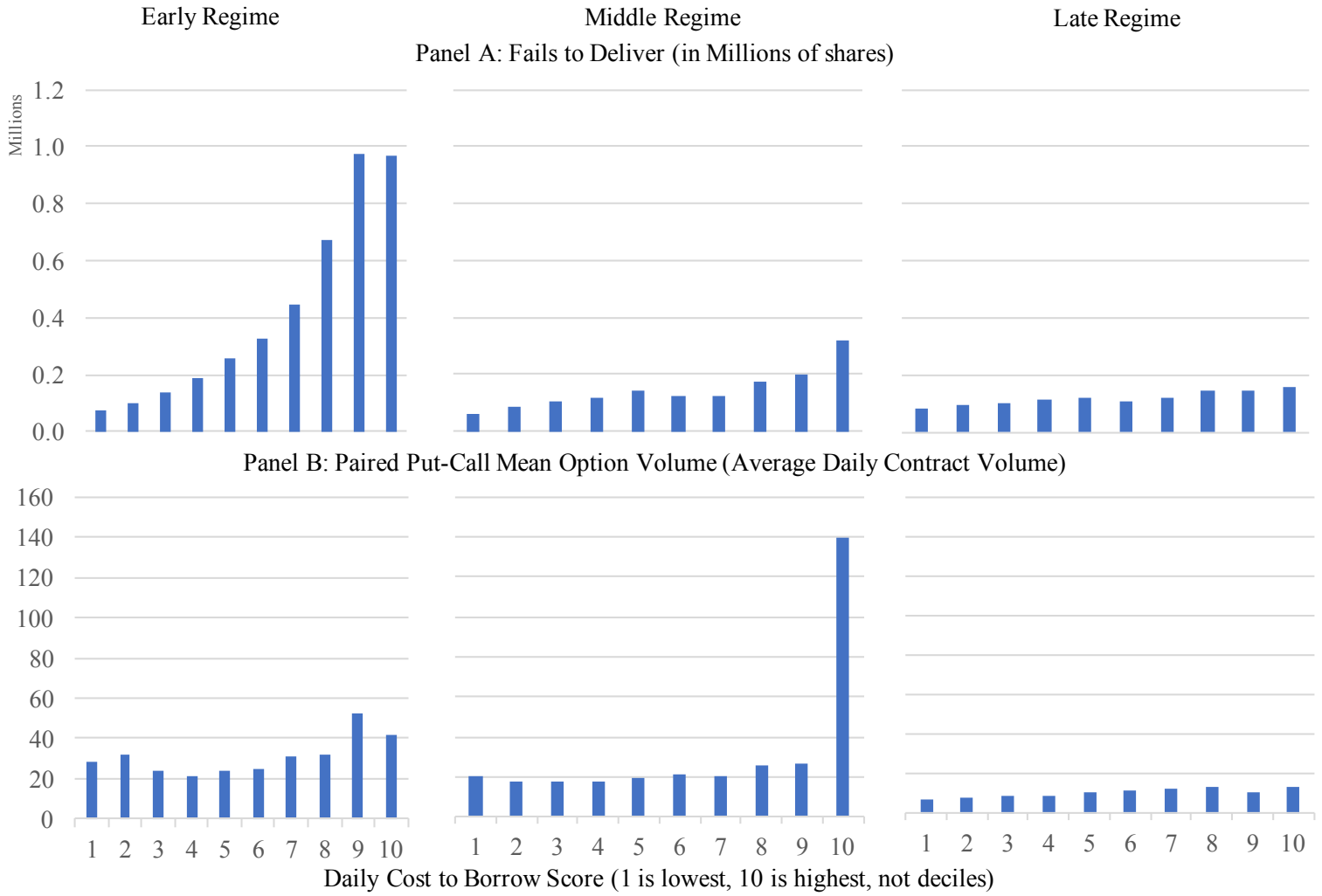

Figure 2. Loan Fees and Option Implied Loan Fees across Regimes

This set of plots shows changes in stock loan fees and option implied loan fees across the three regimes. "Early" is pre-Sept 2008 when the OMM Exception was in place. "Middle" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. "Late" is Sept 2013 to Dec 2015 and represents the current state. Panel A shows the daily loan fees from Markit. Panel B shows the daily average option implied loan fees. Panel C shows differences between the two, computed by stock-day and then summarized.

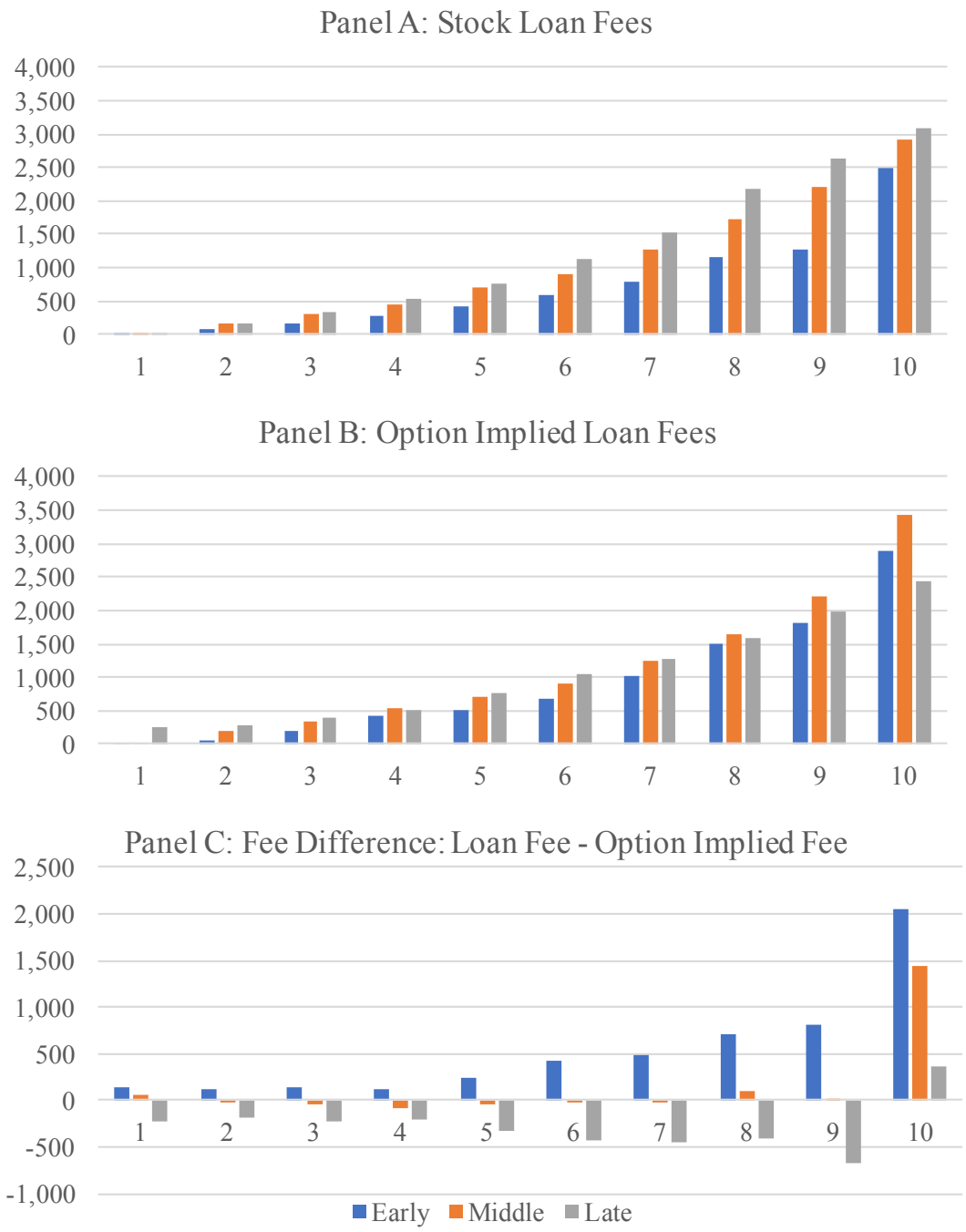

Figure 3. Relationship Between Lending Fees and Utilization by Regime

"Early" is pre-Sept 2008 when the OMM Exception was in place. "Middle" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. "Late" is Sept 2013 to Dec 2015 and represents the current state. Data are daily, summarized by Markit's Daily Cost to Borrow Score (DCBS) which a 1-10 grouping based on how hard a stock is to borrow. Plotted is the average Utilization versus average Lending Fee, by DCBS in each regime, such that each regime has 10 points plotted. The trendline included is a simple power law best fit line to help ease comparison. Of note is how this relationship has changed across regimes: for the same utilization, stocks are more expensive in each regime.

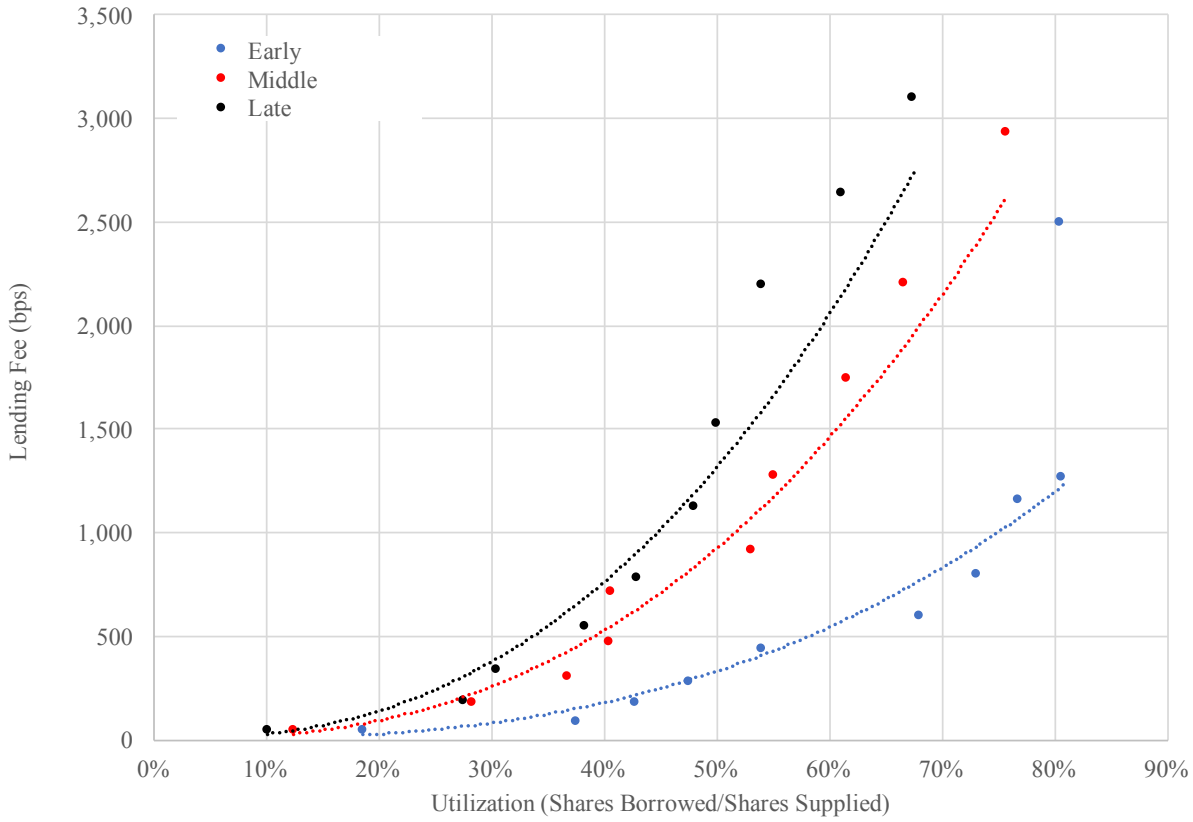

Figure 4. Option Volume and Open Interest

Plotted are equity option volume and open interest by year. In Panel A, volume or open interest are averaged across all strike-expiration pairs per day, then averaged again for the annual summary statistic. In Panel B, volume or open interest are summed daily across all strike-expiration pairs, then averaged for the annual summary statistic. We drop options with greater than 180 days or less than 7 days to maturity, zero open interest, and an offer price greater than an ask price.

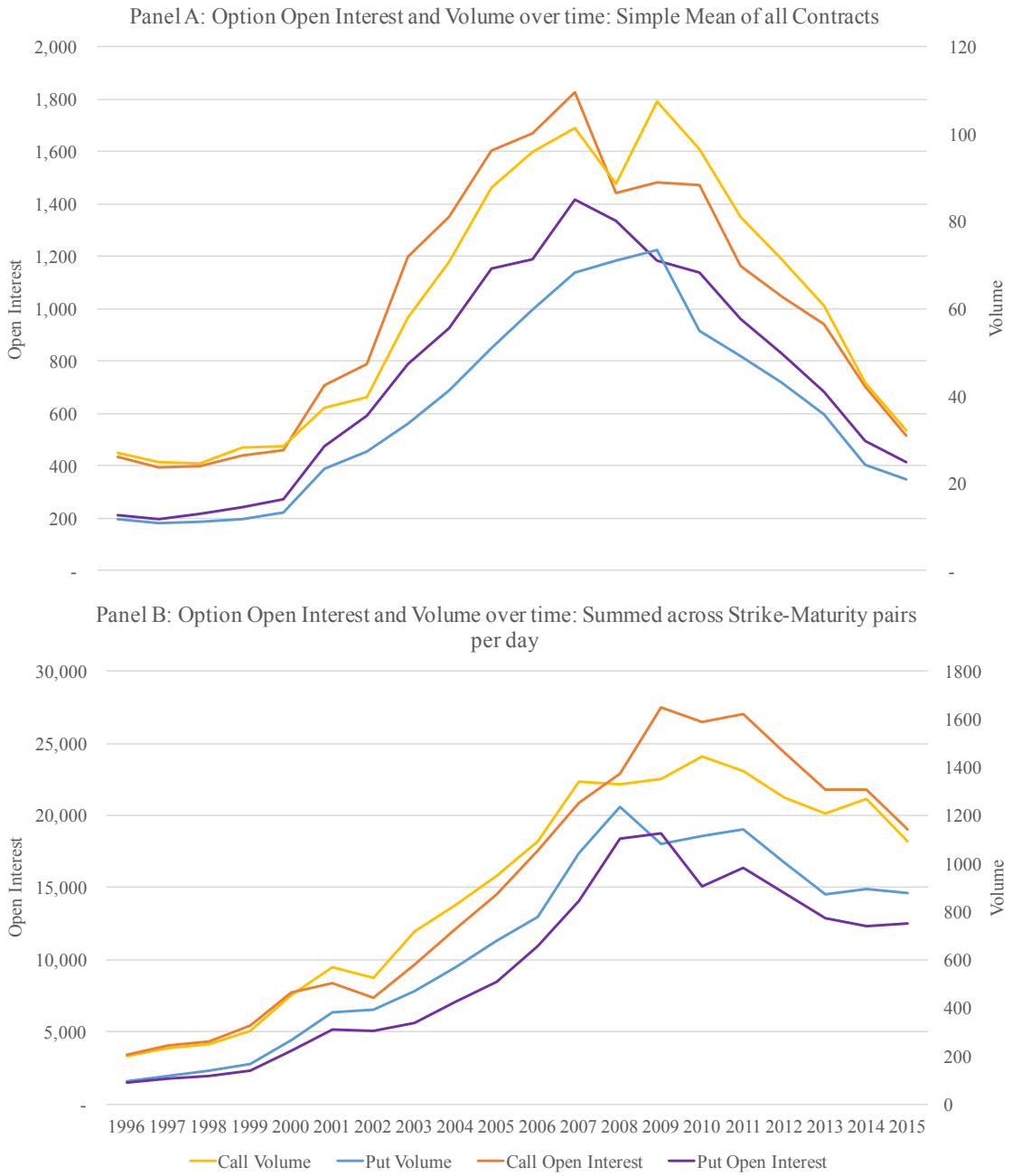

Figure 5. Distribution of Lending Fees through time

Plotted is the distribution of Markit's Simple Average Fee (SAF), annually, from 2007-2015 using daily data. Both panels plot the same data, but the lower panel zooms in the Y axis to focus on the range between -50 bps and 200 bps. The box-and-whisker plot shows the range from the 5th to 95th percentile, and the box represents the interquartile range.The line between light and dark grey is the median. The black line is the mean of the distribution. On the bottom panel, the dotted line is the average option implied fee.

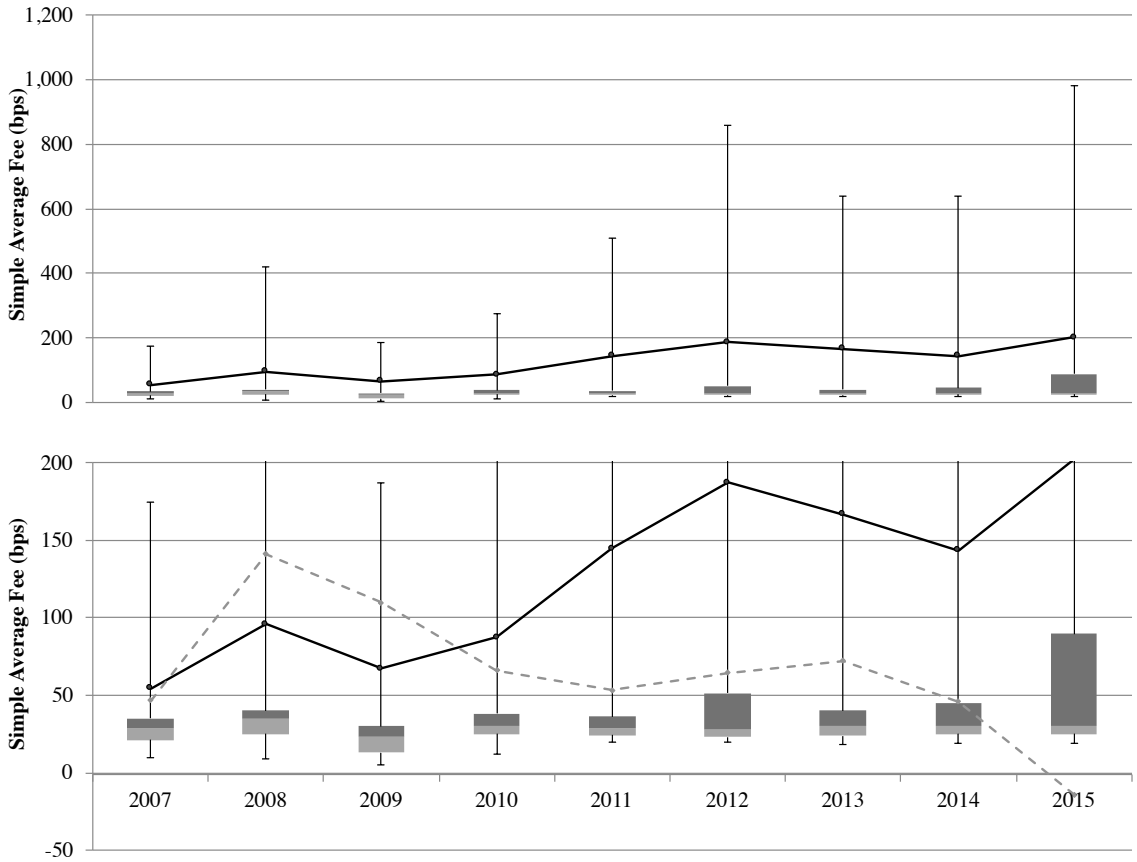

Table I
Summary Statistics - Options and Option Implied Lending Fees

Summary statistics for Options data from 2006-2015. Data are daily from OptionMetrics. Implied volatilities are from OptionMetrics. Early Exercise Premiums (EEP) are computed using the binomial model as the difference between a European and American option. Missing values are non-dividend paying stocks that have an EEP of 0. The Ofek-Richardson-Whitelaw Measure is as computed in Ofek, Richardson, and Whitelaw (2004). Option Implied Lending Fees are computed by solving for the necessary lending fee to bring each Put-Call option pair into parity.

	Num Obs	Mean	Std Dev	Min	Max
Days to Expiration	110,789,775	81.75	51.05	7.25	179.81
Implied Volatility (Call)	103,829,046	0.45	0.22	0.01	3.00
Implied Volatility (Put)	106,314,105	0.46	0.23	0.01	3.00
Open Interest (Call)	109,276,798	1,057.13	6,600.05	-	1,974,755.03
Open Interest (Put)	109,185,384	829.10	4,814.22	-	1,549,734.77
Volume (Call)	110,789,775	67.49	1,170.82	-	1,054,830.91
Volume (Put)	110,789,775	42.87	531.33	-	455,567.07
Early Exercise Premium (Call)	110,789,775	0.04	0.22	-	16.45
Early Exercise Premium (Put)	110,789,775	0.02	0.10	-	6.84
Ofek-Rich-Whitelaw Measure	110,785,521	0.10	1.91	(249.85)	340.77
Option Implied Lending Fee (bps)	110,785,738	52.13	1,494.33	(674,789.08)	212,635.08

Table II
Summary Statistics - Monthly Master Sample

Summary statistics for CRSP stock data from 2006-2015. Data are Monthly, share code 10 and 11. Market capitalization deciles use NYSE-NASDAQ-AMEX breakpoints. Mkt Cap is daily market capitalization computed as price times shares outstanding, in $M. Volume is daily shares traded times closing price, in $M. Annualized volatility is computed using daily data over the past 21 days and annualized. Spread is the bid minus ask divided by the midpoint. Demand and Supply are in $M from Markit, Utilzation is the ratio of the two. Lending fee is the interpolated lending fee in basis points. Volume and Open Interest are the daily mean across option contracts, averaged across days to get a monthly estimate. Paired option estimate are for matched put-call pair contracts, where volume and open interest is the minimum of the put and call across contracts. The option implied fee is the required fee to enforce put-call parity, in basis points.

Panel A: Sorted by Market Capitalization Decile

Decile	N	Mkt Cap ($M)	Volume ($M)	Ann Vol (%)	Spread	Demand ($M)	Supply ($M)	Util (%)	Lending Fee (bps)	Pair Vol	Call Vol	Put Vol	Pair Open Int	Call Open Int	Put Open Int	Pair Spread	Call Spread	Put Spread	Option Implied Fee (bps)
N/A	528	$1,281	$405.01	66.0%	0.015	26.88	371.18	24.9%	221	3.0	26.0	10.7	277	867	371	0.62	0.46	0.34	261
1	31,895	$22	$4.56	82.8%	0.042	0.23	0.87	15.6%	460	1.7	19.8	5.3	132	570	253	1.05	0.90	0.62	605
2	40,290	$56	$6.78	61.1%	0.026	0.64	3.22	14.0%	316	1.3	14.5	4.7	93	431	156	1.06	0.88	0.67	483
3	38,609	$104	$13.58	56.4%	0.016	2.01	9.58	17.3%	257	2.0	16.5	6.3	129	489	210	0.99	0.79	0.65	406
4	38,220	$182	$25.90	53.4%	0.008	5.46	25.60	19.4%	175	1.7	14.6	6.7	115	400	213	0.94	0.72	0.62	335
5	38,761	$296	$53.03	53.2%	0.004	12.83	54.72	21.9%	152	1.9	15.5	7.2	116	415	210	0.87	0.65	0.59	312
6	40,719	$490	$97.29	49.2%	0.003	26.07	107.22	22.9%	121	1.9	14.2	7.3	108	338	209	0.83	0.59	0.57	276
7	44,009	$834	$193.32	45.4%	0.002	54.96	211.90	24.0%	102	2.3	16.7	8.9	124	384	245	0.74	0.51	0.51	237
8	46,486	$1,547	$379.79	40.7%	0.001	104.32	405.72	24.2%	86	3.4	21.2	13.0	160	457	336	0.68	0.45	0.48	210
9	48,518	$3,478	$897.57	36.1%	0.001	160.41	871.92	17.9%	60	5.0	30.4	18.8	220	619	446	0.59	0.36	0.41	159
10	50,314	$28,362	$4,976.33	31.2%	0.001	412.20	6,547.62	9.6%	44	30.3	124.8	77.5	909	2,134	1,633	0.41	0.22	0.28	110
All:	418,349	$4,184	$784.64	49.3%	0.009	89.78	971.70	18.7%	164	8.3	40.4	24.1	297	783	554	0.69	0.47	0.47	223

Panel B: Sorted by Daily Cost to Borrow Score (DCBS)

DCBS	N	Mkt Cap ($M)	Volume ($M)	Ann Vol (%)	Spread	Demand ($M)	Supply ($M)	Util (%)	Lending Fee (bps)	Pair Vol	Call Vol	Put Vol	Pair Open Int	Call Open Int	Put Open Int	Pair Spread	Call Spread	Put Spread	Option Implied Fee (bps)
N/A	1,706	$4,536	$1,015.39	42.0%	0.002	N/A	N/A	N/A	N/A	14.7	83.0	39.1	894	2,295	1,277	0.61	0.40	0.39	196
1	320,418	$5,261	$965.15	43.1%	0.006	103.21	1,232.65	12.8%	38	7.9	38.8	23.3	276	732	524	0.68	0.46	0.48	174
2	34,740	$1,055	$273.11	62.7%	0.019	53.81	205.47	26.3%	147	8.5	46.2	26.3	365	964	682	0.71	0.52	0.44	271
3	19,796	$375	$127.88	67.6%	0.019	40.91	52.76	33.4%	270	6.4	38.2	21.7	328	854	616	0.72	0.54	0.43	337
4	12,794	$310	$111.64	72.1%	0.020	39.02	44.31	39.2%	433	8.0	43.6	24.3	348	927	629	0.72	0.56	0.43	417
5	8,332	$291	$109.06	74.7%	0.021	37.78	39.78	43.1%	652	8.2	40.2	24.5	338	940	604	0.75	0.57	0.45	532
6	5,894	$320	$131.99	79.0%	0.017	44.48	45.35	53.4%	923	8.0	41.6	24.5	388	1,038	711	0.74	0.58	0.44	645
7	5,235	$330	$117.80	80.4%	0.017	41.23	39.98	55.5%	1,284	8.6	43.1	24.1	393	1,007	682	0.76	0.61	0.44	769
8	2,874	$418	$221.31	84.1%	0.015	56.44	52.47	62.4%	1,767	20.0	68.5	39.6	523	1,252	857	0.71	0.57	0.39	1,002
9	2,839	$335	$153.00	85.8%	0.014	42.48	38.92	67.0%	2,279	19.2	62.6	40.2	589	1,312	1,026	0.74	0.59	0.41	1,220
10	3,721	$218	$120.82	91.3%	0.013	21.89	19.04	72.7%	2,950	36.4	100.8	63.9	766	1,898	1,139	0.77	0.64	0.42	1,672
All:	418,349	$4,184	$784.64	49.3%	0.009	89.78	971.70	18.7%	164	8.3	40.4	24.1	297	783	554	0.69	0.47	0.47	223

Table III
Stock Loan Fees, Option-Implied Loan Fees, and Regulatory Regimes

Data is monthly from July 2006 to December 2015. The "Early Regime" is pre-July 2008 when the OMM Exception was in place. The "Middle Regime" is between November 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. Sample includes only stocks with both traded options and stock loan fee data. Results include only three and six month symmetric windows around each event, omitting the event month(s). Omitted months are July-Nov 2008 for Early-Middle, August 2013 for Middle-Late, and July 2008 - Aug 2013 for Early-Late. The treatment variable is utilization above 60%, which represents 8.1% of the sample, and the most hard-to-borrow stocks. Untreated is 84% of the sample that is cheap to borrow. The dependent variable in models 1-3 is the logged loan fee. In models 4-6, it is the logged option implied fee. In models 7-9, it is Loan Fee - OI Fee. Util is the indicator for the treatment variable. The Regime indicator is omitted due to collinearity with the month-industry FE, which more rigorously control for time-based effects. Specifications include firm and month-industry fixed effects, and standard errors are clustered by firm and month-industry. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Three Month Symmetric Window

	Loan Fee			Option Implied Fee			Loan Fee - Opt Impl Fee		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ear-Mid	Mid-Late	Ear-Late	Ear-Mid	Mid-Late	Ear-Late	Ear-Mid	Mid-Late	Ear-Late
Regime × Util	0.5218***	0.0531	0.3069*	0.9595***	-0.2084**	0.6662***	-0.4088***	0.2097**	-0.4397***
	(7.96)	(0.76)	(1.97)	(10.72)	(-2.12)	(3.93)	(-3.69)	(2.31)	(-3.16)
Util	0.7313***	1.1258***	1.4221***	-0.1763*	0.6958***	0.4878***	1.0716***	0.5246***	1.0368***
	(9.88)	(8.70)	(18.97)	(-1.93)	(3.97)	(4.88)	(10.25)	(3.39)	(10.35)
Observations	9,415	12,241	10,957	6,092	4,961	6,092	6,043	4,951	6,047
R Squared	0.93	0.96	0.91	0.66	0.58	0.65	0.6	0.47	0.6
Firm-Spec Clusters	1,940	2,275	2,595	1,461	1,244	1,758	1,451	1,241	1,749
Time-Ind Clusters	60	60	60	60	60	60	60	60	60
Panel B: Six Month Symmetric Window									
Regime × Util	0.5789***	0.0009	0.3236**	1.0313***	-0.1362	0.6936***	-0.4279***	0.1057	-0.3617***
	(8.23)	(0.01)	(2.51)	(12.07)	(-1.43)	(4.26)	(-4.79)	(1.34)	(-2.71)
Util	0.7523***	1.3800***	1.3290***	-0.1884**	0.7620***	0.4345***	1.0345***	0.7116***	0.9588***
	(14.46)	(14.60)	(20.29)	(-2.50)	(6.71)	(4.85)	(11.64)	(6.21)	(10.94)
Observations	19,091	24,144	21,958	11,938	9,929	12,047	11,844	9,915	11,960
R Squared	0.91	0.94	0.9	0.58	0.5	0.57	0.51	0.38	0.52
Firm-Spec Clusters	2,131	2,395	2,774	1,677	1,563	2,112	1,669	1,560	2,102
Time-Ind Clusters	120	120	120	120	120	120	120	120	120

Table IV
Showing the Effects of a Supply Shock

Data is monthly from July 2006 to December 2015. The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. The dependent variable is the loan fee, logged. Models 1-3 are only among stocks with traded options; models 4-6 are only among stocks that do not have traded options; models 7-9 are the pooled sample.
Demand/Supply are the monthly average of daily demand/supply divided by shares outstanding. Market Cap is logged market capitalization. Specifications include firm and month-industry fixed effects, and standard errors are clustered by firm and month-industry. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

	(1) Early-Middle	(2) Middle-Late	(3) Early-Late
Regime $\times$ Demand	1.6796***	-0.1732	1.2542***
	(7.11)	(-0.63)	(3.20)
Demand	3.9033***	5.7574***	3.9351***
	(18.45)	(25.11)	(16.00)
Supply	-2.3963***	-2.2216***	-2.3873***
	(-17.32)	(-15.27)	(-14.89)
Market Cap	-0.1386***	-0.1242***	-0.0958***
	(-8.56)	(-7.25)	(-4.98)
Observations	146,428	153,760	75,448
R Squared	0.77	0.80	0.82
Firm Clusters	3,275	3,246	3,417
Time-Ind Clusters	750	860	470

Table V
Increase in Stock Loan Supply

Data is monthly from July 2006 to December 2015. The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. The dependent variable is the Supply Ratio (Shares Supplied/Shares Outstanding), logged. Sample includes only stocks with both traded options and stock loan fee data. Samples include a three/six/twelve month symmetric window around each event for Panels A/B/C, respectively, omitting the event month(s). Omitted months are July-Nov 2008 for Early-Middle, August 2013 for Middle-Late, and July 2008 - Aug 2013 for Early-Late. The treatment variable is utilization above 60%, which represents 8.1% of the sample, and the most hard-to-borrow stocks. Untreated is 84% of the sample that is cheap to borrow. Util is the indicator for the treatment variable, but its coefficient estimates are omitted for visual clarity. The Regime indicator is omitted from the specification due to collinearity with the month-industry FE, which more rigorously control for time-based effects. Specifications include firm and month-industry fixed effects, and standard errors are clustered by firm and month-industry. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Three Month Symmetric Window

	(1) Early-Middle	(2) Middle-Late	(3) Early-Late
Regime × Util	0.0335	0.0378*	0.1564**
	(1.11)	(1.83)	(2.30)
Observations	9,415	12,241	10,957
R Squared	0.95	0.98	0.92
Firm-Spec Clusters	1,940	2,275	2,595
Time-Ind Clusters	60	60	60

Panel B: Six Month Symmetric Window

Regime × Util	0.0441	0.0583**	0.1136*
	(1.42)	(2.45)	(1.82)
Observations	19,091	24,144	21,958
R Squared	0.93	0.96	0.92
Firm-Spec Clusters	2,131	2,395	2,774
Time-Ind Clusters	120	120	120

Panel C: Twelve Month Symmetric Window

Regime × Util	0.0527*	0.0988***	0.1237**
	(1.68)	(3.45)	(2.09)
Observations	39,376	47,965	44,428
R Squared	0.90	0.93	0.90
Firm-Spec Clusters	2,410	2,657	3,117
Time-Ind Clusters	240	240	240

Table VI
Difference-in-Difference Analyzing Price Efficiency

Data is monthly from July 2006 to December 2015. The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. The first difference is around regulatory events that define these regimes. The treatment variable is stock specialness, defined as a month having at least 19 days of daily loan fee above 100 bps. The dependent variable is and Delay2 variable in Hou and Moskowitz (2005), based on coefficient estimates. Models 1-3 are estimated in six month symmetric windows, models 4-6 are estimated in twelve month symmetric windows, omitting the event month(s). Omitted months are July-Nov 2008 for Early-Middle, August 2013 for Middle-Late, and July 2008 - Aug 2013 for Early-Late. Specifications include firm and month-industry fixed effects, and standard errors are clustered by firm and month-industry. The Regime indicator is omitted because month-industry FE are collinear with it. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

	Six Month Window			Twelve Month Window		
	(1)	(2)	(3)	(4)	(5)	(6)
	Early-Middle	Middle-Late	Early-Late	Early-Middle	Middle-Late	Early-Late
Regime × Special	0.0035	0.0140	0.0930***	-0.0044	0.0080	0.0730***
	(0.29)	(1.21)	(4.62)	(-0.40)	(0.71)	(4.47)
Special	0.0107	-0.0100	0.0070	0.0208**	0.0115	0.0011
	(0.85)	(-0.54)	(0.56)	(2.12)	(1.05)	(0.11)
Observations	19,690	24,446	22,225	41,065	48,595	45,460
R Squared	0.64	0.67	0.66	0.59	0.58	0.55
Firm-Spec Clusters	2,105	2,337	2,741	2,387	2,564	3,024
Time-Ind Clusters	120	120	120	240	240	240

Table VII
Difference-in-Difference Analyzing Price Efficiency: Asymmetric Measure

Data is monthly from July 2006 to December 2015. Delay is measured asymmetrically, including the current plus four lags of negative and positive market returns, respectively (ten explanatory variables total). Positive market returns have any negative market returns set to zero. Negative market returns have any positive market returns set to zero. The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. The first difference is around regulatory events that define these regimes. The treatment variable is stock specialness, defined as a month having at least 19 days of daily loan fee above 100 bps. The dependent variable is and Delay2 variable in Hou and Moskowitz (2005), based on coefficient estimates. Positive Delay2 is based on coefficients from the positive market return, Negative Delay2 is based on coefficients from the negative market return. Models 1-3 are estimated in six month symmetric windows, models 4-6 are estimated in twelve month symmetric windows, omitting the event month(s). Omitted months are July-Nov 2008 for Early-Middle, August 2013 for Middle-Late, and July 2008 - Aug 2013 for Early-Late. Specifications include firm and month-industry fixed effects, and standard errors are clustered by firm and month-industry. The Regime indicator is omitted because month-industry FE are collinear with it. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Positive Delay2 Measure

	Six Month Window			Twelve Month Window		
	(1)	(2)	(3)	(4)	(5)	(6)
	Early-Middle	Middle-Late	Early-Late	Early-Middle	Middle-Late	Early-Late
Regime × Special	-0.0184	0.0222*	0.0242	-0.0019	0.0143	0.0235
	(-1.13)	(1.71)	(0.99)	(-0.13)	(1.12)	(1.34)
Special	0.0104	-0.0355**	0.0205	0.0300**	-0.0128	0.0212*
	(0.65)	(-2.24)	(1.26)	(2.54)	(-1.22)	(1.68)
Observations	19,724	24,492	22,273	41,128	48,717	45,578
R Squared	0.55	0.64	0.63	0.49	0.52	0.52
Firm-Spec Clusters	2,109	2,341	2,748	2,389	2,570	3,034
Time-Ind Clusters	120	120	120	240	240	240

Panel B: Negative Delay2 Measure

	Three Month Window			Six Month Window		
	(1)	(2)	(3)	(4)	(5)	(6)
	Early-Middle	Middle-Late	Early-Late	Early-Middle	Middle-Late	Early-Late
Regime × Special	0.0598***	0.0068	0.0900***	0.0457***	0.0005	0.0801***
	(4.02)	(0.58)	(4.07)	(3.58)	(0.05)	(4.83)
Special	-0.0299*	-0.0096	-0.0443***	-0.0255**	0.0101	-0.0388***
	(-1.94)	(-0.55)	(-3.13)	(-2.23)	(0.97)	(-3.48)
Observations	19,724	24,492	22,273	41,128	48,717	45,578
R Squared	0.58	0.62	0.62	0.55	0.52	0.52
Firm-Spec Clusters	2,109	2,341	2,748	2,389	2,570	3,034
Time-Ind Clusters	120	120	120	240	240	240

Table VIII
Mispricing: Return Predictability

Data is monthly from July 2006 to December 2015. The "Early Regime" is pre-Sept 2008 when the OMM Exception was in place. The "Middle Regime" is between September 2008 and August 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. July-Nov 2008 and August 2013 are omitted. Hard-to-borrow is defined as 19 days (or more) above 100 bps, 200 bps or the 95th percentile in Panel A, B, and C, respectively. Returns listed are Fama-French 3 factor abnormal returns (raw return less portfolio return), and are measured in the subsequent month after hard-to-borrow is defined. The sample includes stocks with traded options or not as indicated. Differences are between hard-to-borrow and easy-to-borrow stocks.

Panel A: Hard-to-borrow defined as 19 days in a month with fees 100 bps or more.

		Hard-to-Borrow		Easy-to-Borrow		Difference	T-statistic	p value
Loans Only	Late	-0.38%	10,373	0.46%	16,246	0.84%	2.76	0.0059
	Middle	-0.50%	15,576	0.75%	47,976	1.25%	5.96	<.0001
	Early	-1.10%	2,902	-0.10%	18,798	1.00%	2.83	0.0046
Opts + Loans	Late	-1.94%	5,180	-0.13%	44,476	1.80%	6.95	<.0001
	Middle	-0.34%	8,584	0.21%	77,587	0.55%	2.72	0.0066
	Early	-2.12%	1,763	0.05%	20,799	2.17%	5.14	<.0001

Panel B: Hard-to-borrow defined as 19 days in a month with fees 200 bps or more.

		Hard-to-Borrow		Easy-to-Borrow		Difference	T-statistic	p value
Loans Only	Late	-0.64%	7,503	0.58%	25,178	1.22%	3.24	0.0012
	Middle	-0.75%	11,437	0.92%	68,473	1.66%	6.48	<.0001
	Early	-1.49%	1,529	-0.22%	29,073	1.27%	2.46	0.0139
Opts + Loans	Late	-2.52%	3,431	-0.18%	47,735	2.34%	7.14	<.0001
	Middle	-0.63%	5,305	0.24%	84,468	0.86%	3.07	0.0022
	Early	-1.78%	937	-0.09%	24,256	1.69%	2.84	0.0046

Panel C: Hard-to-borrow defined as avg monthly fee above the 95th pctile.

		Hard-to-Borrow		Easy-to-Borrow		Difference	T-statistic	p value
Loans Only	Late	-0.60%	5,711	0.49%	26,970	1.09%	2.32	0.0205
	Middle	-0.34%	16,523	0.94%	63,387	1.28%	5.97	<.0001
	Early	-0.60%	5,435	-0.22%	25,167	0.38%	1.28	0.2022
Opts + Loans	Late	-2.61%	2,468	-0.22%	48,698	2.39%	6.11	<.0001
	Middle	-0.49%	6,186	0.23%	83,587	0.73%	2.76	0.0058
	Early	-1.80%	1,950	-0.02%	23,243	1.79%	4.42	<.0001

Table IX
Multivariate Specification of Return Predictability by Regulatory Regime.

The "Early Regime" is pre-July 2008 when the OMM Exception was in place. The "Middle Regime" is between November 2008 and July 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. Omitted months are July-Oct 2008 and August 2013. The dependent variable in all specifications is the t+1 monthly return in excess of the risk free rate. Special is defined as avg monthly fee above the 95th pctile. All control variables are computed at time t, all except return are logged. Book to Market is the book value of equity divided by the market value of equity. Market Cap is market capitalization. Spread is the spread divided by the midpoint. Volatility is computed over the previous 21 days, annualized. Lag Returns is the time t stock return. The specification follows Fama and MacBeth (1973) and includes 109 monthly cross-sectional regressions summarized below. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

	Early Regime		Middle Regime		Late Regime	
	(1)	(2)	(3)	(4)	(5)	(6)
	Returns	Returns	Returns	Returns	Returns	Returns
Special	-0.0088***	-0.0068***	-0.0159***	-0.0176***	-0.0179***	-0.0124**
	(-4.35)	(-3.65)	(-5.17)	(-7.04)	(-3.04)	(-2.51)
Book to Market	-0.0165***	-0.0173***	-0.0149***	-0.0160***	-0.0151***	-0.0171***
	(-7.78)	(-8.35)	(-11.09)	(-11.66)	(-5.64)	(-6.51)
Market Cap	-0.0007	-0.0019	-0.0049***	-0.0044***	-0.0025**	-0.0032*
	(-0.78)	(-1.46)	(-4.79)	(-4.45)	(-2.27)	(-2.01)
Stock Spread		-0.0005		-0.0002		0.0021
		(-0.21)		(-0.09)		(0.99)
Volatility		-0.0089**		0.0051		-0.0171***
		(-2.28)		(0.76)		(-3.41)
Lag Returns		-0.0312		-0.0436***		-0.0302**
		(-1.39)		(-3.95)		(-2.14)
Observations	78,633	78,353	194,313	193,809	58,665	58,337
R Squared	0.02	0.04	0.02	0.05	0.03	0.06

Table X
Comparing Return Predictability by Regulatory Regime.

The "Early Regime" is pre-July 2008 when the OMM Exception was in place. The "Middle Regime" is between November 2008 and July 2013 when reverse conversions were the only method to use option markets to short stocks. The "Late Regime" is Sept 2013 to Dec 2015 and represents the current state. Omitted months are July-Oct 2008 and August 2013. Models 1-4 are on the subsample of stocks with options, Models 5-8 on those with no options. The dependent variable in all specifications is the t+1 monthly return in excess of the risk free rate. Regime indicators are set for that regime, and zero for the Early Regime only, missing for third regime. Special is defined as avg monthly fee above the 95th pctile. All control variables are computed at time t, all except return are logged. Book to Market is the book value of equity divided by the market value of equity. Market Cap is market capitalization. Spread is the spread divided by the midpoint. Volatility is computed over the previous 21 days, annualized. Lag Returns is the time t stock return. Firm fixed effects included, standard errors clustered by firm and month. T-statistics are in parentheses. ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.

	Stocks with Options				Stocks with No Options			
	Middle vs Early		Late ve Early		Middle vs Early		Late ve Early	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Returns
Special × Regime	-0.0240**	-0.0230**	-0.0344***	-0.0313**	-0.0174***	-0.0194***	-0.0088	-0.0098
	(-2.26)	(-2.25)	(-2.96)	(-2.60)	(-2.75)	(-3.11)	(-0.94)	(-0.99)
Special	0.0170*	0.0167*	0.0209**	0.0201**	-0.0001	0.0010	0.0017	0.0034
	(1.99)	(1.86)	(2.38)	(2.33)	(-0.01)	(0.17)	(0.33)	(0.67)
Regime	0.0086	0.0092	0.0180	0.0146	-0.0041	-0.0023	0.0151*	0.0142
	(0.70)	(0.66)	(1.43)	(1.19)	(-0.40)	(-0.23)	(1.69)	(1.61)
Book To Market	-0.0420***	-0.0432***	-0.0312***	-0.0323***	-0.0468***	-0.0483***	-0.0406***	-0.0420***
	(-6.55)	(-6.69)	(-5.34)	(-5.57)	(-9.25)	(-8.95)	(-6.76)	(-7.06)
Market Cap	-0.0679***	-0.0706***	-0.0422***	-0.0448***	-0.0841***	-0.0921***	-0.0680***	-0.0715***
	(-4.52)	(-6.92)	(-6.84)	(-6.95)	(-7.07)	(-8.75)	(-10.20)	(-11.28)
Spread		-0.0003		-0.0027		-0.0052		-0.0041
		(-0.04)		(-0.76)		(-1.30)		(-1.18)
Volatility		-0.0047		-0.0082		-0.0086		-0.0120**
		(-0.34)		(-1.04)		(-0.93)		(-2.41)
Lag Return		-0.0408		-0.0702***		-0.0581***		-0.0903***
		(-1.28)		(-3.27)		(-3.14)		(-5.46)
Observations	153,681	153,629	82,370	82,328	118,851	118,094	54,491	53,885
R Squared	0.07	0.08	0.08	0.09	0.09	0.10	0.11	0.12
Firm Clusters	3,244	3,244	3,371	3,371	3,955	3,905	3,615	3,551
Time-Ind Clusters	81	81	52	52	81	81	52	52