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Regulatory Reforms and Price Heterogeneity in an OTC Derivative Market*

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Abstract

After the great financial crisis in the late 2000s, the over-the-counter (OTC) derivative markets started to face a set of new regulatory reforms. In this study, we empirically examine how and whether these reforms have achieved the transparent OTC derivative market accompanied by homogeneous prices as one of its intended goals. To do so, we use data from the universe of JPY-denominated interest rate swap (IRS) contracts that were executed in the period from April 2013 to October 2021 and involved at least one Japan-based entity. First, as reported in Cenedese et al. (2020), we observe a higher fixed rate for bilateral clearing than for central clearing even after the introduction of a quantity-based measure: the central counterparty (CCP) mandate. Second, such price heterogeneity temporarily increased but eventually diminished after the introduction of new margin rules for bilateral clearing. These results indicate that the ultimate source of price heterogeneity had been the insufficient margin provision in the bilateral clearing that the reforms effectively resolved.

Keywords: Interest rate swap, regulatory reforms, over-the-counter, central clearing, margin
JEL classification: G12, G15, G18, G20, G28.

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1. Introduction

Since the great financial crisis (GFC) in the late 2000s, financial authorities in advanced countries have been collaboratively introducing various regulatory reforms to their over-the-counter (OTC) derivative markets (OECD (2009), FSB Progress Report (2010), and FSB Progress Report (2019)). Developing better OTC derivative markets is one of the main goals of the Dodd-Frank Wall Street reform and Consumer Protection Act in the US as well as of the European Market Infrastructure Regulation (EMIR).[1] These newly introduced reforms aimed to avoid the catastrophic incidents, such as the "fire sale" of assets observed amid the GFC, and to maintain market quality. These aims are exemplified by the insulation from the propagation of default shocks and the transparency of the market accompanied by homogeneous prices.

Unfortunately, such public perspectives toward better market quality do not necessarily align with the private perspectives of the participants in the OTC derivative markets. This nonalignment could be due to, for example, the coordination failure among private parties, the existence of default externality that is not internalized by them, or the existence of some (e.g., information) frictions among them (Menkveld and Vuillemey (2021)). Namely, the coordination failure and default externality might result in the underuse of the central counterparty (CCP) or insufficient margin provision, which could propagate default shocks. Further, information friction might result in price discrimination. Such heterogeneous prices are not supposed to exist in a transparent market. Given these concerns, the aforementioned regulatory initiatives chose to mainly target major financial institutions such as dealers by mandating the use of the CCP for standardized contracts and to further introduce new margin rules to the bilateral clearing of non-standardized contracts.

As the regulated parties need to provide appropriate size of margins regardless of whether they centrally or bilaterally clear their contracts under those reforms, the reforms effectively insulate

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[1] A concise review of the regulatory reforms right after the GFC is provided in, for example, Menkveld and Vuillemey (2021).

them from the propagation of default shocks. However, the contribution of those reforms toward transparent markets, which ensure the homogeneous prices, is not necessarily clear. In fact, it is not obvious how these reforms affect the centrally and bilaterally cleared derivative prices.

As a prominent study, Cenedese et al. (2020) provide an analysis that partly addresses the empirical relationship between regulatory reforms and the homogeneity of OTC derivative prices. Using the data accounting for the periods after the introduction of the Basel III capital charge, but before the introduction of quantity-based measures such as the CCP mandate; they report that there was in fact the difference in the interest rate swap (IRS) prices between the transactions cleared centrally and bilaterally. They name this heterogeneity the "OTC premium" and also find that this premium occurs when dealers receive a fixed interest rate and pay a floating rate in the dealer-to-customer (D2C) segment but that it is absent in the customer-to-dealer (C2D) segment.[2] Given such price heterogeneity, they conclude that the "*implementation of the reform is halfway through*" (pp. 87). In this study, we aim to revisit the question on the pricing implication of the reforms. We use highly granular data on transactions that account for the periods during which not only one quantity measure (i.e., CCP mandate) but also two price-based measures (i.e., new rules for initial and variation margins) were sequentially introduced. Then, we demonstrate whether and how (if any) those reforms have achieved the homogeneous price in an OTC derivative market.

As illustrated in Cenedese et al. (2020), multiple types of adjustments could be driving the responses of derivative prices to the reforms. As a primary and straightforward adjustment, the reforms could affect the costs and thus the prices of derivatives through the so-called "X-Value Adjustment (XVA)" (Gregory (2015)). In Table 1, we summarize the standard valuation adjustments. To illustrate, when the margin rules for bilateral clearing are introduced, CVA and KVA associated with bilateral

[2] Throughout this study, we call the case in which a party A receives a fixed interest rate from party B and pays a floating rate to B as A2B segment. For example, D2C segment accounts for the case where dealers receive a fixed interest rate from C and pays a floating rate to C.

clearing are reduced while FVA and MVA become higher. As such, CVA and KVA affect the cost of clearing in an opposite way that FVA and MVA do. Thus, it is purely an empirical question how we quantitatively evaluate this tradeoff among the multiple cost adjustments (Ghamami and Glasserman (2017) and Cenedese et al. (2020)).

The XVA is directly applicable to the regulated parties as the transactions among them are the ones targeted by the reforms. However, the reforms could also affect the derivative prices faced by non-regulated parties. To illustrate, the bilaterally cleared margin rules that mainly target the D2D segment could affect the prices in the D2C segment through, for example, the exercise of dealers' bargaining power over their customers to pass through the regulatory costs (Cenedese et al. (2020)). Comprehensively understanding how derivative prices respond to the regulatory shocks through those multiple adjustments is necessary to evaluate the reforms. One of the purposes of this study is to empirically examine not only the straightforward XVA but also other subtle but potentially important adjustments through which market reforms affect derivative prices. While Cenedese et al. (2020) report that such a pass-through of regulatory costs by regulated dealers (i.e., sellers) to non-regulated customers (i.e., buyers) is sizable in their data, it is still an open question whether and how (if any) the full introduction of quantity- and price-based measures alter such a phenomenon of heterogeneous prices, which we examine in this study.

Despite such a clear need to empirically examine the multiple pricing implications of regulatory reforms, there are at least two burdens we need to overcome. First, the empirical examination inevitably requires granular data covering a sufficiently long period. Only data such as transaction-level records allow us to estimate how the prices of IRSs are affected by regulatory reforms on top of the various attributes of contracts such as their notional size and maturity as well as the characteristics of the buyers and sellers. Omitting these important attributes from the list of explanatory variables results in biased estimates of the pricing implications of the reforms.

To address this first issue, recent studies (e.g., Cenedese et al. (2020), Du et al. (2019), Hau et al. (2021)) have already started to use the granular data collected by financial authorities since the occurrence of GFC. As a byproduct of the reforms, these authorities have accumulated comprehensive records accounting for the universe of the OTC derivatives markets. In this study, we also take advantage of this recent progress in regulatory data accumulation administered by Financial Services Agency, The Japanese Government (JFSA), which it shares with the Bank of Japan (BOJ). These data account for more than a half million transactional records that represent a non-negligible share (i.e., approximately 5%) of the entire IRS global market including USD-denominated IRSs for the period from April 2013 to October 2021. Those data represent the universe of JPY-denominated IRS contracts made by the counterparties of which at least one is a Japan-based entity (including subsidiaries of foreign financial institutions). The data are also accompanied by various attributes of the IRS contracts and thus allow us to examine the pricing implications of the regulatory reforms. Yet, despite such a significant presence, other preceding studies have not touched these data due to extremely limited accessibility regarding the JPY-denominated IRS. To the best of our knowledge, our study is the first to use this rich dataset for examining the pricing implications of regulatory reforms in Japan.

Second, to identify the pricing implications of regulatory reforms, we need to examine clean exogenous institutional shocks. If a natural experiment that uses these shocks as one of the determinants of derivative prices is not implementable, it is difficult for us to disentangle the pricing implications of regulatory reforms from other incidents that potentially affect that pricing.

Against this second issue, the JPY-denominated IRS market provides an ideal research ground where we can identify the pricing implications of reforms through a natural experiment. The JFSA has introduced a set of important reforms by following the international agreements among financial authorities in advanced countries, which to a large extent ensures the exogeneity of the introduction of reforms in Japan. The JFSA introduced the mandatory use of the CCP in November

2012, and then gradually expanded the scope of the trading parties obliged to follow the mandate in December 2014, December 2015, and December 2016. Then, slightly overlapping the introduction of the CCP mandate, the JFSA also sequentially introduced a set of margin rules for bilateral clearing which consist of the requirements for initial margins (IM) and variation margins (VM) after September 2016. This reform introduces the margin requirements for bilaterally cleared derivatives among regulated parties whose outstanding notional amounts exceed a certain threshold at the point of time.

Because the fair value of IRS is not entirely clear and could be simultaneously affected by various factors such as macro shocks, it is not ideal to compare the prices of the centrally and bilaterally cleared transactions separately with the timing of the introduction of reforms. Therefore, we focus on the difference between the prices of centrally and bilaterally cleared transactions by effectively controlling for those possibly unobservable common factors affecting both the two prices and precisely identify the pricing implications of the reforms. These discussions motivate us to use the OTC premium as an appropriate measure to examine the relation between the regulatory reforms and the price homogeneity in the IRS market.

Given that the main interest of this study is in the pricing implications of the reforms, we estimate the time-variant OTC premium in addition to the time-invariant OTC premium reported in Cenedese et al. (2020) for the USD-denominated IRS trades. Specifically, we implement a set of panel estimations of the OTC premium by using the data corresponding to separate periods with and without the CCP mandate, the margin rule for the IM, and the margin rule for the VM. Explicitly taking into account whether each party is subject to each reform or not in our estimation, we further show how the introduction of those reforms results in the evolution of the estimated OTC premium. To further complement this analysis, under the assumption that the introduction of each reform is exogenous to each party, we also use dummy variables accounting for the exact trades subject to each reform and estimate the pricing implications of the reforms in the framework of a natural experiment.

A summary of the facts obtained from our estimation are as follows: First, the time-invariant estimation based on the entire dataset accounting for the periods from April 2013 to October 2021 confirms the price heterogeneity. Furthermore, the separately obtained estimates based on the data of each segment also demonstrate that the difference between the received fixed rates of bilaterally and centrally cleared trades is positive and statistically away from zero in the D2D and D2C segments. The OTC premium is also positive in the C2D segment although the size is relatively small, and the statistical significance is lower. While the estimated size of the OTC premium for the D2C segment in our analysis (i.e., 2-3 bp) is substantially smaller than that reported for the USD-denominated IRS in Cenedese et al. (2020) (i.e., 10bp), our result is thus qualitatively consistent with their findings. The fact that the OTC premium in the D2C segment is positive and statistically and significantly away from zero while weaker in the C2D segment reconfirms the conjecture of Cenedese et al. (2020) that the dealers might take advantage of their bargaining power on average to pass through to their customers any regulation-related inventory costs in the case of bilateral clearing.

Here, one subtle but important additional finding is that the positive OTC premium also occurs in the D2D segment which is not examined at all by Cenedese et al. (2020). This result provides a more nuanced story. Namely, even when the difference in the bargaining powers of sellers and buyers is absent, which could possibly be the case in the D2D segment, the positive OTC premium still holds. This result means that some inherent cost associated with bilateral clearing might exist and thus the price becomes higher in the bilateral clearing than in the central clearing. These discussions motivate us to examine the OTC premium more carefully.

Second, the time-variant estimation based on the subsets of the entire dataset confirms that the positive OTC premium is observed for the D2D and the D2C segments over the first half of the data periods (i.e., the year 2013 to 2016) while not statistically and significantly away from zero after the year 2017. Further estimations that explicitly account for whether or not each seller or buyer is subject to each reform show that the OTC premium is observed only in the case where neither the seller nor the buyer is constrained by the new margin rules. These results show that the introduction of the IM and VM rules results in the reduction of the price (i.e., fixed rate) of bilaterally cleared IRSs. This reduction could be the case, for example, when the originally provided margins before the introduction of the new margin rules had been insufficient and led to higher CVA and KVA. If this higher cost was not completely offset by the lower FVA and MVA associated with smaller margins, the provisions of larger margins could result in reducing the price of bilaterally cleared IRS. This is likely to be the case when interest rates are low as in the periods of our dataset. We reconfirm this result through regression analyses using multiple dummy variables accounting for the application of each reform. Our results show that the time-invariant estimation of the OTC premium, which is employed in Cenedese et al. (2020), might mask important dynamics in the premium and thus the effects of regulatory reforms.

Third, as one subtle but important additional finding from this natural experiment, we find that the OTC premium temporarily became greater in the D2C segment right after the introduction of the VM rule. Thus, the pass-through of the regulatory cost, which is reported for other markets (e.g., Araujo and Leao (2016) and Arnold (2017)), is at least temporarily borne by dealers in the JPY-denominated IRS market.

These results jointly show that the ultimate source of price heterogeneity (i.e., positive OTC premium) was the insufficient margin provision for bilateral clearing. Such insufficiency was effectively resolved by the reforms. Ghamami and Glasserman (2017) report that, under the regulatory framework in their study, central clearing is more costly than bilateral clearing. Our finding updates their evaluation of the reforms and shows that trading parties become indifferent between the central and bilateral clearings after the full introduction of regulatory reforms that achieves price homogeneity in the OTC derivative market.

The rest of the study is organized as follows: We summarize the status of related studies and the practical backgrounds in Sections 2 and 3, respectively. After showing our empirical strategy and the data used for the estimation in Sections 4 and 5, we present the empirical results and their implications in Section 6. Section 7 has a summary of the study and has recommendations for future works.

2. Related Literature

The extant research has theoretically examined the illiquid nature of the OTC derivative market from the viewpoints of cost adjustment, bargaining power, and information asymmetry (e.g., Duffie et al. (2005)). The recent collection of high-quality granular data by financial authorities allows researchers to empirically examine the implications derived from those theoretical discussions.

As the most closely related work to ours, Cenedese et al. (2020) use the transactions of USD-denominated spot fixed-to-float IRS contracts that were between non-US-based and UK-based entities (including subsidiaries of foreign financial institutions). Using the data recorded by the Depository Trust & Clearing Corporation (DTCC) for the period from December 2014 to February 2016, the authors examine those contracts for price heterogeneity. They find concrete evidence that the swap returns, which are measured as the difference between the transaction-level swap rate and the quoted benchmark rate, of bilaterally cleared transactions turn out to be much higher than those of centrally cleared ones. Outside of IRS trades, such a violation of the law of one price is also reported in the context of foreign currency derivatives (Du et al. (2019)) and credit default swaps (Hau et al. (2021)) based on the comprehensive granular data.[3]

Despite these studies using the new regulatory data, we do not yet fully understand how the

[3] Apart from the pricing implication, Riggs et al. (2020) examine the trading behaviors of dealers and customers in the two largest dealer-to-customer swap execution facilities (SEFs) for index CDS. They find that order size, market conditions, the number of competitors, and customer-dealer relationships determine customers' choice of trading patterns and dealers' liquidity provision.

reforms matter in this context. As a prominent study, Cenedese et al. (2020) find an OTC premium and conjecture that it might come from the inventory cost associated with the regulatory reforms that promote the XVA (Gregory (2015)). However, due to the lack of time variation in the estimates of the OTC premium, the authors do not fully address the response of the derivative prices to the introduction of the reforms. In fact, Cenedese et al. (2020) (pp. 104) conjecture that the newly introduced reforms such as a central clearing mandate and the margin rules for bilateral clearing could play important roles.

There are a few recent studies that examine the implications of regulatory reforms. Ghamami and Glasserman (2017) construct and calibrate a model accounting for the cost and benefit of the CCP mandate as well as higher capital and margin requirements to see whether or not these requirements create a cost incentive that leads to wider use of central clearing. They use the data on the OTC derivatives market collected by the Federal Reserve and report that a sufficient cost incentive may not be present to support the use of central clearing. In their calibration study, there is price heterogeneity between the centrally and bilaterally cleared transactions that favors the use of bilateral clearing. As another example, Wang and Zhong (2021) find that the negative association between dealers' net long (i.e., inventory) positions on CDS protection and CDS spreads has become stronger after the US implemented the Volcker Rule. Their finding indicates that the newly introduced reform affected derivative prices through the XVA. While both of these studies succeed on quantifying the overall effects of market reforms, they do not necessarily provide the estimates of price responses to specific institutional changes associated with those regulatory reforms. Our study complements these studies by focusing on the actual introduced reforms that affected the centrally and bilaterally cleared transactions separately as clean exogenous shocks.

Focusing on a specific institutional aspect, Collin-Dufresne et al. (2018) find that index CDS in the D2D segment showed narrower spreads than that in the D2C segment possibly because of a combination of order book and matching sessions that were typically used in the swap execution facilities (SEF) of the D2D segment that led to lower transaction costs. Also, Ranaldo et al. (2021) use regulatory data from the market for reverse repurchase agreements (repos) and find that the increase in the supply of cash in repos by CCPs induced by the EMIR and the decrease in borrowing demand due to the tightening of banks' balance sheet constraints after Basel III jointly resulted in decreasing short-term rates. We follow the direction of these studies that pay specific attention to the newly introduced institutional features.

One of the unique features of our analysis is paying attention to the case in which the regulatory shock might be passed through to non-regulated parties. In this regard, there are some recent studies that examine the transmission of the effects of a regulatory reform. For example, Araujo and Leao (2016) investigate how a regulatory reform introduced in 2011 to the Brazilian FX derivative market affected the nonfinancial sector. They find that after the Brazilian government taxed short positions in FX derivatives to reduce the carry trade, the local currency appreciated; banks passed through the extra cost to clients; and the cost of FX hedges for nonfinancial firms (esp., importers) more than doubled, which made them move away from hedging their FX positions. Arnold (2017) also theoretically investigates how the introduction of central clearing in credit risk transfer markets affects a bank's lending. He shows that central clearing undermines banks' discipline in lending while the capital requirements, disclosure standards, risk retention, and access to uncleared credit risk transfer can mitigate this problem.

3. Practical and Policy Backgrounds

In this section, we overview the practical and policy backgrounds regarding the JPY-denominated IRS market. We start from the description of the market and provide the event-log book of the regulatory reforms introduced to the market.

Based on the BIS OTC Derivatives Statistics[4] that account for the outstanding contracts among the 70 major financial institutions all over the world and their customers, the IRS market accounts for more than half of the entire OTC derivative market. The total notional amount from the statistics is approximately USD 350 trillion on average during the 2010s. Out of this amount, JPY-denominated IRS accounts for around USD 35 trillion. About half of the JPY-denominated IRS trades include at least one Japanese financial institution as a counterparty.

As summarized in Table 2, during the data period used in the present paper (i.e., April 2013 to October 2021), Japan introduced a series of regulatory reforms. These reforms were largely motivated by the GFC occurring in the late 2000s. Initiated by the public statements at the Pittsburg and the Cannes summits, the G20 introduced various regulatory reforms to the OTC derivative markets. They consisted of the following three items: the mandatory use of the CCP for standardized trades, the implementation of margin rules for bilateral clearings, and the obligation of detailed transaction reports.

Regarding the JPY-denominated IRS market, there were the following three phases during our sample period. The first (benchmark) phase started in April 2013 and ended in November 2014. During this period, Japan basically adopted no additional regulatory reforms. However, a de facto introduction of the CCP mandate started in November 2012. One month before that, only particularly large financial institutions, which were clearing members of Japan Securities Clearing Corporation (JSCC) at that time, actually started to use CCP for part of the JPY-denominated IRS transactions.

The second (CCP mandate) phase started in December 2014. Since then, Japan has widened the scope of the CCP mandate for trades among financial institutions three times (i.e., December 2014, December 2015, and December 2016). These iterations of the CCP mandate came from the revision of the Financial Instruments and Exchange Act and the introduction of the Cabinet Office Ordinance on the Regulation of Over-the-Counter Derivatives Transactions. In December 2014, the financial

[4] https://stats.bis.org/statx/toc/DER.html.

institutions that had monthly average outstanding notional amounts over JPY 1 trillion (roughly equal to USD 10 billion) above the (second) last accounting year had to use the CCP for the trades executed between (April and November) December and March. Then, in December 2015, the threshold was decreased to JPY 300 billion (USD 3 billion). Finally, in December 2016, the insurance companies with monthly average outstanding notional amounts over JPY 300 billion above the (second) last accounting year also had to use the CCP for the trades executed between (April and November) December and March.

The third (non-centrally cleared margin rules) phase started after September 2016. In parallel with the US and Canada, the Japanese financial authority introduced margin rules for bilaterally cleared transactions. These rules reflected the margin requirements for non-centrally cleared derivatives framed by The Basel Committee on Banking Supervision (BCBS) and the International Organization of Securities Commissions (IOSCO). As Table 2 shows, Japan sequentially introduced the requirements for the IM and the VM after September 2016. Particularly after March 2017, all the financial institutions have faced the VM requirements for bilaterally cleared transactions. Introducing margin rules to bilaterally cleared transactions reduced the CVA and the KVA while possibly increasing the MVA and the FVA.

There are some cases for these trades not to be targets of the reforms. For example, when the average of the notional amounts of all OTC derivatives at the end of 12 months in the (second) last fiscal year is less than a particular threshold for either of parties involved in a trade executed between (April and November) December and March, the trade is not constrained by the regulation. Plus, even if a trade satisfies this condition, when the average of the notional amounts of all OTC derivatives at the end of each month from March to May in the previous (present) year is less than or equal to a particular threshold for either party involved in a trade executed between January and August (September and December), the trade is not constrained by the margin requirements. Also, if the institutions are not located in Japan, they are not in general affected by the Japanese reforms. In this study, we explicitly identify whether each seller and buyer in a transaction is bound by the regulations by considering whether they meet those criteria.

Apart from the distinction of being subject to the reforms or not, we also want to know whether a party is categorized as a "dealer" or not. This need reflects our presumption that dealers are in a better position to exercise their bargaining power in their transactions. It is necessary to clarify the definition of a dealer as we intend to analyze multiple mechanisms through which reforms affect IRS prices. In this respect, Cenedese et al. (2020) define a dealer as in G16 of the participating dealers classification by the OTC Derivatives Supervisors Group that is chaired by the New York Fed.[5] In this study, we follow the same definition.

4. Empirical Strategy

In this section, we explain our empirical strategy to examine the association between the swap return and the regulatory reforms. Our empirical strategy is based on the time-invariant OTC premium proposed in Cenedese et al. (2020). To obtain the time-variant estimates of OTC premium, we further apply their framework to various subsamples corresponding to whether or not each trade is affected by specific reforms as well as who the seller and buyer of IRS are. To explicitly see the responses of the OTC premium (i.e., price heterogeneity) to the introduction of each reform, we also use dummy variables that account for whether or not each trade is affected by a specific reform.

4.1 Time-invariant OTC premium in Cenedese et al. (2020)

Cenedese et al. (2020) estimate the OTC premium as the coefficient associated with the

[5] It consists of Bank of America, Barclays, BNP Paribas, Citibank, Credit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, Societe Generale, UBS, and Wells Fargo.

dummy variable that denotes whether the transaction is centrally or bilaterally cleared while controlling for various fixed effects.

$$SwapReturn_{i,s,b,t} = \alpha + \beta Non\text{-}CCP_{i,s,b,t} + FE_{s,b,t} + \varepsilon_{i,s,b,t} \tag{1}$$

Here, $SwapReturn_{i,s,b,t}$ accounts for the difference (in basis points (bp)) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day for the i-th transaction between the counterparties (i.e., seller s and buyer b at the fixed rate) on day t. $Non\text{-}CCP_{i,s,b,t}$ denotes a dummy variable that equals one if transaction i is not cleared via the CCP (i.e., cleared bilaterally) and zero otherwise (i.e., cleared centrally). $FE_{s,b,t}$ accounts for the unobservable factors corresponding to various configurations such as $date$, $seller$, and $buyer$. Cenedese et al. (2020) use the $date$ as well as the $month \times seller \times buyer$ as the most comprehensive configuration of $FE_{s,b,t}$. $\varepsilon_{i,s,b,t}$ is an error term.

Cenedese et al. (2020) estimate equation (1) by exclusively using the data for the D2C and C2D segments. The D2C segment accounts for the case where dealers sell IRS to their customers and receive fixed rates while the C2D segment accounts for the opposite. Cenedese et al. (2020) report that OTC premium as denoted by β in equation (1) is positive and significantly away from zero only for the D2C segment.

As the swap return is likely to depend on the characteristics of each trade, it is ideal to augment the equation with the basic characteristics of a plain vanilla IRS as in equation (2). Here, $Log\text{-}Notional_{i,s,b,t}$ and $Maturity_{i,s,b,t}$ are the natural logarithm of the notional amount of transaction i and the maturity of transaction i, respectively.

$$\begin{aligned} SwapReturn_{i,s,b,t} &= \alpha + \beta Non\text{-}CCP_{i,s,b,t} \\ &+ \gamma Log\text{-}Notional_{i,s,b,t} + \delta Maturity_{i,s,b,t} + FE_{s,b,t} + \varepsilon_{i,s,b,t} \end{aligned} \tag{2}$$

It is possible that the β depends on the segments (e.g., D2C, D2D, C2D, and customer-to-customer (C2C)) as well as whether or not parties are affected by the reforms. In addition to pooling the data, we also separately estimate these equations for each segment and the status of being affected by reforms so that we can see the differences in the estimated β corresponding to those conditions.

We estimate these equations with the following configuration of the fixed effects $FE_{s,b,t}$: The configuration contains the $date$-specific fixed effects. The $buyer$ and $seller$ fixed effects are controlled by their individual identity (i.e., bank-a, security company-b, insurance company-x, and so on). Those $buyer$ and $seller$ fixed effects are further interacted with the $time$-specific fixed effects which are measured in months.

4.2 Time-variant OTC premium

The estimated time-invariant OTC premium based on equation (2) informs us of how much the price of the IRS differs between the cases of central and bilateral clearings. Such a time-invariant estimate is helpful to measure, for example, the status of the average market quality (i.e., transparency or the law of one price) over the estimation periods. To see the pricing implication of market reforms, it is necessary to have the time-variant estimates of the OTC premium.

As already summarized in the previous section, only the centrally cleared transactions were affected by the CCP mandate in the second phase, while only the bilaterally cleared transactions were affected by the non-centrally cleared margin rules. To see the responses of the OTC premium to these two reforms, we estimate equation (2) separately by using the data during the periods up to the second phase (i.e., the year from 2013 to 2016) and during the third phase (i.e., after the year 2017). These estimates illustrate how the OTC premium evolves over those two subperiods. Same as the time-invariant estimate, we run the estimations by pooling the four segments as well as separately estimating the equation for each segment.

Although these subsample analyses are useful to illustrate the relations between the price heterogeneity and the reforms, it is more ideal to explicitly account for whether or not each transaction is affected by a specific reform. Thus, we split the data into whether the seller or buyer is affected by either the initial margin requirement or the variation margin requirement for the bilaterally cleared transaction. For this study, we separately estimate the equation for each segment. As we have two sides of the transaction that are affected by the reforms or not, and two statuses for dealers and non-dealers, the total number of estimations is (2*2)*(2*2)=16 cases.

Finally, to see the responses of the OTC premium to the introduction of each reform, we estimate equation (3) in which we use a set of dummy variables $Reg(j)$ that equal one if the trade denoted by $\{i, s, b, t\}$ is affected by the j-th regulatory reform. For this estimation, we use the data from April 1, 2013. The list of reforms consists of the five initial margin rules and two variation margin rules that account for each expansion in terms of the affected parties. We also use a specification which adds the CCP mandate to the list of reforms.

$$\begin{aligned} SwapReturn_{i,s,b,t} = \alpha + \textstyle\sum_j \beta_j Non\text{-}CCP_{i,s,b,t} \times 1\big(\{i,s,b,t\} \in Reg(j)\big) \\ +X_{i,s,b,t}\gamma + FE_{s,b,t} + \varepsilon_{i,s,b,t} \end{aligned} \tag{3}$$

Here, $X_{i,s,b,t}$ is a row vector that consists of control variables such as the natural logarithm of the notional amount and the maturity of transaction i on day t. And γ is a column vector that consists of the coefficients associated with the control variables in $X_{i,s,b,t}$. This estimation shows how the OTC premium has evolved over the course of the sequential introduction of reforms.

5. Data

The data (JFSA Trade Repository (TR) data) consist of the identification of sellers and buyers of IRSs and their notional amount, maturity, and fixed rate. The data cleaning process we use is as follows: Originally, we have a total of 736,841 trades reported to the JFSA. First, we exclude the records missing any of the above information. Second, we also exclude the records for which we cannot find the corresponding Bloomberg benchmark rate. The rate is obtained from Bloomberg and accounts for the end-of-day swap rate mid-quote of the same maturity and currency as the target swap contract. This rate is used by practitioners to represent the "fair" value of the prevailing fixed rate. To measure the swap return, which we use as a dependent variable in our estimation, we subtract the mid-quote of the swap rate provided by Bloomberg one day prior to each data point from the fixed rates recorded in the TR data. Finally, we exclude the records with a fixed rate that is more than 150 bps from Bloomberg's benchmark rate in accordance with Cenedese et al. (2020). After these sample selections, we are left with 603,038 records of trades.

The panels in Figure 1 show the historical transaction frequency (upper, with YonY growth rate) and the transaction volume (lower, with YonY growth rate) in total. The overall frequency and volume of transactions show a certain level of fluctuations but are almost stable over the seven years of our sample period. Both the frequency and volume declined in 2020.

The left panel in Figure 2 shows the breakdown of the frequencies for the centrally and bilaterally cleared transactions and the classifications of counterparties (e.g., CCP-D2D etc.). The right panel also depicts the breakdown of the volume of transactions. In a similar fashion, the panels in Figure 3 show the same breakdown of the frequency and volume of transactions so that the share of each item sums up to 100%.

Unlike the relatively stable movements of the total frequency and volume, the shares of each segment show remarkable dynamics. Namely, the frequency, volume, and share of the transactions in the CCP segment stably increased over the first phase (benchmark) and the second phase (CCP mandate). In particular, the transactions in the CCP-D2D segment have largely increased due to the expansion of the CCP mandate.

The frequency, volume, and share of the bilaterally cleared transactions decline and become low during the early periods of the third phase (non-centrally cleared margin rules) starting after September 2016. Nonetheless, the bilaterally cleared transactions after 2019 still account for 5 to 10% of the total transactions, which is not negligible.

These findings indicate that the CCP mandate strongly affected the choice of clearing in the IRS market and increased the use of the CCP not only for the D2D segment but also for other segments such as D2C and C2D. Furthermore, the non-centrally cleared margin rules drew more trades from bilateral clearing. This draw could be a natural response given the increasing cost of a bilateral clearing because of the newly introduced margin rules. Some of the increased cost due to the reform are avoided by the participants in the D2D segments moving away from bilateral clearing, especially right after the introduction of the margin rules. Interestingly, we also observe that the transactions in other segments also move away from bilateral clearing after the introduction of the new margin rules. This move indicates that the XVA-related costs placed on the transactions might be at least temporarily passed through to, for example, the transactions in other segments. Third, the bilateral clearing increased both in terms of its frequency and volume after the middle of the third phase (non-centrally cleared margining rules). Although the largest part of the bilateral clearing is accounted for by the transactions in the D2D segment, the transactions in the D2C segment are also cleared bilaterally.

6. Empirical Results

6.1 Univariate Analysis

Before showing the estimation results based on the proposed empirical strategies, we implement a univariate analysis.

First, as shown in Table 3, the data consist of around 600,000 observations recorded over the period from April 2013 to October 2021. The average number of observations in each month is around five to six thousand, which is comparable to the number of observations in Cenedese et al. (2020). Second, we further break down the data into centrally cleared contracts and bilaterally cleared ones. Possibly reflecting the CCP mandate introduced in the early timing of our sample periods, the number of observations for the centrally cleared transactions is more than double that for the bilaterally cleared ones. Third, as reported in Cenedese et al. (2020), the swap returns of the centrally cleared transactions are lower than those of the bilaterally cleared transactions. On average, the difference amounts to 12 bp (i.e., 13.09 - 0.56). Fourth, regarding the notional size and maturity, the centrally cleared transactions are characterized as larger and longer than the bilaterally cleared transactions.

6.2 Time-Invariant Estimates

In this subsection, we present the estimation results of equation (2) that was formulated in Section 4. The estimation measures whether our dataset confirms the price heterogeneity between the centrally and bilaterally cleared transactions. The OTC premium accounts for various items consisting of, for example, the costs associated with XVA, central and bilateral clearing demands, and the bargaining power of each player.

Using the definition of G16 dealer-banks (D), we compare our results with Cenedese et al. (2020). Non-dealer customers (C) are defined as the complements to D. First, as presented in Table 4, we confirm the existence of the OTC premium from our estimation using the data pooling of all segments. Namely, the swap return of bilaterally cleared transaction is 1.527 bp higher than that of centrally cleared transactions. This positive OTC premium is mainly driven by the results in the D2D and D2C segments while it is weak in the C2D and C2C segments. Although the size of the OTC premium for the D2C segment (i.e., 2-3 bp) is substantially smaller than that reported for USD-denominated IRS in Cenedese et al. (2020) (i.e., 10 bp), it is qualitatively similar to their findings. The asymmetry of the status of the OTC premium between the D2C and C2D segments supports the conjecture in Cenedese et al. (2020) that the dealers took advantage of their bargaining power on average to pass through the regulation-related inventory cost.

One more important finding is the positive OTC premium in the D2D segment. As it is natural to assume that the relative bargaining powers among dealers are not highly heterogeneous, the story in Cenedese et al. (2020) is not applicable to this result. Instead, there are two alternative explanations for this assumption to be realized. First, if the price of centrally cleared transactions is lower thanks to, for example, risk reduction schemes such as netting, the relative size of the fixed payment in the bilateral clearing could be higher than that in the central clearing. Second, such a positive OTC premium could be the case if the risk, such as CVA and KVA, that is associated with the bilaterally cleared transactions is higher than that of centrally cleared transactions. In Figures 4 and 5, we depict the time series of the swap return in the cases of central clearing and bilateral clearing, respectively. As these are the plots of the raw numbers and we are not controlling for anything (e.g., notional and maturity), it is not straightforward to obtain implications from these figures. Nonetheless, first, we observe that at least the swap return in the case of central clearing is not necessarily lower than that of bilateral clearing. Second, the swap return in the case of bilateral clearing shows a temporal hike after 2016.

The coefficients associated with the log-notional and maturity, both of which are rarely significantly away from zero in Cenedese et al. (2020), turn out to be significant. Regarding the association between the notional size and the OTC premium, the signs are negative. On the association between the maturity and the OTC premium, regardless of whether the dealer receives or pays a fixed rate, the OTC premium is likely to be smaller as the maturity becomes longer.

6.3 Time-Variant Estimates

In Table 5, we summarize the set of the estimated coefficients associated with $Non\text{-}CCP_{i,s,b,t}$. Each cell of the table accounts for the combination of the specific period used for the estimation (i.e., whole period, from 2013 to 2016, and 2017 to 2021) and the segments including the pooled one. In this table, we summarize only the estimated coefficients accounting for the OTC premium.[6] The second and the third columns show the remarkable time-variation in the OTC premium. Namely, there is a positive OTC premium for the D2D and D2C segments up to 2016. The size of the point estimates becomes substantially smaller after 2017, and all the estimates are not statistically away from zero. Thus, the OTC premium in fact diminishes in the JPY-denominated IRS market. In Table A6, we repeat this exercise by using the year-by-year estimated coefficients associated with the OTC premium and confirm the same pattern.[7]

These results indicate that first, the CCP mandate did not solely resolve the price heterogeneity in the D2D and D2C segments. While standard IRS contracts executed among regulated parties have to be centrally cleared, any other trades can be bilaterally cleared and therefore have higher fixed rates. Unfortunately, we cannot compare the price change due to the introduction of CCP mandate from this estimation as we do not have enough data before the introduction of the CCP mandate. Still, it could be the case that the price in CCP becomes lower due to larger use of risk reduction scheme such as netting, which could result in larger OTC premium. Second, and more importantly, the introduction of margin rules resulted in homogenous prices, which is not an obvious price response. If the regulated parties with large bargaining power face the new margin rules, then they could exert their bargaining power to pass through the additional cost (i.e., FVA and MVA) to their customers. In this case, the OTC premium should be higher. The fact that the OTC premium is lower indicates that the requirement of margin provisions under those new rules lowers the cost

[6] The results for the entire estimation that include the other independent variables are in the Tables A1 to A5 in the appendix.

[7] All the estimation results including the estimated coefficients associated with other independent variables and the basic statistics such as the number of observations are listed in Tables A7 to A11 in the appendix.

associated with CVA and KVA in the bilateral clearing, which exceeds the hike in the FVA and MVA. This is likely to be the case when interest rates are low as in the periods after 2017.

To see the working of reforms more explicitly, Table 6 gives a list of the estimated coefficients that are associated with $Non\text{-}CCP_{i,s,b,t}$ for the four segments when distinguishing between regulated or non-regulated parties.[8] In the table, R (NR) denotes that the party is (not) affected by the reform while D (C) denotes the party is classified as a dealer (customer). Moreover, in this estimation, we focus on the parties regulated by either initial or variation margin rules while ignoring the CCP mandate given the fact that we observed the positive OTC premium for the period up to 2016 in Table 5. In this sense, the non-regulated category includes the trades under the CCP mandate. First, the table shows a positive OTC premium only in the case of trades among non-regulated parties. This result means that the introduction of the margin rules significantly contributes to the reduction in price heterogeneity. Second, although it is relatively minor in terms of the number of observations (1.2% of the entire observations), there is also a positive OTC premium for the case when non-regulated dealers sell IRSs to regulated customers.

Table 7 has a summary of how IRS prices respond to each reform. In this estimation, as in the baseline estimation, we exclusively focus on the introduction of the initial and variation margin rules and omit the introduction of the CCP mandate given the introduction of the latter does not affect the OTC premium. As an alternative specification, we repeat the same estimation by further adding the introduction of the CCP mandate. The results are summarized in Table A16 in the appendix and are similar to those in Table 7. Here, each of $IM\ \ mandate\ \ dummy\ \ M_{i,s,b,t}$ for $\mathrm{M} \in \{1,2,3,4,5\}$ is a dummy variable respectively for the case of being cleared among the parties obliged to report trade records and satisfying the condition of the initial margin requirement in September 2016, September

[8] The results for the entire estimation that include the other independent variables are in Tables A12 to A15 in the appendix.

2017, September 2018, September 2019, and September 2021.[9] Similarly, $VM\ mandate\ dummy\ 1_{i,s,b,t}$ and $VM\ mandate\ dummy\ 2_{i,s,b,t}$ are both dummy variables for the case of being cleared among the parties obliged to report trade records and satisfying the condition of the variation margin requirement at the time of September 2016 and March 2017 respectively.[10]

We confirm that the interaction terms between $Non\text{-}CCP\ dummy_{i,s,b,t}$ and those bilateral clearing margin dummies are mostly associated with the negative coefficient except for the dummy variable accounting for the introduction of the variation margin rules for bilaterally cleared transactions. The estimated coefficients suggest that the OTC premium becomes temporarily higher right after the introduction of the variation margin to the D2C segment but eventually diminishes.[11]

7. Concluding remarks

In this study, we use the sequentially introduced regulatory reforms in the JPY-denominated IRS market to identify their pricing implications. Based on the estimation using the data covering the universe of JPY-denominated IRS transactions contracted with at least one Japan-based entity from April 2013 to October 2021, we find that the price heterogeneity in the form of the OTC premium existed in the Japanese IRS market mainly due to the insufficient margin provision in the case of

[9] Note that none of these dummy variables equals one at the same time. For example, a trade cleared in October 2019 might make only $IM\ mandate\ dummy\ 4_{i,s,b,t}$ one and all the other dummy variables (i.e., $IM\ mandate\ dummy\ 1_{i,s,b,t}$, $IM\ mandate\ dummy\ 2_{i,s,b,t}$, $IM\ mandate\ dummy\ 3_{i,s,b,t}$, and $IM\ mandate\ dummy\ 5_{i,s,b,t}$) are automatically zero because, at the time when the trade is cleared, initial margin requirement is represented only by $IM\ mandate\ dummy\ 4_{i,s,b,t}$ after it is renewed in September 2019.

[10] Note that none of these dummy variables equals one at the same time for the same reason as $IM\ mandate\ dummies$.

[11] In the estimation accounting for the D2D segment, we cannot estimate the coefficients associated with Non-CCP dummy×IM mandate dummy 1 and Non-CCP dummy×VM mandate dummy 1 as those dummy variables are zero in the segment. In the estimation accounting for the C2D segment, we cannot estimate the coefficient associated with Non-CCP dummy×VM mandate dummy 1, as it is perfectly correlated with Non-CCP dummy×IM mandate dummy 1. In the estimation accounting for the C2D segment, we cannot estimate the coefficient associated with Non-CCP dummy×IM mandate dummy 2 as Non-CCP dummy and IM mandate dummy 2 do not simultaneously take one, so that Non-CCP dummy×IM mandate dummy 2 always take zero. In the estimation accounting for the C2C segment, we cannot estimate the coefficients associated with Non-CCP dummy×IM mandate dummy 1 and Non-CCP dummy×VM mandate dummy 1 as both IM mandate dummy 1 and VM mandate dummy 1 are always zero when Non-CCP dummy equals one. In the estimation accounting for the C2C segment, we cannot estimate the coefficient associated with Non-CCP dummy×IM mandate dummy 2 because IM mandate dummy 2 is invariably zero.

bilateral clearing. The introduction of the non-centrally cleared margin rules results in the temporary increase in the OTC premium for the transactions exclusively in the D2C segment but eventually eliminates the OTC premium possibly due to the sufficient provision of margins. As the source of the price heterogeneity is not rooted in the central clearing but in the bilateral clearing, the CCP mandate did not resolve this phenomenon but the bilaterally clearing margin rules did.

The OTC derivative markets are in general illiquid and consist of various players. Thus, it is necessary for financial authorities and policymakers to understand the pricing implications of regulatory reforms. In particular, the price heterogeneity, that is, the positive OTC premium in selected segments, which is essentially absent in the liquid markets of stocks or government bonds, needs to be monitored by financial authorities. Understanding the status of price heterogeneity as in this study contributes to precise evaluations of the current reforms and appropriate design for future ones.

The empirical findings obtained in this study generate additional research questions. First, it would be informative to take a closer look at the data and examine whether or not there are still some cases (e.g., segments) where we can find price heterogeneity. Second, in this direction, it would be promising to focus on more illiquid and opaque markets such as credit derivatives. Third, given the low interest rates observed in our dataset could be one important factor driving the results we report, it would be informative to see how the results change under the hike of interest rates in future. All of these questions are important for appropriately evaluating the current regulatory forms and further designing new regulations in the future.

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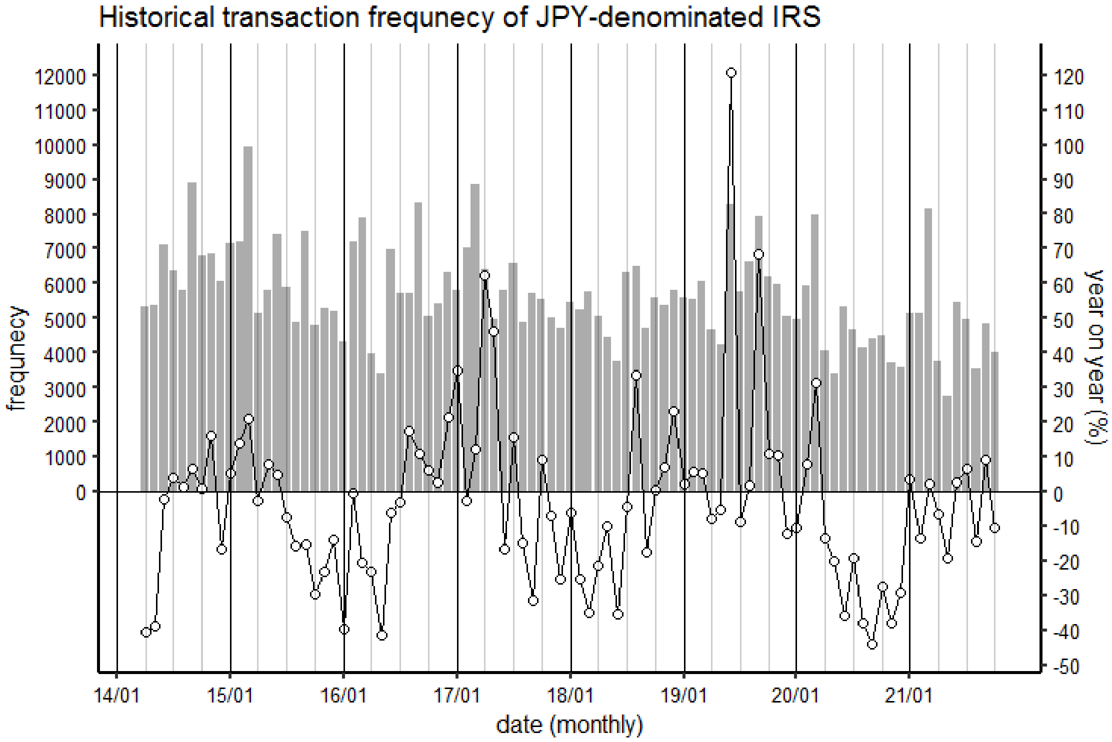
Figure 1 Historical transaction frequency and transaction volume



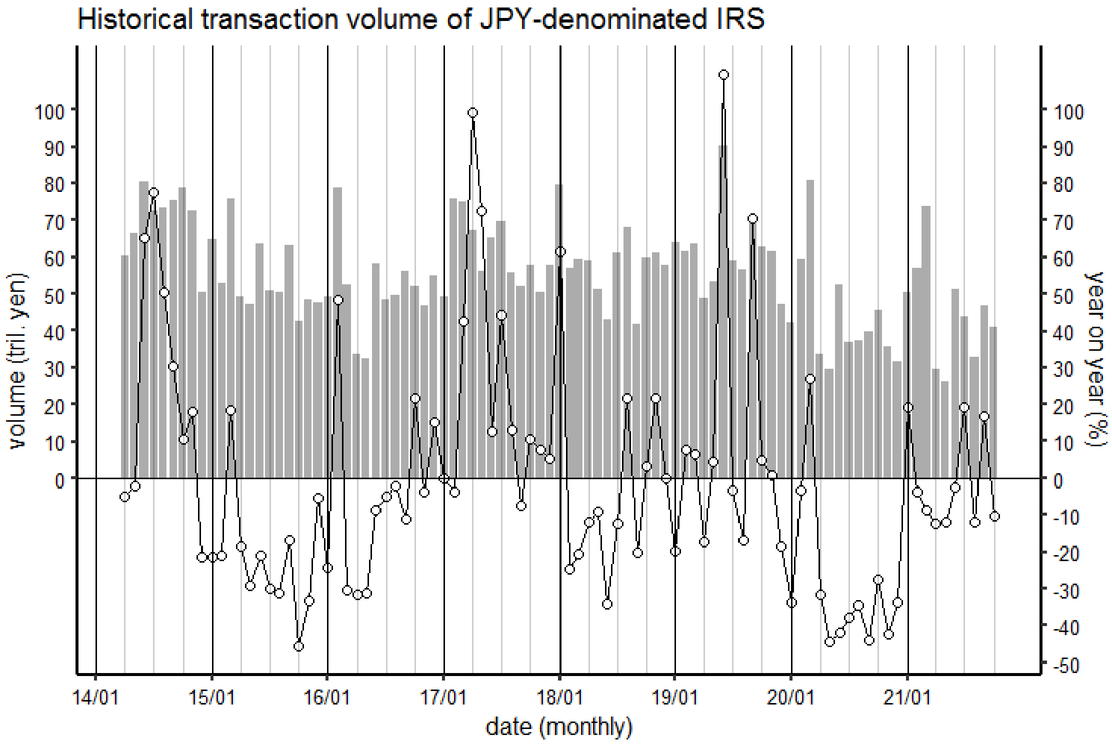


Figure 2 Historical transaction frequency and transaction volume broke down with regard to markets and counterparts

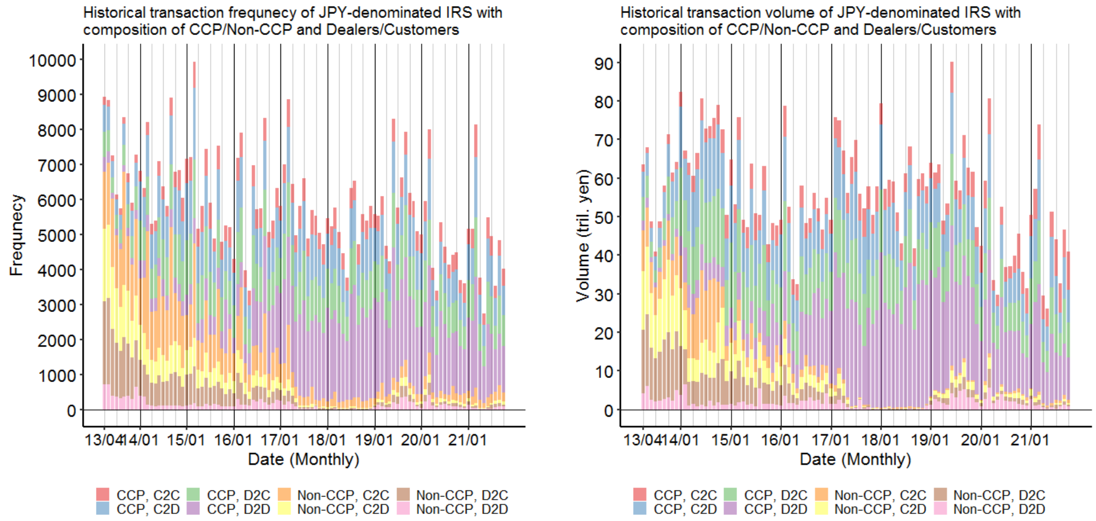


Figure 3 Historical transaction frequency and transaction volume broke down with regard to markets and counterparts

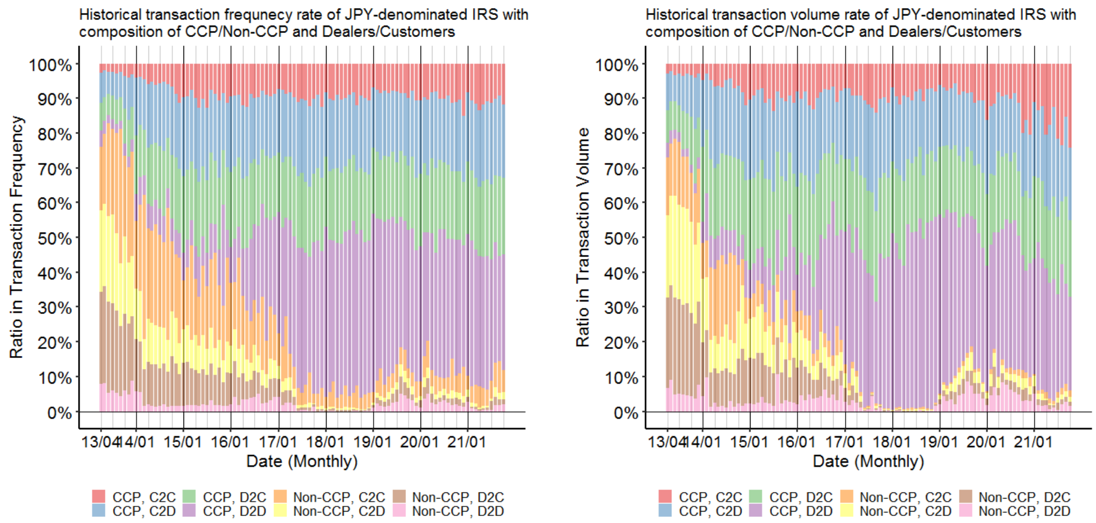


Figure 4 Historical movement of swap return in CCP

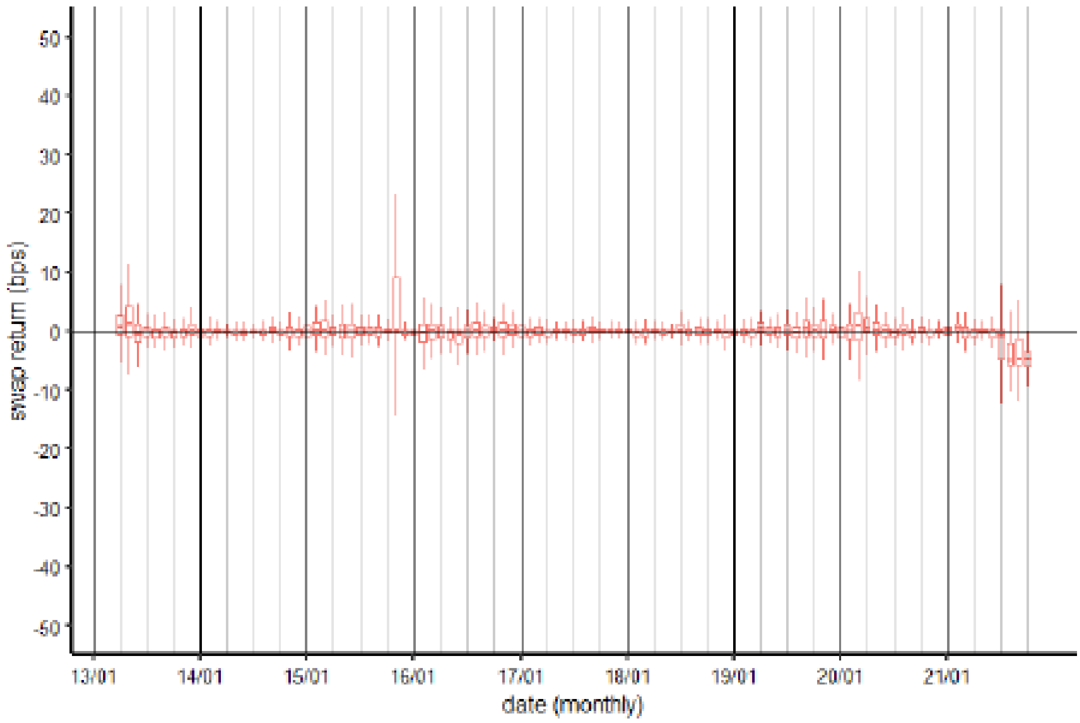


Figure 5 Historical movement of swap return in Non-CCP

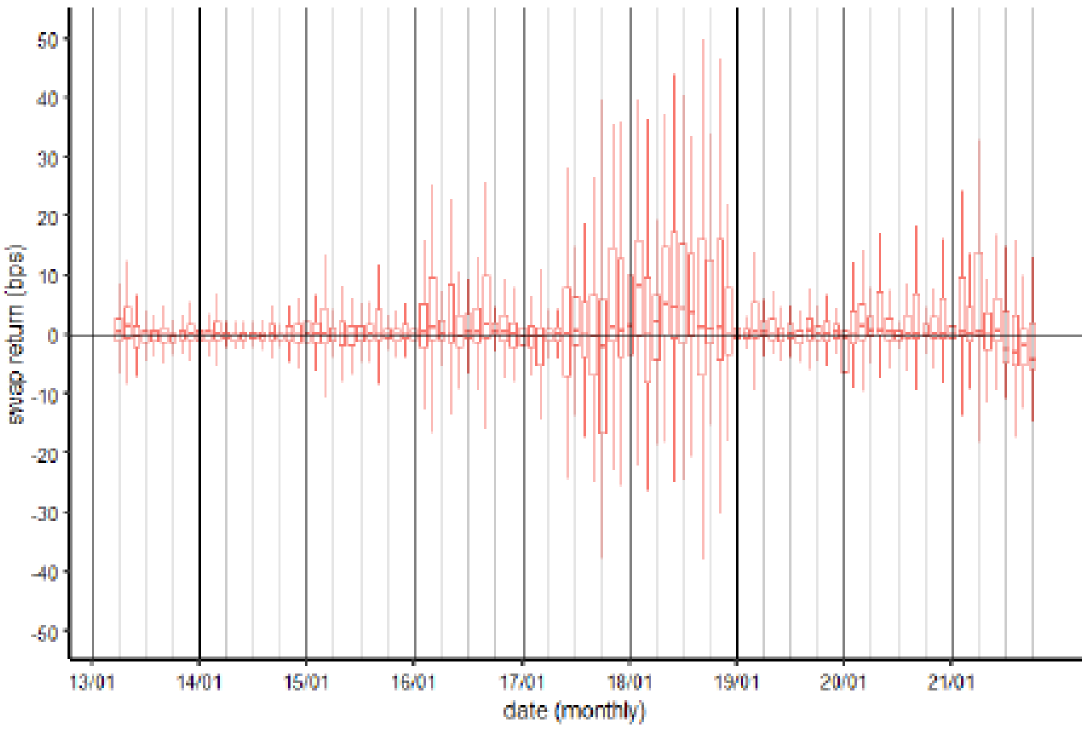


Table 1 Major valuation adjustments on derivatives

The tightening of financial regulations in the aftermath of the global financial crisis may have affected the prices (swap rates) of interest rate swap transactions through a complex set of adjustments (defined in the table). One of the most common adjustments is an X-Value Adjustment (XVA) in derivative transactions. Depending on the different evaluation targets, several types of XVA exist as shown in the table below. Under the Basel III capital rules (capital adequacy and leverage ratio rules) introduced after the global financial crisis, the implementation of OTC derivative transactions requires capital allocations (based on the amount of risk-weighted assets and exposures) in case of counterparty default or changes in credit quality which leads to the emergence of CVA and KVA. On the other hand, when a CCP is used or a margin is established for OTC derivative transactions, they reduce CVA and KVA but they increase MVA and FVA by the amount of margin established between counterparties including CCPs, which is a kind of trade-off. Therefore, it is an excellent empirical question whether or not the price of a bilaterally cleared transaction without an established margin (reflecting CVA and KVA) is more expensive than the price of a centrally cleared transaction with an established margin (reflecting MVA and FVA), that is, whether or not there is an OTC premium. In this regard, Cenedese et al. (2020) have empirically demonstrated the existence of a positive OTC premium attributable to CVA and KVA for interest rate swap transactions executed prior to the reforms in the OTC derivative market.

Title	Evaluation targets
CVA (Credit Valuation Adjustment)	Cost of credit of counterparties (and of own)
KVA ('K'apital Valuation Adjustment)	Cost of procuring related to regulatory capital
FVA (Funding Valuation Adjustment)	Cost of raising collateral (variation margin) for market value changes
MVA (Margin Valuation Adjustment)	Cost of initial margin and other funding

Table 2 Applicability of central clearing mandate and margin requirements and start date of application

The range of application based on notional amounts, etc.			Start date
Central Clearing Mandate[15]	Initial Margin (IM)[16]	Variation Margin (VM)[16]	
Clearing members of Japan Securities Clearing Corporation (JSCC)	-	-	November 1, 2012
1 trillion yen or more	-	-	December 1, 2014
0.3 trillion yen or more (excluding insurance companies)	-	-	December 1, 2015
-	Over 420 trillion yen (Over 3 trillion euros)	Over 420 trillion yen (Over 3 trillion euros)	September 1, 2016
0.3 trillion yen or more (including insurance companies)	-	-	December 1, 2016
-	-	No threshold	March 1, 2017
-	Over 315 trillion yen (Over 2.25 trillion euros)	-	September 1, 2017
-	Over 210 trillion yen (Over 1.5 trillion euros)	-	September 1, 2018
-	Over 105 trillion yen (Over 0.75 trillion euros)	-	September 1, 2019
-	Over 7 trillion yen (Over 50 billion euros)	-	September 1, 2020 (Postponed to September 1, 2021)
-	Over 1.1 trillion yen (Over 8 billion euros)	-	September 1, 2021 (Postponed to September 1, 2022)

[15] Financial Instruments and Exchange Act, and Cabinet Office Order on the Regulation of Over-the-Counter Derivatives Transactions.
[16] Basel Committee on Banking Supervision and Board of the International Organization of Securities Commissions (2013) “Margin requirements for non-centrally cleared derivatives.”

Table 3 Summary statistics by trade — breakdown by segment

This table reports summary statistics (by trade) of the main variables used in our analysis split by segment. CCP denotes trades cleared through a central counterparty, while Non-CCP denotes non-centrally cleared trades. Notional is the JPY amount (in ¥b) on which the exchanged interest payments are based. Maturity refers to the number of years between the effective and maturity date of the swap contract. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. The sample covers every JPY-denominated spot vanilla interest rate swap by Japan-based counterparties, which was reported to JFSA between April 1, 2013 and October 31, 2021.

	N	Mean	Std.dev.
Panel A: CCP			
Notional (bil yen)	424,129	10.51	22.54
Log-notional	424,129	22.22	1.26
Maturity (years)	424,129	10.35	7.02
Swap return (bps)	424,129	0.56	12.76
Panel B: Non-CCP			
Notional (bil yen)	178,909	7.42	18.88
Log-notional	178,909	21.30	1.89
Maturity (years)	178,909	8.00	5.35
Swap return (bps)	178,909	13.09	33.09
Panel C: All			
Notional (bil yen)	603,038	9.60	21.57
Log-notional	603,038	21.95	1.53
Maturity (years)	603,038	9.66	6.66
Swap return (bps)	603,038	4.28	21.73

Table 4 Time-invariant estimates of OTC premium with other variables

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of all (including D2D, D2C, C2D, and C2C) trades. Column 2 - 5 show the results of D2D, D2C, C2D, and C2C trades respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	D2D	D2C	C2D	C2C
	(1)	(2)	(3)	(4)	(5)
Non-CCP dummy	1.527***	2.288**	2.575***	0.652*	0.127
	(0.373)	(0.889)	(0.718)	(0.364)	(0.421)
Log-notional	-0.906**	-0.379**	-0.303***	-0.158**	-2.773**
	(0.392)	(0.149)	(0.104)	(0.068)	(1.289)
Maturity	-0.094*	-0.014	-0.054***	-0.023	-0.260*
	(0.048)	(0.016)	(0.019)	(0.016)	(0.153)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.61524	0.22916	0.38603	0.32623	0.72166
Obs	603,038	169,415	150,911	149,439	133,273

Table 5 Estimated OTC premium by each period

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

		Whole period (from FY2013 to FY2021)	from FY2013 to FY2016	from FY2017 to FY2021
		(1)	(2)	(3)
Non-CCP dummy of all trades		1.527***	1.953***	0.057
		(0.373)	(0.422)	(0.427)
	Non-CCP dummy of D2D trades	2.288**	4.234***	-0.161
		(0.889)	(1.234)	(0.436)
	Non-CCP dummy of D2C trades	2.575***	3.056***	0.395
		(0.718)	(0.840)	(0.569)
	Non-CCP dummy of C2D trades	0.652*	0.701	0.454
		(0.364)	(0.426)	(0.521)
	Non-CCP dummy of C2C trades	0.127	0.477	-1.430
		(0.421)	(0.345)	(1.136)

Table 6 Estimated OTC premium by subject category and transaction type

The matrix reports time-invariant estimates of OTC premia for each pair of a seller and a buyer based on the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Here, R represents parties which are constrained by either the initial margin requirement or the variation margin requirement while NR does otherwise. And D represents G16 dealers while C does otherwise. Based on these definitions, for example, NR_D represents G16 dealers which are constrained by neither the initial margin requirement nor the variation margin requirement. The same is the case with other symbols. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses and the ratios of observations over the whole data in square brackets. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

Seller \ Buyer	NR_D	NR_C	R_D	R_C
NR_D	4.612*** (1.319) [7.1%]	3.093*** (0.840) [14.3%]	2.134 (1.248) [3.3%]	1.615*** (0.551) [1.2%]
NR_C	0.756* (0.434) [14.1%]	0.642** (0.311) [14.4%]	-0.477 (1.240) [1.5%]	-4.181* (2.047) [0.8%]
R_D	0.616 (0.887) [3.2%]	3.009 (2.136) [1.6%]	-0.325 (0.314) [14.5%]	0.749 (0.559) [7.8%]
R_C	0.099 (0.871) [1.2%]	-3.198 (3.867) [2.4%]	0.489 (0.499) [8.0%]	-0.412 (1.012) [4.5%]

Table 7 The effects of the introduction of the margin requirements

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. IM mandate dummy 1 - 5 equal one if the trade is constrained by the IM mandate introduced in September 2016, September 2017, September 2018, September 2019, and September 2021, respectively, and zero otherwise. Likewise, VM mandate dummy 1 - 2 equal one if the trade is constrained by the VM mandate introduced in September 2016 and March 2017, respectively, and zero otherwise. Column 1 shows the results of All trades. Column 2 shows the results of D2D trades. Column 3 shows the results of D2C trades. Column 4 shows the results of C2D trades. Column 5 shows the results of C2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	D2D	D2C	C2D	C2C
	(1)	(2)	(3)	(4)	(5)
Non-CCP dummy	1.918***	4.215***	2.964***	0.705*	0.405
	(0.412)	(1.212)	(0.819)	(0.414)	(0.331)
Non-CCP dummy × IM mandate dummy 1	-1.141*		-2.335**	1.102	
	(0.578)		(0.860)	(0.703)	
Non-CCP dummy × VM mandate dummy 1	9.365*		16.491***		
	(5.296)		(1.179)		
Non-CCP dummy × VM mandate dummy 2	-1.270*	-4.829***	-1.762*	0.672	-1.619
	(0.660)	(1.311)	(0.997)	(0.862)	(1.566)
Non-CCP dummy × IM mandate dummy 2	-5.065**	-7.926***	-4.477***		
	(2.038)	(0.495)	(1.002)		
Non-CCP dummy × IM mandate dummy 3	0.093	1.082	-0.420	-0.800	5.846*
	(1.391)	(1.242)	(2.034)	(0.829)	(2.930)
Non-CCP dummy × IM mandate dummy 4	-1.098	0.624	-1.557	-1.977*	-2.154
	(0.711)	(0.476)	(1.109)	(1.046)	(1.855)
Non-CCP dummy × IM mandate dummy 5	-1.604***	-1.325***	1.315*	-1.558	0.894
	(0.433)	(0.448)	(0.739)	(1.506)	(1.705)
Log-notional	-0.905**	-0.372**	-0.299***	-0.157**	-2.777**
	(0.392)	(0.148)	(0.103)	(0.068)	(1.289)
Maturity	-0.096*	-0.019	-0.057***	-0.024	-0.262*
	(0.048)	(0.016)	(0.019)	(0.016)	(0.153)
Day, (Month × Seller ID × Buyer ID) FE	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.61532	0.23021	0.38650	0.32631	0.72169
Obs	603,038	169,415	150,911	149,439	133,273

Appendix

Table A1 Estimated OTC premium by each period on all trades, including D2D, D2C, C2D, and C2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. These results are based on all trades, including D2D, D2C, C2D, and C2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	from FY2013 to FY2016	from FY2017 to FY2021
	(1)	(2)	(3)
Non-CCP dummy	1.527***	1.953***	0.057
	(0.373)	(0.422)	(0.427)
Log-notional	-0.906**	-1.400**	-0.289
	(0.392)	(0.641)	(0.187)
Maturity	-0.094*	-0.209**	0.007
	(0.048)	(0.080)	(0.024)
Day, (Month $\times$ Buyer ID $\times$ Seller ID) FE	Yes	Yes	Yes
$\overline{R}^2$	0.61524	0.70498	0.41727
Obs	603,038	313,110	289,928

Table A2 Estimated OTC premium by each period on D2D trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. These results are based on D2D trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	from FY2013 to FY2016	from FY2017 to FY2021
	(1)	(2)	(3)
Non-CCP dummy	2.288**	4.234***	-0.161
	(0.889)	(1.234)	(0.436)
Log-notional	-0.379**	-0.364	-0.380*
	(0.149)	(0.216)	(0.193)
Maturity	-0.014	-0.073**	-0.004
	(0.016)	(0.034)	(0.017)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes
$\overline{R}^2$	0.22916	0.36171	0.17565
Obs	169,415	47,118	122,297

Table A3 Estimated OTC premium by each period on D2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. These results are based on D2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	from FY2013 to FY2016	from FY2017 to FY2021
	(1)	(2)	(3)
Non-CCP dummy	2.575***	3.056***	0.395
	(0.718)	(0.840)	(0.569)
Log-notional	-0.303***	-0.203**	-0.491**
	(0.104)	(0.095)	(0.233)
Maturity	-0.054***	-0.080***	-0.040
	(0.019)	(0.024)	(0.026)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes
$\overline{R}^2$	0.38603	0.44854	0.32610
Obs	150,911	88,890	62,021

Table A4 Estimated OTC premium by each period on C2D trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. These results are based on C2D trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	from FY2013 to FY2016	from FY2017 to FY2021
	(1)	(2)	(3)
Non-CCP dummy	0.652*	0.701	0.454
	(0.364)	(0.426)	(0.521)
Log-notional	-0.158**	-0.183**	-0.112
	(0.068)	(0.067)	(0.158)
Maturity	-0.023	-0.032	-0.012
	(0.016)	(0.023)	(0.019)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes
$\overline{R}^2$	0.32623	0.35655	0.30194
Obs	149,439	86,978	62,461

Table A5 Estimated OTC premium by each period on C2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 shows the results of regressions on the trades from FY2013 to FY2016. Column 3 shows the results of regressions on the trades from FY2017 to FY2021. These results are based on C2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	from FY2013 to FY2016	from FY2017 to FY2021
	(1)	(2)	(3)
Non-CCP dummy	0.127	0.477	-1.430
	(0.421)	(0.345)	(1.136)
Log-notional	-2.773**	-4.010**	-0.117
	(1.289)	(1.627)	(0.547)
Maturity	-0.260*	-0.528**	0.165
	(0.153)	(0.199)	(0.117)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes
$\overline{R}^2$	0.72166	0.75209	0.60716
Obs	133,273	90,124	43,149

Table A6 Estimated OTC premium by each year

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

		Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dummy of all trades		1.527***	1.101	2.309**	2.187**	2.141**	1.121	3.170*	-0.651	-0.277	0.740
		(0.373)	(0.475)	(0.545)	(0.591)	(0.655)	(0.582)	(1.043)	(0.304)	(0.324)	(1.012)
	Non-CCP dummy of D2D trades	2.288**	2.447	8.274**	5.305*	1.877**	-1.311*	1.789	-0.185	-0.092	1.086
		(0.889)	(1.602)	(2.284)	(1.818)	(0.577)	(0.447)	(1.744)	(0.475)	(0.581)	(0.704)
	Non-CCP dummy of D2C trades	2.575***	2.003*	3.222*	3.419**	4.091**	2.863**	3.935*	-0.826	-0.771	1.119
		(0.718)	(0.738)	(1.112)	(1.035)	(1.029)	(0.696)	(1.374)	(0.596)	(0.624)	(0.838)
	Non-CCP dummy of C2D trades	0.652*	0.001	1.029	0.714	1.212	1.277	3.876**	-0.487	-0.124	2.522*
		(0.364)	(0.624)	(0.554)	(0.532)	(0.770)	(0.871)	(0.801)	(0.331)	(0.850)	(0.749)
	Non-CCP dummy of C2C trades	0.127	0.260	0.562	0.696*	0.358	-0.976	0.218	-2.590	-0.909	-1.930
		(0.421)	(0.612)	(0.307)	(0.286)	(0.820)	(1.554)	(2.472)	(2.004)	(1.934)	(2.389)

Table A7 Estimated OTC premium by each year in all trades, including D2D, D2C, C2C, and C2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. These results are based on all trades, including D2D, D2C, C2D, and C2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

	Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dummy	1.527***	1.101	2.309**	2.187**	2.141**	1.121	3.170*	-0.651	-0.277	0.740
	(0.373)	(0.475)	(0.545)	(0.591)	(0.655)	(0.582)	(1.043)	(0.304)	(0.324)	(1.012)
Log-notional	-0.906**	-1.202	-2.473	-1.468	0.019	0.222	-0.696	-0.572	-0.185	-0.080
	(0.392)	(0.658)	(1.193)	(0.790)	(0.166)	(0.226)	(0.572)	(0.304)	(0.098)	(0.178)
Maturity	-0.094*	-0.269*	-0.409*	-0.198*	0.044	-0.016	0.002	-0.025	0.062**	0.007
	(0.048)	(0.097)	(0.150)	(0.074)	(0.070)	(0.032)	(0.082)	(0.046)	(0.016)	(0.035)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.61524	0.79306	0.74959	0.66098	0.54369	0.58740	0.47207	0.36125	0.35728	0.37715
Obs	603,038	86,436	82,811	71,320	72,543	66,111	64,747	73,639	56,151	29,280

Table A8 Estimated OTC premium by each year in D2D trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. These results are based on D2D trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

	Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dummy	2.288**	2.447	8.274**	5.305*	1.877**	-1.311*	1.789	-0.185	-0.092	1.086
	(0.889)	(1.602)	(2.284)	(1.818)	(0.577)	(0.447)	(1.744)	(0.475)	(0.581)	(0.704)
Log-notional	-0.379**	0.313	-0.441	-1.248	-0.071	0.003	-0.717	-0.564	-0.219*	-0.296
	(0.149)	(0.449)	(0.239)	(0.566)	(0.167)	(0.233)	(0.678)	(0.373)	(0.070)	(0.188)
Maturity	-0.014	-0.071	-0.184*	-0.166**	0.005	-0.061*	-0.004	0.006	0.046*	-0.031
	(0.016)	(0.056)	(0.073)	(0.031)	(0.020)	(0.025)	(0.056)	(0.040)	(0.019)	(0.027)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.22916	0.43948	0.31745	0.44105	0.19948	0.17958	0.17676	0.17252	0.16803	0.18640
Obs	169,415	8,575	7,199	9,421	21,923	27,309	30,054	31,278	23,092	10,564

Table A9 Estimated OTC premium by each year in D2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. These results are based on D2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dummy	2.575***	2.003*	3.222*	3.419**	4.091**	2.863**	3.935*	-0.826	-0.771	1.119
	(0.718)	(0.738)	(1.112)	(1.035)	(1.029)	(0.696)	(1.374)	(0.596)	(0.624)	(0.838)
Log-notional	-0.303***	-0.344*	-0.163	-0.210	-0.012	-0.025	-1.048	-0.703*	-0.305	-0.296
	(0.104)	(0.137)	(0.098)	(0.200)	(0.319)	(0.212)	(1.012)	(0.279)	(0.266)	(0.586)
Maturity	-0.054***	-0.111**	-0.099*	-0.072*	-0.032	-0.057***	-0.032	-0.069	0.007	-0.081
	(0.019)	(0.034)	(0.039)	(0.030)	(0.057)	(0.003)	(0.081)	(0.071)	(0.053)	(0.044)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.38603	0.48126	0.49151	0.41383	0.39272	0.46207	0.34895	0.32934	0.25047	0.31814
Obs	150,911	26,472	24,573	20,834	17,011	14,110	12,800	16,141	12,262	6,708

Table A10 Estimated OTC premium by each year in C2D trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. These results are based on C2D trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dumy	0.652*	0.001	1.029	0.714	1.212	1.277	3.876**	-0.487	-0.124	2.522*
	(0.364)	(0.624)	(0.554)	(0.532)	(0.770)	(0.871)	(0.801)	(0.331)	(0.850)	(0.749)
Log-notional	-0.158**	-0.203	-0.195***	-0.186	-0.114	0.206	-0.238	-0.221	-0.378**	0.135
	(0.068)	(0.112)	(0.031)	(0.248)	(0.216)	(0.207)	(0.441)	(0.433)	(0.078)	(0.474)
Maturity	-0.023	-0.087	-0.045	-0.016	0.025	-0.044*	0.001	-0.034	0.033*	-0.025
	(0.016)	(0.039)	(0.021)	(0.027)	(0.070)	(0.018)	(0.082)	(0.032)	(0.012)	(0.072)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.32623	0.34492	0.39356	0.34153	0.34650	0.40674	0.34236	0.31051	0.25670	0.25062
Obs	149,439	25,322	24,557	20,091	17,008	14,517	13,073	15,923	12,011	6,937

Table A11 Estimated OTC premium by each year in C2C trades

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 shows the results of regressions on the whole trades from FY2013 to FY2021. Column 2 - 10 show the results of regressions on the trades in FY2013, FY2014, FY2015, FY2016, FY2017, FY2018, FY2019, FY2020, and FY2021, respectively. These results are based on C2C trades. Here, A2B trades represent trades where A receives fixed rates while B pays them and D represents G16 dealers while C does otherwise. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	Whole period	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Non-CCP dummy	0.127	0.260	0.562	0.696*	0.358	-0.976	0.218	-2.590	-0.909	-1.930
	(0.421)	(0.612)	(0.307)	(0.286)	(0.820)	(1.554)	(2.472)	(2.004)	(1.934)	(2.389)
Log-notional	-2.773**	-3.505	-6.949*	-3.558	-0.010	0.946	-0.827	-0.795	-0.037	0.249
	(1.289)	(1.891)	(2.578)	(1.797)	(0.685)	(0.652)	(0.684)	(1.082)	(0.468)	(0.303)
Maturity	-0.260*	-0.830**	-1.075**	-0.423	0.289	0.267	0.150	-0.017	0.245	0.251
	(0.153)	(0.231)	(0.275)	(0.191)	(0.328)	(0.169)	(0.193)	(0.198)	(0.115)	(0.173)
Day, (Month $\times$ Buyer ID $\times$ Seller ID) FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.72166	0.84447	0.80409	0.70763	0.55739	0.66063	0.69078	0.54600	0.57341	0.53629
Obs	133,273	26,067	26,482	20,974	16,601	10,175	8,820	10,297	8,786	5,071

Table A12 Time-invariant estimates of OTC premium with other variables when the seller is NR_D

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 - 4 show the results of (NR_D)2(NR_D) trades, (NR_D)2(NR_C) trades, (NR_D)2(R_D) trades, and (NR_D)2(R_C) trades, respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them. Plus, R represents parties which are constrained by either the initial margin requirement or the variation margin requirement while NR does otherwise. And D represents G16 dealers while C does otherwise. Based on these definitions, for example, NR_D represents G16 dealers which are constrained by neither the initial margin requirement nor the variation margin requirement. The same is the case with other symbols. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

	(NR_D)2(NR_D)	(NR_D)2(NR_C)	(NR_D)2(R_D)	(NR_D)2(R_C)
	(1)	(2)	(3)	(4)
Non-CCP dummy	4.612***	3.093***	2.134	1.615***
	(1.319)	(0.840)	(1.248)	(0.551)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.37782	0.45337	0.24955	0.49955
Obs	42,889	86,484	19,623	7,270

Table A13 Time-invariant estimates of OTC premium with other variables when the seller is NR_C

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 - 4 show the results of (NR_C)2(NR_D) trades, (NR_C)2(NR_C) trades, (NR_C)2(R_D) trades, and (NR_C)2(R_C) trades, respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them. Plus, R represents parties which are constrained by either the initial margin requirement or the variation margin requirement while NR does otherwise. And D represents G16 dealers while C does otherwise. Based on these definitions, for example, NR_D represents G16 dealers which are constrained by neither the initial margin requirement nor the variation margin requirement. The same is the case with other symbols. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

	(NR_C)2(NR_D)	(NR_C)2(NR_C)	(NR_C)2(R_D)	(NR_C)2(R_C)
	(1)	(2)	(3)	(4)
Non-CCP dummy	0.756*	0.642**	-0.477	-4.181*
	(0.434)	(0.311)	(1.240)	(2.047)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.37986	0.76039	0.44509	0.54053
Obs	84,865	86,666	9,185	4,984

Table A14 Time-invariant estimates of OTC premium with other variables when the seller is R_D

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 - 4 show the results of (R_D)2(NR_D) trades, (R_D)2(NR_C) trades, (R_D)2(R_D) trades, and (R_D)2(R_C) trades, respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them. Plus, R represents parties which are constrained by either the initial margin requirement or the variation margin requirement while NR does otherwise. And D represents G16 dealers while C does otherwise. Based on these definitions, for example, NR_D represents G16 dealers which are constrained by neither the initial margin requirement nor the variation margin requirement. The same is the case with other symbols. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	(R_D)2(NR_D)	(R_D)2(NR_C)	(R_D)2(R_D)	(R_D)2(R_C)
	(1)	(2)	(3)	(4)
Non-CCP dummy	0.616	3.009	-0.325	0.749
	(0.887)	(2.136)	(0.314)	(0.559)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.24774	0.49648	0.16533	0.30034
Obs	19,511	9,907	87,392	47,250

Table A15 Time-invariant estimates of OTC premium with other variables when the seller is R_C

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. Column 1 - 4 show the results of (R_C)2(NR_D) trades, (R_C)2(NR_C) trades, (R_C)2(R_D) trades, and (R_C)2(R_C) trades, respectively. Here, A2B trades represent trades where A receives fixed rates while B pays them. Plus, R represents parties which are constrained by either the initial margin requirement or the variation margin requirement while NR does otherwise. And D represents G16 dealers while C does otherwise. Based on these definitions, for example, NR_D represents G16 dealers which are constrained by neither the initial margin requirement nor the variation margin requirement. The same is the case with other symbols. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. $***$, $**$, $*$ denote significance at 1%, 5%, and 10% confidence level, respectively.

	(R_C)2(NR_D)	(R_C)2(NR_C)	(R_C)2(R_D)	(R_C)2(R_C)
	(1)	(2)	(3)	(4)
Non-CCP dummy	0.099	-3.198	0.489	-0.412
	(0.871)	(3.867)	(0.499)	(1.012)
Day, (Month × Buyer ID × Seller ID) FE	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.41773	0.53271	0.27796	0.52568
Obs	7,406	14,574	47,983	27,049

Table A16 The effects of the introduction of the central clearing mandates and the margin requirements

The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for Non-CCP trades and zero otherwise, and a number of other variables and controls. The swap return is defined as the difference (in bps) between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day. CCP mandate dummy 1 - 3 equal one if the trade is constrained by the CCP mandate introduced in December 2014, December 2015, and December 2016, respectively, and zero otherwise. Plus, IM mandate dummy 1 - 5 equal one if the trade is constrained by the IM mandate introduced in September 2016, September 2017, September 2018, September 2019, and September 2021, respectively, and zero otherwise. Likewise, VM mandate dummy 1 - 2 equal one if the trade is constrained by the VM mandate introduced in September 2016 and March 2017, respectively, and zero otherwise. Column 1 shows the results of All trades. Column 2 shows the results of D2D trades. Column 3 shows the results of D2C trades. Column 4 shows the results of C2D trades. Column 5 shows the results of C2C trades. The sample covers every JPY-denominated spot vanilla interest rate swap reported to JFSA between April 1, 2013 and October 31, 2021. All specifications include time, seller ID, and buyer ID fixed effects. We report clustered standard errors (by quarter and pairs of seller and buyer ID) in parentheses. ∗∗∗, ∗∗, ∗ denote significance at 1%, 5%, and 10% confidence level, respectively.

	All	D2D	D2C	C2D	C2C
	(1)	(2)	(3)	(4)	(5)
Non-CCP dummy	1.619***	3.698***	2.577***	0.566	0.255
	(0.419)	(1.191)	(0.781)	(0.495)	(0.445)
Non-CCP dummy × CCP mandate dummy 1	0.945**	3.853**	0.854	0.232	0.660
	(0.454)	(1.755)	(0.626)	(0.500)	(0.448)
Non-CCP dummy × CCP mandate dummy 2	0.674	-0.340	1.297	0.621	0.246
	(0.536)	(1.146)	(0.825)	(0.837)	(0.618)
Non-CCP dummy × IM mandate dummy 1	-1.141*		-2.333**	1.444	
	(0.578)		(0.860)	(1.244)	
Non-CCP dummy × VM mandate dummy 1	10.110*		16.379***		
	(5.220)		(0.878)		
Non-CCP dummy × CCP mandate dummy 3	-0.897**	-3.026**	-0.023	-0.359	-1.759
	(0.418)	(1.312)	(0.431)	(0.501)	(1.429)
Non-CCP dummy × VM mandate dummy 2	-0.074	-1.286**	-1.353*	1.170	0.290**
	(0.509)	(0.472)	(0.744)	(0.759)	(0.109)
Non-CCP dummy × IM mandate dummy 2	-5.067**	-7.931***	-4.482***		
	(2.038)	(0.495)	(1.002)		
Non-CCP dummy × IM mandate dummy 3	0.092	1.082	-0.420	-0.800	5.845*
	(1.391)	(1.242)	(2.034)	(0.829)	(2.931)
Non-CCP dummy × IM mandate dummy 4	-1.098	0.624	-1.558	-1.978*	-2.154
	(0.711)	(0.476)	(1.109)	(1.046)	(1.856)
Non-CCP dummy × IM mandate dummy 5	-1.604***	-1.324***	1.313*	-1.557	0.892
	(0.433)	(0.447)	(0.737)	(1.505)	(1.705)
Log-notional	-0.904**	-0.372**	-0.297***	-0.156**	-2.778**
	(0.392)	(0.148)	(0.104)	(0.068)	(1.289)
Maturity	-0.096*	-0.019	-0.057***	-0.024	-0.262*
	(0.048)	(0.016)	(0.019)	(0.016)	(0.153)
Day, (Month × Seller ID × Buyer ID) FE	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.61535	0.23061	0.38659	0.32633	0.72169
Obs	603,038	169,415	150,911	149,439	133,273