When Leverage Ratio Meets Derivatives: Running Out Of Options? *

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Abstract

This paper examines the impact of Basel III leverage ratio on the competitive landscape of US derivatives markets. Because the leverage ratio focuses on notional amounts and does not fully recognize offsetting positions and risk-mitigating collateral, it is more likely the binding constraint for derivatives. The leverage ratio also put heterogeneous constraints on different types of institutions and activities. Using daily positions of clearing members and their customers on S&P 500 E-mini futures options, we test the following four hypotheses when the public disclosure of the leverage ratio became mandatory in January 2015: (1) banks lose market share to nonbanks; (2) US banks lose market share to European banks; (3) banks' clearing activities shift away from customer accounts to house accounts; (4) low-delta options are affected most by the leverage ratio. All hypotheses are confirmed in the data. Short-dated US Treasury futures options, which receive zero exposure in the leverage ratio calculation, do not exhibit such behavior. Our evidence suggests that the leverage ratio requirement pushes derivatives activities toward less constrained institutions and market segments.

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1 Introduction

In the wake of the global financial crisis of 2008–2009, Basel III introduced a more comprehensive set of capital and liquidity requirements for banks in order to address shortcomings in the pre-crisis capital framework and improve the resilience of the financial system. In addition to higher standards for the risk-based capital ratios and the credit quality of capital, the Basel committee also issued the Basel III leverage ratio framework as a simple, transparent, non-risk based approach to pair with the risk-based standards. Though US banks have long been subject to a less comprehensive leverage ratio that requires capital only against on-balance-sheet assets, Basel III expands it by including off-balance-sheet exposure for derivatives and a few other businesses in the leverage calculation. Therefore, the Basel III leverage ratio significantly increases the capital requirement for banks' derivatives activities.

In this paper, we study how the leverage ratio requirement affects behavior in US derivatives markets as well as the associated shift in their competitive landscape. As described in more detail in Section 2, the method for calculating leverage ratio during our sample period is the Current Exposure Method (CEM), developed in 1988. Exposure measure calculated from CEM could deviate from the underlying risk of a derivative portfolio in several ways. First, the leverage ratio calculation is based on the notional size of a derivative trade, which may or may not have high correlation with its risk. Second, total exposure under the leverage ratio requirement does not fully recognize netting across derivatives trades. Thus, a derivatives portfolio with a large number of distinct, yet highly correlated, instruments could have a low risk (due to netting) but a substantially higher total exposure as determined by the leverage ratio requirement. Finally, despite its role as a risk mitigant, initial margin posted by a customer to its clearing bank to back up derivative trades does not offset the "potential future exposure" of the clearing bank in the leverage ratio calculation; in fact, if a customer's initial margin is posted as cash, it is considered an on-balance-sheet asset of the clearing bank, which increase the total exposure of the bank for its leverage calculation.

As a result, many market participants have argued that the Basel III leverage ratio has effectively become the binding constraint in many derivatives businesses, especially those with low risks. This constraint has increased the cost of offering customer clearing services and in some cases made it difficult for certain customers to access central clearing altogether. For example, the number of institutions acting as direct members of clearinghouses and providing customers access to clearing, known as Futures Commission Merchants (FCMs) in the US, has decreased from 84 at the beginning of 2008 to 55 at the beginning of 2018, according to the recent Derivatives Assessment Team (DAT) consultative report, commissioned by the Financial Stability Board (2018). The same report also finds that 72% of surveyed client clearing service providers identify the leverage ratio as a disincentive to central clearing. As a result, many customers face restrictions in their clearing activity and higher costs of clearing; some are even "off-boarded" by their clearing banks.[1] These developments have, in an unexpected fashion, conflicted with the G-20's commitment in 2009 to reform OTC derivatives market by mandating central clearing for standardized OTC derivatives.

Motivated by these concerns and survey evidence, the objective of this paper is to empirically examine the effect of the Basel III leverage ratio requirement on US derivatives markets. To do so, we focus on futures options markets, for a number of reasons. First, notional amounts in options tend to have low correlations with risks, which increases the likelihood that the leverage ratio comes in as a separate constraint that is orthogonal to risk-based capital requirement and risk-based margin methodology of the clearinghouses. In particular, option activities span many strikes and maturities, with out-of-the-money options most likely to be constrained by the leverage ratio due to their low risk (as their value is close to zero). Second, exchange-traded options have been cleared long before the financial crisis, hence not affected by the post-crisis reform of OTC derivatives markets such as mandatory central clearing. Third, the futures options markets are highly liquid and attract many types of investors and intermediaries, which increase the heterogeneity of our sample and hence the power of the tests.

Following the publication of Basel III leverage ratio framework (see Basel Committee on Banking Supervision (2014a)), mandatory quarterly public disclosure for the Basel III leverage ratio requirement started in January 2015 to allow for calibration and comparison across institutions. We compare the activities before and after this date, under the rationale that such public disclosure encourages banks to move toward the compliance of the leverage ratio to signal their strength. Our sample period is from February 2013 to January 2018. (January 2018 was also the effective date of Basel III leverage ratio.)

For identification, we explore the important institutional feature that the leverage ratio requirements are heterogeneous across regions and institution types. The heterogeneity enables us to use the difference-in-difference technique. We test the following five predictions.

Prediction 1. The leverage ratio affects banks more than nonbanks. While FCMs

[1]See Financial Stability Board (2018) and FCMs try to 'off-board' credit and commodity funds, *Risk*, July 30, 2015.

affiliated with banks are subject to the Basel III leverage requirement (in addition to other Basel III requirements), nonbank FCMs in the US are subject to the CFTC's net liquid asset approach. The latter requires capital to be at least 8% of margin, which is generally a risk-based measure.

Prediction 2. The leverage ratio affects US banks more than European banks. While the leverage ratio is benchmarked at 3% of total leverage exposure in Europe as recommended by Basel III, the US supplementary leverage ratio (SLR) is set at 5%–6% for US G-SIBs and their subsidiaries. US banks that are not GSIBs are subject to 3% leverage ratio, the same as European banks.

Prediction 3. The leverage ratio affects customer activity more than house activity. As mentioned above, a clearing bank that guarantees a customer's performance at the clearinghouse cannot use the customer's posted margin to reduce its leverage ratio measure. In fact, cash margin posted by customers to bank FCMs is typically treated as on-balance-sheet exposure of the bank and is also counted toward the bank's leverage calculation. This treatment effectively increases the cost of providing customer clearing services, relative to trading on the FCM's house account.

Prediction 4. The leverage ratio affects low (absolute) delta options more than high (absolute) delta options. Options with low delta have low market value, low market risk, but comparable notional amount to high-delta options. Because the leverage ratio is highly sensitive to notional amount, it is much more likely the binding constraint for low-delta, out-of-the-money options, relative to high-delta, in-the-money options.

Prediction 5. Finally, the leverage ratio has a larger effect on derivatives classes that receive a higher weight in the leverage calculation. As explained in Section 2, under the Current Exposure Method, the conversion factor is a linear multiplier used to convert portfolio notional values to potential future exposure (PFE), which count toward the total exposure of a bank FCM. Clearly, a higher conversion factor translate to a higher PFE. For derivatives with maturity less than a year, equity derivatives have a conversion factor of 6%, while interest rate derivatives have conversion factor of zero (implying zero PFE-related charge).

Our main test asset is the E-mini S&P 500 futures options, which carries a conversion factor of 6% for maturities within one year. We find that all five predictions are confirmed in the data. For example, before January 2015, 46% of all E-mini futures option positions were held in customer accounts at US banks; after the date, this number declines to an average of 36.5%. By contrast, during that same period, customer positions in E-mini futures options cleared through EU banks, which are subject to a lower leverage ratio, increased from 38.6% to 47.9% of the total. US banks have also lost market share to US nonbanks in providing customer clearing services. Moreover, US banks have shifted activities away from customer clearing (toward house activities), relative to US nonbanks and European banks. These shifts in market shares are most evident in low-delta options, which have relatively low risk for a given notional amount. By comparison, these trends are absent in US Treasury futures options, which are subject to a lower leverage ratio requirement.

Official sector and private sector responses

The effect of the leverage ratio in derivatives clearing and in other low-risk activities such as repo has generated much discussion and action among policymakers and market participants.

In response to concerns about the CEM-based leverage methodology, the Basel Committee on Banking Supervision (2017) replaced CEM by the Standardized Approach for Counterparty Credit Risk (SA-CCR) for calculating the leverage ratio, and this change is to be implemented by January 2022.[2] SA-CCR was developed by the Basel Committee on Banking Supervision (2014b) and is more risk-sensitive than the CEM methodology. For example, SA-CCR acknowledges some degree of risk adjustments (e.g. duration for interest rates, delta for options, and volatility) and allows position offset within pre-specified "netting sets." Like CEM, however, SA-CCR does not allow initial margin to offset potential future exposures. The lack of initial margin offset, as many argue, continues to constrain client clearing. In October 2018, the Basel Committee on Banking Supervision (2018) published a consultative document that considers two alternative treatments of client cleared derivatives under the leverage ratio.[3]

US banking regulators (the Federal Reserve, the FDIC, and the OCC) have responded by issuing guidance in 2017 on the treatment of variation margin payments as settlement rather than collateral.[4] Already implemented by major clearinghouses, this "settle-to-market" treatment effectively reduces the maturity of a centrally cleared derivative to one day, hence reducing leverage ratio-based capital. In 2018, the Federal Reserve and the OCC issued a proposal to, among other things, adjust the enhanced supplementary leverage ratio (e-SLR) of US G-SIBs from the current 2% of total expo-

[2]Also note that different from risk-based capital requirement, firms are not allowed to use their internal model for the leverage calculation.

[3]For additional discussions of alternative treatment of customer initial margin, see Bourahla, Fialon, Garcia, and Violon (2018) and Basel to propose IM offset in leverage ratio, *Risk*, October 17, 2018.

[4]See Regulatory Capital Treatment of Certain Centrally-cleared Derivative Contracts Under Regulatory Capital Rules, August 14, 2017.

sure to 50% of the relevant G-SIB's risk-based capital surcharge.[5] Similarly, the Basel Committee on Banking Supervision's (2017) update of leverage ratio requirement also includes a leverage ratio buffer on G-SIBs, equal to 50% of a G-SIB's "higher-loss absorbency risk-weighted requirements," to be implemented by January 2022.

In the meantime, market participants have employed a series of methods to reduce capital requirements associated with derivatives, including "portfolio compression,"[6] providing nonbank customers direct access to central clearing,[7] and moving segregated client cash margin off banks' balance sheets.[8] For example, by our estimate, the CME's equity index option compressions from October 2018 to February 2019 have reduced capital requirement of more than $200 million.[9] For more discussion of recent developments around the leverage ratio, see Bourahla, Fialon, Garcia, and Violon (2018).

Contribution to the literature

Our analysis contributes to a growing literature on addressing the impacts of the Basel III leverage ratio on financial markets. At the bank holding company level, Greenwood, Hanson, Stein, and Sunderam (2017) and Duffie (2018) find that the leverage ratio

[5] See Joint notice of proposed rulemaking to modify the enhanced supplementary leverage ratio standards applicable to U.S. global systemically important bank holding companies and certain of their insured depository institution subsidiaries, April 5, 2018.

[6] Portfolio compression replaces many (partly offsetting) derivatives trades by a smaller number of trades with essentially the same market risk, hence reducing the notional amount and the capital requirement. TriOptima is currently the largest provider, although compression services are also offered by Quantile, Capitalab, CBOE, and CME.

[7] Clearinghouses that either offer, or have proposed, direct clearing solutions include ICE Clear Europe, Eurex Clearing, LCH, and CME. In these solutions, the clients usually manage the collateral and margin exchange directly with the clearinghouse, but they still need clearing members (usually banks) to provide guarantee fund contributions and insurance against client default. In such an arrangement, however, the clearing banks' capital costs are not reduced substantially as long as they guarantee the customers' performance to the clearinghouse. An exception is Eurex's model, in which the clearing bank does not guarantee the performance of the customer who is a direct member of the clearinghouse. LCH has also proposed changes to their rule book so that if customers post additional margin, it can offset the customer's clearing bank's guarantee fund contribution.

[8] For example, *Risk* reports that Citi and UBS have removed, or "derecognized" billions of dollars of customer cash margin from the balance sheet by passing on income generated by the cash margin back to customers net of fees. Under this practice, the clearing bank does not guarantee the performance of the clearinghouse, broker, or deposit bank that holds the customers' initial margin, and the customers' cash balance is legally separated from the clearing bank. For more discussions, see UBS takes Sfr4.2bn of client collateral off balance sheet, *Risk*, February 13, 2015; Banks try to copy Citi and UBS clearing leverage cuts, *Risk*, December 17, 2015; and OTC client clearer of the year: Citi, *Risk*, January 27, 2016.

[9] Assuming an average S&P index level of 2885, CME's compression has reduced the notional outstanding of S&P index options by about $145 billion. Equity derivatives have a conversion factor of 6%. Further assuming a leverage ratio of 6% and a net-to-gross ratio of zero, the reduced notional amount reduces equity capital requirement by $145 \times 0.6 \times 0.6 \times 0.4 = \$209$ million.

requirement is the most binding constraint for most US G-SIBs, according to data from the Federal Reserve's stress tests in 2017. The most recent US stress test results in 2018 show a very similar pattern.[10]

To the best of our knowledge, the only other academic paper on the impact of leverage ratio on client clearing is Acosta-Smith, Ferrara, and Rodriguez-Tous (2018). In the interest rate swap markets and using the introduction of the leverage ratio in the UK in January 2016, the authors find that affected UK banks traded with fewer clients and also reduced the average number of transactions with a typical client, relative to non-UK banks not affected by the leverage ratio. The tightening of the leverage ratio in the UK in January 2017[11] also reduced the number of transactions per client, but no significant effect was found on the number of clients served.

A few earlier studies have examined the effect of leverage ratio on repo markets, another market segment that tends to be constrained by the leverage ratio given its low risk. Two papers focus on the US repo markets. Allahrakha, Cetina, and Munyan (2016) find that after the Federal Reserve published its draft supplementary leverage ratio rule in June 2012, bank broker-dealers decrease their overall repo borrowing but increase their relative use of repo backed by riskier collateral such as equity. They also find that nonbank dealers become more active in triparty repos markets backed by Treasuries and agency MBS. Anbil and Senyuz (2018) find that EU banks' "window dressing" behavior—reducing their repo activities around quarter-ends and month-ends, relative to other time periods—became more pronounced after Basel III's leverage ratio disclosure date.[12] Two other papers focus on the UK repo markets. Bicu, Chen, and Elliott (2017) find that after UK regulators announced their version of the leverage ratio in December 2011, banks that are more constrained by the leverage ratio reduced their liquidity provision in gilt and gilt repo markets, but the effect is not statistically significant. Using the recent tightening of the leverage ratio in the UK in January 2017, Kotidis and van Horen (2018) find that affected banks reduced repo volume with their clients, especially small clients, relative to banks not affected by the rule. Affected dealers also reduced the frequency of transactions and the interest rate paid to their small clients.

[10] See Visuals of 2018 CCAR and DFAST Results, *Davis Polk*, July 3, 2018.

[11] Starting in January 2017, for the purpose of leverage ratio, four large UK banks must measure their on-balance sheet assets by taking the daily average within a quarter, rather than taking the average of three month-end numbers. The broader coverage of days effectively tightens the leverage ratio constraint. See also Kotidis and van Horen (2018).

[12] They use 2014 Q2 as the start of the leverage ratio disclosure date, based on the rationale that the banks' first disclosure in 2015 Q1 must also include three quarters of historical leverage ratios.

2 Basel III and the Leverage Ratio

This section describes the institutional background of the leverage ratio under Basel III. As the leverage ratio requirement continues to evolve as of this writing, the description below focuses on the applicable rules during our sample period, February 2013–January 2018. For additional background materials on the leverage ratio and its impact on derivatives markets, see Financial Stability Board (2018) and Bourahla, Fialon, Garcia, and Violon (2018).

At a high level, the Basel III framework includes capital requirements and liquidity requirements. Included in the capital requirements are a risk-weighted capital ratio, a non-risk-weighted leverage ratio, and the single counterparty credit limit, among others. Included in the liquidity requirements are the liquidity coverage ratio and the net stable funding ratio.

Many of the capital requirements are risk-based. A risk-based capital requirement reflects the risk of the underlying activity, and is often calculated using an internal model or a more standardized risk-based model. Under the risk-based rules, banks that offer derivative clearing service to customers are required to have sufficient capital to account for the credit risk of both the customers and the clearinghouse, the banks' default fund contribution to the clearinghouse, market risk, and operational risk.

The Basel III leverage ratio is designed to be a backstop to the risk-based standard. It is defined as Tier 1 capital as a percentage of total leverage exposure. Though Basel Committee on Banking Supervision (2014a) proposed a 3% minimum leverage ratio,[13] US regulators set a higher leverage ratio, known as the supplementary leverage ratio (SLR). Specifically, US G-SIBs must maintain an SLR of at least 5% on a consolidated basis, and their depository subsidiaries must maintain an SLR of at least 6%.[14]

The denominator of the Basel III leverage ratio, the total leverage exposure, includes both on-balance-sheet assets and off-balance-sheet exposure for derivatives. Important for our purposes, on-balance-sheet assets include segregated client cash collateral. That is, any cash margin posted by the client, which effectively reduces credit exposure, actually increases the capital requirement through the leverage ratio. Treating client cash margin as on-balance-sheet exposure increases the banks' cost of providing clearing services to customers.

More specifically, off-balance-sheet exposures for the derivatives book are derived using the Current Exposure Method (CEM), which was developed in 1988. Under

[13] In December 2017, Basel Committee on Banking Supervision (2017) added, among other items, a leverage ratio buffer on G-SIBs. The revised version of leverage ratio is to be implemented by January 2022.

[14] See Supplementary Leverage Ratio, Davis Polk, September 2014.

the CEM, off-balance sheet exposure is defined as the sum of Current Exposure (CE) and Potential Future Exposure (PFE). CE is the net Mark-to-Market (MTM) value of derivatives within a given "netting set," and it can be offset by variation margin payments. For cleared derivatives, CE is effectively zero, since variation margin is posted on a daily basis.

Table 1: Conversion factors for equity and interest rate derivatives under the Current Exposure Method

Remaining Maturity	Equity	Interest Rate
$\leq$ 1 year	6%	0%
$>$ 1 year & $\leq$ 5 years	8%	0.5%
$>$ 5 years	10%	1.5%

PFE is typically defined as the maximum expected credit exposure over a specified period of time calculated at some level of confidence. Under CEM, PFE is defined using a combination of net and gross risk exposures. Specifically, the CEM methodology defines the PFE of a portfolio as

$$\text{PFE} = 0.4 \times A_{gross} + 0.6 \times NGR \times A_{gross}. \tag{1}$$

Here, A_{gross} is the adjusted gross notional of a portfolio, where the notional of each individual instrument in the portfolio is adjusted by multiplying by the appropriate conversion factor (see Table 1). NGR is the net-to-gross ratio, and is defined as the ratio of net current mark-to-market (MTM) value and gross current MTM value of the portfolio. NGR is intended to measure the extent of hedging and netting, but it can be argued that NGR does not properly measure netted risk.[15] Netting is limited here due to the contributions of the first term, $0.4 \times A_{gross}$. In general, highly netted portfolios can reduce the PFE only up to 60%. Unlike the CE calculation, the PFE calculation does not allow for any margin offsets, so the posting of initial margin provides no capital benefit.

To illustrate the CEM methodology, we provide a numerical example on the following hypothetical and simple derivative portfolio. Suppose that the current level of the S&P 500 index is 2500 and a customer of a bank clearing member enters three derivatives trades: (a) buys one call option on the E-mini S&P 500 futures with a strike price of 2500, expiring at the end of the month; (b) shorts one put option with the same

[15] For a discussion of the limitations of NGR, see Giancarlo and Tuckman (2018) p.90.

strike and maturity; and (c) shorts one S&P 500 futures contract at the price of 2500. Given the offsetting payments of these instruments, this portfolio is close to riskless, if held to maturity (the put-call parity).[16] The leverage calculation, however, is quite different. Because a single E-mini futures contract has a notional of 50 times the S&P 500 index value, the portfolio's total gross notional is $3 \times 2500 \times 50 = \$375,000$ and gross PFE is $375,000 \times 0.06 = \$22,500$. According to equation (1), the PFE for the portfolio of three trades is $0.4 \times \$22,500 + 0.6 \times 0 \times \$375,000 = \$9,000$, because the net current MTM value of the portfolio at trade inception is zero. The clearing bank's exposure increases by $9,000 plus whatever initial margin is posted. If the leverage ratio is binding, a US clearing bank would need to raise equity that is equal to 5% or 6% of this exposure. Finally, the customer's cost of clearing this derivative portfolio can be approximated by multiplying the required amount equity by the required return on equity, after adjusting for the profitability that the clearing bank aims to achieve.[17]

3 Data and Summary Statistics

Starting on January 1, 2015, G-SIBs and other large banking institutions were required to make public disclosures related to the Basel III leverage ratio. While the leverage ratio is not yet in effect, it is reasonable to assume that public disclosures still put a reputational constraint on banks. For example, reporting a leverage ratio significantly lower than the required minimum or even the peer average could signal institutional weakness, and negatively impact share prices, funding costs, and business prospects. We thus label days before the January 1, 2015 as "pre-LR" and days after January 1, 2015 as "post-LR." While we believe that the January 1, 2015 date is a reasonable choice, it is important to note that like many other regulations, the leverage rule does not come in as a "big bang," but over an extended period of discussion, consultation, and final adoption.

Our analysis focuses on S&P 500 E-mini futures options and US Treasury futures options. As discussed before, under the CEM methodology, equity derivatives are subject to a much higher conversion factor than Treasury derivatives, so we expect the effect of leverage requirement to be stronger for equity derivatives. Our sample period is from February 2013 to January 2018, for 1,259 trading days. Given the cutoff date of January 1, 2015, there are 477 trading days pre-LR and 782 trading days post-LR.

[16]There is one subtlety here: monthly and weekly options are European, but other options on the E-mini futures contracts are American, not European. For American options, the put-call parity would not hold exactly but only approximately. If the risk-free interest rate is close to zero, the approximation error is small.

[17]See What the Leverage Ratio Means for Clearing Fees - Citi Analysis, *Risk*, November 25, 2014.

The CFTC collects daily information from clearing members on their option positions for each contract. Five data fields uniquely identify each option contract: the option type (American vs European), whether the option is a call or a put, the expiration date of the option, the expiration date of the underlying futures contract, and the option strike price. For the purposes of this report, positions are aggregated at the level of the clearing member, with separate aggregates for the member's house account and the member's customer accounts. Customers are aggregated together into a single group. We classify each clearing member into different categories based on a few different metrics: the jurisdiction of their parent company (US, EU, Asia Pacific), the institution type (banks that clear for customers, nonbanks that clear for customers, and self-clearers who do not hold customer positions), and the account type (house, customer). As discussed earlier, the e-SLR levels are only applicable to US G-SIBs and their banking affiliates, which account for about 99.8% of open positions out of all positions held by US banks. Our results only show US and EU institutions because Asian institutions account for less than 1% of positions. Similarly, we focus on banks and nonbanks that clear for customers because self-clearers account for less than 1% of open positions.

Table 2 reports the market shares of each of the eight "clearing member groups:" $\{\text{US, EU}\} \times \{\text{Bank, nonbank}\} \times \{\text{customer, house}\}$, pre-LR and post-LR, for S&P 500 E-mini futures options and Treasury futures options, including all maturities and all strikes. Numbers below 0.5% are indicated as "-". The market shares are calculated for each group on each trading day and then averaged across days. We observe that the vast majority of option positions sit in customer accounts at US and EU banks. For S&P 500 E-mini futures options, positions in US banks' customer accounts fell from 46.0% of the total pre-LR to 36.5% post-LR, a 9.5% reduction, while positions in EU banks' customer accounts increased from 38.6% to 47.9%; and positions in US nonbank's customer accounts increased from 9.6% to 11.9%. Further, despite US banks losing customer share in S&P 500 E-mini futures options, their market share of US Treasury futures options increased from 32.9% to 37.3%.

The difference between E-mini futures options and Treasury futures options is consistent with the way they are treated in the calculation of leverage ratio. Recall from Table 1 that the conversion factor for interest rate derivatives (including Treasury futures options) with maturity less than a year is 0, contrasting with the higher 6% conversion for equity derivatives. Because actively traded futures options in practice almost always have tenors less than a year, we would expect that higher leverage requirement for US banks would show up in equity options but not in Treasury options.

Panel A of Figure 1 shows the fraction of US customer positions held by banks (vs

Table 2: Market shares of clearing members in S&P 500 E-mini futures options (Panel A) and Treasury futures options (Panel B) by region, bank/nonbank, and customer/house. Pre-LR and post-LR refer to dates before and after the mandatory leverage disclosure date of January 1, 2015, respectively.

Panel A: S&P 500 E-mini Futures Options

	Pre-LR	Post-LR		Pre-LR	Post-LR
US	60.8%	50.7%	EU	39.2%	49.3%
US Bank	46.5%	37.6%	EU Bank	38.6%	48.0%
US Nonbank	14.3%	13.1%	EU Nonbank	0.6%	1.3%
US Bank House	0.5%	1.1%	EU Bank House	-	-
US Bank Customer	46.0%	36.5%	EU Bank Customer	38.6%	47.9%
US Nonbank House	4.7%	1.2%	EU Nonbank House	-	-
US Nonbank Customer	9.6%	11.9%	EU Nonbank Customer	0.6%	1.3%

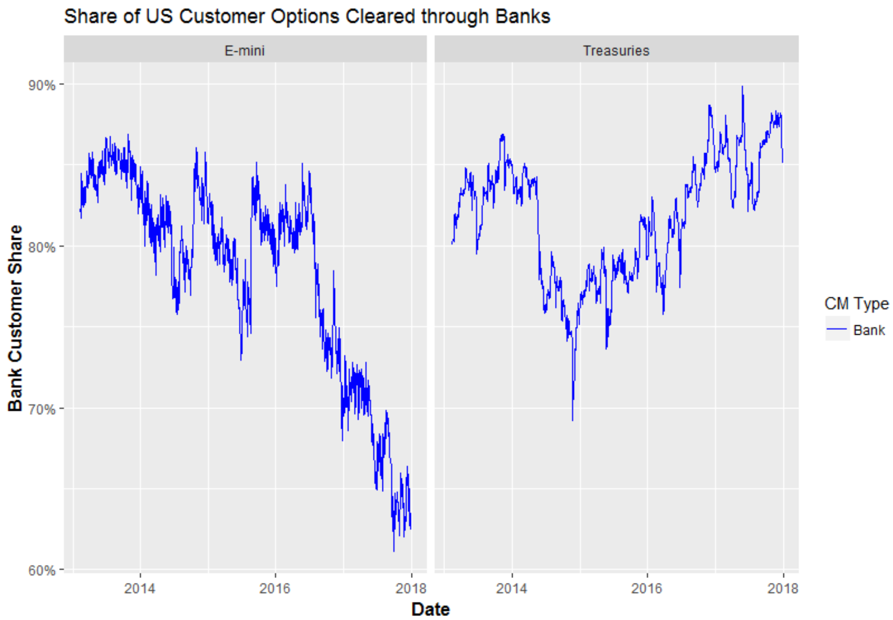
Panel B: US Treasury Futures Options

	Pre-LR	Post-LR		Pre-LR	Post-LR
US	51.0%	52.9%	EU	49.0%	47.1%
US Bank	42.9%	44.9%	EU Bank	47.9%	42.8%
US Non-Bank	8.1%	7.9%	EU Nonbank	1.2%	4.3%
US Bank House	10.0%	7.6%	EU Bank House	4.6%	3.3%
US Bank Customer	32.9%	37.3%	EU Bank Customer	43.2%	39.5%
US Nonbank House	0.5%	-	EU Nonbank House	-	-
US Nonbank Customer	7.6%	7.8%	EU Nonbank Customer	1.1%	4.3%

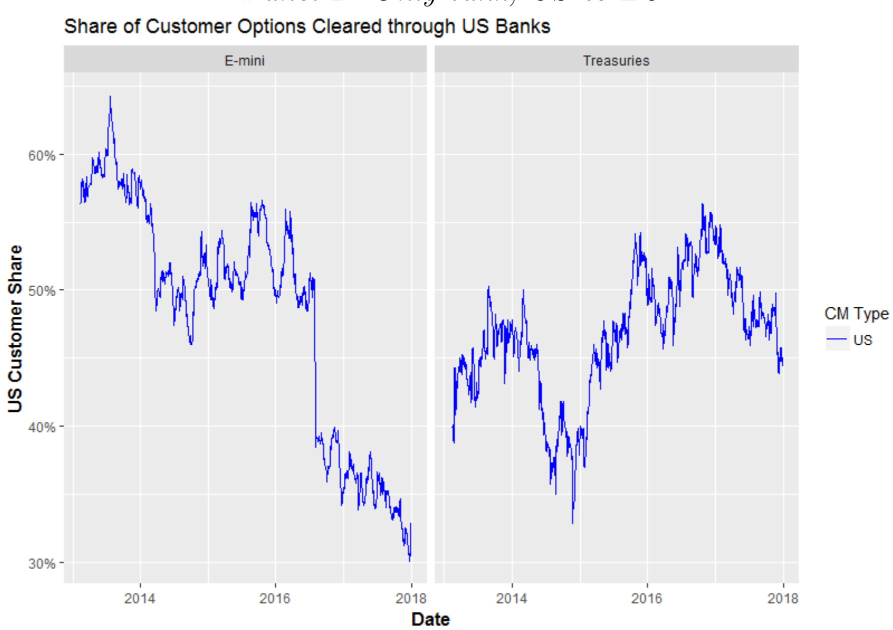
nonbanks) in the E-mini and Treasury futures options contracts. Across the sample period, the banks' market share in customer positions in E-mini options fell significantly from over 85% to just under 65%, while banks' market share in customer positions in Treasury options remained stable. Similarly, panel B of Figure 1 shows the fraction of customer option positions held by US banks (as opposed to EU banks). The US bank market share fell over our sample period, but, once again, we do not see a similar trend in Treasury futures options.

Figure 1: Share of customer option positions on E-mini and Treasury futures

Panel A: Only US, bank vs nonbank



Panel B: Only bank, US vs EU



4 Hypotheses and Empirical Tests

In this section, we conduct formal empirical tests on how the Basel III leverage ratio affects the competitive landscape of US derivatives markets.

For each day t, we aggregate the data into 3 levels of heterogeneity:

- US ($D_{US} = 1$) vs EU ($D_{US} = 0$)
- Bank ($D_{bank} = 1$) vs nonbank ($D_{bank} = 0$)
- Customer ($D_{customer} = 1$) vs house ($D_{customer} = 0$)

Given these aggregations, for each day we aggregate positions in each of the eight groups: {US, EU} × {bank, nonbank} × {customer, house}. For example, we denote by $Z_t(US, bank, customer)$ the total option positions in the {US, bank, customer} category on day t. We can similarly calculate $Z_t(\cdot, \cdot, \cdot)$ for the other 7 categories.

Using these aggregated daily positions, we can compare the market share of these groups in a difference-in-difference sense. The first difference is over time, that is, pre-LR disclosure period versus post-LR disclosure period. For any day t, define

$$D_{post} = \begin{cases} 1, & \text{if } t \text{ is before Jan 1, 2015} \\ 0, & \text{if } t \text{ is on or after Jan 1, 2015} \end{cases}. \tag{2}$$

The second difference exploits the heterogeneous treatment of leverage rule on different types of accounts: US versus EU, bank versus nonbank, and customer versus house. We would expect the shift in market shares to be more pronounced in E-mini options than in Treasury options, given the difference in their conversion factors.

4.1 Customer share

We begin our regressions analysis by examining the shift of derivatives activities between customer and house accounts. Recall that a customer's derivative positions count toward its clearing bank's leverage exposure, with conversion factors given by CEM. Because US banks face higher required leverage ratio than EU banks, we expect that customer positions, as a fraction of total positions, should fall more for US banks than for EU banks in the post-LR period. In addition, because Basel III leverage requirements are imposed on banks, we also expect that customer positions, as a fraction of total positions, should fall more for US banks than for US nonbanks. These two hypotheses are summarized below.

Hypothesis 1. Bank customer positions, as a fraction of total bank positions (customer + house), should fall for US banks relative to EU banks.

Hypothesis 2. US customer positions, as a fraction of total US positions (customer + house), should fall for US banks relative to US nonbanks.

To test Hypothesis 1, we restrict the sample to banks and define, for $i \in \{US, EU\}$,

$$y_{i,t} = \frac{Z_t(i, bank, customer)}{Z_t(i, bank, customer) + Z_t(i, bank, house)}. \tag{3}$$

That is, $y_{i,t}$ represents the fraction of positions dedicated to customer accounts. We then run the regression

$$y_{i,t} = \beta_0 + \beta_1 D_{post} + \beta_2 D_{US} + \beta_3 D_{post} D_{US} + \epsilon_{i,t}, \tag{4}$$

where i indexes region (US or EU) and t indexes the day. All standard errors are Newey-West.

To test Hypothesis 2, we restrict the sample to US institutions and define, for $i \in \{bank, nonbank\}$,

$$y_{i,t} = \frac{Z_t(US, i, customer)}{Z_t(US, i, customer) + Z_t(US, i, house)}. \tag{5}$$

Then, we run regression

$$y_{i,t} = \beta_0 + \beta_1 D_{post} + \beta_2 D_{bank} + \beta_3 D_{post} D_{bank} + \epsilon_{i,t}, \tag{6}$$

where i indexes the type of institution (bank or nonbank) and t indexes the day. The dependent variable $y_{i,t}$, as before, represents the fraction of positions dedicated to customer accounts.

We use E-mini options as our primary test asset, and use Treasury options as a comparison. Tests of Hypotheses 1 and 2 are summarized in Table 3, with the same regressions run on both E-mini options and Treasury options.

Column 1 shows our test of Hypothesis 1 for E-mini options. The key coefficient of interest is the one on the interaction term, $D_{post} D_{US}$. Confirming Hypothesis 1, it is negative and significant, both in statistical and economic terms. The coefficient of -0.021 means that US banks shifted additional 2.1% of their activity away from customer clearing, relative to EU banks.

Our test of Hypothesis 2 for E-mini options is shown in Column 2. Here, the coefficient on the interaction term of US bank activity in the post-LR period is also negative

Table 3: Diff-in-diff regressions for options clearing, customer share

	Customer Share					
	E-mini			Treasuries		
	Bank CM Accts	US Accts	Full	Bank CM Accts	US Accts	Full
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.001***	0.229***	0.017***	0.018***	0.054***	0.014***
	(0.000)	(0.019)	(0.004)	(0.004)	(0.019)	(0.004)
US	−0.009***		−0.309***	−0.134***		−0.048***
	(0.000)		(0.011)	(0.006)		(0.005)
Post × US	−0.021***		0.211***	0.042***		0.040***
	(0.002)		(0.013)	(0.007)		(0.006)
Bank		0.316***	0.016***		−0.169***	−0.083***
		(0.017)	(0.004)		(0.017)	(0.004)
Post × Bank		−0.248***	−0.017***		0.006	0.004
		(0.021)	(0.004)		(0.021)	(0.005)
US × Bank			0.300***			−0.086***
			(0.012)			(0.009)
Post × US × Bank			−0.232***			0.002
			(0.014)			(0.009)
Constant	0.998***	0.673***	0.981***	0.903***	0.937***	0.985***
	(0.000)	(0.017)	(0.004)	(0.003)	(0.017)	(0.004)
Observations	2,518	2,518	5,036	2,518	2,518	5,036
Adjusted R^2	0.687	0.813	0.853	0.845	0.903	0.913

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors are in parentheses.

and significant, confirming Hypothesis 2. US banks moved 24.8% of their activities away from customer clearing, relative to US nonbanks. The economic magnitude is large.

To further strengthen these diff-in-diff regressions, we compare these interaction coefficients for E-mini options to those using US Treasury options (Columns 4 and 5). We see in this case that the interaction coefficient is either significant and positive (Column 4) or insignificant (Column 5). That is, while activities in E-mini options have moved toward entities with lower leverage requirement (US nonbanks and EU banks, relative to US banks), this pattern is not present for Treasury options that have a 0 conversion factor (see Table 1).

As a robustness check, we also run a regression which combines Hypotheses 1 and 2:

$$y_{i,t} = \beta_0 + \vec{\beta} \cdot [D_{post}, D_{US}, D_{bank}, D_{post}D_{US}, D_{post}D_{bank}, D_{US}D_{bank}, D_{post}D_{US}D_{bank}] + \epsilon_{i,t}, \quad (7)$$

where i is US bank, US nonbank, EU bank, or EU nonbank; t is a day; and

$$y_{USbank,t} = \frac{Z_t(US, bank, customer)}{Z_t(US, bank, customer) + Z_t(US, bank, house)}, \tag{8}$$

and likewise for the other three y's.

The results are reported in Column 3 for E-mini options and in Column 6 for Treasury options. The main variable of interest is the coefficient in front of the triple interaction term $D_{post}D_{US}D_{bank}$. As expected, this term is significantly negative for E-mini options but not for Treasury options.

4.2 Bank share

Next, we turn to the market share of banks.

Hypothesis 3. Bank customer positions, as a fraction of total customer positions (bank + nonbank), should fall for US institutions relative to European institutions.

Hypothesis 4. US bank positions, as a fraction of total US positions (bank + nonbank), should fall for customer accounts relative to house accounts.

We test these hypothesis using the following specifications.

To test Hypothesis 3, we restrict attention to customer accounts and run the regression

$$y_{i,t} = \beta_0 + \beta_1 D_{post} + \beta_2 D_{US} + \beta_3 D_{post} D_{US} + \epsilon_{i,t}, \tag{9}$$

where i is US or EU, t is a day, and

$$y_{i,t} = \frac{Z_t(i, bank, customer)}{Z_t(i, bank, customer) + Z_t(i, nonbank, customer)}. \tag{10}$$

To test Hypothesis 4, we restrict attention to US institutions and run the regression

$$y_{i,t} = \beta_0 + \beta_1 D_{post} + \beta_2 D_{customer} + \beta_3 D_{post} D_{customer} + \epsilon_{i,t}, \tag{11}$$

where i is customer or house, t is a day, and

$$y_{i,t} = \frac{Z_t(US, bank, i)}{Z_t(US, bank, i) + Z_t(US, nonbank, i)}. \tag{12}$$

As before, we use the E-mini options as our primary test asset and use Treasury options for comparison. The results are summarized in Table 4. Column 1 reports the test of Hypothesis 3 for E-mini options. The key variable of interest is the coefficient

Table 4: Diff-in-diff regressions for options clearing, bank share

	Bank Share					
		E-mini			Treasuries	
	Cust Accts	US Accts	Full	Cust Accts	US Accts	Full
	(1)	(2)	(3)	(4)	(5)	(6)
Post	−0.015***	0.403***	0.052***	−0.067***	0.037***	0.001***
	(0.002)	(0.038)	(0.018)	(0.006)	(0.005)	(0.000)
US	−0.160***		−0.811***	−0.163***		−0.044***
	(0.004)		(0.017)	(0.006)		(0.001)
Post × US	−0.060***		0.351***	0.077***		0.036***
	(0.011)		(0.035)	(0.012)		(0.002)
Customer		0.717***	0.066***		−0.141***	−0.023***
		(0.013)	(0.019)		(0.011)	(0.001)
Post × Cust		−0.479***	−0.068***		−0.027**	−0.068***
		(0.046)	(0.019)		(0.012)	(0.002)
US × Cust			0.650***			−0.118***
			(0.016)			(0.003)
Post × US × Cust			−0.412***			0.041***
			(0.041)			(0.004)
Constant	0.988***	0.110***	0.921***	0.975***	0.954***	0.998***
	(0.002)	(0.010)	(0.018)	(0.002)	(0.005)	(0.000)
Observations	2,518	2,518	5,036	2,518	2,518	5,036
Adjusted R^2	0.882	0.741	0.846	0.765	0.881	0.885

* p< 0.10, ** p< 0.05, *** p < 0.01; Standard errors are in parentheses.

in front of the interactive term $D_{post}D_{US}$. The negative and significant coefficient of −0.06 indicates that banks' market share in customer clearing (as a fraction of bank plus nonbank) in the US drops by 6% more than that in the EU, confirming Hypothesis 3.

Our test of Hypothesis 4 for E-mini options is reported in Column 2. Here, the coefficient on the interaction term −0.479 is also statistically significant and economically material, indicating that the US banks' share of customer clearing as percent of total US customer clearing (bank plus nonbank) fell 47.9% relative to US banks' share of house activity as a fraction of total US house activity (bank plus nonbank). This confirms Hypothesis 4.

To further strengthen these diff-in-diff regressions, we compare these interaction coefficients for E-mini options to those using US Treasury options (Columns 4 and 5). We see that the interaction coefficient for Treasury options are much less negative (or even positive) than those for E-mini options. Again, the migration of market activity toward entities with lower leverage constraint is clear for E-mini options but not for

Treasury options.

Finally, we run a regression by combining Hypotheses 3 and 4:

$$y_{i,t} = \beta_0 + \vec{\beta} \cdot [D_{post}, D_{US}, D_{customer}, D_{post}D_{US}, D_{post}D_{customer}, D_{US}D_{customer}, D_{post}D_{US}D_{customer}] + \epsilon_{i,t}, \tag{13}$$

where i is US customer, US house, EU customer, or EU house; t is a day; and

$$y_{UScustomer,t} = \frac{Z_t(US, bank, customer)}{Z_t(US, bank, customer) + Z_t(US, nonbank, customer)}, \tag{14}$$

and likewise for the other three y's.

The estimate of interest is the coefficient in front of the triple interaction term, $D_{post}D_{US}D_{customer}$. As expected, this estimate is negative and significant for E-mini options, but it is positive for Treasury options.

4.3 US share

Finally, we consider the market share of US institutions versus EU institutions.

Hypothesis 5. US customer positions, as a fraction of total customer positions (US + EU), should fall for banks relative to nonbanks.

Hypothesis 6. US bank positions, as a fraction of total bank positions (US + EU), should fall for customer accounts relative to house accounts.

We test Hypothesis 5 with the following regression:

$$y_{i,t} = \beta_0 + \vec{\beta} \cdot [D_{post}, D_{bank}, D_{post}D_{bank}] + \epsilon_{i,t}, \tag{15}$$

where i is bank or nonbank (only for customer), t is the day, and

$$y_{i,t} = \frac{Z_t(US, i, customer)}{Z_t(US, i, customer) + Z_t(EU, i, customer)}. \tag{16}$$

Likewise, we test Hypothesis 6 with the following regression:

$$y_{i,t} = \beta_0 + \vec{\beta} \cdot [D_{post}, D_{customer}, D_{post}D_{customer}] + \epsilon_{i,t}, \tag{17}$$

where i is customer or house (only for bank), t is a day, and

$$y_{i,t} = \frac{Z_t(US, bank, i)}{Z_t(US, bank, i) + Z_t(EU, bank, i)}. \tag{18}$$

These two hypotheses can be tested jointly with the following regression:

$$y_{i,t} = \beta_0 + \vec{\beta} \cdot [D_{post}, D_{bank}, D_{customer}, D_{post}D_{bank}, D_{post}D_{customer}, D_{bank}D_{customer}, D_{post}D_{bank}D_{customer}] + \epsilon_{i,t}, \tag{19}$$

where i is bank customer, bank house, nonbank customer, or nonbank house; t is a day; and

$$y_{bankcustomer,t} = \frac{Z_t(US, bank, customer)}{Z_t(US, bank, customer) + Z_t(EU, bank, customer)}, \tag{20}$$

and likewise for the other three y's.

Table 5 shows the results. In Column 1, the negative coefficient of -0.056 on the interactive term $D_{post}D_{bank}$ suggests that the US share of E-mini options on customer clearing drops 5.6% more for banks than for nonbanks, confirming Hypothesis 5. In Column 2, the negative coefficient of -0.182 on the interactive term $D_{post}D_{customer}$ suggests that the US banks' share of E-mini options, as a total of US and EU banks', drops 18.2% more for customer accounts than for house accounts, confirming Hypothesis 6. The magnitude is also large. The triple interactive term in Column 3 is also significantly negative, at -0.134. None of these patterns show up in Treasury options, shown in Columns 4–6. If anything, the coefficients on Treasury options are positive.

Table 5: Diff-in-diff regressions for options clearing, US share

	US Share					
		E-mini			Treasuries	
	Cust Accts	Bank Accts	Full	Cust Accts	Bank Accts	Full
	(1)	(2)	(3)	(4)	(5)	(6)
Post	−0.053***	0.074***	−0.005***	−0.207***	0.013*	−0.050***
	(0.008)	(0.014)	(0.001)	(0.023)	(0.008)	(0.011)
Bank	−0.404***		−0.137***	−0.443***		−0.289***
	(0.006)		(0.010)	(0.010)		(0.007)
Post × Bank	−0.056***		0.078***	0.260***		0.063***
	(0.017)		(0.011)	(0.024)		(0.014)
Customer		−0.316***	−0.048***		−0.248***	−0.094***
		(0.014)	(0.005)		(0.010)	(0.007)
Post × Cust		−0.182***	−0.048***		0.041***	−0.156***
		(0.022)	(0.007)		(0.012)	(0.017)
Bank × Cust			−0.267***			−0.154***
			(0.009)			(0.011)
Post × Bank × Cust			−0.134***			0.198***
			(0.017)			(0.019)
Constant	0.951***	0.862***	0.999***	0.876***	0.682***	0.970***
	(0.007)	(0.012)	(0.000)	(0.010)	(0.006)	(0.005)
Observations	2,518	2,518	5,036	2,518	2,518	5,036
Adjusted R^2	0.940	0.917	0.944	0.779	0.905	0.840

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors are in parentheses.

5 Further Evidence: Delta Buckets

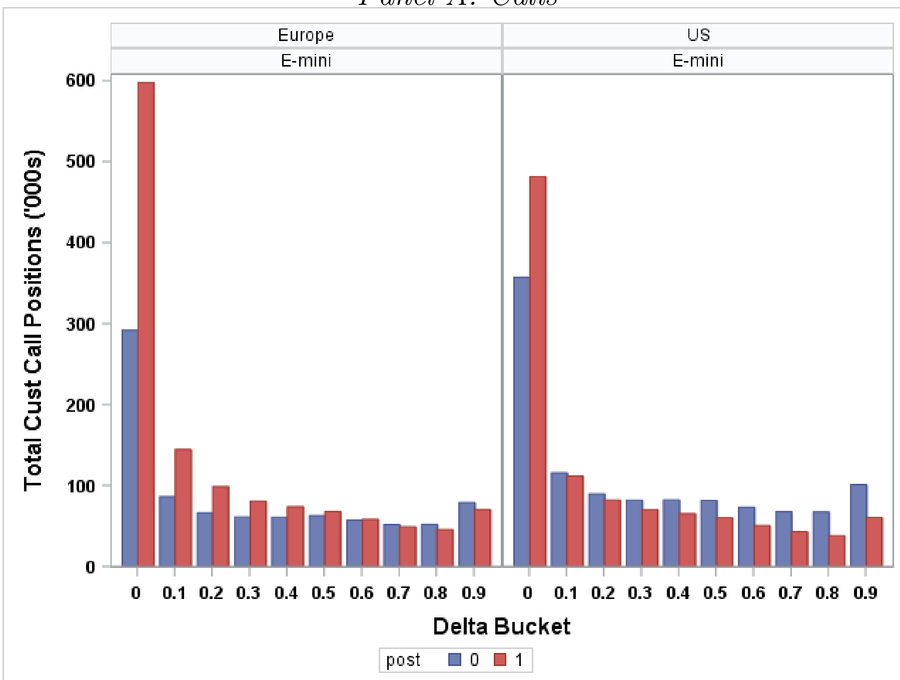
In this section, we provide further evidence by breaking down the option positions into various delta buckets. Because leverage calculations are highly sensitive to notional amounts, the greatest divergence between leverage-based capital requirements and option risks usually arises for low-delta options. We thus expect the leverage ratio to have the largest effects on low-delta options.

Figure 2 shows the daily average option positions held by banks' customers, broken down by various (absolute) delta buckets. US and EU banks are shown separately. Panel A shows calls and Panel B shows puts. The pre-LR period is shown in blue and post-LR period is in red. For example, a bar with a label of 0 means the delta of the call option is in the interval $(0, 0.1]$ and the delta of the put option is in the interval $[-0.1, 0)$. As we can see, these deep out-of-the-money options are by far the most popular. Conversely, a deep in-the-money option with a delta close to 1 (or -1) is very close to a long (or short) futures contract.

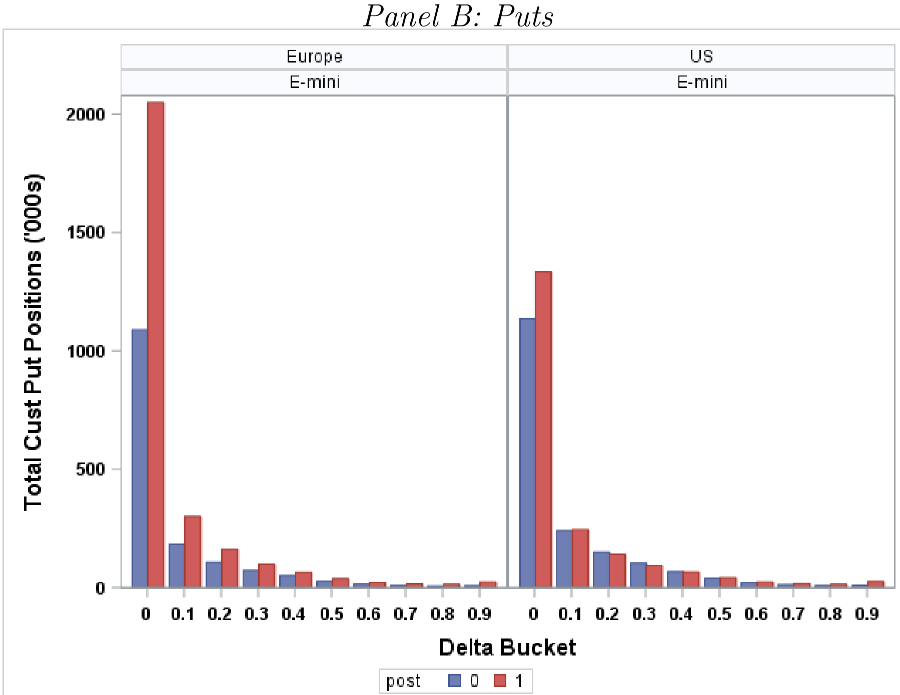
Figures 3 and 4 translate the raw customers' option positions held at banks into

Figure 2: Customer E-mini option positions at US and EU banks by delta buckets, daily average

Panel A: Calls

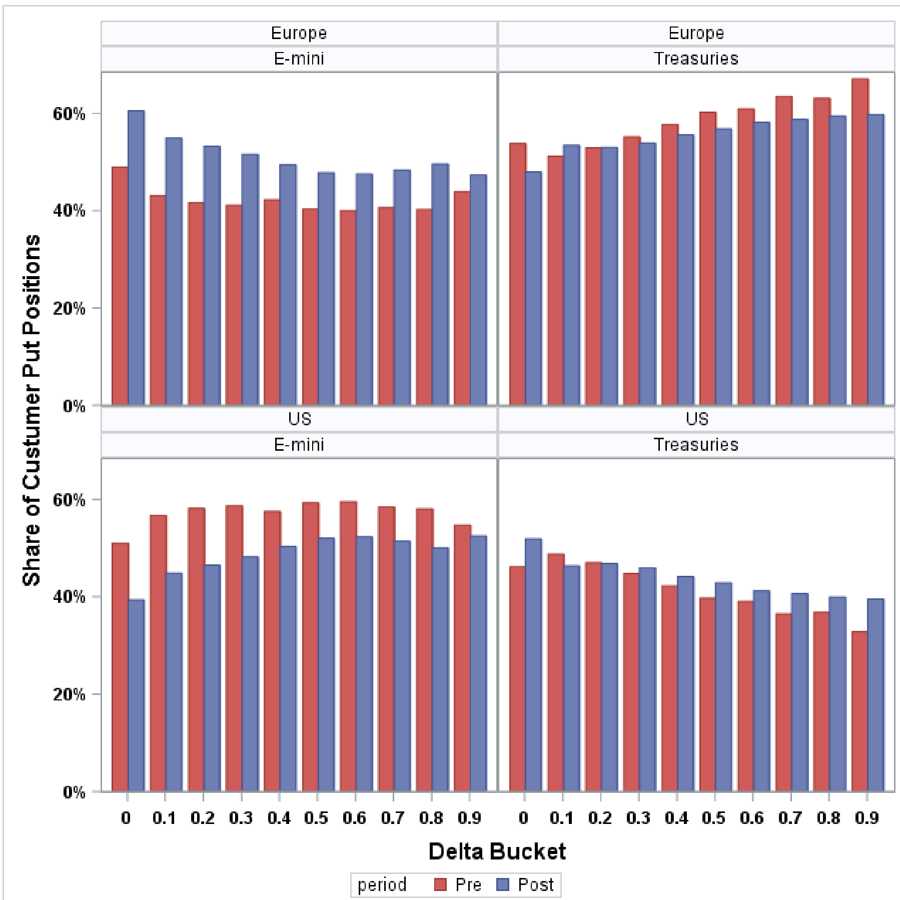


Panel B: Puts



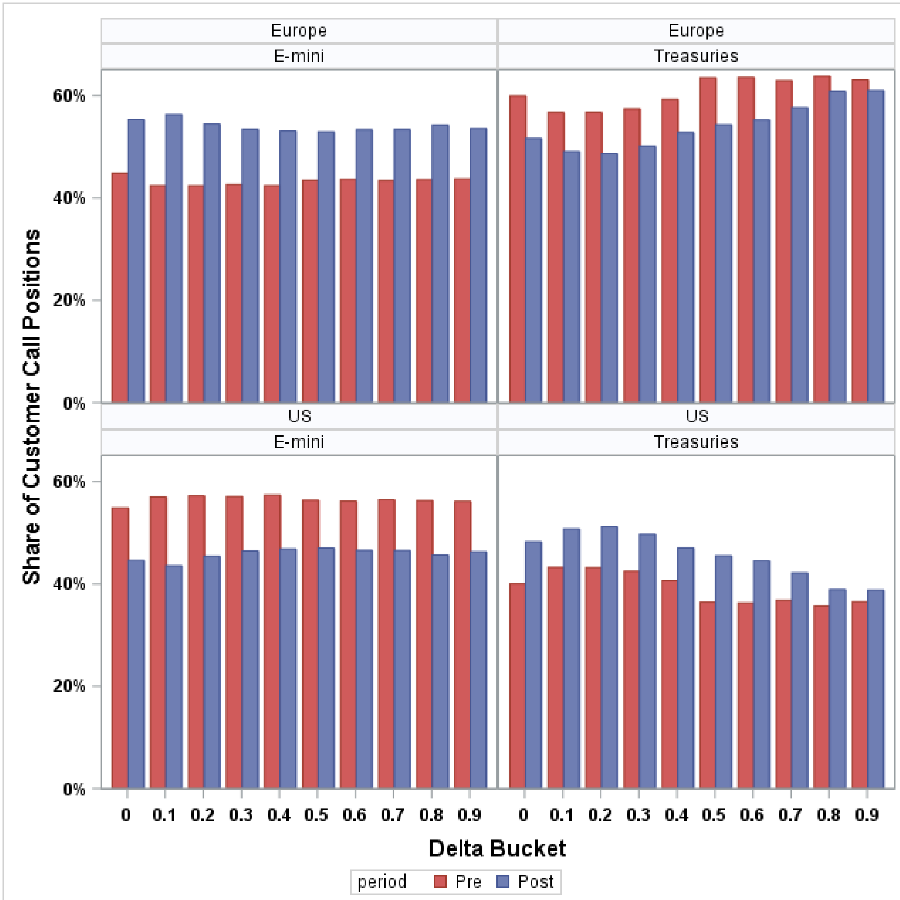
market shares, again by delta buckets, separately for US and EU banks. We calculate the market shares day by day and then take the daily average. Indeed, we see in Figure 3 and 4 that the shift of E-mini option positions from US to EU banks tends to be larger for lower-delta options. The differences may be somewhat hard to see, but are statistically significant (see tests below). As before, Treasury options do not see a similar shift of activity from US to EU banks.

Figure 3: Share of customer put option positions by region, pre-LR vs post-LR



To formally test whether low-delta options are particularly affected by the leverage ratio, we repeat the six tests conducted in the previous section by adding a "low-delta" dummy that is set to be 1 if the absolute option delta is in $(0, 0.1]$ and 0 otherwise. This low-delta dummy is then interacted with the time-series D_{post} as well as one of the cross-section dummies, D_{US}, D_{bank}, or $D_{customer}$. These tests are run only on E-mini options.

Figure 4: Share of Customer call option positions by region, pre-LR vs post-LR



Our tests are run separately for calls and puts, and this separation is prudent for two reasons. First, deep out-of-the-money put options can be viewed as insurance against stock market crashes. In this sense, they are riskier than their moneyness would suggest. Deep out-of-the-money call options do not have this additional crash risk. Second, the moneyness of options also depends on the path of market prices. Our sample period witnesses a stock market rally, which may potentially lead to asymmetries in the distribution of the moneyness of calls versus puts.

Table 6 reports the regression results for calls on E-mini futures contracts. The six columns correspond to the six hypotheses in the previous section, after adding the low-delta dummy and its interacted terms. The rows for the triple-interactive terms are indicated by bold. We observe that for call options, the triple interactive term is negative, meaning that the effect is stronger for low-delta options. For example, column 2 shows that US banks have shifted more activities from customer accounts to house accounts, relative to US nonbanks, and this trend is more pronounced by 4.6% for low-delta calls. Likewise, column 6 shows that US banks have lost market share in customer clearing to EU banks, relative to their market shares in house activities, and this trend is more pronounced by 3.5% for low-delta calls.

Table 7 reports the results from the same regressions but done on E-mini put options. Five out of the six triple-interactive terms involving the low-delta dummy are negative, supporting the hypothesis that low-delta options are affected most by the leverage ratio. For example, column 4 shows that US banks have lost market share in customer clearing to US nonbanks, relative to their house activities, and this trend is more pronounced by 7.2% for low-delta puts. The only triple-interactive term that shows an opposite sign is in column 2. It shows that US banks have shifted more activities away from customer accounts to house accounts, relative to EU banks, but this trend is less pronounced for low-delta puts by 4.9%.

Table 6: Diff-in-diff regressions for options clearing, with low-delta dummy, only calls

	Cust Share Bank Accts	Cust Share US Accts	Bank Share Cust Accts	Bank Share US Accts	US Share Cust Accts	US Share Bank Accts
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.000	0.237***	−0.009***	0.331***	−0.065***	0.015
	(0.000)	(0.021)	(0.001)	(0.031)	(0.008)	(0.010)
US	−0.011***		−0.091***			
	(0.000)		(0.003)			
Bank		0.426***			−0.379***	
		(0.016)			(0.006)	
Cust				0.752***		−0.335***
				(0.010)		(0.008)
Low Delta	0.001***	0.060***	−0.007***	−0.113***	0.009*	0.015
	(0.000)	(0.010)	(0.001)	(0.007)	(0.004)	(0.011)
Post × US	−0.012***		−0.025***			
	(0.001)		(0.007)			
Post × Bank		−0.249***			−0.033**	
		(0.022)			(0.016)	
Post × Cust				−0.365***		−0.113***
				(0.037)		(0.015)
Post × Low Delta	−0.001**	0.042***	−0.014***	0.066***	−0.013*	0.001
	(0.000)	(0.014)	(0.002)	(0.017)	(0.007)	(0.018)
Low Delta × US	0.008***		−0.109***			
	(0.001)		(0.006)			
Post × Low Delta × US	−0.004**		−0.021**			
	(0.001)		(0.010)			
Low Delta × Bank		−0.051***			−0.016***	
		(0.010)			(0.006)	
Post × Low Delta × Bank		−0.046***			−0.021**	
		(0.014)			(0.009)	
Low Delta × Cust				−0.002		−0.022*
				(0.008)		(0.012)
Post × Low Delta × Cust				−0.101***		−0.035*
				(0.018)		(0.020)
Constant	0.998***	0.561***	0.992***	0.149***	0.945***	0.901***
	(0.000)	(0.015)	(0.001)	(0.009)	(0.004)	(0.007)
Observations	5,104	5,104	5,104	5,089	5,104	5,089
Adjusted R^2	0.609	0.771	0.804	0.754	0.895	0.835

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors are in parentheses.

Table 7: Diff-in-diff regressions for options clearing, with low-delta dummy, only puts

	Cust Share Bank Accts (1)	Cust Share US Accts (2)	Bank Share Cust Accts (3)	Bank Share US Accts (4)	US Share Cust Accts (5)	US Share Bank Accts (6)
Post	0.002***	0.255***	−0.012***	0.372***	−0.056***	0.060***
	(0.000)	(0.019)	(0.001)	(0.033)	(0.007)	(0.015)
US	−0.013***		−0.095***			
	(0.001)		(0.003)			
Bank		0.361***			−0.360***	
		(0.016)			(0.007)	
Cust				0.682***		−0.277***
				(0.017)		(0.014)
Low Delta	0.002***	0.114***	−0.006***	−0.133***	0.010**	−0.031**
	(0.000)	(0.012)	(0.001)	(0.010)	(0.005)	(0.015)
Post × US	−0.015***		−0.053***			
	(0.002)		(0.009)			
Post × Bank		−0.268***			−0.054***	
		(0.020)			(0.016)	
Post × Cust				−0.436***		−0.170***
				(0.039)		(0.018)
Post × Low Delta	−0.001***	−0.065***	−0.003	0.065***	0.012*	0.045**
	(0.000)	(0.014)	(0.002)	(0.022)	(0.007)	(0.018)
Low Delta × US	0.006***		−0.128***			
	(0.001)		(0.006)			
Post × Low Delta × US	−0.015***		−0.004			
	(0.003)		(0.007)			
Low Delta × Bank		−0.106***			−0.081***	
		(0.012)			(0.006)	
Post × Low Delta × Bank		0.049***			−0.007	
		(0.014)			(0.009)	
Low Delta × Cust				−0.000		−0.041***
				(0.011)		(0.013)
Post × Low Delta × Cust				−0.072***		−0.040**
				(0.023)		(0.017)
Constant	0.996***	0.622***	0.991***	0.213***	0.943***	0.861***
	(0.000)	(0.016)	(0.001)	(0.015)	(0.004)	(0.014)
Observations	5,104	5,104	5,104	5,104	5,104	5,104
Adjusted R^2	0.589	0.779	0.889	0.713	0.936	0.877

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors are in parentheses.

6 Conclusion

This paper is part of a growing body of quantitative evidence on how Basel III banking reform affects market activities. The leverage ratio, in particular, is often quoted as the most binding constraint. Exploiting the differential constraints that the leverage ratio imposes across various types of market participants and across product classes, we find that the leverage ratio requirement has shifted market activities toward less constrained market segments, and by a significant amount. This change in the competitive landscape could, in turn, have important implications on market liquidity, the distribution of risks in financial markets, and access to key market infrastructure such as central clearing. Further analysis on these indirect effects should better clarify which policy adjustments, if any, would be the most beneficial.

References

Acosta-Smith, J., G. Ferrara, and F. Rodriguez-Tous (2018): "The Impact of the Leverage Ratio on Client Clearing," Staff working paper No. 735, Bank of England.

Allahrakha, M., J. Cetina, and B. Munyan (2016): "Do Higher Capital Standards Always Reduce Bank Risk? The Impact of the Basel Leverage Ratio on the US Triparty Repo Market," Working paper No. 16-11, Office of Financial Research.

Anbil, S. and Z. Senyuz (2018): "The Regulatory and Monetary Policy Nexus in the Repo Market," Working paper No. 2018-027, Federal Reserve Board.

Basel Committee on Banking Supervision (2014a): "Basel III leverage ratio framework and disclosure requirements."

——— (2014b): "The standardised approach for measuring counterparty credit risk exposures."

——— (2017): "Basel III: Finalising post-crisis reforms."

——— (2018): "Leverage ratio treatment of client cleared derivatives," Consultative document.

Bicu, A., L. Chen, and D. Elliott (2017): "The Leverage Ratio and Liquidity in the Gilt and Repo Markets." Staff working paper No. 690, Bank of England.

Bourahla, S., E. Fialon, A. Garcia, and A. Violon (2018): "Leverage ratio and client clearing," ACPR discussion paper, Banque de France.

Duffie, D. (2018): "Post-Crisis Bank Regulations and Financial Market Liquidity," Baffi lecture.

Financial Stability Board (2018): "Incentives to centrally clear over-the-counter (OTC) derivatives: A post-implementation evaluation of the effects of the G20 financial regulatory reforms."

Giancarlo, J. C. and B. Tuckman (2018): "Swaps Regulation Version 2.0: An Assessment of the Current Implementation of Reform and Proposals for Next Steps," White paper, CFTC.

Greenwood, R., S. G. Hanson, J. C. Stein, and A. Sunderam (2017): "Strengthening and Streamlining Bank Capital Regulation," *Brookings Papers on Economic Activity*.

Kotidis, A. and N. van Horen (2018): "Repo Market Functioning: The Role of Capital Regulation," Staff working paper No. 746., Bank of England.