Central Clearing, Pandemic, and Derivative Offsetting

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ABSTRACT: Duffie et al. (2015) provide theory showing the viability of central clearing model lies in its ability to provide the benefits of derivative offsetting. In this paper, we provide the initial empirical evidence on how central clearing reform leads to the changes in derivative offsetting. Using a difference-in-differences testing procedure, we find that derivative offsetting increases more for banks with higher capital ratios after the central clearing reform, suggesting banks choose to utilise the offsetting benefits to suit their targets. We also find mixed results for the relation between central clearing and derivative offsetting during the Covid 19 Pandemic, which suggests that central clearing, although negatively affected, held up to some extent during the Pandemic.

I. Introduction

Financial institutions can choose whether to offset their derivative assets with liabilities and only recognise the net values (Acharya and Ryan 2013). Derivative offsetting saves the banks from the need to raise additional capital amounting to trillions of dollars[1] and can significantly impact the banking system. To enhance the stability of financial systems, the regulators implemented central clearing reform of derivatives, which fundamentally changed the way derivatives are traded. Duffie et al. (2015) provide a theoretical framework on how central clearing can increase the opportunities of derivative offsetting. They show the benefit of offsetting is a key contributor to the viability of the central clearing reform. In this study, we provide the first empirical evidence on the impact of central clearing on derivative offsetting.

We investigate the relation between central clearing on derivative offsetting around two endogenous shocks (i.e., the initial adoption of central clearing rules and the shock of Covid 19 Pandemic). First, to implement the reform on central clearing, the US Commodities Futures Trading Commission (CFTC) issued rules, requiring mandatory central clearing for the OTC trading derivatives of financial institutions by the end of 2013.[2] Second, Covid 19 Pandemic in 2020-21 caused significant disruptions to the financial markets and derivative trading, which created the first system-wide shock experienced by the clearing model after the regulatory reform. These natural experiments allow a more comprehensive causal inference of how central clearing impacts derivative offsetting over the cycle from the initial adoption to the end of the premier shock.

We adopt a difference-in-differences (DID) approach by utilising the exogenous events. Specifically, we use the asset-level data on derivative offsetting of the asset class affected by the central clearing regulation (i.e., treatment assets of trading derivatives) and the asset class

[1] 'Derivatives Tide Rises at Big Banks', *Wall Street Journal* (WSJ.com, November 2011).
[2] Commodity Futures Trading Commission 2012, 17 CFR Parts 39 and 50, Clearing Requirement Determination Under Section 2(h) of the CEA; Final Rule.

not affected by the regulatory change (i.e., control assets of bank loans) during 2010–2016 (with year 2013 as the year of the regulatory change) around the adoption of central clearing reform and during 2018–2021 (with the years 2020–2021 as the period during the Covid 19 Pandemic) to study the relation between central clearing and derivative offsetting.

We find that mandatory central clearing leads to significant changes in banks' derivative offsetting. Specifically, banks with higher target capital ratios significantly increased their derivative offsetting after the implementation of mandatory central clearing. The magnitude of our results is economically nontrivial. Our DID tests demonstrate that, with the adoption of mandatory central clearing, banks with higher target capital ratios have increased their derivative offsetting by 25.8 percent more in fair value than banks with lower target capital ratios over the sample period in comparison to the offsetting of the control assets. To put the result into perspective, as the fair value of trading derivatives is typically times over a bank's total assets, 25.8 percent of the derivative's gross value is equivalent to a significant portion of the bank's total assets. These findings indicate that banks choose to utilise derivative offsetting benefits to suit their targets of capital adequacy. By comparison, our DID tests around the Covid 19 Pandemic show mixed results. Across all banks, although derivative offsetting decreased as percentage of total fair value of trading derivatives during the Pandemic, it still shows an increase as percentage of total assets. These mixed findings indicate, although negatively affected, the clearing model at least partially held up during the Pandemic.

Our paper connects with the literature on the effects of central clearing. The prior research on central clearing shows that central clearing increases transparency in derivative trading and hence reduces the counterparty and systemic risks in the derivative market (Acharya and Bisin 2014; Loon and Zhong 2014). Central clearing can lead to lower system-wide collateral demand and have significantly different effects across market participants

(Duffie et al. 2015). We extend the prior research by showing that mandatory central clearing has significantly different impacts on derivative offsetting of different banks.

Our paper also connects with the literature on derivative offsetting. The prior research on derivative offsetting focuses on the economic consequences of offsetting. Neilson et al. (2020) find that derivative offsetting does not affect default risk assessment but matters for systemic risk assessment. Ryan and Seitz (2020) find the gross and net fair value disclosures of offset derivatives help investors evaluate the credit risk of derivative dealers. We focus on the central clearing rules as the driver of derivative offsetting. Our findings highlight the impact of clearing rules on net versus gross presentation of derivatives in the balance sheets. Our results are thus relevant to regulators who are concerned with converging global standards on offsetting.

We also contribute to the theory on how market transparency drives financial reporting choices. Economic theory suggests that market transparency is a key driver of management's financial reporting choices (e.g., Verrecchia 2001; Dye 2001; Fields et al. 2001; Beyer et al. 2010). However, prior literature has not provided conclusive evidence on this relation. The endogenous nature of the firm's information environment and financial reporting practices makes it difficult to establish causal links and identify the exact effect that one mechanism might have on the other (Beyer et al. 2010). In this paper, we overcome this challenge by studying a setting that offers an exogenous variation in market transparency (i.e., the regulatory reform on central clearing), which is not influenced by managerial discretion to provide causal evidence on how market transparency impacts financial reporting choices. We show that when market transparency increases with the implementation of mandatory central clearing, banks with higher target capital ratios resort to the less transparent financial reporting choice to offset more derivatives.

The remainder of study is organised as follows. Section II provides background information on derivative offsetting and central clearing. Section III reviews prior research and develops hypotheses based on theory and prior research. Sections IV describes the model and sample. Sections V discusses the empirical results. Finally, Section VI concludes.

II. Institutional Background

Derivative Offsetting

The accounting principle governing offsetting is 'the offsetting of assets and liabilities in the balance sheet is improper except where a right of setoff exists (APB 10, 1966).' In US GAAP, FIN 39 (1992) clarifies what constitutes 'a right of set off' in the context of derivatives and financial instruments. FIN 39 (1992) states that a right of set off 'exists when all the following conditions are met: (a) each of the two parties owes the other determinable amounts; (b) the reporting party has the right to set off the amount owed with the amount owed by the other party; (c) the reporting party intends to set off; (d) the right of set off is enforceable by law.' FIN 39 exempts parties under a master netting agreement (MNA) from conditions (b) and (c), as long as the MNA is enforceable and specifies net settlement only in the event of default. As most derivatives are traded under MNAs in US, this exemption allows most trading derivates to be offset and only the net amount is recognised in the balance sheet under US GAAP (Ryan and Seitz 2020).

By comparison, in IFRS, IAS 32 (1995) allows offsetting and net presentation only when the reporting party 'currently has a legally enforceable right to set off the recognised amounts; and (b) intends to settle on a net basis, or to realise the asset and settle the liability simultaneously.' IAS 32 does not offer exemptions for MNAs and the requires 'current' legal right to set off, which means the right to set off should be unconditional and cannot be conditional on future events such as counterparty default. This requirement makes derivative offsetting much more difficult under IFRS as most derivative contracts do not come with a 'current' unconditional legal right to set off. The different requirements in accounting treatment of derivative offsetting accounts for the single largest difference between US GAAP and IFRS in balance sheet presentation (FASB 2011).

The difficulty in converging standards on offsetting may be due in part to the complexity in how derivatives are traded. Financial Accounting Standard Board (FASB) issued exposure draft of proposed accounting standards on offsetting in 2011 in an attempt to align GAAP with IFRS on offsetting. IFRS is more restrictive in allowing the net presentation (offsetting) of derivatives. The proposed accounting standards on offsetting were widely opposed by U.S. bankers. For example, in the comment letter to the exposure draft, JPMorgan Chase & Co. objected to the assumption that gross presentation is more accurate than net presentation. They stated: '…the proposed ASU is based in large part on the view that gross presentation of these transactions more accurately conveys the resources of an entity and the claims against it. Inherent in this view is the assumption that derivative receivables…represent resources to creditors… and that derivative payables…represent claims against the entity. We believe this assumption is simply not true in bankruptcy or on a going concern basis because in both cases the gross cash flows are only available to derivative counterparties and only the *net* amounts are available to general creditors.' They further illustrate that clearing house rules provide Close Out netting in the event of default. Upon default, positive and negative payment obligations related to derivative transactions are settled net. Clearing house rules also provide for net settlement of cash flows (including coupons and margins) on a daily basis in the normal course of derivative trading. Such Payment Netting is enforceable by market participants. Hence, it is not true that cash flows in derivative trading are netted only conditionally.[3] Due to the opposition from the stakeholders, FASB eventually did not approve the proposed accounting standards and decided to retain the separate offsetting models from IFRS.[4]

[3] See JPMorgan Chase & Co.'s comment letter on FASB Exposure Draft on offsetting (FASB 2011), available at: https://www.fasb.org/jsp/FASB/CommentLetter_C.
[4] News Release 12/16/11. IASB and FASB Issue Common Offsetting Disclosure Requirements. Available at: https://www.fasb.org/.

Mandatory Central Clearing

Under new section 2(h)(1)(A) of the Commodity Exchange Act enacted under Title VII of the Dodd-Frank Wall Street Reform and Consumer Protection Act, CFTC adopted regulations to mandate clearing requirements for trading derivatives in 2012. Derivatives not held for trading (end-user derivatives) are exempt from the central clearing requirements.[5] Under these regulations, certain classes of credit default swap (CDS) and interest rate swap (IRS) trades are required to be cleared by a derivative clearing organization (DCO) registered with CFTC. Classes of CDS that are required to be cleared through a DCO include CDS trades that reference the market indices. Classes of IRS that are required to be centrally cleared include IRS in four major currencies (USD, EUR, GBP, JPY) and in four major classes (fixed-to-floating swaps, basis swaps, forward rate agreements, overnight index swaps). In 2016, CFTC expanded the clearing requirement of IRS to include IRS in other currencies (such as AUD and HKD). This mandatory clearing requirement covers the majority of the CDS and IRS trades. CDS and IRS are normally the most valuable derivative contracts among the trading derivatives. According to CFTC's statistics, IRS accounts for about $500 trillion of the $650 trillion global OTC swaps market.[6] Covering both IRS and CDS, the CFTC's mandatory central clearing rules effectively regulate most of the bank's trading derivatives.

Under the compliance schedule of the mandatory clearing requirement, category 1 entities must comply with the clearing requirement by March 11, 2013. Category 1 entities include swap dealers, major swap participants and active funds. Category 2 entities must comply with the clearing requirement by June 10, 2013. Category 2 entities include commodity pools, private funds, banks and financial service providers. Category 3 entities are all other counterparties and must comply by September 9, 2013. Any evasion of the mandatory clearing

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[5] See *End-User Exception to the Clearing Requirement for Swaps*, 77 FR 42560, 42562 (July 19, 2012).

[6] Commodity Futures Trading Commission 2012, 17 CFR Parts 39 and 50, Clearing Requirement Determination Under Section 2(h) of the CEA; Final Rule.

requirement is an unlawful violation of the Commodity Exchange Act and subject to prosecutions by the enforcement division of CFTC.[7] Under this schedule, banks should have complied with the mandatory clearing requirement by the end of 2013.

Compared with trading mechanism of OTC markets, a central clearing mechanism has several distinct characteristics. First, central clearing transforms the contractual structure of a derivative trade. When a derivative contract between the customer and the dealer is cleared through a DCO, this contract is effectively transformed into two contracts with the DCO selling the derivative to the customer and buying the derivative from the dealer. With this transformation, the original customer and dealer no longer directly transact with each other and the DCO guarantees the fulfilment of the contract if either the customer or the dealer defaults. As dealers often have exposures to each other, DCOs can carry out multilateral netting of the contracts and reduce the chances of defaults. Second, DCOs collect collateral in the form of initial and maintenance margins from the trading parties and set trading position limits for them. By doing so, central clearing through DCOs can prevent excessive build-up of risky exposures and further reduce counterparty risk. Third, DCOs publish daily trading volume, open interest and settlement price by obligors. By doing so, central clearing increases transparency of trading activities and make it possible to price the risk based on overall portfolio positions of market participants, which is impossible in the opaque OTC markets (Acharya and Bisin 2014; Long and Zhong 2014).

The CFTC's mandatory clearing regulation is a significant step to implement the Dodd-Frank Act. From the experience of large financial institution failures in the 2008 financial crisis, regulators recognise that uncleared derivatives traded in OTC markets pose significant threats to the stability of the financial system. Only limited checks on the risk taken by a market

[7] Commodity Futures Trading Commission 2012, 17 CFR Parts 39 and 50, Clearing Requirement Determination Under Section 2(h) of the CEA; Final Rule.

participant is possible in OTC markets. Such opaqueness of overall exposures by counterparties creates great uncertainty in the market and amplifies the financial crisis. Clearing hence is at the heart of Dodd-Frank financial reform. With the mandatory clearing requirements, regulators aim to collateralise risk exposures of swaps through central clearing mechanism and ensure the future stability of the financial system through increased derivative market transparency.

III. Hypotheses Development

The central clearing fundamentally changes the way the derivatives are traded. Loon and Zhong (2014) examine the effect of voluntary clearing on the CDS market. They argue that central clearing reduces counterparty and systemic risks in the CDS market through the process of novation, margin requirements and position limits. Consistent with this argument, they find that the value of CDS protection increases around the commencement of central clearing and the relation between the value of CDS protection and dealer credit risk weakens after central clearing begins. They also argue that central clearing increases post-trade transparency through the public dissemination of obligors' position information, such as daily trading volume, open interest and settlement prices. Consistent with this argument, they find that voluntary clearing increases the liquidity of CDS trades.

Acharya and Bisin (2014) theoretically show that a lack of position transparency in OTC markets results in a counterparty risk externality. Due to opacity of exposures, counterparty risk cannot be sufficiently priced in response to counterparties' overall portfolio positions and hence market participants can choose to collect premium upfront and default later. By contrast, a centralised clearing mechanism registers all trades through clearing and creates position transparency that enables market participants to price their contracts based on the risk in the counterparty's overall positions. Thus, transparency created by central clearing discourages build-up of excessive leverage and reduces counterparty risk externality in the market.

Acharya and Bisin (2014)'s model illustrates that contractual terms of prices and collateral can better function to mitigate counterparty risk if the contracts are traded through a central clearing mechanism, as position transparency in centrally cleared trades enables contract terms to be conditioned on the counterparty's overall positions. Under a central clearing mechanism, the moral hazard that a counterparty tries to take on excessive leverage through short positions would be countered by steeper price and collateral demand. To implement competitive pricing in central clearing with transparency is a trading mechanism that allows prices and other contractual terms to adjust *continuously* with each agent's total position, and such a mechanism would be a margin or collateral arrangement.

However, banks' OTC derivative contracts are often significantly undercollateralized, as collateral is normally rehypothecated (or re-used) for other purposes and is not dedicated for the OTC derivative contract for which the collateral is pledged. By contrast, CCPs would require all positions to have collateral against them and collateral posted with CCPs would be unavailable for re-use. Hence, central clearing raises the concern of significantly increasing collateral demand and banks' capital constraint (Singh 2010).

Studying voluntary central clearing in the CDS market, Duffie et al. (2015) show that collateral demand of central clearing can be separated into three components: initial margins, a buffer stock for margin calls, and the 'velocity drag' of collateral movement.[8] The significant increase in initial margins required by CCPs are mitigated by the decrease in buffer stock and 'velocity drag' in a central clearing system. Hence, there is no system-wide increase in collateral demand from central clearing requirements. Duffie et al. (2015) explain their findings through a theoretical model showing that higher collateral demand by CCPs can be substantially mitigated by the increased benefits of multilateral netting and diversification

[8] Initial margin is a contract-specific short charge for net sellers. A buffer stock consists of unencumbered liquid assets to cover variations in margin payments. The 'velocity drag' is the lag between the time at which margin funds are sent and the time at which payments are received Duffie et al. (2015).

provided by central clearing. Netting is the key determinant of collateral demand, given a certain level of protection against counterparty risk. Increased novation to CCPs implies increased cross-counterparty netting benefits. While initial margins increase under central clearing, the velocity drag decreases due to the fact that central clearing pools multiple bilateral exposures under one counterparty which reduces the number of bilateral links and increases netting opportunities. An increase in multilateral netting also reduces the amount needed for the buffer stock. Duffie et al. (2015)'s model also shows that central clearing has significant distributional effects across market participants, as central clearing's benefits of multilateral netting and diversification work differently for different types of market participants.

We conjecture that offsetting likely works differently for banks with different target capital adequacy ratios. Regulatory capital adequacy ratios are designed to hold a bank's equity against expected losses given default on its assets and consider riskier assets and considered to be a key component in evaluating a bank's safety and soundness. Tier 1 capital especially contains core equity capital items that can better absorb losses (Beatty and Liao 2014). Berger et al. (2008) show that US banks report capital ratios in excess over the regulatory minima and such 'excess' capital is the result of active management by banks to reach their target capital ratios.

As shown by Duffie et al. (2015)'s theory, smaller trading derivative portfolios with fewer counterparties result in increased margin requirements outweighing the benefits of multilateral netting provided by central clearing. As participants in a central clearing mechanism are evaluated against their overall positions (Acharya and Bisin 2014), expansion of derivative portfolios and offsetting would also be more costly for the banks with lower target capital ratios. On the other hand, banks with higher target capital ratios would be better positioned to expand their derivative portfolios and utilise more the offsetting opportunities. Thus, we predict the increase of offsetting around the adoption of central clearing rules would be more significant for banks with higher capital ratios. These discussions lead to our first hypothesis as follows:

H1: *The offsetting benefits of central clearing are utilised more by the banks with higher capital adequacy ratios.*

The Covid 19 Pandemic during 2020–21 caused disruptions to central clearing. The market volatility during the Pandemic forced CCPs to increase their margin calls, which squeezed the liquidity of the banks and exacerbated procyclicality of the clearing model (Huang and Takats 2020). Duffie et al. (2015)'s theory can also be applied in explaining the impact of the Pandemic. The increased margins would discourage the increase or derivative portfolios of the market participants, which could reduce the offsetting opportunities. On the other hand, the netting benefits brought by central clearing would allow dealers to reduce the liquidity commitments required on their balance sheets, countering the procyclicality of margins (Duffie 2020; Fleming and Keane 2021). Therefore, how central clearing fared during the Pandemic, as reflected in offsetting, is an empirical question. These discussions lead to our second hypothesis as follows:

H2: *The Covid-19 Pandemic has insignificant impact on the relation between central clearing and derivative offsetting.*

IV. Data and Empirical Design

Data

We collect our financial data of US Bank Holding Companies (BHCs) from regulatory Y-9C filings to calculate the variables in our empirical analyses. Y-9C filings contain BHCs' financial data made publicly available by the Federal Reserve Bank of Chicago. These financial data include the reported fair value of assets after netting and the netted amounts in determination of the fair value of the assets. We use these data to calculate our dependent variable *Offset*, which is calculated as the offset fair value divided by the gross fair value before any offsetting, for both the treatment group of trading derivative assets and the control group of loans held for investment. BHCs' Y-9C filings classify derivatives as either held for trading or held for purposes other than trading (end-user derivatives). Only the derivatives held for trading (i.e., trading derivatives) are subject to the mandatory central clearing requirements. End-user derivatives are exempt from the central clearing requirements.[9] Hence, we use trading derivatives as our treatment assets. We use loans held for investment as our control assets as these loans also contain offsetting and are unrelated to the derivatives subject to the central clearing regulations.

Our sample period starts from three years before the year 2013 when central clearing requirements were implemented and ends three years after 2013 inclusive of year 2013 (i.e., 2010 to 2016) for the test around the adoption of central clearing rules. In the test for the impact of the Pandemic, we include the period of the Pandemic (i.e., 2020 and 2021) and two years before the Pandemic (i.e., 2018 and 2019). After deleting all the missing observations, we obtain 2,678 observations for *Offset* (*trading derivative assets*) and 1,673 observations for *Offset* (*loans held for investment*) for the sample around the adoption of central clearing (i.e., 2010 to 2016). We also obtain 754 observations for *Offset* (*trading derivative assets*) and 1,097 observations for *Offset* (*loans held for investment*) for the sample around the Pandemic (i.e., 2018 to 2021). We pool the treatment and control assets to form the dependent variable *Offset*, together with the independent variables, to test our hypotheses. This process produces the final sample of 4,351 bank-quarter observations to estimate our regressions for the period from 2010 to 2016 and 4,351 bank-quarter observations to estimate our regressions for the period from 2018 to 2021.

[9] See *End-User Exception to the Clearing Requirement for Swaps*, 77 FR 42560, 42562 (July 19, 2012).

Triple Difference-in-Differences Analysis for the Period from 2010 to 2016

We start by sorting offsetting (*Offset*) of trading derivatives (treatment group) into 21 groups. First, we split the sample of derivative offsetting by year into seven groups. Within each year, we then form three terciles of derivative offsetting based on the annual tercile rank of the bank's Tier 1 capital ratios. Then we average the derivative offsetting. This procedure creates a seven-by-three matrix for derivative offsetting. We repeat this procedure for the offsetting of loans held for investment (control group).

We calculate the first difference by subtracting the offsetting the average offsetting of the low target capital group from the average offsetting of the high target capital group for the same year. We perform a two-tailed *t-test* to determine if the difference is statistically significant. We perform this procedure for each year, from 2010 through 2016. The first difference demonstrates whether, for a given year, offsetting of banks with high target capital ratios is different from offsetting of banks with low target capital ratios.

We calculate the second difference by subtracting the first difference for 2010 from the first difference for 2016. We perform a two-tailed *t-test* to determine if the second difference is statistically significant. The second difference shows whether the difference in offsetting between banks with high and low capital adequacies increases with the shift to mandatory central clearing.

We calculate the third difference by comparing the second difference of trading derivatives (treatment group) with that of loans held for investment (control group). This third difference illustrates whether the increase in the second difference is unique to trading derivatives or also happens to assets not affected by central clearing requirements.

Difference-in-Differences Regression Specification for the Period from 2010 to 2016

For our DID regression specification for the period from 2010 to 2016, we use the asset class of 'trading derivatives', which would be directly impacted by the mandatory central clearing reform, as the treatment group. We use the asset class of 'loans held for investment' as the control group, since these loans are not required to be centrally cleared. Then we pool these two groups of assets to estimate our baseline regression with asset and year fixed effects. We include asset fixed effects to capture the diverging trends in offsetting that are generated from the different properties of the two assets. We include year fixed effects to capture time varying trends in offsetting. The regression is specified below:

$$Offset = \alpha_1 PostTreatment * Capial + \alpha_2 PostTreatment + \alpha_3 Post * Capital + \alpha_4 Post + \alpha_5 Capital + Controls + AssetandYearFixedEffects + \varepsilon \qquad (1)$$

where *Offset* is the offset fair value divided by the gross fair value before any offsetting for the pooled observations of trading derivative assets and loans held for investment for the period from 2010 to 2016. *Offset* measures the amount that has been offset per one unit of the asset and proxies for offsetting. We regress *Offset* on indicators for the treatment group asset (trading derivatives) after the regulatory change on central clearing, the bank's capital adequacy and the period when central clearing becomes mandatory for trading derivatives. Specifically, *PostTreatment* is an indicator equal to 1 if an observation belongs to the treatment group and occurs after the implementation of the mandatory clearing requirement in 2013, and 0 otherwise. As we include asset and year fixed effects, the coefficient on *PostTreatment* indicates the incremental change in offsetting for the treatment group after the regulatory change on central clearing relative to the control group. *Capital* proxies for the bank's target capital ratios, which is an indicator equal to 1 if the asset belongs a bank whose quarterly tier 1 risk-based capital ratio falls within the highest annual tercile rank of the sample, and 0 otherwise. *Post* is an indicator equal to 1 if an observation occurs after the implementation of mandatory clearing requirement in 2013, and 0 otherwise.

We include the interaction term of *PostTreatment* with *Capital* in equation (1). The coefficient α_1 on the interaction term captures the differential effect of mandatory central clearing on derivative offsetting for banks with higher capital adequacies for the treatment group. We expect α_1 to be positive as banks with higher capital ratios, relative to banks with lower capital ratios, would engage in more derivative offsetting after mandatory central clearing for trading derivatives.

We also include a series of control variables in the equations. Specifically, we include the natural log of total assets, total liabilities divided by total equity, and net income divided by total assets and to control for the bank's size, leverage and profitability. We include total securities and deposits to control for the bank's liquidities. We include loan charge-offs and non-performing loans to control for the quality of the bank's loan portfolios. We include total notional amounts of derivative contracts to control for the overall size of the bank's derivative portfolios. A list of detailed variable definitions is provided in the Appendix.

Difference-in-Differences Regression Specification for the Period from 2018 to 2021

Our DID regression specification for the period from 2018 to 2021 is similar to equation (1) without the interaction term with *Capital*. We pool the asset class of 'trading derivatives', as the treatment group, and the asset class of 'loans held for investment' as the control group to estimate our equation (2) with asset and year fixed effects. The equation (2) is specified below:

$$Offset = \beta_1 PostTreatment + Controls + AssetandYearFixedEffects + \varepsilon \qquad (2)$$

where *Offset* is the offset fair value divided by the gross fair value before any offsetting for the pooled observations of trading derivative assets and loans held for investment for the period from 2018 to 2021. *PostTreatment* is an indicator equal to 1 if an observation belongs to the treatment group and occurs during the Covid 19 Pandemic 2020–21, and 0 otherwise. As we include asset and year fixed effects, the coefficient β_1 on *PostTreatment* indicates the incremental change in offsetting for the treatment group during the Pandemic relative to the control group. The control variables in equation (2) are the same as those in equation (1). The variables are defined as in the Appendix.

V. Empirical Results

Descriptive Statistics

Table 1 reports the descriptive statistics for the variables used to test our first hypotheses for the period of 2010 to 2016. The mean value of *Offset* (*trading derivative assets*) is much higher than that of *Offset* (*loans held for investment*), which indicates that offsetting of trading derivatives happens more often than that of loans. The sample bank size is evenly distributed with close mean and median values in *Size*. The sample banks are highly leveraged with a mean *Leverage* value of 9.24. The banks are, on average, profitable and with loan portfolio accounting for more than half of the total assets. The banks are, on average, liquid with liquid securities accounting for 19 percent of the total assets. The banks engage in large amounts of derivative transactions as the notional amounts of derivative contacts are on average more than twice the size of their total assets.

Table 2 reports the correlations between the variables for the period from 2010 to 2016. *Offset* is positively correlated with bank size, suggesting that larger banks engage in more derivative offsetting. *Offset* is also positively correlated with the derivative contracts (*Contracts*), suggesting that banks with more derivative transactions engage in more offsetting. *Offset* is negatively correlated with deposits, suggesting that banks engaging in more traditional way of banking business (such as taking deposits and issuing loans) engage in less derivative offsetting.

Table 5 reports the descriptive statistics for the variables used to test our second hypotheses for the period of 2018 to 2021. The mean value of *Offset* (*trading derivative assets*) during the period of 2018 to 2021is lower at 0.095 than that of 0.147 during the period from

2010 to 2016. The mean value of the total derivative contacts (*Contracts*) during the period of 2018 to 2021 is also lower at 0.325 than that of 2.666 during the period from 2010 to 2016. These differences in the descriptives indicate the impact of the Pandemic on the trading derivatives held by the banks. Table 6 reports the correlations between the variables for the period from 2018 to 2021. Similar to those reported in Table 2, *Offset* continues to be positively correlated with bank size and the derivative contracts (*Contracts*), and negatively associated with deposits.

Primary Results

Triple Difference-in-Differences Analysis for the Period from 2010 to 2016

Table 3 reports the results for the triple DID approach. Our results in Panel A show that offsetting for trading derivatives has increased by 25.8 percent more in banks with high capital adequacy than in banks with low capital adequacy. This is equivalent to more than a quarter of the gross fair value of all trading derivatives in these banks. In contrast, as shown in Panel B, the difference in offsetting for loans between banks with different levels of capital adequacies shows insignificant changes over the sample period.

These results indicate how central clearing affects derivative offsetting when a regulatory change that mandates central clearing for derivatives is introduced. Banks with high capital ratios respond to the higher collateral demand from central clearing requirements by increasing their derivative offsetting. By comparison, banks with low capital ratios experienced a decline in derivative offsetting. As expected, the difference in offsetting of loans, which are unaffected by mandatory central clearing, between banks with high and low capital adequacies has remained static over time.

Difference-in-Differences Regression Results for the Period from 2010 to 2016

Table 4 reports the results of pooled DID regression testing our first hypothesis on the relation between central clearing and derivative offsetting around the adoption of central clearing rules. Column (1) reports the regression estimations with year fixed effects. Column (2) reports the regression estimations with asset fixed effects. Column (3) reports the regression estimation with asset and year fixed effects. The results across the three columns are qualitatively similar and we focus on the results in Column (3).

Column (3) reports the results of estimating equation (1) which pools treatment assets of trading derivatives with control assets of loans held for investment over the sample period 2010–2016 and includes 4,351 asset-quarter observations. The regression results reveal a positive and significant relation between derivative offsetting and the triple interaction term of treatment asset group, post regulatory change period and high capital adequacy indicator. The coefficient on the triple interaction term is 0.101, which means the change in derivative offsetting, incremental to that of loan offsetting, after the implementation of central clearing requirement is significantly higher in banks with high capital ratios. The results are consistent with our hypothesis. The results are not driven by unobserved asset- or year-level factors, as we include asset and year fixed effects in the regression. The magnitude of the change is equivalent to 10 percent increase in offsetting over per unit of the gross fair value of total trading derivatives after controlling for the main bank characteristics. To put the magnitude of this result into perspective, as the gross fair value of derivatives is on average several times greater than total assets, the coefficient of 0.101 signals a fair value which amounts to a significant portion of total assets.

Difference-in-Differences Regression Results for the Period from 2018 to 2021

Table 7 reports the results of pooled DID regression testing our second hypothesis on the impact of the Pandemic on the relation between central clearing and derivative offsetting. Column (1) reports the regression estimations with year fixed effects. Column (2) reports the regression estimations with asset fixed effects. Column (3) reports the regression estimation with asset and year fixed effects. The results across the three columns are qualitatively similar and we focus on the results in Column (3).

Column (3) reports the results of estimating equation (2) which pools treatment assets of trading derivatives with control assets of loans held for investment over the sample period 2018–2021 and includes 1,851 asset-quarter observations. The regression results reveal a negative and significant relation between derivative offsetting and *PostTreatment* indicator. This result indicates that derivative offsetting, relative to that of loan offsetting, significantly decreased during the Pandemic.

Sensitivity Tests

Alternative Measurements of Derivative Offsetting

Our dependent variable *Offset* is defined as the offset fair value deflated by the gross fair value before any offsetting for trading derivative assets. To test the robustness of our results, we also estimate equation (1) using alternative measurements of the dependent variable *Offset*. Specifically, we deflate offset fair value of derivatives by total assets and report the results using these alternative measurements of derivative offsetting in Table 8. The reported results in Column (1) are qualitatively similar to the primary results and consistent with our first hypothesis. The results in Column (2), however, shows a positive and significant coefficient on the *PostTreatment* indicator, which is the opposite to that reported in Table 7. These mixed findings of derivative offsetting under central clearing during the Pandemic suggest that central clearing system at least partially held up in the Covid 19 crisis.

Alternative Control Assets

Instead of using loans held for investment as our control assets, we also use repurchase agreement assets (repo assets) as the alternative control assets and estimate equations after pooling offsetting for repo assets with offsetting for trading derivatives. The results are reported in Tables 9. The results remain qualitatively similar to the primary results.

Alternative Measurements of Capital Ratios

To test the sensitivity of our measure of capital adequacy ratios in the first hypothesis, we substitute the ranking of quarter-end tier 1 risk-based capital ratios used in the baseline regressions with the ranking of tier 1 risk-based capital ratios at the beginning of the quarter as the measure of capital adequacy. Capital ratios at the beginning of the quarter will not be affected by derivative offsetting at the quarter-end. We further use the ranking of loan charge-offs instead of capital ratios as another alternative measure of capital adequacies. Loan portfolios are normally a bank's largest asset class and loan charge-offs are often the most significant element in computing regulatory capital ratios and unlikely to be related to derivative offsetting. As shown in Table 10, using these alternative measures of capital adequacies that are less likely linked with derivative offsetting at quarter-end produces similar results as the tier 1 capital ratios used in the baseline regressions.

Alterative Sample Period

We select an alternative sample period to test whether the observed DID results for our first hypothesis are unique to the period around the time when the exogenous shock in central clearing requirements occurred in the year 2013. We select five the years after the implementation of mandatory central clearing as the alternative sample period to carry out a similar triple DID analysis. The untabulated results show that, during the five years after the implementation of mandatory central clearing (2014 to 2018), the triple DID results reported in Panel A of Table 3 can no longer be observed. The findings indicate the results reported in Table 3 are unique to the time period around the regulatory change of central clearing requirements in the derivative market.

VI. Conclusion

In this paper we examine the impact of adopting mandatory central clearing by U.S. regulators on derivative offsetting of financial institutions. Using a difference-in-differences analysis, we find that, after the adoption of mandatory central clearing, banks with higher capital ratios engage in significantly more derivative offsetting than banks with lower capital ratios. This difference amounts to 25 percent of the gross fair value of the banks' average trading derivative assets in contrast to no significant difference between the two groups before the regulatory change. We also conduct an analysis of the relation between central clearing and derivative offsetting during the Covid 19 Pandemic. We find mixed results during the Pandemic.

Acharya and Bisin (2014) theoretically show that central clearing enhances transparency in derivative market and enables derivative contract terms to condition on each counterparty's overall positions and risks. Duffiet et al. (2015)'s model further illustrates that central clearing does not increase system-wide collateral demand, because central clearing provides the benefits of multilateral netting which can outweigh the higher initial margin requirements. Their model also shows that central clearing has significant distributional effects for collateral demand across different types of market participants. In this paper, we contribute to this line of research by showing mandatory central clearing has significant and differential effects on derivative offsetting for different types of banks. We also show that central clearing system, although negatively affected, held up to some extent during the Pandemic in relation to offsetting benefits.

Despite the benefits of multilateral netting and offsetting in mitigating the concerns about a system-wide increase of collateral demand under mandatory central clearing, derivative offsetting can also cause concerns. As offsetting could potentially increase the difficulty in credit risk evaluation for financial institutions (e.g., Ryan and Seitz 2020). Our evidence indicates that, with higher market transparency provided by central clearing, banks with higher target capital ratios engage in more derivative offsetting and the benefits of offsetting held up during the shock of the Pandemic. As such, our results may be relevant to regulators and practitioners.

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Appendix
Variable Definitions

Capital	=	an indicator variable equal to 1 if the bank's tier 1 risk-based capital ratio is within the highest annual tercile rank of the sample, and 0 otherwise;
ChargeOff	=	loan charge-offs divided by total assets;
Contracts	=	total gross notional amounts of derivative contracts divided by total assets;
Deposits	=	total deposits divided by total assets;
Leverage	=	total liabilities divided by total equity;
NonPerform	=	non-performing loans divided by total assets;
Offset	=	the offset fair value divided by the gross fair value before any offsetting; this variable includes the offsetting of trading derivative assets and loans held for investment;
Post	=	an indicator variable equal to 1 if a sample observation occurs after year 2013, and 0 otherwise;
PostTreatment	=	an indicator variable equal to 1 if a sample observation belongs to the treatment group and occurs after year 2013, and 0 otherwise; the treatment group contains the assets of trading derivatives;
Profitability	=	net income divided by total assets;
Securities	=	total securities divided by total assets;
Size	=	natural log of total assets in thousands;
TotalDerivatives	=	the gross fair value of trading derivative assets before any offsetting divided by total assets;

Table 1
Descriptive Statistics: Adoption of Central Clearing

Variable	N	Mean	Q1	Median	Q3	Std.
Offset (trading derivative assets)	2,678	0.147	0.000	0.000	0.019	0.296
Offset (loans held for investment)	1,673	0.005	0.000	0.000	0.000	0.028
Size	4,351	16.361	14.361	16.037	18.185	2.349
Leverage	4,351	9.241	7.000	8.360	10.025	72.334
Profitability	4,351	0.005	0.002	0.004	0.007	0.009
NonPerform	4,351	0.021	0.007	0.013	0.026	0.027
ChargeOff	4,351	0.003	0.000	0.001	0.004	0.007
Securities	4,351	0.189	0.120	0.167	0.236	0.115
Contracts	4,351	2.666	0.029	0.126	0.440	9.346
Deposits	4,351	0.708	0.689	0.766	0.821	0.191

This table reports the descriptive statistics of the variables used in the test on the relation between central clearing requirements and derivative offsetting around the adoption of central clearing. The variables are defined as in Appendix.

Table 2

Correlations: Adoption of Central Clearing

	(1)	*(2)*	*(3)*	*(4)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
(1)Offset	1.000								
(2)Size	**0.518**	1.000							
(3)Leverage	0.006	-0.001	1.000						
(4)Profitability	0.001	**0.051**	**-0.065**	1.000					
(5)NonPerform	**-0.075**	**-0.098**	**-0.046**	**-0.130**	1.000				
(6)ChargeOff	-0.021	**0.031**	0.023	**0.238**	**0.313**	1.000			
(7)Securities	**-0.097**	**-0.128**	-0.013	**0.067**	**-0.196**	**-0.086**	1.000		
(8)Contracts	**0.476**	**0.507**	0.002	**-0.014**	**-0.096**	**-0.040**	**-0.209**	1.000	
(9)Deposits	**-0.343**	**-0.574**	-0.010	**-0.073**	**0.062**	**-0.048**	**0.214**	**-0.559**	1.000

Pearson correlations for the sample around the adoption of central clearing requirements are reported in this table.

The number of observations is 4,351. Correlations significant at the 5 percent level are in boldface.

The variables are defined as in Appendix.

Table 3
Univariate Tests of Treatment and Control Assets by Year:
Around the Adoption of Central Clearing

Panel A: Offsetting for Treatment Asset Group (Trading derivative assets)

year	Capital Adequacy: low to high			Difference (high–low)
2010	0.150	0.186	0.179	0.030
2011	0.105	0.203	0.143	0.038
2012	0.118	0.147	0.234	0.116
2013	0.143	0.096	0.203	0.060
2014	0.084	0.126	0.278	0.194
2015	0.078	0.154	0.274	0.197
2016	0.068	0.141	0.356	0.288
Difference (2016–2010)	-0.082	-0.044	0.177	0.258

Panel B: Offsetting for Control Asset Group (Loans held for investment)

year	Capital Adequacy: low to high			Difference (high–low)
2010	0.006	0.004	0.008	0.292
2011	0.007	0.006	0.012	0.444
2012	0.007	0.005	0.012	0.513
2013	0.000	0.012	0.010	1.011
2014	0.000	0.018	0.007	0.721
2015	0.000	0.000	0.000	0.000
2016	0.000	0.000	0.000	0.000
Difference (2016–2010)×100	-0.537	-0.366	-0.829	-0.292

This table reports the univariate tests of the offsetting for treatment and control assets using a two-way sort. *Difference* represents the difference between the average *Offset* associated with the highest and lowest capital adequacy ranks for a given year (right column), or the difference between the average *Offset* associated with the earliest and latest years for a given capital adequacy rank (bottom row). *Difference* in Panel B has been multiplied by 100 for the ease of reading. The variables are defined as in Appendix. *,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed t-tests for the differences in means.

Table 4
Central Clearing and Derivative Offsetting: Adoption of Central Clearing

Dep. Var.=*Offset*	(1)	(2)	(3)
*PostTreatment*Capital*	0.113***	0.118***	0.117***
	(5.92)	(6.21)	(6.13)
PostTreatment	0.103***	0.018	0.02
	(10.32)	(1.35)	(1.50)
*Post*Capital*	−0.026	−0.035**	−0.033*
	(−1.47)	(−1.97)	(−1.88)
Post	−0.063***	−0.032***	−0.011
	(−3.31)	(−2.88)	(−0.54)
Capital	0.041***	0.043***	0.043***
	(3.87)	(4.11)	(4.09)
Size	0.041***	0.036***	0.036***
	(24.42)	(21.05)	(21.09)
Leverage	0.001	0.001	0.001
	(0.57)	(0.64)	(0.63)
Profitability	−0.336	−0.213	−0.246
	(−0.94)	(−0.61)	(−0.69)
NonPerform	−0.035	0.112	0.076
	(−0.29)	(0.92)	(0.62)
ChargeOff	−0.754	−0.589	−0.658
	(−1.45)	(−1.17)	(−1.28)
Securities	−0.011	0.001	−0.006
	(−0.41)	(0.63)	(−0.21)
Contracts	0.008***	0.008***	0.008***
	(19.55)	(21.01)	(20.84)
Deposits	0.093***	0.086***	0.089***
	(4.48)	(4.18)	(4.34)
Year Fixed Effects	Yes	No	Yes
Asset Fixed Effects	No	Yes	Yes
N	4,351	4,351	4,351
Adj. R^2	37.99%	39.13%	39.23%

*,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed tests. t-statistics, in parentheses, are based on standard errors adjusted for firm-level clustering. This table reports the pooled regressions for the offsetting of trading derivative assets and loans held for investment. The regressions specification is from equation (1). Column (1) reports the regression results with year-fixed effects. Column (2) reports the regression results with asset-fixed effects. Column (3) reports the regression results with year and asset fixed effects. The dependent variable is *Offset*.
The variables are defined as in Appendix.

Table 5
Descriptive Statistics: Impact of the Pandemic

Variable	N	Mean	Q1	Median	Q3	Std.
Offset (trading derivative assets)	754	0.095	0.000	0.000	0.001	0.260
Offset (loans held for investment)	1097	0.006	0.004	0.006	0.008	0.003
Size	1851	16.915	14.895	16.652	18.703	3.239
Leverage	1851	13.952	0.000	0.298	2.297	59.576
Profitability	1851	0.003	0.000	0.000	0.000	0.066
NonPerform	1851	0.063	0.000	0.000	0.001	0.813
ChargeOff	1851	0.021	0.000	0.000	0.000	0.408
Securities	1851	0.168	0.000	0.001	0.006	2.844
Contracts	1851	0.325	0.000	0.000	0.021	1.520
Deposits	1851	0.311	0.000	0.000	0.002	7.012

This table reports the descriptive statistics of the variables used in the test of the impact of the Covid 19 Pandemic on the relation between central clearing requirements and derivative offsetting. The variables are defined as in Appendix.

Table 6

Correlations: Impact of the Pandemic

	(1)	*(2)*	*(3)*	*(4)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
(1)Offset	1.000								
(2)Size	**0.141**	1.000							
(3)Leverage	-0.012	**-0.115**	1.000						
(4)Profitability	-0.007	**-0.135**	-0.002	1.000					
(5)NonPerform	**0.058**	**-0.182**	**0.228**	**0.531**	1.000				
(6)ChargeOff	-0.009	**-0.082**	-0.012	0.000	-0.001	1.000			
(7)Securities	-0.006	**-0.156**	-0.005	**0.928**	**0.475**	0.000	1.000		
(8)Contracts	0.021	**-0.143**	**0.123**	**0.290**	**0.233**	**0.057**	**0.303**	1.000	
(9)Deposits	-0.009	**-0.127**	-0.004	**0.648**	**0.331**	0.021	**0.848**	**0.234**	1.000

Pearson correlations for the sample around the impact of the Covid 19 Pandemic are reported in this table.
The number of observations is 4,351. Correlations significant at the 5 percent level are in boldface.
The variables are defined as in Appendix.

Table 7
Central Clearing and Derivative Offsetting: Impact of the Pandemic

Dep. Var.=*Offset*	(1)	(2)	(3)
PostTreatment	−0.031***	−0.778***	−0.752***
	(3.80)	(−75.59)	(−59.58)
Size	0.003***	0.003***	0.002**
	(11.51)	(5.47)	(1.95)
Leverage	−0.001	−0.001	−0.001
	(−0.90)	(−1.05)	(−0.17)
Profitability	−0.331	−0.176	−0.155
	(−1.43)	(−1.61)	(−1.42)
NonPerform	0.019***	0.006***	0.004
	(3.31)	(2.54)	(1.37)
ChargeOff	−0.004	0.001	0.001
	(−0.40)	(0.01)	(0.30)
Securities	0.006	0.004	0.003
	(0.83)	(1.16)	(0.91)
Contracts	0.004	0.007***	0.008***
	(1.55)	(5.08)	(5.87)
Deposits	−0.001	−0.001	−0.001
	(−0.83)	(−1.00)	(−0.92)
Year Fixed Effects	Yes	No	Yes
Asset Fixed Effects	No	Yes	Yes
N	1,851	1,851	1,851
Adj. R^2	2.71%	78.13%	78.63%

*,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed tests. t-statistics, in parentheses, are based on standard errors adjusted for firm-level clustering. This table reports the pooled regressions for the offsetting of trading derivative assets and loans held for investment. The regressions specification is from equation (2). Column (1) reports the regression results with year-fixed effects. Column (2) reports the regression results with asset-fixed effects. Column (3) reports the regression results with year and asset fixed effects. The dependent variable is *Offset*.

The variables are defined as in Appendix.

Table 8

Central Clearing and Derivative Offsetting: Alternative Measurement of Offsetting

Dep. Var.=*Offset*	(1)	(2)
*PostTreatment*LowRisk*	0.033***	
	(6.85)	
PostTreatment	−0.011***	0.091***
	(−3.24)	(4.27)
*Post*LowRisk*	−0.024***	
	(−5.38)	
Post	0.005	
	(1.11)	
LowRisk	0.006**	
	(2.28)	
Controls	Yes	Yes
Year Fixed Effects	Yes	Yes
Asset Fixed Effects	Yes	Yes
N	4,351	1,851
Adj. R^2	56.73%	53.48%

*,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed tests. t-statistics, in parentheses, are based on standard errors adjusted for firm-level clustering. This table reports the regression results from estimating equation (1) using the alternative measurements of the variable *Offset*. Instead of being deflated by the gross fair value, the offset fair value is deflated by adjusted total assets. Column (1) reports the regression results around the adoption of central clearing. Column (2) reports the regression results for the impact of Covid 19 Pandemic.
Adjusted total assets = total assets plus the offset fair value of the assets.
The other variables are defined as in Appendix.

Table 9
Central Clearing and Derivative Offsetting: Alternative Control Assets

Dep. Var.=*Offset (Repo)*	(1)	(2)
*PostTreatment*LowRisk*	0.161***	
	(4.31)	
PostTreatment	−0.030	−0.693***
	(−0.99)	(−18.86)
*Post*LowRisk*	−0.088***	
	(−2.48)	
Post	−0.003	
	(−0.07)	
LowRisk	0.082***	
	(3.87)	
Controls	Yes	Yes
Year Fixed Effects	Yes	Yes
Asset Fixed Effects	Yes	Yes
N	1,151	1,602
Adj. R^2	67.55%	46.01%

*,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed tests. t-statistics, in parentheses, are based on standard errors adjusted for firm-level clustering. This table reports the regression results from estimating equation (1) using the offsetting of repurchase agreement assets (repo assets) as the control assets. Column (1) reports the regression results around the adoption of central clearing. Column (2) reports the regression results for the impact of Covid 19 Pandemic.

Offset(Repo) = the offset fair value divided by the gross fair value before any offsetting; this variable includes the offsetting of trading derivative assets and repo assets.

The other variables are defined as in Appendix.

Table 10
Central Clearing and Derivative Offsetting: Alternative Capital Adequacy Measures

Dep. Var.=*Offset*	(1)	(2)
*PostTreatment*LowRisk1*	0.090***	
	(4.67)	
*PostTreatment*LowRisk2*		0.073***
		(4.00)
PostTreatment	0.026**	0.023*
	(2.00)	(1.74)
*Post*LowRisk1*	−0.023	
	(−1.28)	
*Post*LowRisk2*		−0.023
		(−1.30)
Post	−0.011	0.002
	(−0.57)	(0.10)
LowRisk1	0.039***	
	(3.76)	
LowRisk2		0.044***
		(4.12)
Controls	Yes	Yes
Year Fixed Effects	Yes	Yes
Asset Fixed Effects	Yes	Yes
N	4,351	4,351
Adj. R^2	38.80%	38.75%

*,**,*** Indicates statistical significance at the 0.10, 0.05 and 0.01 levels, respectively, under two-tailed tests. t-statistics, in parentheses, are based on standard errors adjusted for firm-level clustering. This table reports the regressions results from estimating equation (1) using alternative capital adequacy measures. Column (1) uses the quarterly tier1 capital ratio at the beginning of the quarter. Column (2) uses the quarterly loan charge-offs divided by total assets.
LowRisk1 = an indicator variable equal to 1 if the bank's tier 1 risk-based capital ratio at the beginning of the quarter is within the highest annual tercile rank of the sample, and 0 otherwise.
LowRsk2 = an indicator variable equal to 1 if the bank's loan charge-offs divided by total assets is within the lowest annual tercile rank of the sample, and 0 otherwise.
The other variables are defined as in Appendix.