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ABSTRACT

This paper examines the incentives to voluntarily centrally-clear swaps. It exploits changes resulting from a regulation mandating collateral on uncleared swaps to analyze determinants of traders' clearing decisions. The rule promoted voluntary clearing by decreasing the relative cost of clearing swaps. Using unique regulatory data, the paper finds that clearing more than quadrupled for exchange rate derivatives that were implicated by this regulation, while clearing for similar but exempt derivatives increased by about one-third. These changes were driven by traders who were already clearinghouse members, suggesting that clearing members have substantially lower marginal clearing costs.

JEL classification: G18, G15

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1. Introduction

Central clearing is an important, but largely invisible, aspect of financial markets. Its importance derives in part from its role in enhancing the stability of the financial system through greater transparency and reduced counterparty settlement risk (Duffie, 2020). When a trade is designated for clearing through a central clearinghouse (sometimes called a central clearing counterparty, or CCP), the initial trade is novated, and the CCP becomes the legal counterparty to each trader and therefore bears the risk of trader default (Acharya and Bisin, 2014; Menkveld and Vuillemey, 2021). While clearing is required for exchange-traded derivatives, it remains a voluntary decision of the trading parties for the majority of over the counter products.

Many of the financial regulations in G-20 countries that were enacted following the 2007-2008 recession sought to increase the central clearing of swaps. For some financial instruments, rules were created that made clearing mandatory, and a literature has developed regarding the consequences of mandatory clearing on traders and on systemic risk (see, e.g., Duffie and Zhu, 2011; Loon and Zhong, 2016). Other rules that came into effect during this period, such as the Uncleared Margin Rule (UMR) in the U.S., affect financial instruments for which clearing remains voluntary.[1] The UMR makes clearing a relatively less expensive option, but traders retained the choice of whether to clear their trades (Roberson, 2018). We look at the change in incentives created by the UMR to learn about the underlying economics behind the clearing decisions of individual traders.

Our findings highlight the costs and benefits associated with the decision to centrally clear trades. We find that the decision to clear an individual trade likely reflects a trader's

[1]The UMR was the U.S. rule adopted to reflect the recommendations of the Basel Committee on Banking Supervision and the International Organization of Securities Commission's Global Framework for Margin Requirements (September 2, 2013). Other G-20 countries imposed similar requirements that took effect in the same general time period. A description of the timing of these requirements can be found at https://av.sc.com/corp-en/content/docs/margin-reform-client-outreach.pdf.

previous decision as to whether to become a clearing member (CM) of a clearinghouse. We show that the UMR has a large effect on the clearing decisions of CMs, but has little effect on the clearing decisions of non-CMs. One plausible mechanism by which this could occur is that the UMR lowers the (relative) marginal cost of clearing for CMs, but because of the higher clearing costs faced by non-CMs, clearing remains prohibitive for those entities.

Additionally, we find that the decision to clear each trade between two CMs is significantly influenced by whether clearing that trade will reduce the collateral traders are required to post with the clearinghouse. Specifically, clearing an additional trade may actually reduce the required collateral if it reduces a trader's net position with the clearinghouse. We show that trades are more likely to be centrally cleared when clearing the trade reduces both traders' collateral requirements with the clearinghouse.

We also show that the UMR causes an increase in clearing. This likely reflects the incentives created by the UMR, which provides a cost-related motive for traders to centrally clear, even though the rule is not a direct clearing mandate. Specifically, using a difference-in-differences (DiD) approach, we show that the increases in clearing for the financial instruments we study (non-deliverable forwards, or NDFs) far exceeds the increases for similar instruments that are exempt from the UMR (deliverable forward swaps, or FWDs).

The UMR promotes central clearing by increasing the required collateral (which is referred to as margin in the derivatives context) on uncleared trades for certain large traders, who we refer to as covered entities in the rest of the paper. Prior to the UMR's implementation in the United States in 2016, traders were free to choose the margin level for their uncleared swaps, and some traders chose zero margin for their trades. The UMR places a floor on margins for the uncleared swaps of covered traders. By increasing the cost of using uncleared swaps in some cases, the rule creates an incentive

for these participants to choose central clearing for some of their swaps.

We use a U.S. regulatory data set that includes identifiers for the two parties to each trade. This allows us to see how the decision to clear a trade varies with whether the traders are covered entities, whether they are members of the clearinghouse (CMs), and the size and direction of their pre-trade cleared position with the clearinghouse.

The first step in our analysis is to examine whether the UMR increased the overall frequency of clearing. We look at this question in a DiD framework; did clearing increase for NDFs when the UMR came into effect, relative to FWDs that were exempt from the UMR? Comparing the three-month periods before and after the rule's implementation, we find that clearing rates for NDF swaps rose more than four-fold, whereas clearing rates for FWDs rose by less than one-third.

We next evaluate whether the increase in clearing rates is due to a change in behavior by those entities directly impacted by the UMR, or alternatively, whether traders in general are more likely to clear NDFs. We find that clearing for swaps for which both parties are covered increased from less than 9% of trades to nearly 28% following the rule change, while there was little effect on the clearing of trades between entities not covered by the UMR. This finding points to the importance of the cost of clearing; when the cost of clearing falls relative to the cost of not clearing, entities subject to the rule indeed choose to clear their trades.

Moreover, we find that even for trades between covered entities, clearing decisions are largely determined by whether the trader was a CM. The observed increase in clearing is limited to trades between covered entities who are both CMs. This highlights an important aspect of the trade-off in the choice of whether to become a CM; CMs have lower costs of clearing than other entities. Set against this benefit is that becoming a CM requires a large up-front investment, in the form of a capital contribution to the clearinghouse, and the costs of establishing the infrastructure to connect with the

clearinghouse. Because the UMR increases the benefit of having lower marginal cost of clearing, it may induce some non-CMs to pay this up-front cost, and become CMs.[2]

Even for trades between two CMs, we find that only about half are cleared. We explore whether this decision is influenced by the potential for a trade to result in "netting" of positions. Netting occurs if, for example, a trader has an existing long position in an instrument with a counterparty, and is taking the short position in a new trade with the same counterparty. If a trade does result in netting, the trader's required collateral may decline by virtue of the new trade. We find that if a trade does allow both of the CMs to net against an existing position with the CCP, it is about 3 to 4 percentage points more likely to be cleared.

The implications of our analysis extend well beyond the effect of the UMR on the NDF market.[3] While our focus on the NDF market is primarily due to data availability and presence of a viable control group, our findings regarding the incentives to clear can be extrapolated to other classes of derivatives for which clearing is optional, namely the interest rate, credit, equity, foreign exchange and commodity asset classes of swaps. The uncleared portion of all classes of derivatives comprises more than one-third of all swaps in the U.S., with a total outstanding notional amount of more than $100 trillion.[4]

The rest of the paper proceeds as follows. In Section 2, we summarize related literature, while we describe some relevant features of NDF trading and the UMR in Section 3. In Section 4, we describe our data and presents descriptive statistics. In Section 5, we present the empirical analysis of which market participants choose to clear and why. We conclude in Section 6.

[2]Perhaps reflecting this cost savings, we are aware that several entities that were subject to the UMR rule but were not CMs during our sample period chose to become CMs in later periods.

[3]See CCP12 for evidence on increased clearing in other assets classes associated with the implementation of the UMR.

[4]https://www.cftc.gov/MarketReports/SwapsReports/L1GrossExpCS.html accessed on November 10, 2020.

2. Related literature

Our paper is connected to three strands of literature. First, we analyze traders' decisions to centrally clear trades, and provides additional quantification of the determinants of voluntary central clearing, which provides insight on empirical and theoretical research on this issue. Second, we analyze the impact of a significant multi-jurisdictional change in swaps market regulation, and hence contribute to the literature on measuring the impact of financial policy. Third, our analysis of the NDF market adds to our general understanding of FX derivatives trading.

In regard to evaluating the costs and benefits of clearing, Duffie and Zhu (2011) base their analysis on the observation that there can be significant cost savings due to netting, and mandating clearing can have ambiguous effects on the extent of netting. On the one hand, because the CCP becomes the legal counterparty on every cleared trade, central clearing can allow a trader to net trades that were initially made with different counterparties. On the other hand, netting can occur between correlated instruments (e.g., an exchange rate swap between USD and Korean won and another swap between USD and Indian rupee) within a pair of counterparties. They show that mandating a contract be cleared will tend to lead to lower margin costs and lessen counterparty risk if the contract that is mandated for clearing is within the same "clearing set" (i.e., contracts with highly correlated values) as other contracts offered by the CCP, so that the mandate would encourage netting, but might reduce netting if many other contracts within that clearing set cannot be cleared. Ghamami and Glasserman (2017) use data on bank holding company positions to evaluate these off-setting effects. Cont and Kokholm (2014) show that having a single CCP that clears multiple assets can result in reduced interdealer exposures, but may lead to increased systemic risk issues.

On a related topic, Benos et al. (2023) analyze the costs to traders of fragmentation

(i.e., multiple CCPs for the same product). While their focus is different, a critical element of their analysis is that fragmentation reduces the potential for netting, and hence increases the requisite margin. Their results show that the higher margin cost due to fragmentation results in a 1-3.5 basis point difference in the price of IRS faced by end-users across markets. As discussed below, our analysis shows the importance of netting at a single exchange, and hence, the magnitude of the potential harm from fragmentation. Greater netting also means less demand for collateral, as emphasized in Duffie et al. (2015). They analyze the credit default swaps (CDS) market and empirically estimate the impact of central clearing on collateral demand. Additionally, Cenedese et al. (2021) show that swap contracts that are bilaterally cleared trade at a premium relative to centrally cleared ones, due to higher regulatory costs (e.g., higher risk weights) that are passed on to market prices via the so-called valuation adjustments.

A paper that is in some ways similar to ours is Bellia et al. (2019). Looking at trading in the single-name sovereign CDS market, they find evidence that the ability to net a trade against an existing position with the CCP helps explain the decision to clear the trade. However, they acknowledge that their data do not allow them to identify the two parties to any transaction. This means the authors cannot distinguish trades where one counterparty receives netting benefits from clearing versus those for which both counterparties receive netting benefits. By contrast, our data allow us evaluate the benefit to clearing a trade to both parties, and we present strong evidence that clearing is more likely when both parties receive netting benefits from clearing. In addition, we relate these benefits to the potential costs of clearing.

Moreover, because we have access to data on each entity's positions in all cleared NDF currency pairs, we examine not only the extent to which netting within a currency pair is an important determinant of clearing, but also the extent to which netting across different currency pairs is important. We find that netting within a single NDF is an

important determinant of clearing decisions, but that the potential netting across NDFs pairs does not seem to be relevant to clearing decisions. For example, our results suggest that an entity with an outstanding long cleared position with the CCP in the Korean won/USD NDF is more likely to clear her next trade if that trade involves her taking the short position in a Korean won/USD trade, but not if the trade is a short position in a Indian rupee/USD trade.

Finally, there is a growing literature on analyzing the impact of other recent financial regulations that like the UMR, came into effect after the 2007-2008 financial crisis. Two papers that study the effect of post-crisis financial regulations on clearing are Cenedese et al. (2020) and Acosta-Smith et al. (2022). Cenedese et al. (2020) study the impact of a rule that sets a floor on risk-weighted capital (i.e., the ratio of capital to risk-weighted assets) on decisions banks make regarding clearing and pricing. They find that uncleared IRS trades that do not impact the banks' risk-weighted capital ratio (because their counterparties are exempt from the rules) are priced more favorably to the customer than trades that do impact the banks' ratios. They suggest this implies that the capital rule has an impact on banks' trading decisions. Because the risk-weighted capital requirement also provides an incentive to large banks to clear their trades (by imposing a lower capital charge on cleared trades), this provides indirect evidence that the rule has induced increased clearing. Acosta-Smith et al. (2022) study the effect of a related rule imposing a floor on the leverage ratio (the ratio of tier 1 capital to risk exposure) of large financial institutions.[5] Because the positions of customers for whom they cleared is treated as part of the CM's exposure, the regulation requiring a floor on leverage ratio made it more costly for CMs covered by the rule to clear for third parties. The authors show that financial institutions that were in scope of the leverage ratio rule reduced their clearing of interest rate swaps for third parties, relative to institutions that

[5]See https://www.bis.org/fsi/fsisummaries/b3_lrf.pdf.

were not in scope of the rule.

More generally, studies of the effect of regulations that were enacted after the 2007-2008 financial crisis look at how these regulations affect trader activity. For example, Haynes and McPhail (2021) look at the impact of the supplementary leverage ratio rule on equity options, and Bao et al. (2018) and Allahkra et al. (2019) analyze the impact of the Volcker rule on financial markets. More specific to the impact of financial regulation on swaps markets, Loon and Zhong (2016) show that regulations that allowed for the creation of swap execution facilities (SEFs) that feature central clearing lower trading costs in CDS. Benos et al. (2023) analyze how the introduction of SEFs, and the requirement that certain swaps must be traded on them, affect the interest rate swaps market. Similarly, Riggs et al. (2020) study the trading decisions of customers and dealers on SEFs. Our study differs from their studies by analyzing the impact of the UMR on swaps markets while focusing on its impact on voluntary clearing.

3. Institutional background

Non-deliverable forwards (NDFs) are contracts for the difference between a foreign exchange rate agreed upon in the contract (typically the spot exchange rate when the contract is initiated) and the actual spot rate at maturity.[6] They are typically settled with a single payment at maturity in U.S. dollars from one party to the other. They allow hedging and speculation in a currency without the requirement to exchange that currency at maturity. This feature of NDFs is useful when there are restrictions that prevent direct payment in the non-dollar currency (Lipscomb, 2005). For NDF trading in the U.S., almost all trades have the U.S. dollar as one of the two currencies. Central clearing was available for 14 of the most-heavily traded NDF currency pairs during our

[6]See Park (2001), Misra and Behera (2006), Gu and McNelis (2013), Wang et al. (2014), McCauley and Shu (2016), and Wang et al. (2017) for research on NDF markets.

sample period, all of which had the U.S. dollar as on one side.

For many derivatives, including swap contracts such as NDFs, margins serve as collateral traders post (typically to third-party depositories) at trade initiation. Margins help to ensure that both parties to the trade meet their obligations and potentially mitigate the loss should one party not meet its obligation.[7]

In the U.S., prior to September 2016, for swaps that were not novated to a clearinghouse, the trading parties were free to choose the terms of their swaps, including not posting any margin. As part of the regulation implementing the Dodd-Frank Act, the Commodity Futures Trading Commission (CFTC), along with U.S. prudential regulators, such as the Federal Reserve Board, established rules mandating the posting of margins for all uncleared swaps for large entities, and effectively setting floors for those margins.[8] The rule mandating margin for uncleared swaps applies to all swaps in the U.S., except for the physically deliverable FX swaps and forwards that were explicitly exempted from the swap definition by the U.S. Treasury Department.

Two features of NDF markets make them useful for studying the economics of clearing. First, unlike several other important swap categories, such as fixed-for-floating interest rate swaps and index CDS swaps, clearing remained voluntary for all NDF swaps during our sample period of June-November, 2016. Second, physically delivered FX forwards and swaps were exempt from the UMR. This exemption creates a suitable control group for analyzing the direct effect of the UMR on voluntary clearing.

The rule was implemented in phases, with smaller entities being implicated over time. During the initial phase, which took effect on September 1st, 2016, an entity was covered by the rule if it was part of a parent company (which we refer to as Covered Parent

[7]These contracts typically feature an initial collateral payment (initial margin), and on-going payments to maintain the original collateral as prices move (variation margin).

[8]17 CFR Parts 23 and 140 Margin Requirements for Uncleared Swaps for Swap Dealers and Major Swap Participants; Final Rule (Jan. 2, 2016). 81 FR 635

Companies - CPCs) whose average aggregate notional amount (AANA) of outstanding uncleared derivatives positions were more than $3 trillion. After this date, any new swap for which both parties are Phase 1 entities is implicated by the rule.[9] Subsequent phases reduced the $3 trillion notional threshold for determining which traders are required to post margin on their uncleared swaps. For example, during the final phase, which was implemented in September 2022, uncleared swap transactions between two entities, each of whom was part of a CPC that had more than $8 billion in notional uncleared derivative positions, became subject to exchanging mandatory uncleared margin.

By posting collateral, participants incur an opportunity cost in the form of tied up assets. As a practical matter, prior to the UMR, it was fairly common for swap dealers to post zero margin on their uncleared trades. The rule also provides a framework for calculating margins for uncleared swaps. As a result, the rule imposes a requirement of a minimum margin on all uncleared swap positions when both traders were sufficiently large to be covered by the rule.

For this reason, the UMR raised the cost of trading some uncleared swaps.[10] Since the rule has no effect on the cost of trading cleared swaps, the implication is that the cost of trading cleared swaps has fallen relative to uncleared swaps.[11] Hence, for some portion of their swaps, the UMR creates an economic incentive for a covered entity to clear a swap that would have remained uncleared absent the UMR.[12] As a result, we

[9]Specifically, Phase 1 entities are those for whom the aggregate notional amount of derivatives (AANA) for all entities within the same parent company, averaged over a three-month period in spring of 2016, exceeded $3 trillion. Margin is required for any trade between two Phase 1 entities for which at least one entity is a swap dealer, and neither entity is an end-user (commercial entity) or other exempted entity.

[10]While we do not directly estimate the effect of the UMR on the cost of margining a swap, Roberson (2018) does such a calculation for both typical cleared and uncleared swaps.

[11]For a covered entity, another alternative to trading an uncleared swap with another covered entity is to instead trade with a non-covered entity, since such a trade is not subject to the UMR. Consistent with this premise, we find some evidence that covered entities do more trading with non-covered entities after the UMR goes into effect, but this effect is not statistically significant. See Section A.1 of the Appendix for details.

[12]There are a number of differences between a cleared and an uncleared swap in addition to required

would expect that swaps subject to the UMR (those between two covered entities) are more likely to be cleared than those same trades would have been prior to the UMR.[13]

To be sure, margin is not the only cost of trading a cleared swap. There are costs to accessing the CCP to clear trades, and those costs depend on whether an entity is a CM. The primary benefit to becoming a CM is that only CMs can directly clear trades with the clearinghouse. Non-members can only indirectly clear trades, by using the services of a CM, but face higher incremental costs of clearing than a CM does. Set against that benefit is that becoming a CM requires an upfront capital contribution to the clearinghouse, an annual payment to the clearinghouse, as well as costs involved in establishing the clearing infrastructure.[14] The implication of the difference between CMs and non-members is that CMs face lower marginal clearing costs, and hence we would expect them to clear their swaps at a higher rate.[15] We examine this prediction in Section 5.[16]

We focus on Phase 1 (and to lesser extent, Phase 2). While the number of CPCs in these phases is public information, the identities of the CPCs are not.[17] Instead, we identify the CPCs in Phases 1 and 2 using a non-public monitoring report provided by the International Swaps and Derivatives Association (ISDA). These 20 Phase 1 CPCs represent at least one side of the trade for about 93% of NDF dollar trading volume,

margin. Among other things, when a swap is cleared, the risk of non-performance is transferred from one's counterparty on the trade to the clearinghouse.

[13]Aggregate data confirm this prediction. See CCP12 and https://www.clarusft.com/bis-2016-fx-data-how-much-of-the-ndf-market-is-cleared.

[14]For more details on costs, see https://www.lch.com/membership/ltd-membership/ltd-fees for associated fees and https://www.lch.com/resources/ccp-disclosures for default fund contribution amounts.

[15]For more information on clearing costs to non-CMs, see https://www.bloomberg.com/news/articles/2019-07-19/wall-street-trading-costs-to-surge-as-new-rules-hit-derivatives.

[16]Of course, the relationship may not be causal. It may be that for exogenous reasons, some entities both choose to become CMs and clear more of their trades.

[17]See, Robert M. Smith "UMR phases 5 & 6: Margin rules to alter derivatives market", Bloomberg Intelligence, September 1, 2021.

and both sides of about half of NDF trading, in the third quarter of 2016.[18]

Importantly for our analysis, clearing membership is at the entity level, not the parent level. An entity within a CPC that is not a CM cannot directly clear trades at the clearinghouse, even if another entity within the same CPC is a CM. Hence, even within CPCs, entities face different clearing costs. We exploit these differences in clearing costs in explaining observed clearing decisions.

Several other post-crisis rules also affect the decision to clear. Acosta-Smith et al. (2022) note that the leverage ratio (LR) rule, which went into effect in the United Kingdom in 2016, and in the U.S. and elsewhere in 2018, made it more expensive for certain CMs to clear trades for third parties. Specifically, the LR rule requires certain large financial entities to maintain a minimum ratio of tier 1 capital to total exposure, and a client's exposure at the clearinghouse is treated as the CM's exposure (and the collateral posted by the client with the CM is not treated as an offset). As a result, the rule implies that clearing for a client may require a CM to increase its capital to maintain the required LR. Because our analysis focuses on 2016, it is unlikely the LR rule affected clearing in our sample.[19] Similarly, there is a requirement for a minimum ratio of capital to risk-weighted assets for these entities was instituted as part of the post-crisis regulatory changes (see Cenedese et al.,2020). Because a CM's exposure to the clearinghouse receives a lower risk-weight than their exposure to other counterparties, the risk-weighted asset ratio requirement encourages CMs to clear their own trades. We examine the effect this latter rule had on clearing behavior in our analysis as well.

[18] Additional CPCs became subject to the UMR rule during the later implementation phases as the threshold entity size for coverage fell. We estimate that six additional CPCs became subject to the rule in September, 2017 (Phase 2), and additional entities the next two Septembers. For more details, see, e.g., Lukas Becker "Just six banks caught by phase two of IM regime" risk.net, 6/14/2017 available at https://www.risk.net/derivatives/5290656/just-six-banks-caught-by-phase-two-of-im-regime.

[19] As discussed below, the LR rule was relevant to some UK-domiciled CMs, but none of those CMs did any client-clearing of NDFs even prior to the rule's implementation.

4. Data

4.1. Description of data sets

Our primary source of trade data is regulatory data obtained by the CFTC through Part 45 of the Dodd-Frank Act. Our data covers a six-month period from June 1 to November 30 of 2016, which is three months before and after the implementation date of the first phase of the UMR.[20] The data include fields identifying the two parties to each trade, as well as the two traded currencies and which party received which currency. This regulatory data detail terms of each trade, such as the tenor, whether the trade is cleared, the currency in which payment will be made, and other relevant economic terms. The data identify trading parties by their legal entity identifier (LEI), which is a global identifier mainly used by entities who trade swaps.[21] The trader identification is the main attribute that distinguishes this data from publicly-available data, and knowing the identities of parties allows us to determine whether a trade is subject to margin requirements under the UMR.

As noted above, whether an LEI-level entity is required to post margin on its uncleared swaps depends on the combined position of the entity and all of its affiliates. A large financial firm typically consists of multiple LEIs (e.g., subsidiaries). To determine whether an entity is required to post margin under the UMR, the rule requires that LEIs' trading positions are aggregated up to the parent company level. If the aggregated positions of all LEIs within a parent reach a specific level (e.g., $3 trillion for Phase 1), then all LEIs within that parent are subject to the UMR. We begin by identifying the CPCs implicated in Phases 1 and 2, using a non-public monitoring report provided to regulators by ISDA. We then determine which LEI-level entities are part of each of the

[20] However, we also extend our sample to October 2022 for a longer time-series perspective on aggregate clearing.

[21] See https://www.gleif.org/en/ for a complete list of global LEIs.

implicated CPCs. Because the parent affiliation link is not part of the information contained in the regulatory data, we use affiliate structure data from S&P's Cross Reference Services as a basis for determining which LEI-level entities should be included as part of the in-scope CPCs under the UMR. Since inter-affiliate trades within CPCs are treated differently than market-facing trades under the UMR, knowing the affiliate relationships allows us to focus on trades for which the UMR has the biggest impact. Specifically, we filter out inter-affiliate trades so that we can consider market-facing trades only.

In addition, to understand clearing decisions, we need to determine which entities are CMs of the LCH. To do so, we use a second regulatory data source: data submitted under part 39 regulations adopted by the CFTC. Part 39 is reported to the CFTC by clearing organizations and it lists all cleared positions of CMs and their customers. Using it allows us to determine which entities (at the LEI level) clear their own NDF trades, and which entities are clearing for other entities.

While a large number of currency-pairs are traded in OTC markets, both as NDFs and forward swaps (FWD), not all are available for central clearing. Because we are interested in the decision of whether to clear an individual swap, we limit our analysis to those currency-pairs for which central clearing was available.[22]

One additional reason we view NDF trading as a useful market for understanding voluntary clearing decision of traders is that we likely observe a substantial portion of all trading in these instruments. Although we only observe the NDF transactions that are within the CFTC's jurisdiction, the results in Table 1 suggest we are capturing a large share of all NDF trading.[23] Table 1 shows the average daily volume traded in the

[22]The NDF and FWD currency pairs in our study are distinct; none of the currency pairs in our control group are included in our set of NDF currencies.

[23]CFTC jurisdiction covers any swap with at least one counterparty who is a U.S. entity; or any swap with at least one counterparty registered with the CFTC. The latter case covers situations where a non-U.S. entity that is registered as a swaps dealer with the CFTC might trade with another non-U.S. entity.

CFTC's jurisdiction during April 2016 and the same estimate for the global market from the Bank of International Settlements (BIS). The results suggest that we are capturing more than one-half of global NDF trading. Our coverage of Asian currencies is slightly below 50% but coverage for the BRL and RUB are 83% and 93% respectively.

4.2. Summary statistics

In Table 2, we present the number of trades, trading volume in notional dollars, and the number of Phase 1 market participants, as well as the number of Phase 1 CMs in our subsample around the implementation of Phase 1 of the UMR. Panel A provides summary statistics on the number of transactions in total and by different types of market participants, while Panel B provides notional volume disaggregated similarly, and Panel C provides counts on the number of LEIs and CMs that were subject to Phase 1 of the UMR. Our regulatory data shows that the 20 CPCs contained about 545 LEI-level entities. These 545 LEIs were on at least one side of the vast majority of trades – 95% over the entire six month period — and both sides of about 40% of trades.

One conclusion from Table 2 is that the trading measures associated with the post-UMR period are higher than in the pre-UMR period in both panels. That is, both the total number of transactions and the total notional dollar volume increase after the implementation of the UMR. This increase is particularly pronounced (about a 24% increase in transactions and 27% increase in total notional) when both sides to the trade are CMs who are covered by the UMR. The bottom row in Panels A and B report an increase in the number and notional value of cleared swaps, respectively, and the observed increase in both values is almost four-fold. Altogether, these statistics suggest a slight increase in trading in the NDF market but a large jump in the extent of clearing following the implementation of the UMR.

Based on the regulatory part 39 data, we observe only 17 Phase 1 LEI-level CMs (that is, entities that cleared their own trades) in 2016, as shown in Panel C of Table 2. Hence, some CPCs did not clear any of their own trades, and the vast majorities of LEI-level entities were not CMs. These 17 represented at least one side of the trade on 95% of all post-UMR trades for which a Phase 1 entity was on both sides of the trade.

4.3. Initial look at clearing at the NDF market

As discussed in Section 3, the direct effect of the UMR is to raise the cost of using uncleared swaps for covered entities, relative to cleared swaps, to establish a position. Hence, the implication is that entities should clear a higher share of their NDF swaps after the UMR goes into effect. Figure 1 shows the percentage of NDF trades cleared in our sample from June 2016 until the end of October, 2022. The biggest increase in clearing rates comes after Phase 1 of the UMR implementation in September 1, 2016; clearing rates increase from less than 5% just prior to the implementation of Phase 1 to more than 15% just prior to Phase 2 implementation. There is another increase associated with Phase 2 of the UMR implementation, as clearing rates average about 25% between September, 2017 and September, 2018.[24] By contrast, Figure 1 suggests that phases 3-6 do not seem to have a substantial effect on the clearing ratio.[25] It is not surprising that Phase 1 had a larger effect than Phases 2-4; since the 20 largest CPCs were affected by Phase 1, whereas a smaller number of smaller entities were implicated over the next three phases. Phases 5 and 6 brought a large number of smaller entities into

[24]This increase in clearing could also in part reflect the variation margin requirement for virtually all NDF trades, which went into effect in September 2017. Between September 2016 and September 2017, uncleared swaps between Phase 1 entities were subject to the variation margin requirement, while most uncleared swaps involving other financial entities were not subject to a variation margin requirement (see CFTC Letter No. 17-11 No-Action February 13, 2017 Division of Swap Dealer and Intermediary Oversight).

[25]Hong Kong Monetary Authority Monetary Management Department (2018) find that clearing among trades reported to the Hong Kong Trade Repository rose dramatically after UMR was introduced across many jurisdictions.

scope in September 2021 and 2022, respectively. There does appear to a small upward drift in clearing in early 2022, which does not directly correspond to the implementation date of either phase.[26]

In Figure 1 in Section A.2 of the Appendix, we examine the impact of Phase 2 more closely by looking at the change in clearing by Phase 1 entities and separately, Phase 2 entities. It shows that Phase 2 entities reacted to becoming in-scope in a similar way to how Phase 1 entities responded during the previous September: increasing their clearing rate up to about 15%. Hence, while our analysis is primarily focused on the effect of Phase 1, we believe our results reflect the UMR more generally.

To evaluate whether changes other than the UMR might have caused an increase in clearing in the NDF market associated with Phase 1, we compare the clearing rate on NDF to clearing rates for deliverable forwards and FX swaps (which together we refer to as FWD) in our analysis (as noted above, the UMR did not apply to these instruments). In Figure 2, we show the aggregate percentage of NDF and FWD that were cleared around Phase 1 of the UMR implementation. The figure shows that the Phase 1 implementation in the fall of 2016 is associated with a fairly dramatic effect in clearing for NDF, and a much smaller change for FWDs. Specifically, a little under 1% of NDF trades were cleared in the three months prior to the UMR going into effect, and nearly 4.4% in the three months after the change. By contrast, clearing for FWDs increased from 0.062% before the change to 0.08% afterwards. This stands in contrast with the pre-UMR trends for the two categories, which are sufficiently similar that we cannot reject the assumption of parallel trends for FWD and NDF in the period before the UMR went into effect.[27] This validates the use of DiD estimates of the effect of

[26]The trade press suggested that higher market volatility in early 2022 increased required margins on uncleared swaps, which moved many smaller in-scope entities above an exemptive limit. This in turn made clearing more attractive. See e.g., Helen Bartholomew "Phase six margin cohort may exceed estimates as vol bites" Risk.net, July 29, 2022.

[27]In Section A.3 of the Appendix, we present an estimation showing that the trend in clearing for

the UMR on clearing rates for NDF. The differential effect on NDFs suggests that the increase in NDF clearing was not due to factors affecting foreign exchange trading in general, but rather was due to the UMR. Furthermore, the low clearing rate for FWD trades continues even after the period we analyze. Collin-Dufresne et al. (2019) report virtually no trades in the FX forward market were cleared between May 2018 and April 2019 for EUR/USD.

We provide quantification of this effect in Table 3 and test the hypothesis that the clearing rate in the NDF market is significantly higher than the clearing rate in the FX forward market after the UMR. We run the following probit regression using a DiD approach to evaluate the effect of UMR. Our treatment group is NDF transactions while the control group is FWD transactions.

$$P(Y_i = 1) = \Phi(\alpha_0 + \beta_1 NDF_i + \beta_2 UMR_t + \beta_3 Trend_t + \beta_4 UMR_t * NDF_i + \beta_5 UMR_t * Trend_t + \beta_6 UMR_t * NDF_i * Trend_t), \quad (1)$$

where Y_i is equal to 1 if trade i is cleared and $\Phi(.)$ is the cumulative distribution function of the standard normal distribution. The explanatory variables include a dummy for NDF (vs. FWD), a dummy for the UMR period, the interaction of those two dummies, a time trend variable $Trend$ that is at daily frequency (divided by 100 to facilitate presentation), and a trend interaction ($Trend*UMR*NDF$) term. The standard errors are clustered at the currency pair level. The coefficient on the $NDF*UMR$ interaction term indicates the extent to which the UMR had a larger effect on NDF clearing than

FWDs in the pre-UMR period is positive. In Section A.4 of the Appendix, we describe the parallel trends test, showing that the positive trends in the pre-UMR period for FWDs and NDFs are sufficiently similar that one cannot reject the assumption of parallel trends.

FWD clearing. Table 3 shows the marginal effect of our estimated coefficients.[28] As shown in column (2), we find that the marginal effect of NDF is 0.0154, implying that clearing is 1.5% higher for NDFs compared to FWDs in the pre-UMR world. The marginal effect of the interaction term of UMR and NDF is 0.0043, suggesting that clearing is an additional 0.43% more likely for NDF at the UMR implementation date (day 0). Looking at the median of our post-UMR period (45 days) and multiplying by the coefficient on the differential trend (0.0038), our estimates imply that on the median post-UMR day, the clearing rate for NDF increased by about 0.6% (0.0043 + 45/100 * 0.0038 = 0.006) relative to FWD. To put this in perspective, this represents a 39% (=0.006/0.0154) increase in the difference in clearing rates between NDF and FWD.

We realize that the 0.6% result described above seems small relative to the impression one gets from looking at the data in Figure 2. One potential explanation for the discrepancy is suggested by the work of Lechner (2011), who notes that DiD estimates using a non-linear estimation (like probit) can lead to misleading results. This suggests that running a linear specification could provide more appropriate DiD estimates than probit. A second potential reason to try ordinary least squares (OLS) estimation is that probit estimation assumes a normal distribution of the residuals (see, e.g., Amemiya, 1981), whereas OLS does not. Our estimates of the residuals from the results of either of the regressions reported in Table 3 suggest the skewness and kurtosis of the residuals exceed those implied by the normal distribution.[29] The estimates from our OLS regressions are reported in Table 4. Columns (1) and (2) report the results of regressions similar to those in Table 3 in that we use each individual swap in our regression. Finally, as Amemiya (1981, p. 1498 ff) discusses, using group averages tends to produce

[28]Specifically, for continuous variables, Table 3 shows the slope of the clearing rate with respect to the variable evaluated at each variable's mean, while for indicator variables, the relevant entry in Table 3 is the partial difference associated with a discrete change from 0 to 1.

[29]For example, the skewness of the distribution of the data used in our estimation of equation (1) is 12.3 and its kurtosis is 157.2.

more accurate linear estimates than the ungrouped data when the dependent variable is dichotomous. As such, we estimate OLS regressions in which the dependent variable is the daily average clearing rate for (alternatively) NDF or FWD and report those results in columns (3) and (4), respectively.

The implied change from the UMR is quite similar across our four specifications. For example, from column (4), the marginal effect of the interaction term of UMR and NDF is 0.0175, suggesting that clearing was an additional 1.753 percentage points more likely for NDF at the UMR implementation date (day 0). Looking at the median of our post-UMR period (45 days) and multiplying by the coefficient on the differential trend (0.0351), our estimates imply that on the median post-UMR day, the clearing rate for NDF increased by about 3.3 percentage points (1.753 + 45/100 * 0.00352 = 0.033) relative to FWD after the UMR went into effect. Hence, the implied clearing rate for NDF is about 4.2 percentage points higher than for FWD on that date. The estimates in columns (1) – (3) likewise imply a difference of about 4.2 percentage points by day 45 of the UMR regime, which more closely corresponds to what we observe in Figure 2 at the mid-point of our post-UMR sample. Hence, we conclude that the UMR had an impact on clearing in addition to any other factors associated with FX swaps during the period in this it was implemented.

5. Analysis of clearing decisions

Section 4 provided a test for the most direct implication of how the UMR's requirement of collateral for uncleared NDF swaps would affect clearing. Other implications follow from the institutional details described above. The first implication is that there would be differential effects for covered vs. non-covered entities. Since only trades between two parties that are both affiliated with covered CPCs are required to post

margin on uncleared swaps, we test whether the UMR has a larger effect on trades between covered entities.

The second implication is that there would be differential effects for CMs vs. non-CMs for covered entities. As emphasized above, CMs have lower clearing costs than non-CMs. Hence, we test whether the increase in clearing is larger for entities that were CMs, within the 20 covered CPCs.

The third implication is that there would be differential effects due to the impact of clearing on aggregate margins at the clearinghouse. As shown below, even for trades between CMs during the period in which the UMR is in effect, only about half of them are cleared. Hence, other factors beyond the UMR requirement and CM status affect the clearing decision. Specifically, we test the implication that a trade that allows both parties to reduce their margin obligations to be the clearinghouse is more likely to be cleared. In this section we examine these three implications.

5.1. Do covered entities make different clearing decisions?

Under the UMR, only swaps between two covered entities are required to post margin on an uncleared swap. As such, the implication is that, comparing the September to November 2016 period to the pre-UMR period, the change in NDF clearing will be concentrated among Phase 1 covered entities. Because our data allow us to know the identity of the traders, we know which trades would be required to have margin posted during the UMR period if they are not cleared. Figure 3 shows the clearing rates separately for NDF trades between covered entities and other NDF trades for the six-month period surrounding the implementation of the UMR, looking only at trades in currency pairs for which clearing was available. Consistent with our earlier interpretation, we find that the effect of the UMR is primarily on trades between covered

entities; the percentage of such trades cleared rose from about 8.6% on average before the rule change to about 28% on average afterwards. The corresponding change for trades for which one or both parties are not covered during the Phase 1 of the UMR is from 0.05% to 0.1%, which is substantially smaller.

While testing for the effect of the regime change on clearing rates using a DiD framework within NDF would have been desirable (i.e., covered vs. non-covered), the inapplicability of the (necessary) parallel trends assumption means that DiD was not an appropriate methodology here.[30] Statistical tests show that the trends for clearing for trades between Phase 1 entities and for other trades are quite different in the pre-UMR period. For this reason, the regression in equation (2) only includes trades between covered entities, and analyzes how clearing decisions on those trades were affected by the UMR:

$$P(Y_i = 1) = \Phi(\alpha_0 + \gamma * M_i + \delta * C_i + \beta_1 UMR_t + \beta_2 Trend_t + \beta_3 UMR_t * Trend_t + \beta_4' X_i), \quad (2)$$

where the Y_i, UMR, and $Trend$ variables and $\Phi(.)$ are defined for equation (1). X_i denotes the control variables for observation i, which includes the tenor of the swap, its notional size in USD, and whether is it traded on a SEF. γ is a vector of coefficients on the currency fixed effects M_i, and δ is a 2 x 9 matrix of coefficients on the CPC fixed effects for the two parties (C_i) for trade i. The reason for currency-specific fixed effects is that clearing rates differ substantially across currencies. Similarly, we include the matrix of trader fixed-effects because clearing rates differ substantially across CPCs. Table 5 presents estimates of the effect of the UMR on clearing for the NDF transactions between the entities that were covered under the Phase 1 of the UMR. In Table 5, we

[30] An F-test for the null hypothesis that the pre-UMR trends are parallel is rejected with a p-value of .044.

report the marginal effects from the probit estimation. Notably, the effects of the UMR dummy variable and the interactive UMR*$Trend$ variables are positive and statistically significant, and quite similar across specifications. Column (4) shows that the effect of the UMR is nearly a seven percentage-point increase in clearing, and the interacted coefficient on the $Trend$ is 0.13 per hundred days, which means that the trend towards clearing more than doubles after the UMR went into effect. Combining the UMR and the UMR*$Trend$ coefficients, the regression implies that by 30 days after the UMR went into effect, clearing is almost 11 percentage points higher because of the UMR, which amounts to more than doubling the pre-UMR level for covered entities. We also find that clearing is more likely for larger swaps and less likely for longer tenor swaps. For example, this means that doubling of notional trade size from its mean leads to about a two percentage-point increase in clearing.

To create a heuristic visual comparison, we estimate linear regressions of daily average clearing rates for Phase 1 entities to show the implied change in clearing from the UMR, relative to the implied clearing rate had the UMR had not gone into effect in Figure 4. The bold, dense line to the right of the UMR Phase 1 implementation date marker is hypothetical, showing our estimate of what clearing would have been without the UMR, assuming the trend in clearing maintained its pre-UMR trajectory. The steeper line in the post-UMR section of the figure represents the actual trend in clearing post-UMR, and the difference between these two lines illustrates the impact of the UMR on clearing. It shows that not only did the UMR lead to an immediate increase in clearing, but also the effect seems to increase over time.

This is not to say that other post-crisis regulations did not affect clearing rates as well. As Cenedese et al., (2020) discuss, the Basel III capital regulations may encourage clearing by some of the larger CPCs. They find some evidence that dealer pricing of IRS swaps was influenced by how the trade affected the dealer's capital ratio. In principle,

this same incentive might encourage entities to clear trades, since cleared trades receive a more favorable treatment under the Basel III regulations. However, we were unable to detect this effect in our data.[31]

5.2. Which trades are likely to be cleared?

We next turn to the question of which NDF trades by "covered" entities are most likely to be cleared. As discussed above, the marginal cost for clearing is lower for CMs than other entities. If only one party is a CM, the non-CM party has to contract with a CM for clearing services in order for the trade to be cleared. Table 2 shows there are about 545 entities that traded NDF during our sample period and were covered under Phase 1 of the UMR, and only 17 of them are CMs in 2016.[32]

These CMs are parties to the vast majority of cleared trades, however. Of the roughly 90,000 NDF trades between two covered entities that are cleared in the three months following the UMR, more than 99% have a CM on at least one side, and 98% have CMs on both sides. By contrast, virtually none of the trades between two non-CM covered entities are cleared. One implication is that, since several in-scope CPCs did not have any CMs among their LEIs, this means that some CPCs cleared very few trades. Another implication is that the costs of using the clearing mechanism apparently were substantially higher for non-CMs than CMs.

To test the hypothesis that the probability of a post-UMR swap being cleared is higher when one or both of the two parties are CMs, we run the following regressions on

[31]Specifically, we looked at the relationship between the rate at which CMs clear and the associated CPC's capital ratio for the last half of 2016 and all of 2017 using data from https://www.fdic.gov/about/learn/board/hoenig/capitalizationratio2q16.pdf. The hypothesis that clearing is a way for capital-constrained entities to increase their ratio would imply a negative relationship between the observed capital ratio and the clearing rate, but we find a positive relationship. Our analysis is described in Section A.5 of the Appendix.

[32]That is, only 17 entities could clear their own trades. Some additional entities could clear trades for other entities.

the sub-sample of NDF trades between two Phase 1 entities during the UMR period:

$$P(Y_i^{Cov} = 1 \,|\, 0\, or\, 1\, CM) = \Phi(\alpha_0 + \beta_1 OneCM_i + \beta_2 Trend_t + \beta_3' X_i + \gamma * M_i + \delta * C_i) \quad (3)$$

$$P(Y_i^{Cov} = 1 \,|\, 1\, or\, 2\, CMs) = \Phi(\alpha_0 + \beta_1 TwoCM_i + \beta_2 Trend_t + \beta_3' X_i + \gamma * M_i + \delta * C_i), \quad (4)$$

where Y_i^{Cov} is equal to 1 if trade i between two covered entities is cleared, and the right-hand side variables $Trend$, X, M, and $\Phi(.)$ are defined for equation (2). Equations (3) and (4) estimate conditional probabilities. In equation (3), we analyze the universe of trades for which the two parties include either 0 or 1 CMs, while in equation (4), we analyze the universe of trades for which the two parties include either 1 or 2 CMs. $OneCM$ is a dummy variable that equals one for trades in which one of the two parties is a CM and zero otherwise, and $TwoCM$ is a dummy variable that equals one for trades in which both parties are CMs and zero otherwise. For both equations, we ask how does the presence of an additional CM (e.g., one CM compared to zero for equation (3)) influence the likelihood that a trade is cleared.

Table 6 presents the estimates from two different versions of probit estimation of the specification in equations (3) and (4). Columns (1) and (3) show the estimates from regressions without fixed effects and columns (2) and (4) present the estimates from regressions with currency and trader fixed effects. The coefficient on $OneCM$ in columns (1) and (2) shows that the effect of having one CM as a party to the trade, rather than zero, is small – on the order of 1 percentage point. However, the coefficients on $TwoCM$ in columns (3) and (4) show that having two CMs as parties to a trade has a substantial effect on the likelihood of clearing; e.g., a 56 percentage point increase, after accounting for fixed effects, as shown in column (4).

These results suggest that even for Phase 1 entities, non-CMs rarely clear their trades. We infer from this that firms that are not CMs generally find it prohibitively expensive to clear their trades. By contrast, firms that paid the fixed cost of becoming a CM find that many trades are less expensive to make if they are cleared (at least in part due to lower margin requirements). One additional piece of evidence pertaining to the cost of clearing is that 11 of the entities that were non-clearing entities during our sample period (all of whom are apparently covered in one of the early phases of the UMR), have chosen to become CMs of the LCH in the six years after our sample period. This is consistent with the premise that there is a trade-off between the fixed costs of becoming a CM and the resultant lower clearing costs, and that the UMR increases the benefit to covered entities of having lower clearing costs.

These findings indicate that CMs are much more likely to clear their trades than other covered traders. Even for trades between two CMs, however, only about half are cleared during the UMR period. We next address the question of the determinants of which trades between two CMs get cleared. One hypothesis discussed above is that a trade will be cleared if it reduces the traders' net positions with the clearinghouse, which allows the entities to reduce the amount of margin they needs to post with the clearinghouse (netting).

To test this, we calculate the net position of each CM with the clearinghouse by aggregating all of their existing, still open, cleared NDF trades in our data dating back to June 1st, 2016.[33] This allows us to determine whether a trade between two CMs would be beneficial to both in terms of netting a previous NDF position with the clearinghouse.

[33]Because our sample begins on June 1, 2016, we need to assume all cleared positions are zero as of that date. Since the median tenor of trades in our sample is 34 days, we view our calculation of net aggregate position dating from June 1 as increasingly accurate for later dates. For this reason, we choose to leave out trades made in June from the analyses in Tables VI and VII, although untabulated results that include June trades or exclude July trades are qualitatively similar to those presented in those tables.

For example, if a CM's aggregate net cleared trades in a certain currency pair results in an existing long position (in USD), then a new cleared swap in that currency pair for which the trader would be paying USD would be beneficial, as it would allow for a smaller exposure when netted at the clearinghouse level. Following this logic, we characterize a swap as beneficial ($Benefit = 1$) if both CMs entering into the swap will reduce their existing NDF exposure with the CCP by virtue of the swap being cleared. Note that because we are interested in how an existing position affects clearing decisions, we limit the sample to trades for which both parties have previously cleared at least one trade in the currency pair of that trade.

Using this variable, we run the following probit regression to test the hypothesis that the probability of a covered swap between two CMs being cleared is significantly higher when the direction of the swap allows both CMs to net positions, and thereby reduce their exposure at the CCP level:

$$P(Y_i = 1) = \Phi(\alpha_0 + \gamma * M_i + \delta * CM_i + \beta_1 UMR_t + \beta_2 Trend_t + \beta_3 UMR_t * Trend_t + \beta_4 Benefit_i + \beta_5' X_i), \quad (5)$$

where the Y_i, UMR, and $Trend$ variables and $\Phi(.)$ are defined for equation (1) and M is defined for equation (2). Our indicator variable $Benefit$ is different than the variable used in Bellia et al. (2019) as we set it equal to one if and only if both sides will reduce their net position with the clearinghouse by clearing the trade.[34]

Table 7 presents the estimates of three versions of equation (5), where the versions differ in regard to inclusion of fixed effects. Column (1) does not include fixed effects,

[34] Bellia et al. (2019) cannot observe both sides to each trade, so in their estimation, the dummy is set equal to 1 if a trader they observe will reduce its position with the clearinghouse by virtue of clearing the trade.

while column (2) adds trader fixed effects, and column (3) includes both trader and currency fixed effects. Note that the trader fixed-effect variables are different from those in previous regressions; here they consist of a vector of 156 dummy variables (one for each pair of CMs), reflecting the property that clearing rates differ between CM pairs.[35] The results in column (1) suggest that trades are nearly 10 percentage points more likely to be cleared if the trade benefits both traders through netting effects. Inclusion of these fixed effects reduces the estimated marginal effect of $Benefit$ by about two-thirds, as shown in columns (2) and (3). It also increases the pseudo-R^2 substantially, suggesting that CMs differ in their willingness to clear for reasons that are independent of their positions, as well there being important differences between currencies. Table 7 also indicates that, holding $Benefit$ fixed, the UMR increased clearing for CMs by 5.2 to nearly 7 percentage points. The estimates for the remaining variables tend to have similar magnitudes and signs as in previous tables. For example, the estimated marginal effect on $Trend$ suggests that the likelihood of clearing rose about 2 percentage points per week during the sample period.

The results in Table 7 answer the question of whether traders choose to clear when a trade lowers the outstanding position of CMs with the CCP in a specific currency pair. An issue that is central in the literature on the effect of mandatory clearing is whether netting occurs within a currency pair, across currency pairs, or more generally across asset classes (e.g., Duffie and Zhu, 2011). That is, for example, if a trader has a long position in dollars in rupee/dollar trades and a short position in dollars in won/dollar trades, is the trader's required margin lower than would be required by the two individual positions? If it is, then it may be appropriate to calculate the $Benefit$ variable based

[35]For example, during the UMR period, the median clearing member cleared 55.5% of its trades, and the inter-quartile range of clearing rates across members varied from 0.4 to 0.74. As this would suggest, the average rate at which at trades between two CMs were cleared varied considerably across pairs; from close to zero for some pairs of CMs to over 90%, depending on the members.

on positions aggregated across currency pairs. Unfortunately, while the LCH website notes that there are inter-currency offsets in margin calculations, the exact model used by the LCH to calculate these inter-currency offsets is not publicly available. Instead, to examine if these effects are important, we use a simple model for offsets.[36] We calculate whether each trader enters a trade long or short the dollar side in cleared NDF trades overall. If the party taking dollars in the trade was short the dollar side in cleared NDFs entering the trade, and the party paying dollars in the trade was long the dollar side entering the trade, we characterize the trade as beneficial to both party's margin obligations (i.e., $Benefit\_USD = 1$). Table 8 provides the estimates of regressions that are similar to those for Table 7 except they include this alternative measure of netting benefit. The coefficients on the netting benefit variables fall dramatically compared to those in Table 7. Comparing column (1) in the two tables, we find that estimated effect of the netting benefit falls by about 80%, and becomes statistically insignificant. The netting variable remains insignificant in columns (2) and (3) of Table 8 as well. We conclude that to the extent cross-currency netting does occur at the LCH, the impact is limited. Analysis based on netting on currency-by-currency bases seems to better explain CMs' clearing behavior.

6. Conclusion

This paper analyzes the clearing choices made by traders in regard to trades in a financial instrument for which clearing is voluntary. We find that traders choose to centrally clear more of their trades when the relative cost of clearing decreases, which in our study results from a new global financial regulation relating to exchanging collateral. Our findings also illuminate the importance of an entity's status as a CM in determining

[36] In addition, there may be offsets from positions in non-NDF instruments, such as forward swaps and options. This adds additional noise to our measures of $Benefit$

their clearing decisions, which is informative about the costs and benefits of becoming a CM.

We first show that the aggregate clearing rate for NDFs increased with the introduction of the UMR, a regulation that mandates additional collateral for uncleared swaps. Taking advantage of a difference in coverage of the UMR between NDFs and a similar product (FX forwards), we show that this change is substantially greater for NDFs; clearing rates rose more than four-fold for NDFs after the UMR came into effect, whereas the change in clearing rates for FX products that are not subject to the UMR increased by about one-third. This suggests that the observed change is not due to factors that are common to all foreign exchange swaps, but rather specific to those affected by the UMR.

Additionally, we look at the cross-sectional aspects of clearing. We show that the increase in NDF clearing is almost exclusively due to change in behavior by the entities directly affected by the UMR; CPCs that were covered under Phase 1 of the rule increase their clearing rates dramatically, while clearing rates for other entities have little or no change. Within those Phase 1 CPCs, the change in clearing is overwhelmingly the result of an increase in clearing by CMs; clearing by non-CMs is infrequent during the post-UMR portion of our sample. Finally, we examine the clearing decisions for trades between CMs. We find that a swap is 3.5 percentage points more likely to be cleared if the trade brings netting benefits to both CMs entering into the trade.

Our findings with respect to how the UMR affects clearing yield insights into the clearing process. The result that entities who were already CMs dramatically increased their clearing rate after the UMR went into effect suggests that under the UMR, clearing leads to substantial savings in the amount of collateral a covered entity is required to post. Despite these apparent savings, several covered CPCs chose not to have any of their subsidiaries become CMs of the clearinghouse during our sample period. As such,

it would appear that the costs of, and potentially delays associated with, becoming a CM are substantial.[37] At the same time, our finding that Phase 1 entities who are not CMs rarely clear their trades suggests there are substantial additional costs to non-CMs of using the clearing mechanism.

The UMR is one of several financial regulations enacted after the 2007-2008 financial crises that had the goal of ensuring there is adequate collateral on swaps. Our evidence suggests that up to now, a principal effect of the UMR has been to increase clearing by CMs, who are generally large swap dealers. Because the margins on cleared trades are determined by the clearinghouse, and clearinghouses have considerable expertise in calculating suitable margins, it seems likely that these swaps now have appropriate collateral. More recent phases, especially the last two, apply to much smaller entities, and these entities are unlikely to become CMs (since becoming a CM is capital-intensive). Analyzing how these entities will adapt to the new environment will be informative about the costs and benefits of alternative means of ensuring adequate collateral.[38] This information is likely to be valuable to decision-makers, such as regulators and market participants, as well as academics interested in the clearing process.

[37] We note that several Phase 1 entities became CMs subsequent to our sample period. As such, we can interpret the delay in becoming a CM as a cost of transitioning into CM status.

[38] While Figure 1 suggests that some of these smaller entities have been clearing some portion of their trades over the past few years, clearing remains infrequent for smaller entities.

References

Acharya, V., Bisin, A., 2014. Counterparty risk externality: Centralized versus over-the-counter markets. Journal of Economic Theory 149, 153–182. URL: https://www.sciencedirect.com/science/article/pii/S0022053113001191, doi:https://doi.org/10.1016/j.jet.2013.07.001.

Acosta-Smith, J., Ferrara, G., Rodriguez-Tous, F., 2022. Bank capital regulation and derivatives clearing. Bank of England Staff Working Paper No. 735 .

Allahkra, M., Cetina, J., Munyan, B., Watugala, S., 2019. The effects of the volcker rule on corporate bond trading: Evidence from the underwriting exemption. OFR Working Paper .

Amemiya, T., 1981. Qualitative response models: A survey. Journal of Economic Literature 19, 1483–1536. URL: http://www.jstor.org/stable/2724565.

Bao, J., O'Hara, M., Zhou, X.A., 2018. The volcker rule and corporate bond market making in times of stress. Journal of Financial Economics 130, 95–113. URL: https://www.sciencedirect.com/science/article/pii/S0304405X18301491, doi:https://doi.org/10.1016/j.jfineco.2018.06.001.

Bellia, M., Girardi, G., Panzica, R., Pelizzon, L., Peltonen, T., 2019. The demand for central clearing: To clear or not to clear, that is the question. SAFE Working Paper No. 193 .

Benos, E., Huang, W., Menkveld, A.J., Vasios, M., 2023. The cost of clearing fragmentation. Management Science doi:https://doi.org/10.1287/mnsc.2023.4867.

CCP12, 2019. Incentives for central clearing and the evolution of otc derivatives.

Cenedese, G., Della Corte, P., Wang, T., 2021. Currency mispricing and dealer balance sheets. The Journal of Finance 76, 2763–2803. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/jofi.13079, doi:https://doi.org/10.1111/jofi.13079, arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/jofi.13079.

Cenedese, G., Ranaldo, A., Vasios, M., 2020. Otc premia. Journal of Financial Economics 136, 86–105. URL: https://www.sciencedirect.com/science/article/pii/S0304405X19302296, doi:https://doi.org/10.1016/j.jfineco.2019.09.010.

Collin-Dufresne, P., Hoffman, P., Vogel, S., 2019. Informed traders and dealers in the fx forward market. Working paper .

Cont, R., Kokholm, T., 2014. Central clearing of otc derivatives: Bilateral vs multilateral netting. Statistics & Risk Modeling 31, 3–22. URL: https://doi.org/10.1515/strm-2013-1161, doi:doi:10.1515/strm-2013-1161.

Duffie, D., 2020. Still the world's safe haven? redesigning the u.s. treasury market after the covid-19 crisis. Hutchins Center Working Paper #62 .

Duffie, D., Scheicher, M., Vuillemey, G., 2015. Central clearing and collateral demand. Journal of Financial Economics 116, 237–256. URL: https://www.sciencedirect.com/science/article/pii/S0304405X14002761, doi:https://doi.org/10.1016/j.jfineco.2014.12.006.

Duffie, D., Zhu, H., 2011. Does a Central Clearing Counterparty Reduce Counterparty Risk? The Review of Asset Pricing Studies 1, 74–95.

Ghamami, S., Glasserman, P., 2017. Does otc derivatives reform incentivize central clearing? Journal of Financial Intermediation 32, 76–87. URL: https://www.sciencedirect.com/science/article/pii/S1042957317300402, doi:https://doi.org/10.1016/j.jfi.2017.05.007.

Gu, L., McNelis, P.D., 2013. Yen/dollar volatility and chinese fear of floating: Pressures from the ndf market. Pacific-Basin Finance Journal 22, 37–49. URL: https://www.sciencedirect.com/science/article/pii/S0927538X12000649, doi:https://doi.org/10.1016/j.pacfin.2012.09.002.

Haynes, R., McPhail, L., 2021. When leverage ratio meets derivatives: Running out of options?*. Financial Markets, Institutions & Instruments 30, 201–224. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/fmii.12154, doi:https://doi.org/10.1111/fmii.12154, arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/fmii.12154.

Hong Kong Monetary Authority Monetary Management Department, H., 2018. Understanding foreign exchange derivatives using trade repository data: The non-deliverable forward market. Hong Kong Monetary Authority Quarterly Bulletin, March, 2018 .

Lechner, M., 2011. The estimation of causal effects by difference-in-difference methods. Foundations and Trends® in Econometrics 4, 165–224. URL: http://dx.doi.org/10.1561/0800000014, doi:10.1561/0800000014.

Lipscomb, L., 2005. An overview of non-deliverable foreign exchange forward markets. Federal Reserve Bank of New York Working Paper .

Loon, Y.C., Zhong, Z.K., 2016. Does dodd-frank affect otc transaction costs and liquidity? evidence from real-time cds trade reports. Journal of Financial Economics 119, 645–672. URL: https://www.sciencedirect.com/science/article/pii/S0304405X16000258, doi:https://doi.org/10.1016/j.jfineco.2016.01.019.

Luedicke, J., 2022. Difference-in-differences estimation using stata, in: Proceedings of 2022 German Stata Conference, StataCorp LLC.

McCauley, R., Shu, C., 2016. Non-deliverable forwards: impact of currency internationalisation and derivatives reform. Quarterly Review, Bank for International Settlements .

Menkveld, A.J., Vuillemey, G., 2021. The economics of central clearing. Annual Review of Financial Economics 13, 153–178.

Misra, S., Behera, H., 2006. Non-deliverable foreign exchange forward market: an overview. Reserve Bank of India Occasional Papers, Vol 27, No. 3 .

Park, J., 2001. Information flows between non-deliverable forward (ndf) and spot markets: Evidence from korean currency. Pacific-Basin Finance Journal 9, 363–377. URL: https://www.sciencedirect.com/science/article/pii/S0927538X01000129, doi:https://doi.org/10.1016/S0927-538X(01)00012-9.

Riggs, L., Onur, E., Reiffen, D., Zhu, H., 2020. Swap trading after dodd-frank: Evidence from index cds. Journal of Financial Economics 137, 857–886. URL: https://www.sciencedirect.com/science/article/pii/S0304405X20300787, doi:https://doi.org/10.1016/j.jfineco.2020.03.008.

Roberson, M., 2018. Cleared and uncleared margin comparison for interest rate swaps. CFTC Working paper .

Wang, K.L., Fawson, C., Chen, M.L., Wu, A.C., 2014. Characterizing information flows among spot, deliverable forward and non-deliverable forward exchange rate markets: A cross-country comparison. Pacific-Basin Finance Journal 27, 115–137. URL: https://www.sciencedirect.com/science/article/pii/S0927538X14000031, doi:https://doi.org/10.1016/j.pacfin.2014.01.002.

Wang, X., Yang, J.H., Wang, K.L., Fawson, C., 2017. Dynamic information spillovers in intraregionally-focused spot and forward currency markets. Journal of International Money and Finance 71, 78–110. URL: https://www.sciencedirect.com/science/article/pii/S0261560616301401, doi:https://doi.org/10.1016/j.jimonfin.2016.11.002.

Figure 1: NDF clearing ratio, June 2016 - October 2022

The figure shows the percentage of NDF swaps cleared from June 2016 through October 2022. The solid line shows the implementation date for Phase 1 of the UMR, which brought CPCs with uncleared notional positions greater than $3 trillion into scope. The short dashed line shows the implementation date for Phase 2 of the UMR, where the threshold for inclusion was lowered to $2.25 trillion. The short and medium dashed line shows the implementation date for Phase 3 of the UMR, where the threshold was lowered to $1.5 trillion. The short and long dashed line shows the implementation date for Phase 4 of the UMR, where the threshold was lowered to $750 billion. The thin dotted line shows the implementation date for Phase 5, where the threshold was lowered to $50 billion. The dotted line shows the implementation date for Phase 6, where the threshold was lowered to $8 billion. The actual daily clearing percentages are indicated by small circles and the curve passing through the circles represents a smoothed version of the trend.

Figure 2: Phase 1 NDF and FWD clearing ratios

The figure shows clearing rates three months before and after the UMR Phase 1 implementation date, separately for trades in NDF and FWD swaps. Daily clearing ratios for NDF are represented with circles and are scaled to the left vertical axis. Daily clearing ratios for FWDs are represented by crosses and are scaled to the right vertical axis. Smoothed lines are fitted separately for each NDF and FWD clearing ratios. The dashed line marks Phase 1 of the UMR implementation date.

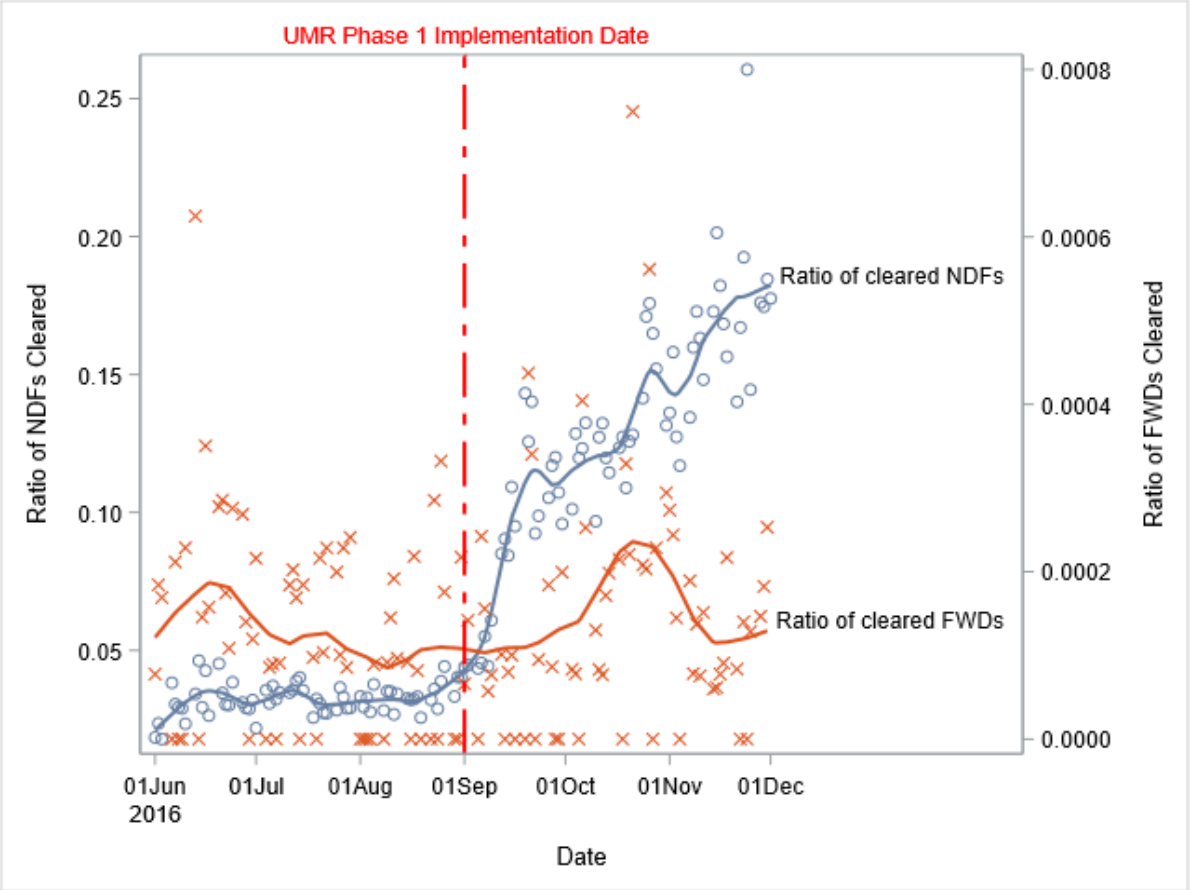


Figure 3: Clearing ratios of trades subject to the UMR and exempt from the UMR

The figure shows daily clearing ratios three months before and after the UMR Phase 1 date, separately for trades between two entities that are covered under the UMR and for those that have at least one non-covered entity as a counterparty. Circles indicate the clearing ratio of covered NDF trades between covered entities, and the crosses indicate the clearing ratio of NDF trades involving non-covered entities. Smoothed lines are fitted separately for each covered and non-covered NDF clearing ratios. The dashed line marks Phase 1 of the UMR implementation date.

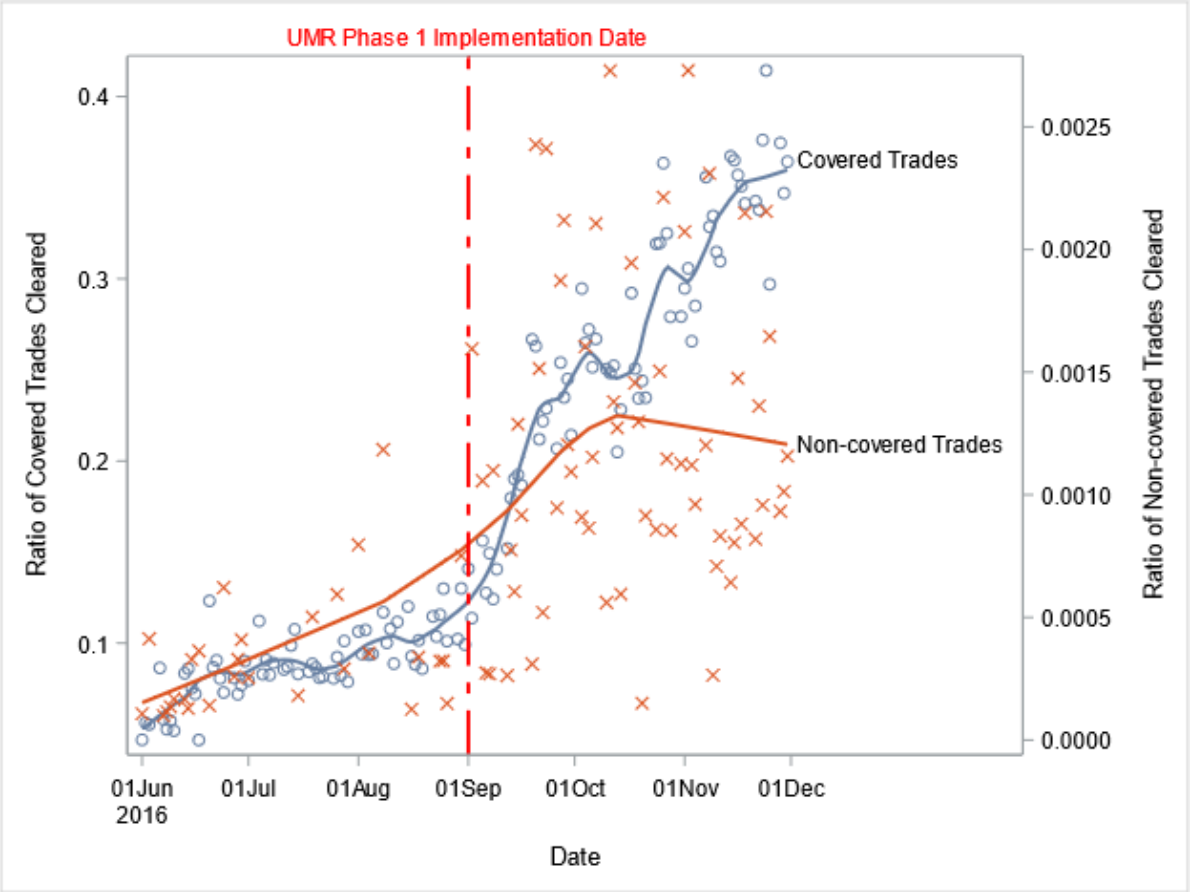


Figure 4: Clearing rates with and without the UMR

The figure shows our estimate of what the clearing rate would have been after September 1, 2016 without the UMR implementation, along with the actual rate after UMR implementation. We regress the daily percentage of swaps cleared on a day trend separately for the pre-UMR and post-UMR period. Circles indicate daily clearing ratios and two separate lines are fitted representing the pre-UMR and the post-UMR regression lines. The bold, dense line to the right of the UMR Phase 1 implementation date shows what the hypothetical clearing rate would have been, had the pre-UMR trend continued. The steeper line in the post-UMR section of the figure represents the actual trend in clearing post-UMR, and the difference between these two lines illustrates the impact of the UMR on clearing.

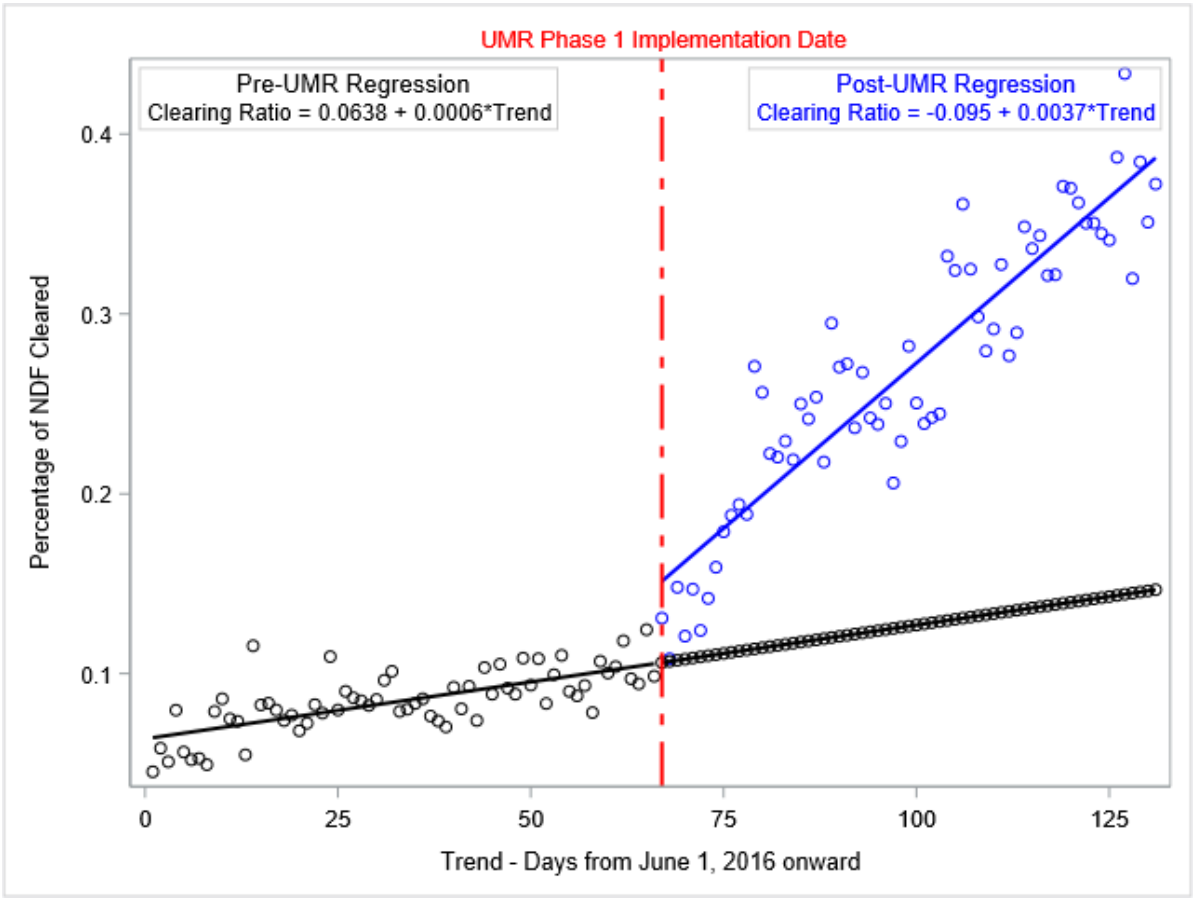


Table 1: Data coverage

The table displays a comparison of the NDF market we analyze with the global NDF market, comparing the average daily volume traded in the U.S. jurisdiction during April 2016 with the same estimate for the global market from the Bank of International Settlements (BIS). We present comparison for the following currencies: Brazilian real (BRL), Korean won (KRW), Indian rupee (INR), Taiwanese dollar (TWD), Chinese yuan (CNY), and Russian ruble (RUB).

NDF Average Daily Vol for April 2016 $bn			
Currencies	BIS	CFTC	Coverage (%)
BRL	19	15	83%
KRW	30	15	49%
INR	16	9	56%
TWD	12	5	47%
CNY	10	5	46%
RUB	3	3	93%
ALL Currencies	134	75	56%

Table 2: Market statistics

The table presents NDF market statistics around Phase 1 implementation of the UMR. Panel A shows the daily average number of trades in thousands; first the total, and then those involving relevant groups of traders. All numbers are shown separately for three months before and three months after the Phase 1 implementation date. Panel B shows the daily average notional value of trades in $ millions; again, both for the market as a whole, and then relevant groups of traders, separately for the pre and post-UMR period. Panel C shows the total number of legal entity identifiers (LEIs), the total number of covered parent companies (CPCs), and the total number of clearing members (CMs) in our data during the 6-month Phase 1 implementation sample.

Market Statistics		
	Panel A: Daily Average Number of Trades (thousands)	
	June 1st 2016 – August 31st 2016	September 1st 2016- November 30th 2016
Total	12.29	13.37
One Side Phase 1 entity	7.47	7.74
Both Sides Phase 1 entities	4.24	5.00
Both Sides Phase 1 CMs	2.62	3.29
Cleared	0.35	1.38
	Panel B: Daily Average Notional Value of Trades ($ millions)	
Total	76,668	89,203
One Side phase 1 entity	40,193	46,456
Both Sides Phase 1 entities	32,417	37,347
Both Sides Phase 1 CMs	19,067	24,682
Cleared trades	3,349	12,614
	Panel C: Number of Phase 1 Market Participants	
Number of Total LEIs	545	
Number of CPCs	20	
Number of CMs	17	

Table 3: Difference-in-differences regressions

The table presents the marginal effects from difference-in-differences probit regressions for the NDF and FWD transactions. The dependent variable is equal to 1 if the trade is cleared. NDF is equal to 1 if the swap is an NDF. UMR is equal to 1 for dates September 1, 2016 and onward. $Trend$ is a daily time trend (in hundreds, to facilitate exposition). Column (1) shows the regression with a term for the interaction between NDF and UMR. The regression in column (2) also includes two additional interactive terms. All standard errors are clustered by currency pair. z-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2
NDF	0.0150***	0.0154***
	(5.35)	(5.43)
UMR	-0.0031***	-0.0006
	(-3.63)	(-1.20)
Trend	0.0033***	0.0002
	(4.55)	(0.85)
UMR*NDF	0.0059***	0.0043***
	(5.64)	(6.00)
Trend*UMR		0.0009
		(1.44)
NDF*Trend*UMR		0.0038***
		(3.34)
Pseudo-R^2	0.2776	0.2759
Observations	1865285	1865285

Table 4: Difference-in-differences OLS regressions

The table presents the coefficients from difference-in-differences OLS regressions for the NDF and FWD transactions. The dependent variable is equal to 1 if the trade is cleared. NDF is equal to 1 if the swap is an NDF. UMR is equal to 1 for dates September 1st, 2016 and onward. $Trend$ is a daily time trend (in hundreds, to facilitate exposition). Columns (1) and (2) use individual swaps as each observation, whereas columns (3) and (4) use daily clearing ratios of NDFs and FWDs in our sample as each observation. Columns (1) and (3) show the regression with a term for the interaction between NDF and UMR. The regressions for the results in columns (2) and (4) add two additional interactive terms. Standard errors of regressions in the first two columns are clustered by currency pair. t-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2	3	4
NDF	0.0087***	0.0087***	0.0089***	0.0089***
	(5.30)	(5.41)	(14.38)	(16.75)
UMR	-0.0041	-0.0008*	-0.0090***	-0.0011**
	(-1.61)	(-2.52)	(-4.13)	(-2.59)
trend	0.0045	0.0025*	0.0100***	0.0032***
	(1.66)	(3.8)	(4.27)	(3.45)
UMR*NDF	0.0342***	0.0179**	0.0334***	0.0175***
	(5.91)	(4.44)	(16.21)	(4.3)
Trend*UMR		-0.0029**		-0.0036***
		(-4.08)		(-3.87)
NDF*Trend*UMR		0.057**		0.0352***
		(4.17)		(4.71)
constant	0.0028*	0.0018***	0.0053***	0.0021***
	(2.07)	(5.05)	(4.75)	(4.98)
Adjusted-R^2	0.0289	0.0301	0.8186	0.8553
Observations	1865285	1865285	262	262

Table 5: Clearing decision of phase 1 entities

The table presents the marginal effects from probit regressions for trades between two Phase 1 entities executed between June 1 and November 30, 2016, for currencies for which clearing was available. The dependent variable is equal to 1 if the trade is cleared. Explanatory variables include an indicator variable, UMR, which is equal to 1 for dates September 1, 2016 and onward. $Trend$ is a daily time trend (in hundreds, to facilitate exposition). $Tenor$ is the number of days until the swap expires, $Notional$ is the log of size of the swap, and SEF is equal to 1 if the swap is executed at a swap execution facility. z-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2	3	4
UMR	0.0719**	0.0704***	0.0678**	0.0663 **
	(3.23)	(5.00)	(3.23)	(3.22)
Trend	0.0729**	0.0732***	0.0681***	0.0672***
	(2.87)	(5.52)	(3.75)	(3.89)
Trend*UMR	0.13**	0.1259***	0.1309**	0.1257*
	(23.92)	(4.16)	(2.42)	(2.37)
Tenor	-.0002***	-0.0003***	-0.0002***	-0.0002***
	(-4.50)	(-5.43)	(-5.83)	(-5.75)
Notional (Log)	0.0345***	0.0368***	0.0318***	0.0340***
	(4.12)	(3.56)	(5.08)	(5.31)
SEF	-0.1201**	-0.1011***	-0.1190***	-0.1004***
	(-2.62)	(-4.78)	(-4.01)	(-3.74)
Fixed effects	No	Currency	CPC	CPC & Currency
Pseudo-R^2	0.1184	0.1407	0.1916	0.214
Observations	540568	540568	540308	540308

Table 6: Clearing decision for trades between two phase 1 entities

The table presents marginal effects from probit regressions of the probability a trade between two Phase 1 entities executed between September 1 and November 30, 2016, is cleared, for currencies for which clearing was available, against a dummy variable indicating the number of parties to a transaction that are CMs, and control variables. The $OneCM$ variable in the regressions for columns (1) and (2) takes the value of 1 when one party to a swap is a CM, and zero when neither party is a CM. The $TwoCM$ variable in the regressions for columns (3) and (4) takes the value of 1 when both parties are CMs, and zero when only one party is a CM. Columns (1)-(2) present marginal effects from probit regressions for the universe of trades between covered entities when either one or both are not CMs. Columns (3) and (4) present marginal effects from probit regressions for the universe of trades between covered entities when either one or both are CMs. The regressions for columns (2) and (4) include CPC and currency fixed effects. Standard errors are clustered by CPC in all regressions. z-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2	3	4
One CM	0.0113**	0.007**		
	(2.99)	(2.34)		
Both CMs			0.6051***	0.5625***
			(9.95)	(31.07)
Trend	0.0015*	0.0008	0.269***	0.269***
	(2.54)	(1.15)	(76.80)	(5.49)
Tenor	0.000	0.000	-.0003***	-0.0003***
	(1.52)	(1.28)	(-4.84)	(-6.39)
SEF	0.0105***	0.0059***	-0.0827**	-0.0710**
	(3.79)	(4.64)	(-2.16)	(-2.40)
Notional (Log)	-0.0004	-0.0001	0.0382***	0.0392***
	(-1.30)	(-0.58)	(4.45)	(5.16)
Fixed effects	No	CPC & Currency	No	CPC & Currency
Pseudo-R^2	0.141	0.3097	0.235	0.379
Observations	107111	94137	304919	299562

Table 7: Clearing decision for trades between two CMs based on currency pair exposure

The table presents the marginal effects from probit regressions of the likelihood a trade between two CMs executed between July 1 and November 30, 2016, will be cleared, against a measure of the netting benefit, for currencies for which clearing was available. Netting benefit is captured by a 0/1 indicator variable ($Benefit$), which equals 1 if the dollar payer in the trade has an existing long position in the currency pair with the clearinghouse and the dollar taker has an existing short position in the currency pair with the clearinghouse. In the regression for column (2), we include CM fixed effects, and in the regression for column (3) we add currency fixed effects as well. In all equations, standard errors are clustered by CPC pair. z-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2	3
Benefit	0.0948***	0.0357***	0.033***
	(6.74)	(3.34)	(3.34)
UMR	0.0521***	0.0663***	0.0677**
	(2.51)	(2.47)	(2.52)
Trend	0.2878***	0.3518***	0.3497***
	(9.07)	(9.03)	(9.00)
Tenor	-0.0004***	-0.0003**	-0.0003**
	(-5.12)	(-5.26)	(-5.53)
SEF	-0.1489***	-0.0851	-0.0807
	(-3.55)	(-1.55)	(-1.48)
Notional (Log)	0.0494***	0.0430***	0.0493***
	(7.35)	(5.83)	(6.28)
Fixed effects	No	CM Pair	CM Pair & Currency
Pseudo-R^2	0.1278	0.3297	0.3453
Observations	320535	286241	286241

Table 8: Clearing decision for trades between two CMs based on USD exposure

The table shows the marginal effects from probit regressions of the likelihood a trade between two CMs executed between July 1 and November 30, 2016, will be cleared, against the netting benefit across currencies for which clearing was available. Netting benefit is captured by a 0/1 indicator variable ($Benefit\_USD$), which equals 1 if the dollar payer in the trade has an existing long position over all currencies with the CCP and the dollar taker has an existing short position over all currencies with the CCP. In the regression for column (2), we include CPC fixed effects and in the regression for column (3) we include CPC and currency fixed effects. In all equations, standard errors are clustered by CPC pair. z-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

	1	2	3
Benefit_USD	0.0151	0.0128	0.0116
	(0.41)	(0.41)	(0.38)
UMR	0.0571	0.0571	0.0579
	(1.46)	(1.36)	(1.38)
Trend	0.2954***	0.3106***	0.0031***
	(3.98)	(3.81)	(3.77)
Standard	0.3415***	0.0768***	0.0768***
	(57.72)	(33.39)	(9.36)
Tenor	-0.0004***	-0.0003***	-0.0348***
	(-5.29)	(-5.78)	(-5.41)
SEF	-0.1504**	-0.1259**	-0.1127**
	(-3.01)	(-2.57)	(-2.56)
Notional (Log)	0.050***	0.0486***	0.0582***
	(4.88)	(5.87)	(6.17)
Fixed effects	No	CPC	CM Pair & Currency
Pseudo-R^2	0.1138	0.2076	0.2271
Observations	318227	318227	318227

A. Appendix

A.1. Do Phase 1 CPCs start trading more with non-covered entities?

Table 1 shows the changes in trading patterns around the implementation of Phase 1 of the UMR. It shows whether in-scope entities (especially non-CMs) increased their trading with non-covered entities in order to avoid the application of the UMR. It also shows the average daily trading volume for different kinds of trading partners, both before and after the UMR went into effect. For example, Panel A shows that the average daily number of trades between two CMs prior to the UMR coming into effect is 2610, with a standard deviation of 502. We find some evidence of shift in trading by covered entities towards more trading with non-covered entities, but the changes are not statistically significant.

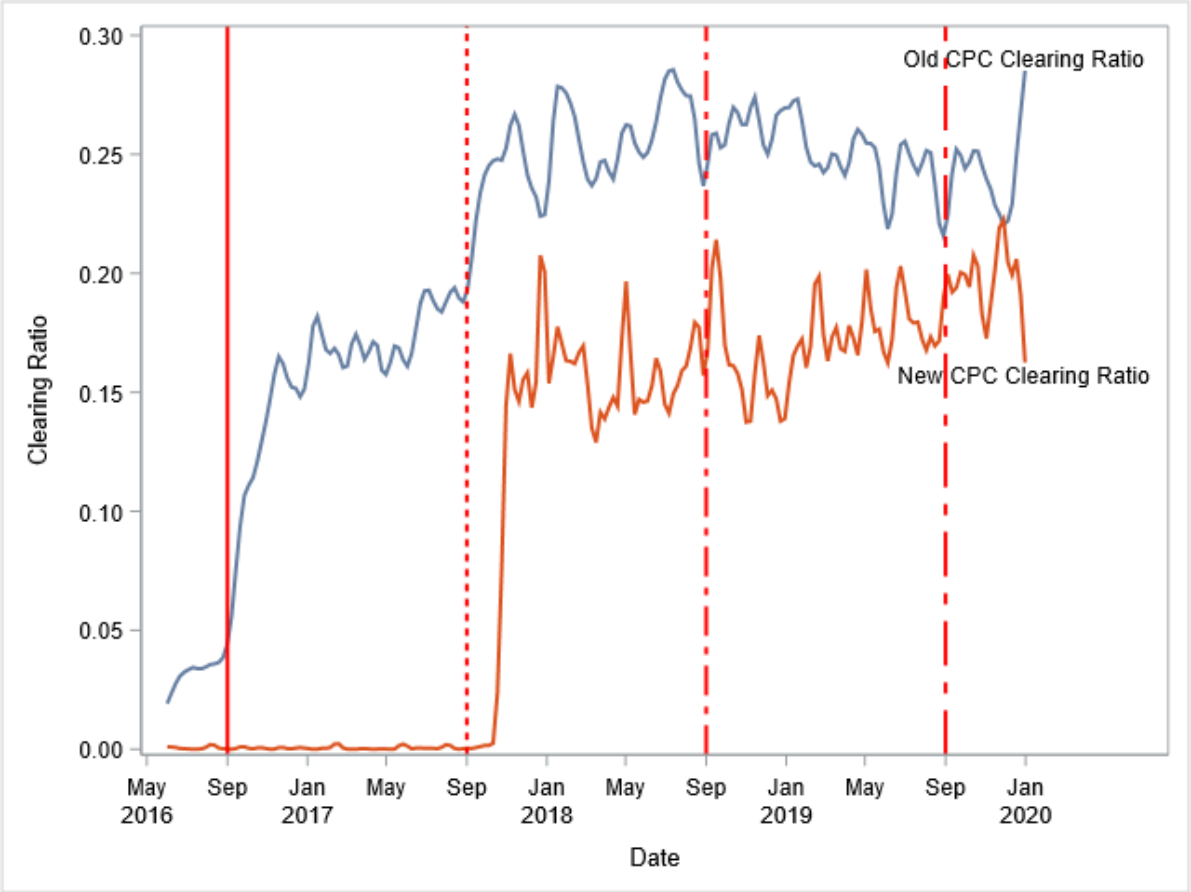
Table 1: Comparison of pre- and post-UMR trading volume

	Number of trades	Std Dev	Average Notional	Std Dev	Total Notional (million)	Std Dev
	Panel A. Both Traders are Phase 1 CMs					
Pre-UMR	2610	502	7343456	2076974	1900	628
Post-UMR	3278	872	7616932	1718903	2450	676
% chng	25.60%		3.70%		28.90%	
t-test	1.331		0.132		0.876	
	Panel B. Both Traders are Phase 1 Covered, But Only One is a CM					
Pre-UMR	1566	287	8413178	2978153	1310	447
Post-UMR	1646	411	7409970	2545831	1220	543
% chng	5.10%		-11.90%		-6.90%	
t-test	0.279		-0.337		-0.201	
	Panel C. One Non-covered Trader and One Phase 1 Non-CM					
Pre-UMR	1461	329	5990873	1631716	881	327
Post-UMR	1640	345	6503484	2178790	1060	369
% chng	12.30%		8.60%		20.30%	
t-test	0.544		0.314		0.547	
	Panel D. One Phase 1 CM and One Non-covered Trader					
Pre-UMR	5578	974	5127514	936599	2870	803
Post-UMR	5658	1187	5726171	1143086	3250	955
% chng	1.43%		11.68%		13.24%	
t-test	0.082		0.639		0.473	

A.2. Clearing Ratio of Phase 1 and Phase 2 CPCs

Figure 1: Clearing ratio of Phase 1 and Phase 2 CPCs

Most of our analysis focuses on changes brought about by Phase 1 of the UMR. To examine the robustness of our findings, Figure A.1 shows the effects of Phases 1 and 2 on the covered parent companies (CPCs) that came into scope during those phases. It shows that that Phase 2 entities reacted to becoming in-scope in a similar way to how Phase 1 entities responded during the previous September; increasing their clearing rate up to about 15% by one year after becoming in-scope. Hence, while our analysis is primarily focused on the effect of Phase 1, we believe our results reflect the UMR more generally.



A.3. Test of whether FWD clearing trend is different than zero

In order to provide statistical evidence that clearing rate for FWDs is statistically different than zero in the pre-treatment period (as also seen in Figure 2), we regress average daily clearing rate, $Clearing_t$ on time trend at daily frequency, $Trend_t$:

$$Clearing_t = \alpha + \beta * Trend_t + \epsilon_t \tag{A.1}$$

We find a positive β estimate of 0.0019 with a t-statistic of 13.16. We conclude that the slope of the clearing rate of FWDs is statistically different than zero.

A.4. Parallel trends test

The augmented model for testing parallel trends consist of adding a 3-way interaction term to the DID framework in equation (1):

$$\begin{aligned} P(Y_i = 1) = \Phi(\alpha_0 + \beta_1 NDF_i + \beta_2 UMR_t + \beta_3 Trend_t + \beta_4 UMR_t * NDF_i + \\ \beta_5 UMR_t * Trend_t + \beta_6 UMR_t * NDF_i * Trend_t + \beta_7 * PRE_t * NDF_i * Trend_t, \end{aligned} \tag{A.2}$$

where PRE is an indicator variable equal to 1 for the pre-treatment period (when UMR=0). Under this specification, the coefficient β_7 captures the differences in slopes between treatment group and control group in pre-treatment periods. If β_7 is 0, the linear trends in the outcome are parallel during pre-treatment periods. Our test (using the Stata command *estat ptrends*) uses a Wald test of β_7 against 0 to assess whether the linear trends are parallel prior to treatment. Thus, the null hypothesis of this test is that the linear trends are parallel. Using this test (which is an F-test), we find a value of 3.05, which leads us to not reject the null hypothesis (p-value of 0.123).[39]

[39] See Luedicke (2022) for more details.

A.5. Do Basel III capital regulations encourage clearing by larger CPCs?

As Cenedese et al. (2020) note, the Basel III capital rules which went into effect in 2016 provide an incentive for the largest banking companies (G-SIBs) to clear trades, especially if their ratio of tier 1 capital to risk-weighted is close to the required minimum. If this effect is significant, it would imply a negative relationship between the capital ratio and clearing for the 15 CMs that are part of one of these large CPCs. Data on tier 1 capital ratios is published twice each year by the FDIC. We examine the relationship between this ratio and clearing over the subsequent six-month period for the second half of 2016 and all of 2017. That is, we regress

$$CR_{jt} = \alpha + \beta * \frac{capital}{risk - weighted\ assets}, \tag{A.3}$$

where CR_{jt} is the average ratio of cleared swaps to total swaps for CM j in six-month period t, and the ratio of capital to risk-weighted assets is as reported by the FDIC in June 2016, December 2016, or June 2017. Our OLS regression finds a value of positive 0.021 for β, with a t-statistic of 1.63. Hence, we tentatively conclude that to the extent a lower ratio does lead to greater clearing, the effect is small in our sample.