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OTC premia

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Abstract

Using trade repository data at transaction and ID levels, we provide the first systematic study of interest rate swaps traded over the counter in the new regulatory regime. We find substantial and persistent heterogeneity in derivatives prices consistent with a pass-through of regulatory costs on to market prices via the so-called valuation adjustments (XVA). Specifically, a client pays a higher price to buy interest-rate protection from a dealer (ie, the client pays a higher fixed rate) if the contract is not cleared via a central counterparty. This OTC premium decreases by posting initial margin and with higher buyer's creditworthiness. Also, OTC premia are absent for dealers suggesting dealers' bargaining power.

Key words: Interest rate swaps, financial regulation, central clearing, over-the-counter market, valuation adjustments.

JEL classification: G18.

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1 Introduction

The Group of Twenty (G20) leaders agreed in 2009 on an ambitious agenda to reform and strengthen the financial system. At the centre of the agenda was the reform of over-the-counter (OTC) derivatives. What are the effects of the new regulation on derivatives pricing? Has it created stronger price heterogeneity? If so, how can we explain it?

To address these important questions, we provide the first empirical study of interest rate swaps (IRS) in the new regulatory regime. Using unique and confidential data at transaction and ID levels, we find substantial and persistent heterogeneity in derivative prices. Besides the standard contract risk, IRS swap rates vary depending on whether the transaction is cleared via a central counterparty (CCP) or cleared bilaterally (non-CCP), if initial margin is posted, and on counterparty credit risk. These price differentials that we call *OTC premia* are highly significant in statistical and economic terms. For instance, when a dealer sells interest rate protection to a client (i.e., the dealer receives the fixed rate), the client pays the dealer around 8 basis points more for a non-CCP contract than an equivalent CCP one, after controlling for counterparty and time fixed effects. This premium substantially decreases when initial margin is posted and with the client's creditworthiness. We rationalise these OTC premia with increased inventory costs induced by recent financial regulation that are passed on to market prices through so-called valuation adjustments (XVA). Also, OTC premia favour dealers in the sense that the extra cost in the non-CCP segment for interest-rate protection (i.e., paying the fixed rate) is absent for dealers and large for clients suggesting regulatory costs and bargaining power for dealers.

A better understanding of derivative markets is important for various entities including policy-makers and market participants. First, derivative markets are complex, opaque, and composed of many segments leading to price heterogeneity (Duffie, 2012). Indeed, there may be many sources of price heterogeneity, including different legal frameworks (e.g., different ISDA agreements, accounting or regulatory rules), counterparty risk, types of agents (e.g., non-financial corporates versus dealers), and the overall difficulty to novate and negotiate across market segments. But at the same time, the sheer size of $544 trillion of notional value (as of June 2016; see BIS, 2016) and the fact that derivatives are heavily traded by professional agents should facilitate price efficiency. Thus, it is uncertain a priori whether the same derivative contract is priced equally across different segments or types of market participants.

Second, in the wake of the recent global financial crisis policy-makers have implemented new regulations that have fundamentally changed the structure and mode of operation of OTC derivative markets. Among the declared objectives, there have been the increase of standardisation, central clearing, and the reduction of systemic risk, especially in terms of credit risk (FSB, 2010). Two questions then arise. First, have the regulators achieved their objectives? Second, have market participants efficiently adapted their pricing and trading activities? On the one end, more expensive non-CCP derivatives incentivising central clearing can be regarded as a suitable achievement. On the other end, more heterogeneity in the form of adverse prices for dealers' customers would be an unintended consequence. All these issues call for an in-depth analysis of derivative contracts at transaction and ID levels, as we do in this paper.

To introduce our pricing analysis, we map the IRS market in the new regulatory regime, which represents the largest part of the entire interest rate derivatives market.[1] More specifically, we analyse every contract by non-US-based counterparties that traded with UK-based entities (including subsidiaries of foreign banks) and that was reported to the Depository Trust & Clearing Corporation (DTCC) between the beginning of December 2014 and the end of February 2016.[2] The time span intentionally starts after the US clearing mandate (March 2013), but before the European one (June 2016). This means that the counterparties in our sample (with access to CCP) had the choice whether to

[1]At end-June 2016, the notional outstanding for interest rate derivatives was $437 trillion (80% of the market), of which 327 trillion (60% of the market) were interest rate swaps, of which one-third was denominated in USD (BIS, 2016).

[2]We remove US persons because in our sample period they were required to centrally clear their transactions.

centrally clear their trades or not throughout our sample period. This setting represents the ideal laboratory to study the distinguishing characteristics between the CCP and non-CCP segments, in terms of contract features, counterparty types, and how the trading activity in these segments evolves across time and risk. A unique feature of our data is the information on counterparties' identity, which allows us to identify and quantify a trader's credit risk, its degree of financial sophistication, and those of its counterparties.[3]

To carry out the core analysis of our paper, we address the question whether there is substantial and persistent heterogeneity in derivative pricing in the new regulatory regime and, if so, why. To do this, we analyse what explains IRS returns as conventionally defined, i.e., the difference between the transaction-level swap rate (i.e.,the fixed leg of the swap contract) and the benchmark rate at the end of the previous day. More specifically, we perform panel regressions with time and counterparty fixed effects in which IRS returns are regressed on the main potential determinants of pricing heterogeneity as outlined by dealers' inventory and bargaining theories as well as XVA methods.

In line with inventory theories, market participants adjust derivative prices to inventory holding costs of derivatives exposures.[4] In addition to hedging costs due to the contract exposure increasing with larger notional and longer maturities, dealers take into account costs originated from new regulations such as the Basel III capital and liquidity requirements. In this new regulatory framework, dealers will require a compensation for holding derivative positions implying 'regulatory' costs. These effects will be different across types of agents and OTC segments generating price heterogeneity. For example, the leverage ratio mostly affects banks that are required to maintain a minimum amount of capital

[3] Sophistication loosely refers to trading experience, financial expertise, and access to infrastructures (e.g., trading venues and central banks standing facilities), which should increase with advanced financial literacy and frequent participation in the derivatives markets. For instance, both dealer and non-dealer banks are deemed sophisticated financial institutions, followed by hedge funds (but with more limited access to market infrastructures), whereas less sophisticated agents are, e.g., non-financial corporates and insurance companies.

[4] Models of inventory effects are proposed in Stoll (1978), Amihud and Mendelson (1980), Ho and Stoll (1981), Mildenstein and Schleef (1983), O'Hara and Oldfield (1986), Grossman and Miller (1986) and Shen and Starr (2002). In particular, in Amihud and Mendelson, 1980, O'Hara and Oldfield (1986), and Shen and Starr (2002) quotes and spreads depend on dealers' inventories. More recently, Pelizzon, Subrahmanyam, Tomio, and Uno (2016) extends the Stoll (1978) model to margins.

against all on-balance-sheet assets and off-balance-sheet exposures, regardless of their risk. This increases the appeal of CCPs, which create more netting opportunities. At the same time, the risk-weighted Basel III capital ratio rules imply that counterparty credit risk is more stringent for uncollateralised OTC derivatives.[5] Hence, we expect a dealer selling protection against interest rate movements (i.e., receiving the fixed rate) to request a higher price (fixed rate) for trading in segments or against market participants inducing higher regulatory costs.

A further source of price heterogeneity is the dealer's bargaining power that can arise from, e.g., the lack of outside options for customers (e.g., Duffie, Garleanu, and Pedersen, 2005, 2007), dealers' network centrality (e.g., Li and Schüfhoff, 2017), financial expertise (e.g., Glode, Green, and Lowery, 2012), as well as information rents (e.g., Bolton, Santos, and Scheinkman, 2016). If dealers possess bargaining power against their customer (Duffie, 2012), then they will charge less favorable prices especially to less sophisticated or less active customers, such as non-bank entities, as these entities tend to have limited outside options and are less affected by the new regulation (e.g., they are not subject to Basel III) thereby less inclined to adjust derivative prices for regulatory costs.

Heterogeneous OTC premia are also fully consistent with the common valuation approach for derivatives that includes XVA elements such as Credit and Debit Valuation Adjustment (CVA, DVA), Funding Valuation Adjustment (FVA), Margin Valuation Adjustment (MVA), and Capital Valuation Adjustment (KVA). Note that the CVA capital charge was introduced by Basel III as a protection against losses caused by an increase in the credit spread of the counterparty. In practice, it penalises counterparties with low credit rating, as they tend to have higher credit spread volatility. More specifically, from XVA pricing one can draw the following empirical predictions: first, the same IRS contract traded in the non-CCP segment (without the exchange of initial margin) rather than the

[5]The Basel III framework includes two counterparty credit risk (CCR) capital charges: the default capital charge and the CVA capital charge. The former is intended to cover any losses due to a counterparty default, while the CVA capital charge reflects (mark-to-market) losses caused by an increase in the credit spread of the counterparty.

CCP one demands larger CVA and KVA resulting in a higher market price to pay fixed. Second, when a customer pays fixed to a dealer in the non-CCP segment, the OTC premium decreases (increases) with the client's (dealer's) creditworthiness because a higher credit rating translates into a lower cost for buying protection (CVA) and lower capital charge (KVA). Third, the exchange of initial margin in Non-CCP trades mitigates the effect of CVA and KVA. Fourth, a higher contract risk exposure in terms of notional and maturity implies higher XVAs for non-CCP rather than CCP contracts.

Some clear results emerge from our study. First, we uncover new stylised facts of the IRS market in the new regulatory regime, which are: (i) the market share of the CCP segment is predominant; (ii) CCP trades are generally more standard contracts with larger notional and longer maturity;[6] (iii) the average market participant on CCPs is a more 'sophisticated' financial firm with higher creditworthiness consistent with the theoretical predictions that the non-CCP venue concentrates higher counterparty risk (Acharya and Bisin, 2014; Biais, Heider, and Hoerova, 2012; Biais, Heider, and Hoerova, 2016);[7] and (iv) in destressed markets, market participants significantly increase their trading outside CCPs suggesting that they tend to circumvent the so-called margin procyclicality, i.e., tighter funding conditions and higher margins imposed by the CCP.

Second, we find substantial and persistent heterogeneity in OTC premia, which is significant in statistical and economic terms. For instance, when a client buys interest rate protection pays a dealer a fixed rate that is around 8 basis points higher for a non-CCP transaction relative to a CCP one. This is a sizeable amount considered the total notional traded of around 7.4 trillion US dollars and compared to the average swap rate over our sample period. The OTC premium reduces by at least half if a non-CCP trade involves posting of initial margin. Through the lens of XVA, our results point to credit risk (CVA) and capital charges (KVA) as important drivers of OTC premia for non-CCP transactions.

[6]'Standard' means that the contract maturity is 1Y, 2Y, 3Y, 4Y,. . . , 50Y or the last digit of the price (fixed rate) is 5 or 0.

[7]To the extent that low credit rating parties are also low volume players, this finding can also be the result of the high entry/usage costs of the CCP infrastructure.

Another finding is that the OTC premium is not fully symmetric when dealers receive or pay the fixed to their clients, that is, OTC premia are significantly positive when dealers receive the fixed rate (consistent with dealers passing on XVA 'costs' to clients) but not systematically negative (i.e., there is no discount) when dealers pay fixed. More precisely, when dealers pay fixed to clients (irrespective of clients' type), OTC premia tend to be smaller but still positive. When we restrict the sample of clients to non-banks only (so we remove transactions by non-dealer banks), OTC premia tend to be negative. Our tentative explanation is bargaining or market power: dealers pass the XVA cost to non-banks, but they are less able to do so against other banks who are also subject to the XVA costs. In addition, it is important to stress that in our sample period the expectation for a rate decrease was virtually non-existent, as suggested by the steepening OIS curve. That is, there was only an upward risk of rate hikes by the Fed. Thus, across our sample period the payer of fixed (including dealers) pays a premium to protect herself against the interest-rate risk. Overall, these findings are consistent with the idea that (i) as any inventory costs, dealers tend to pass on regulatory costs to market prices, and (ii) dealers exercise some bargaining power when they price swap contracts.

Third, we identify the main determinants of the OTC premia. Specifically, we find that swap prices tend to increase with notional amount and remaining time to maturity, which capture the contract risk. Moreover, agents with higher creditworthiness tend to obtain better prices. Conversely, the price a client bank pays (receives) for the fixed rate to (from) a dealer increases (decreases) with the bank's credit risk consistent with the pricing of CVA and KVA. Translated into numbers, if the bank's credit risk is one notch below as assessed by credit-rating agencies, the swap rate is one or two basis points more expensive.

Finally, we analyse the role of market liquidity, relationships, and bilateral exposures in OTC premia. To do this, we exploit the execution of swaps on centralised electronic platforms, known as Swap Execution Facilities (SEF), which increase transparency and dealer competition thus improving market liquidity (Benos, Payne, and Vasios, 2016). We find that IRS prices through SEF are smaller but the OTC premia remain statistically and economically significant. To control for bilateral relationships, we augment our regressions with buyer-seller fixed effects. We also perform further analysis that controls for time-varying bilateral relationships (e.g., time-varying dealer-client exposures). All main results are confirmed.

We contribute to the empirical literature on derivative markets in several ways. First, although price dispersion due to over-the-counter frictions such as search costs and bargaining is well-grounded theoretically (e.g., Duffie et al., 2005, 2007), this is the first study providing empirical evidence of systematic OTC premia in IRS contracts. Our analysis also highlights the main determinants of OTC premia, namely how the contract is cleared (CCP and non-CCP transactions), whether it involves margins, the types of market participants, and contract characteristics (notional and maturity).[8]

Second, our findings provide empirical support to the recent literature on the theory of XVA (e.g., Green, 2015; Gregory, 2015; Ruiz, 2015; and Andersen, Duffie, and Song, 2018). In particular, Andersen et al. (2018) theorise the link between FVA and the dealer's price quotation to align the market-making function with shareholder interests. We provide empirical evidence that (i) overall XVAs are priced in derivatives generating price heterogeneity and that (ii) CVA and KVA are important valuation adjustment factors. Rather than a sign of inconsistency or frictions, our findings suggest that heterogeneity in derivatives prices results from an attempt to adjust efficiently valuations to the new regulatory framework. On the other hand, we also find asymmetric patterns in the dealer-to-customer segment that cannot be explained by market liquidity and relationship issues. Our findings point to dealers' superior bargaining power but they are also consistent with the regulation effects that impact mostly dealers rather than their (non-bank) customers.

[8]Theoretically, price heterogeneity can arise from a number of reasons including search costs (e.g., Duffie et al., 2005; Duffie et al., 2007; Lagos and Rocheteau, 2007; Lagos and Rocheteau, 2009; Atkeson, Eisfeldt, and Weill, 2013; and Afonso and Lagos, 2015) or informational issues (e.g., Duffie, Malamud, and Manso, 2009; Zhu, 2012; Babus and Kondor, 2018; Golosov, Lorenzoni, and Tsyvinski, 2014; and Babus and Hu, 2017). Empirical evidence of price dispersion in OTC markets is provided by, e.g., Jankowitsch, Nashikkar, and Subrahmanyam (2011); and Green, Hollifield, and Schürhoff (2007). More recently, Hau, Hoffmann, Langfield, and Timmer (2018) analyse dealers' discriminatory pricing in FX derivatives market, while Cenedese, Della Corte, and Wang (2018) attribute currency mispricing to dealer balance sheet constraints.

Third, we contribute to the literature on central clearing, which has been studied mainly theoretically (e.g., Duffie and Zhu, 2011; Biais et al., 2012; Acharya and Bisin, 2014; Biais et al., 2016). The empirical literature devoted to CCP and OTC markets in post-crisis periods has mostly focused on CDS (e.g., Arora, Gandhi, and Longstaff, 2012; Loon and Zhong, 2014, 2016; Duffie, Scheicher, and Vuillemey, 2015; Du, Gadgil, Gordy, and Vega, 2016; Bellia, Panzica, Pelizzon, and Peltonen, 2018).[9] By looking at IRS centralised trading, Benos et al. (2016) represent an exception focusing on the effects of Dodd-Frank Act on market liquidity. We contribute to the debate about the benefits and drawbacks of central clearing by providing empirical evidence that in our sample period the CCP segment is relatively safer in terms of counterparty credit risk and demands lower OTC premia, both of which are consistent with the policy objective of promoting central clearing.

Finally, we provide empirical support to the growing literature on intermediary asset pricing (e.g., He and Krishnamurthy, 2013; Adrian, Etula, and Muir, 2014; He, Kelly, and Manela, 2017) showing that financial intermediaries play a crucial role in the pricing of financial assets and creating heterogeneity as well as asymmetry in derivatives prices.

Discussion about the impact of future reforms. It is worth placing our analysis within the context of the derivatives reforms that are outside our sample period, chiefly among them the European clearing mandate (June 2016) and the European uncleared margining rules (phased in between January 2017 and September 2020), as they might have implications for the pricing and trading of derivatives.[10] For example, the uncleared margining rules are introducing stricter standards for the calculation of variation and initial margin (e.g., daily exchange of highly quality collateral by both parties), which points to a more important role for the FVA and MVA, on the one hand, and a greater reduction in the CVA and the KVA, on the other hand. The clearing mandate could also have an impact: the increasing demand for central clearing by players with direct (i.e., clearing members) or indirect (i.e., client clearing) access to the CCP and the concentration in the provision of

[9]Another paper by Menkveld (2017) looks into CCP crowded risk in equity markets.

[10]As discussed earlier, the sample period intentionally ends before the implementation of these reforms, as otherwise the players in this market wouldn't have had the choice to select the segment of execution.

client clearing could overly increase central clearing costs for (non clearing member) clients who are captured by the mandate, which would be an undesirable outcome. Expensive client clearing costs could also affect the incentives for clearing of counterparties, who are outside the scope of the mandate. Would the players not captured by the mandate trade more or less in the CCP segment? Would it be easier for low-volume clients to access the CCP infrastructure? Other macroeconomic factors, such us the move to a higher interest rate environment, might have an impact on the pricing of XVAs too. Although outside the scope of this work, these are questions that need to be carefully addressed by future research.

The remainder of this paper is structured as follows. In Section 2 we provide an overview of the post-crisis derivatives regulatory framework. Section 3 describes the data. Section 4 contains the main empirical analysis, and Section 5 concludes.

2 Policy context

To reduce the risk and severity of future financial crises, global regulatory authorities around the world started a significant post-crisis programme of reforms. In regard to the OTC derivative markets, the main objective has been to incentivise centralised clearing, which was expected to reduce counterparty risk and simplify the network of bilateral exposures. We focus here on two of the reforms that are most relevant to this objective: the European Market Infrastructure Regulation (EMIR), and the Basel III framework.

In July 2012 the European Union issued the EMIR, which lays down clearing requirements for OTC derivative contracts and uniform requirements for the performance of activities of CCPs.[11] The EMIR clearing obligation took effect from June 2016 and required European counterparties to centrally clear certain types of OTC derivative contracts, including interest rate swaps. The clearing obligation applies to financial counterparties,

[11] That is the Regulation (EU) No 648/2012 of the European Parliament and of the Council, of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.

and to non-financial entities whose positions in OTC derivatives exceeds the specified thresholds.[12] Central clearing requires market participants to comply with the CCP's risk management framework, which includes the exchange of initial and variation margin and the contribution to the default fund. EMIR also introduced risk-mitigation techniques for non centrally cleared OTC derivative contracts. Under these uncleared margining rules phased in between January 2017 and September 2020, all covered entities (i.e., financial firms and systemically important non-financial entities), will be required to exchange variation margin and initial margin on a regular basis for Non-CCP trades.

The Basel III framework was announced in 2010 and developed by the Basel Committee on Banking Supervision (BCBS). It consists of a comprehensive set of regulations affecting every aspect of banking, from capital to liquidity and resolution. This framework is structured in several phases, with the first phase starting in 2013, while it has been reviewed a few times more recently in 2017. The leverage ratio (i.e., the ratio of Tier 1 capital to total exposures) and the risk-weighted capital requirements (i.e., the ratio of capital to risk-weighted assets) are at the core of Basel III. The minimum internationally agreed Tier-1 capital requirement is 6% of risk weighted assets, but there are typically additional buffers set to absorb losses under stress. With respect to the leverage ratio, the BCBS required banks to publicly disclose their leverage ratio from January 2015, and proposed a minimum ratio of 3% that was scheduled to become binding in January 2018.[13]

While the scope of Basel III is broad, it has far-reaching implications for the operation of OTC derivative markets. For example, in July 2012, the BCBS, in consultation with the Committee on Payments and Settlement Systems (CPSS) and the International Organization of Securities Commission (IOSCO), assigned a small risk weight of 2% for bank exposures to central counterparties. The BCBS also introduced a cap on the capital

[12]Pension funds benefit from clearing exemption under Article 89(2) of EMIR.

[13]In the UK, regulated firms were encouraged to disclose their leverage ratio publicly from 2013. In 2014, the minimum leverage ratio requirement was calibrated to 3%, and supplemented with and additional buffer for systemically important institutions and a countercyclical buffer. Three quarters of the capital must be met with the higher quality Tier 1 capital, called common equity Tier 1 (CET1). The requirements have been binding since January 2016 for major UK-regulated banks, ahead of the Basel III arrangements.

charge on banks' exposures to CCPs in April 2014. These policies aimed to promote central clearing.

The treatment of counterparty credit risk in Basel III has also impacted the trading of OTC derivatives. Basel II had addressed this risk using the default capital charge, intended to cover any losses due to a counterparty's default. However, the global financial crisis showed that two thirds of counterparty-risk-related losses were due to the movement of the credit quality of counterparties, rather than actual defaults (BCBS, 2009).[14] To address this gap, Basel III introduced (in December 2010) the CVA capital charge as a protection against mark-to-market losses caused by an increase in the credit spread of the counterparty. More importantly, exposures to CCPs were exempted from the CVA capital charge, which otherwise would have been a significant cost of trading in the CCP segment.

Counterparty capital charges differentiate between margined and unmargined Non-CCP transactions too. This is because initial margin reduces the amount of exposure for OTC derivatives transactions. For example, the standardised approach for measuring counterparty credit risk exposures (SA-CCR), introduced by the BCBS in April 2014, allows for a reduction in the exposure at default (EAD) by any initial margin received by the counterparty. Margin also reduces the time risk horizon, the so-called maturity factor, which is an input of the EAD formula. Thus, a smaller time risk horizon leads to a smaller potential future exposure (PFE), and a smaller capital charge.[15]

With respect to the leverage ratio, its calculation does not recognise collateral or other credit risk mitigants as an offset to derivatives exposures. This is fundamentally different to the risk-weighted framework, which favours the exchange of initial margin in centrally or bilaterally cleared transactions.

[14] The UK Financial Service Authority estimated that losses of UK banks during 2007-2009 related to the market risk nature of counterparty risk were five times the amount of actual default losses. See http://www.fsa.gov.uk/pubs/discussion/dp10_04.pdf.

[15] For example, a one-year maturity IRS contract has a maturity factor equal to 1 if it is uncollateralised, 0.21 if it is centrally cleared (with daily margin agreement), or 0.3 if it is non-centrally cleared but subject to daily margin agreement. The time risk horizon is then multiplied by the notional of the trade, which is used to calculate the PFE and the EAD.

2.1 An illustrative example of XVA

The new regulatory landscape is changing the pricing of OTC derivatives. Market participants move away from textbook-type pricing formulas and start to take into account the underlying credit, collateral, funding, and capital implications of every transaction. It is common for banks to actively manage these components and reflect them into prices through valuation adjustments, a practice known as XVA. For example, the CVA is the adjustment taken upfront against counterparty defaults. The KVA takes into account costs related to capital requirements (Basel III). The MVA incorporates the cost of posting initial margin. Finally, the FVA reflects the cost of funding liquidity.

The following example illustrates how new regulation generates (heterogeneous) impacts on swap prices via the XVA. Let's assume that a dealer-bank sells interest-rate protection to a client via a 10-year IRS contract with a theoretical fixed rate of 1%. This fixed rate ensures that the fixed and floating leg of the swap have the same present value. Assuming there are no pre-existing positions between the dealer and the client, and no interdealer hedge, the following valuation adjustments apply:

- If the swap is centrally cleared, it will put pressure on dealer's funding liquidity (FVA, MVA) because of the need to manage the posting of margin, on the one hand, while it will introduce a small capital charge (KVA) because of the 2% risk weight for bank exposures to central counterparties, on the other hand. Given the low counterparty risk associated with CCP trades, there will be no CVA or CVA capital adjustment. In theory, there could be a CVA adjustment to reflect the mutualisation of counterparty risk via the default fund, but in practice this is not generally considered important.

- If the swap is bilateral and uncollateralised, it will introduce costs related to counterparty risk (CVA) and capital (KVA) as a result of the associated cost for hedging the counterparty credit risk, the default capital charge and the CVA capital charge. The magnitude of these costs will be negatively correlated to the creditworthiness of the client. This is because both the cost of buying protection against counterparty default (default probability $\uparrow \Rightarrow$ CVA $\uparrow$) and the credit spread volatility (CVA capital charge $\uparrow \Rightarrow$ KVA $\uparrow$) increases for low-credit-rating counterparties.[16]

- The exchange of initial margin in the bilateral case will reduce the counterparty risk (loss given default $\downarrow \Rightarrow$ CVA $\downarrow$) and capital (exposure at default$\downarrow$ & time risk horizon $\downarrow \Rightarrow$ KVA $\downarrow$) costs, but will increase other costs related to collateral and funding management (MVA). It is unclear how the MVA adjustment for a bilateral trade with initial margin should compare to the MVA adjustment for a CCP trade. Note that our sample period is before the implementation of the uncleared margining rules and as a result counterparties calculate initial margin using their internal (non-standardised) models (Gregory (2015)).[17] On the one hand, CCP risk models calculate initial margin using a 5-day close out period against typically a longer period for bilateral trades and offer more netting opportunities (multilateral netting), which suggests a smaller initial margin for CCP trades (MVA$^{CCP} \downarrow$). On the other hand, CCP's initial margin tends to be more risk-sensitive and is collected daily, whereas bilateral initial margin is less procyclical and is collected less frequently (MVA$^{CCP} \uparrow$). Bilateral initial margin can also be linked to thresholds and minimum transfers, leading to undercollateralisation (CVA$^{Non-CCP} >$ CVA^{CCP}).[18]

Overall, each of these adjustments will push the fixed rate higher than the 1% theoretical price in order to compensate the dealer, who is the receiver of the fixed rate, for incurring the additional costs.

[16] For example, Hull, Predescu, and White (2005) show in a simplified example that the real-world default probability of a Baa bank is 10 times larger than that of a Aaa bank.

[17] After the implementation of the uncleared margining rules (phased in in Europe between January 2017 and September 2020), the covered entities who trade in the non-CCP segment would be required to exchange variation margin regularly (e.g., daily) and initial margin over a 10-day time horizon with more stringent threshold and minimum transfer rules. This will likely increase the MVA for bilateral trades (MVA$^{Non-CCP} \uparrow$) and further reduce their CVA and KVA.

[18] The threshold is the amount below which collateral is not required. A minimum transfer is the smallest amount of collateral that can be transferred. See Chapter 6 in Gregory (2015) for more details.

3 Data

We use transactions of USD denominated spot fixed-to-floating IRS contracts executed between 1 December 2014 and 21 February 2016. The source is the DTCC, the largest European trade repository (TR).[19]

The time span intentionally starts after the US clearing mandate (March 2013), but before the European one (June 2016). This means that European counterparties had the choice to centrally clear or not their trades throughout our sample period. We start our data in December 2014 for data quality reasons. Before December 2014 many values were missing in key variables in the DTCC data until a process of validations was introduced by the European Securities and Markets Authority (ESMA), after which the data quality dramatically improved, as shown in Cielinska, Joseph, Shreyas, Tanner, and Vasios (2017) and Abad et al. (2016). In addition, note that although the European clearing mandate came into force in June 2016, EU counterparties had to centrally clear all transactions with a remaining maturity of more than 6 months from 21 February 2016 onwards, as a result of the EMIR frontloading requirement. Hence, we use 21 February 2016 as the cut-off date.

The DTCC data provide information on flows, for example new trades, modifications, valuation and cancelation updates.[20] Each transaction report contains more than 100 fields that include information on trade characteristics (e.g., price, notional amount, maturity date, execution time, reference rate), whether a trade is centrally cleared and the type of the collateral exchanged, and, more importantly, counterparty identities. This allows us to categorize trades by type of counterparty and location.

We carefully apply a number of filters to clean the data. We start by keeping only USD-denominated spot-starting swaps, which we do by removing any reports whose effective date

[19] Abad, Aldasoro, Aymanns, D'Errico, Rousova, Hoffmann, Langfield, Neychev, and Roukny (2016) report that the European DTCC data cover about 70% of the global interest rate swap market.

[20] Under EMIR the Bank of England is entitled to see (i) trades cleared by a CCP supervised by the Bank and trades in which one of the counterparties is a UK entity. The definition of entities incudes CCPs; financial counterparties, such as banks, insurance firms, and hedge funds; and non-financial counterparties that are EU legal entities, but exempts some other entities, for example EU national central banks and natural people. See Article 2 of Commission Delegated Regulation (EU) No 151/2013 - Data access by relevant authorities.

is more than two business days from the trade date. Next we remove duplicate reports. Duplication is mainly due to three reasons. First, EMIR is a double-sided reporting regime, so we see two copies for a single trade when both counterparties are UK legal entities and both of them report to DTCC. Second, as per the EMIR regulation, the data contain several copies of the same trade to reflect any modification, correction and valuation updates. We remove these duplicates using the unique trade identifier (UTI) of every report.

Another reason for duplication is that for every transaction that is centrally cleared there are typically three reports sent to the TR: the original transaction (alpha trade report) and the two novations (beta and gamma trade reports) to the clearing house. These reports tend to have different UTIs. We remove these duplicate reports by applying an algorithm that matches trades based on trade date and time, effective date, maturity date, notional, swap rate, and counterparty identities. In addition, for every trade that is cleared by the London Clearing House (LCH), which has more than 90% market share in the cleared interest rate swap market, we obtained the trade identifiers of the associated (two) novations directly from LCH. We accurately remove these duplicate novations by using the LCH information in conjunction with the matching algorithm.

Finally, to remove any false or inaccurate reports we only keep trades with fixed rate that is within 150 basis points from the benchmark (same maturity and currency) end-of-day swap rate mid quote from Bloomberg.[21] The Bloomberg benchmark is the rate used by practitioners to proxy the 'fair' value of the prevailing fixed rate. After filtering the data we are left with 169,996 reports out of which 68,945 involve US persons, who were subject to the US clearing mandate and as a result they had no choice but to centrally clear their trades.[22] In the analysis that follows we drop these reports. Therefore, the final

[21]This is necessary as some counterparties mistakenly report the swap rate in basis points instead of percentage points. Our filter ensures the removal of these inaccurate (about 4,800) reports. As robustness analyses, we experimented with other filter methods. For example, (i) we trimmed swap rate log-returns, defined as the log-difference between the transaction-level swap rate and the benchmark end-of-day swap rate mid quote from Bloomberg, at the 2.5% and 97.5%; or (ii) we trimmed swap rate absolute returns, defined as the difference between the transaction-level swap rate and the benchmark end-of-day swap rate mid quote from Bloomberg, at the 2.5% and 97.5%, among others. Our results are not sensitive to the filtering approach and remain qualitatively the same.

[22]The largest group in our data is UK counterparties, who account for two-fifth of total traded notional,

sample consists of 101,051 new trades by about 800 active counterparties, which account for a total \$7,470 billion in traded notional over our sample period.

Figure 1 shows the daily time series of traded notional by segment. The CCP segment includes all trades cleared by a clearing house.[23] The non-CCP segment consist of all no-cleared or bilaterally cleared reports. Figure 1 illustrates the immense size of the IRS market with the daily notional traded hovering around \$15–30 billion, of which about 10% takes place in the non-CCP segment across the whole sample period. To get a sense of the data coverage, we compare them against the data from the global CCP USD IRS market used in Benos et al. (2016). They report a daily notional traded by non-US counterparties of about \$20 billion between 2013 and 2014, which indicates that we see the lion's share of the (non-US counterparty) global USD IRS market, a result of London's status as a global centre for derivatives trading.

4 Empirical Analysis

4.1 Descriptive Statistics

Before conducting any in-depth analysis of OTC premia we present some key insights into the USD IRS market that we summarise in Table 1. We start with the breakdown of the market by segment and counterparty type. The daily notional traded (by non-US investors) of around \$15 billion reiterates that the USD IRS market is economically very important, as depicted in Figure 1. The CCP segment dominates trading with a market share of 85% and 90% in terms of number of trades and notional, respectively. Although a fraction of the total market, the non-CCP segment remains an economically significant quantity with daily notional of about \$1-2 billion or in number of trades terms: about 1

followed by US, FR and DE counterparties with 22%, 13%, and 7% market share, respectively. See Table 1 in the Appendix.

[23] The DTCC data contain a flag that equals one for centrally cleared trades and zero otherwise. However, we observe that some reports with a zero value involve a clearing house as a counterparty (LCH or the Chicago Mercantile Exchange). We classify these cases as centrally cleared. Finally, we require that clearing takes place on the execution date (T+0), which follows the definition of ESMA.

out of 6 trades is non-centrally cleared.

The availability of counterparty IDs allows us to classify entities into meaningful groups: dealers, banks, hedge funds, asset managers, insurance companies and pension funds, other financial companies, and non-financial companies.[24] There are also some entities that could not be classified, mainly because of missing ID information. Their trades are typically small, infrequent and non centrally cleared. Collectively they account for 8% of trades.

In Table 1 (Panel b) we present trading activity variables by type of counterparty throughout our sample period. G16 dealer trading accounts for about two thirds of trading in terms of both notional traded and number of trades. The rest of trading is split between banks (13% of notional), hedge funds (7.8%), asset managers (1.2%), and others. It is worth noting that although smaller non-bank players such as insurance companies, other financial and non-financial companies trade rather infrequently, their trading collectively sums to the economically significant amount of $205 billion or $630 million per day.

We next report descriptive statistics at the trade level and across market segments in Table 2. The average notional of CCP transactions is $79 million, which is 80% larger than that of the typical non-CCP transaction, which averages to $45 million and $40 million for collateralised and uncollateralised transactions, respectively. The distribution of the notional traded is rather dispersed though, with a standard deviation of more than $120 million in all segments. Interest rate swaps are long-lived. CCP contracts have an average maturity of 10 years, which is more than 1 year longer than that of non-centrally cleared swaps. We observe some bunching around 5- and 10-year maturities in all segments.

Table 2 also displays the statistics of the average swap rate return per trade. Note that that this return is calculated against the end-of-day swap rate mid quote from Bloomberg in the previous business day (to avoid any endogeneity concerns), which is publicly avail-

[24]The 'dealers' category includes the so-called 'G16' dealer-banks: 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. This choice is not arbitrary on our part as these banks are also classified as "Participating Dealers" in the OTC Derivatives Supervisors Group, chaired by the New York Fed https://www.newyorkfed.org/markets/otc_derivatives_supervisors_group.html.

able to every market participant at the start of the trading session.[25] The average swap rate return is positive, consistent with the upward OIS term structure and upward interest risk prevailing during our sample period. Interestingly, the average returns are 1.78, 2.19, 2.52 basis points for CCP, non-CCP collateralised, and non-CCP uncollaterlised trades, respectively. This increasing order suggests that the cost for interest-rate protection (i.e., paying fixed) is most (least) expensive in the non-CCP (CCP) segment, especially if uncollateralised. We investigate the determinants of these price differentials in Section 4.3.

Finally, Table 2 reports the average credit rating of the buyer (paying fixed) and the seller (receiving fixed) of a swap contract. We use the credit ratings to proxy for counterparty credit risk, which affects investors' trading decisions (who to trade with and where) and has implications for the pricing of swaps, for example via the CVA channel. Because these rating are typically available at the quarterly frequency, we match the buyer and seller of a swap with their credit ratings in the previous quarter.[26] So, if a swap was executed on 10-Feb-2015 we use the ratings (when available) of the two counterparties in Q4 2014. We take the ratings from three different sources (S&P, Moody's, and Fitch) and average them after first converting them to a scale from 0 to 20, where 0 denotes the worst rating and 20 the maximum rating (see Table 2 in the Appendix for the conversion of each rating). Table 2 shows that credit ratings are available only for a subset of counterparties, and largely for dealers and banks. The average rating is about 14, which corresponds to a rating of A- for S&P and Fitch, and A3 for Moody's. The average rating varies from 14.49 to 14.94 for buyers and 13.72 to 14.73 for sellers across market segments, and the standard deviation corresponds to more than one 'notch' (a unit of in our scale of ratings corresponds to about one notch).

[25]We replicated our regression analyses by computing returns using the same end-of-day swap rate mid quote from Bloomberg and we find similar results in terms of OTC premia.

[26]As an alternative measure of credit risk, we used the credit default swaps and default probability estimates from Kamakura Corporation. The main advantage of these two credit risk proxies is the daily frequency. However, they cover a smaller subset of entities for which we obtain similar results.

4.2 Trading across OTC segments

The summary statistics hinted at some interesting patterns in investor decisions to trade in the different OTC segments. Here we explore these patterns more formally using a probit regression approach. More specifically, we are interested in the role of contract characteristics, counterparty type, and counterparty credit risk in investors decision to trade in the CCP or the non-CCP segment. Note that the counterparties in our data have the option to choose where to trade throughout the sample period, because even if they are clearing members, they are not subject to any central clearing obligation.

We start with investigating the role of contract characteristics. We present the first set of results in Table 3, where the dependent variable is one for non centrally cleared trades and zero otherwise. The first variables of interest are the log-notional and maturity and both have a negative sign in specification 1. This result shows that trades with larger notional and longer maturity are in relative terms more likely to be centrally cleared. We next look at the role of contract standardisation. The basic idea is that bilateral (or no) clearing might best suit to more bespoke contracts. We define two types of standardisation with respect to maturity and price. A transaction is considered 'standardised' when its maturity is 1Y, 2Y, 3Y, 4Y,..., 50Y or when the last digit of the price (fixed rate) is 5 or 0. For example, a 5Y swap with 1.05 fixed rate has a standardised maturity and price. Specification 2 shows that contract standardisation is associated with more central clearing. The results remain qualitatively the same when all four variables are included in the same regression (specification 3). If we translate the findings of specification 3 into probability terms, then they suggest that a one-unit change in (log) notional or maturity, decreases the probability of a CCP trade by 6% and 0.6%, respectively. Similarly, having a standardised maturity or price, decreases the probability of a CCP trade by 5.6% and 1.9%, respectively. However, most of the explanatory power (i.e., R^2) comes from the notional and maturity, and it is for this reason that we use only these variables as controls in what follows.

We next examine the role of counterparty characteristics. As seen already in the descriptive statistics in Table 1, dealers, and other banks rely more on the CCP segment, while small financial and non-financial companies tend to use more often the non-CCP segment. Specifications 1 and 2 in Table 4 make this point more formally. As before the dependent variable in the probit regressions is one for non centrally cleared trades and zero otherwise. We observe an interesting link between counterparty sophistication and centralised clearing. On one end of the spectrum, the more sophisticated or active counterparties tend to centrally clear their transactions, as indicated by the negative coefficients of dealer, bank and hedge-fund dummy variables. On the other end, non-financial or less active counterparties have positive coefficients with an increasing magnitude for the least sophisticated ones, for example the non-financial companies.

Counterparties can also differ with respect to how and at which cost they access the CCP infrastructure. CCPs can be accessed either directly via house accounts for clearing members (CM) or indirectly via client accounts by using the clearing services offered by CMs. Not surprisingly, specifications 3 and 4 in Table 4 suggest that counterparties with indirect access to CCPs are in relative terms less likely to centrally clear their transactions, as shown by the positive coefficient of the 'CCP Client' variable that is one when a counterparty clears via a client account, and zero otherwise. In economic terms, the results in specification 4 suggest that having an established access to a CCP, which is captured by the 'CM/CCP client' variable that is one for investors with direct or indirect access to a CCP and zero otherwise, increases the probability of central clearing by 23%, whereas having only an indirect access reduces this effect by 3%. This is perhaps a result of the higher CCP usage costs (e.g., fees for using the service) for investors with client accounts, who in addition do not benefit from multilateral netting.[27]

Another counterparty classification is with respect to their position in the trading net-

[27] The treatment of the initial margin posted by client accounts in the leverage ratio of the CMs that offer this service is another consideration, as it increases the cost of offering clearing services, making client clearing more expensive. This cost might become more material after the implementation of the clearing mandate and the subsequent increase in demand for client clearing services (given also the high concentration in the provision of client clearing).

work. At the core of the network are the big dealers who speed up the search for counterparties by intermediating in the dealer-to-client (D2C) market, while they re-balance their inventories in the interdealer (D2D) market. The IRS interdealer market is traditionally considered a centrally cleared one, with LCH having a predominant role. Specifications 5 and 6 in Table 4 confirm the anecdotal evidence as they suggest that trading in the DtoC market reduces the probability of central clearing by 21% (specification 6).

Finally, we look at the role of counterparty credit risk at the investor and market level. In a similar probit regression setting as before, we first look at the association between central clearing and investor's credit ratings, which we use to proxy counterparty-specific credit risk. Table 5 reports the results of these regressions for the counterparties for which credit rating information was available.[28] Specification 1 shows that the best banks in credit risk terms tend to use more the CCP segment: a AAA bank is 3% more likely to use the CCP segment compared to a BBB bank (the difference between AAA and BBB is about 8 units of credit rating). One explanation could be the amount of margin or the funding cost for margin, as they are both higher for less creditworthy counterparties.

Another important issue is whether the decision to centrally clear or not changes in times of stress. Intuitively, in stressful times the market concern about counterparty risk should grow. One such stressful time in our sample period was triggered by the decision of the Swiss National Bank (SNB) to remove the Euro-Swiss franc exchange floor on 15 January 2015. The SNB announcement surprised markets and was followed by an intraday currency move of unprecedented speed and scale. Although it primarily affected the Swiss franc segment, its impact was felt across different currencies and markets as traders were trying to minimise losses via aggressive portfolio rebalancing. In specifications 2 to 5 in Table 5, we use the '15Jan2015' ('15-23Jan2015') dummy that equals one on the event day (week, 15-23 January 2015) and zero otherwise, to capture this period of elevated stress. The results show that the probability of a Non-CCP trade increased on the event day and

[28]Note that credit rating information is mainly available for dealers and banks, which explains the drop in the number of observations when we include them in the regressions. These entities trade frequently and have well-established CCP relationships (via home or client accounts).

the following week. Interestingly, this increase was stronger for less creditworthy banks, as depicted in the negative coefficient of the interaction term between credit ratings and the event dummies (specifications 3 and 5). Similar patterns are observed in specifications 8 and 9 where we use changes in VIX and Libor-OIS spread to capture market stresses.

These findings paint an intriguing picture for the use of CCPs. Although the CCP segment is the dominant one in normal markets, in periods of stress there is an increase in trading outside CCPs. This can be a manifestation of the elevated cost of margin during periods of high market volatility, known as margin procyclicality. This procyclicality causes funding liquidity pressure to parties that need to find liquid assets to post as margin, at times when it is most difficult for them to do so (see Brunnermeier and Pedersen, 2008; Murphy, Vasios, and Vause, 2014). Our results support the view that market participants might circumvent the additional funding liquidity stress by trading outside CCPs.

4.3 Determinants of OTC premia

We now turn to the pricing of IRSs across the different OTC segments. An IRS is a plain vanilla swap contract that consists of a fixed leg whose payments depend on a fixed rate and a floating leg whose payments depend on a floating rate (the Libor). It is used by traders to remove interest rate risk from their trading book. The seller of the swap, i.e., the *receiver of fixed*, is selling protection against interest rate risk and would bear a loss in case of upward interest rate movements. Therefore, the market value of the contract, which is typically zero at initiation, is driven by changes in the fixed rate (the term structure), which is the main risk factor. In line with the literature on dealers' inventory effects (e.g., Amihud and Mendelson, 1980) and bargaining power (e.g., Duffie, 2012), we test whether dealers pass any regulatory and XVA-related costs to clients. To do this, we focus on transactions between dealers and clients, that is, excluding the interdealer segment.

Given the OTC nature of trading in swap markets, there is little information about the fair value of a swap before the trade. The market convention is to use an industry benchmark, provided by financial data vendors like Bloomberg, as a proxy for the 'fair' value of the prevailing fixed rate. In line with this practice, we use Bloomberg end-of-day information to construct the *'swap return'*, formally defined as the difference between the transaction-level swap rate and the mid-quote of the Bloomberg benchmark rate at the end of the previous business day.[29] Intuitively, the swap return captures the price divergence from the swap rate's fair value.

To analyse the determinants of swap returns, we run panel regressions of the form

$$R_{k,i,j,t} = \beta Non\text{-}CCP + \gamma' X_{k,i,j,t} + \delta_i + \zeta_j + \theta_t + \epsilon_{k,i,j,t}, \tag{1}$$

where $R_{k,i,j,t}$ is the swap return for transaction k between counterparties i and j on day t; 'Non-CCP' is a dummy variable that is equal to one for Non-CCP trades and zero otherwise; $X_{k,i,j,t}$ is a vector of transaction-level contract and counterparty characteristics; and δ_i, ζ_j, and θ_t denote fixed effects. $X_{k,i,j,t}$ includes the logarithm of the trade size ('Log-notional'), the contracts's maturity ('Maturity') and the credit ratings of the counterparties. In some specifications, we control for additional dealer characteristics, that is the capital ratio ('CR') and leverage ratio ('LR').[30] In all results here and below we report robust standard errors clustered at the quarter and dealer level, unless otherwise stated.

The coefficient β in Equation (1) measures the difference in the price (fixed rate) between CCP and Non-CCP swaps after controlling for time, party IDs, and other contract and counterparty characteristics. If β is positive then a swap executed in the non-CCP segment will be costlier than an equivalent contract that is centrally cleared, in the sense that the buyer of the swap will have to pay a higher fixed rate.

Table 6 shows the main results of IRS return determinants when the dealer receives fixed (that is, sells interest rate protection to the client) and for when the dealer pays

[29] The Bloomberg end-of-day rates are composite measures of indicative quotes from a selected number of 'contributors' (dealers), and as such they reflect the daily market average 'risk-neutral' prices.

[30] Note that the credit rating information is mainly available for banks. This inevitably reduces the sample size. In addition, the capital and leverage ratios are only available for a subset of dealers, and it is for this reason that the number of observations in the specifications with these controls drops by about 50%.

fixed (that is, buys protection from the client). We report results for the former case in columns (1) to (4). This analysis uncovers two important findings. First, it highlights the existence of the 'OTC premium'. That is, the swap return for non-CCP transactions is about eight basis points larger than that of centrally cleared transactions, controlling for other variables. Besides being strongly statistically significant, this OTC premium is also economically significant: given the average fixed rate in our sample period (about 1.82%), the β coefficient suggests that the fixed rate of Non-CCP swaps is on average four per cent higher than that of equivalent CCP ones. The second important result is that when the dealer pays fixed —columns (5) to (8)— the premium is smaller and not statistically significantly different from zero. We could have expected negative OTC premia if dealers paying the fixed fully reverse XVA charges to customers. These asymmetric patterns can arise for at least two reasons: first, when customers are banks who are also subject to regulatory costs and XVAs, and not fully subordinated to dealers bargaining power; second, when the interest-rate risk is mainly on the upper side, as it was during our sample period. The latter implies that the receiver of fixed is likely to have an advantage at setting prices. To test this hypothesis, later we explicitly analyse OTC premia when dealers' customers are non-banks.

The OTC premium is lower when initial margin is posted. We show this using variations of the following empirical model:

$$
\begin{aligned}
R_{k,i,j,t} = \beta_1 Non\text{-}CCP + \beta_2 Non\text{-}CCP\ with\ IM \\
+ \gamma' X_{k,i,j,t} + \delta_i + \zeta_j + \theta_t + \epsilon_{k,i,j,t}.
\end{aligned}
\tag{2}
$$

This model includes a dummy variable ('Non-CCP with IM') that equals one when initial margin is exchanged, and zero otherwise. Columns (3) and (4) in Table 6 show that the exchange of initial margin in the non-CCP segment reduces the swap return by between about four and nine basis points. This result points to the pricing of the counterparty credit risk in non-centrally cleared swaps, which is in line with the CVA and KVA valuation adjustments. These findings support the empirical predictions discussed in Section 2.1: the posting of initial margin reduces (i) the loss given default, (ii) the exposure at default, and (iii) the maturity factor, which reduce the cost to buy protection against counterparty default and Basel III capital charges. The same result also suggests that the funding cost associated with the posting of initial margin (MVA) is a smaller consideration compared to the CVA and KVA, at least during our sample period.[31] Another observation is that margin does not play a significant role when dealers pay fixed (buy protection).

We further split clients into banks and non-banks, as we expect the latter group to be more "submissive" to dealers' pricing and less affected by new regulations especially in terms of CVA and KVA charges. Table 7 reports the results of the analogous regressions described above, but where the sample includes only transactions in which the client is a non-bank. In these regressions the sample size increases, because we have dropped the client specific controls (i.e., credit rating, capital ratio, and leverage ratio) as they are only available for banks. We continue to control for dealer specific variables and client and dealer time-invariant characteristics.

The results in Table 7 indicate a positive OTC premium when dealers receive the fixed rate whereas a negative one when they pay it, although statistically insignificant in column (5). This reinforces the idea that dealers exercise their bargaining power and pass on their costs to non-bank clients. That is, dealers tend to fully charge XVA costs that translate into a positive (negative) OTC premium when they receive (pay) fixed. When they pay fixed, the discount is about three basis point in specification (6), where we control for all dealer characteristics. In line with the pricing of CVA and KVA, when the dealer receives the fixed and initial margin is posted, the OTC premium drops by about 2 basis points. The IM results are less significant (the p-value is 12% in column 3) for non-banks, which is not surprising given that non-banks tend to post margin less frequently (for example,

[31] The move to a higher interest rate environment and the forthcoming implementation of the more stringent uncleared margining rules are likely to increase the future impact of the MVA.

they are linked to thresholds and minimum transfers), resulting to a smaller reduction in CVA and KVA. When dealers pay fixed the role of margin is not significant.

Table 8 digs deeper into the determinants of the OTC premium. We interact the non-CCP dummy variable with the possible determinants in terms of contract and counterparty characteristics. The coefficients on the interaction terms indicate the effect of notional, maturity and buyer/seller credit rating conditional on the contract being transacted on the non-CCP segment. These contract and counterparty characteristics appear to explain most of the OTC premium. In all specifications, the coefficient on the non-CCP dummy becomes not statistically different from zero. When the dealer receives fixed, the larger the notional and the longer the maturity are, the larger the swap return is in the non-CCP segment. Conversely, when the dealer pays fixed, the larger the notional the larger the discount, but the coefficients are generally not very significant in statistical terms.

More importantly, the results in columns (1) to (4) point to the important role of the creditworthiness of dealers' counterparties. When the dealer sells (receives fixed), a more creditworthy customer enjoys a lower price, whereas when the dealer buys (pays fixed), a more creditworthy customer receives a better price. The credit rating coefficients of dealers' customers are statistically and economically very significant: An A+ customer pays (receives) about 4 basis points lower (higher) swap rate than what a A- customer does (the difference in ratings is 2 notches) in the Non-CCP segment.[32]

All in all, our findings shed light on the existence of OTC premia@ (i) generating more expensive non-CCP trades, (ii) decreasing with initial margins, and (iii) favouring dealers. Our results point to the pass-through of valuation adjustments from dealers to customers, in particular the CVA and KVA valuation adjustments.

[32]Note that we do not include any interactions between the non-CCP dummy and ratings in columns (5) to (8), because ratings are not available for non-Banks.

4.4 Liquidity, relationships and bilateral exposures

In this section, we extend our analysis to market liquidity, relationships, and bilateral exposures. By conducting these additional tests, we can also address the question whether there could be some unobservable variables providing additional explanations to the *premium*. This unobservable variable should affect prices at the trade level, i.e., it must be specific to each counterparty and to day/time. Our empirical strategy already controls for this possibility by including time and counterparty fixed effects, time-varying counterparty credit risk, as well additional controls for dealers' balance sheets. Nonetheless, to err on the side of caution, in this section we conduct some additional analysis.

First, we consider the differences in market liquidity across segments. The idea that OTC premia (fully) depend on market illiquidity seems implausible for at least three reasons. First, the effect from liquidity should have been perfectly symmetric as dealers would charge half-spread every time they buy or sell a swap contract. But our results clearly show that this is not the case. Second, the finding that the premium is associated with the type of collateral in bilateral trades or the credit rating of clients is hard to be reconciled with the illiquidity hypothesis. Finally, the current specifications already include some controls for market liquidity such as the trade size (i.e. notional) and dealers characteristics (e.g., balance sheet variables) accounting for the propensity to provide liquidity.

We nonetheless proceed with a more direct test of the liquidity hypothesis. The basic idea is centered on the execution of swaps on centralised electronic platforms, which earlier literature has shown are associated with better liquidity. These platforms were introduced in February 2014 by the Dodd-Frank act, which required US persons to execute centrally cleared interest rate swaps on multilateral pre-trade transparent venues, known as Swap Execution Facilities (SEF). By its very nature, the SEF mechanism reduces many frictions such as information asymmetry, search costs and the dealer's bargaining power by providing more trading options to their customers. Benos et al. (2016) show that indeed SEF trading reduced effective spreads in the USD IRS market by about 25%.[33] Hence, if the OTC premium stems from market illiquidity, then the former should become insignificant once we control for the venue of execution (SEF trading). We test for this by introducing a dummy variable, 'SEF', in specification 1, which equals to one for centrally cleared transactions executed on SEFs and zero otherwise.[34] Table 9 presents the (baseline) results of the specification with the SEF dummy. Columns (1) to (4) show that the SEF dummy is negative and significant, which suggests that prices of trades executed on SEFs are on average closer to the end-of-day Bloomberg benchmark price. More importantly, the Non-CCP dummy coefficients are almost unchanged compared to the ones in Table 6. This evidence is against the liquidity hypothesis: the premium doesn't seem to be a compensation for any differences in liquidity across the different OTC segments.

A second issue that might influence swap prices is the relationships between counterparties. For example, dealers might offer better prices to clients they do more business with. Or they might have different agreements in place to regulate their relationships with different client, for example the agreements that regulate the collateral held by two parties (credit support annex, CSA). Although prior research has not analysed the IRS market, previous papers show that relationships matter in some other OTC markets (e.g., Green, Li, and Schürhoff, 2010, Hendershott, Li, Livdan, and Schürhoff, 2017, and Di Maggio, Kermani, and Song, 2017). Are dealer-client relationships stronger in the IRS CCP segment? Can relationships explain the OTC premia? To answer this question we modify Equation 1 by replacing the buyer ID and seller ID fixed effects with their interaction. Intuitively, the new specification controls for any unobservable time-invariant effects at the pair of counterparties level (i,e., bilateral relationships). We present this specification in columns (5) to (8) in Table 9. The results are qualitatively similar to the ones in Table 6,

[33] SEFs facilitate multilateral trading by a central limit order book and a request-for-quote functionality. See Benos et al. (2016) for the institutional details. Riggs, Onur, Reiffen, and Zhu (2018) report that the use of limit order book on SEFs (for index CDS contracts) is limited.

[34] The European DTCC data do not contain a flag for the venue of execution. Therefore we had to ask LCH to provide us with this information for LCH trades (they account for 97% of centrally cleared trades in our sample). About 1 out 5 LCH trades were executed on SEF. Note that these trades involved non-US persons, who were not subject to the Dodd-Franc act.

but bigger in magnitude in the case when the dealer receives fixed (sells protection).

We next allow for these relationships to vary over time. For example, bilateral dealer-client exposures might influence the decision to clear, the direction of trade (paying vs. receiving fixed), or the pricing of swaps. As a normal practice in trading derivatives, we expect parties to re-calculate these exposures on a regular basis. We capture this effect by replacing δ_i and ζ_j in specification 1 with a month $\times$ buyer ID $\times$ seller ID fixed effect. As plausible in some dealer-client relationships, we assume that the average counterparty re-balances his portfolio at the monthly frequency and as result bilateral exposures change monthly. We present this specification in Table 10. In line with the results in the previous section, our two main findings still hold: first, when dealers receive fixed they charge a premium, and in fact its magnitude is almost twice as much as the one in Table 6; second, there is no premium when dealers pay the fixed rate.

To sum up, the results in this section corroborate the existence of OTC premia and dealer-customer asymmetric patterns, which are unaffected by market illiquidity, relationships and bilateral exposures.

5 Conclusion

Using unique trade repository data at transaction and ID levels, this paper provides the first systematic study of IRS in the post-crisis regime. We uncover the main determinants of centralised and decentralised clearing. A trade is more likely to be centrally cleared with larger (standardised) notional and longer maturity, and involving more ‘sophisticated’ agents (dealers, banks, and hedge funds). In contrast, less ‘sophisticated’ agents (e.g., corporates and insurance companies) trade more in the non-CCP segment, which represents around 15% of the market share in terms of number of trades. In terms of concentration of credit risk, the CCP (non-CCP) segment is more populated by market participants with higher (lower) creditworthiness. Moreover, credit risk concentration in the non-CCP segment increases in destressed markets, perhaps in reaction to CCP margin procyclicality.

Using panel regressions with fixed effects for time and counterparties' IDs, we conduct an in-depth analysis of the price heterogeneity of swap contracts. We find compelling evidence that prices differ across segments and market participants, and we call these price differentials OTC premia. OTC premia arise for decentralised clearing, riskier contracts and counterparties, and are economically important. For instance, when a dealer sells interest rate protection to a client (i.e., the dealer receives fixed), the client pays the dealer around 8 basis points more for a non-CCP contract than an equivalent CCP one. This premium decreases when initial margin is posted. Another finding is that OTC premia favour dealers, especially if their customers are non-banks. Overall, our findings suggest that OTC premia reflect increased inventory costs induced by recent financial regulation that are passed on to prices through the XVA.

Considering that many markets continue to trade bilaterally and via CCPs and that we know little about how derivatives markets were affected by new regulation, our study should deliver important insights for policy makers and market participants. For policy makers, it provides evidence that market participants in derivatives markets have adapted their trading behaviours and pricing in line with some declared objectives of new regulation designed to improve the resilience of OTC markets. In particular, non-CCP swaps being more expensive should incentivise investors to switch to central clearing. In fact, we do observe that central clearing dominates trading, which is expected to reduce systemic risk as credit risk is also less concentrated in the CCP segment. However, evidence of price heterogeneity and dealers' bargaining power against their clients suggests that transparency and efficiency, which are also declared objectives, can be improved. For market participants, our paper should help identify OTC premia across market segments and market participants by quantifying the main determinants of derivative prices. This task is particularly relevant in the post-crisis regime in which XVAs presumably play a major role.

Finally, our findings call for future research to examine the impact of reforms that are outside our sample period, such as the European clearing mandate and the uncleared margining rules.

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6 Figures and Tables

Figure 1: Daily notional traded (in $billion) by segment. In this figure we plot the total notional traded in the CCP and non-CCP segment. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016.

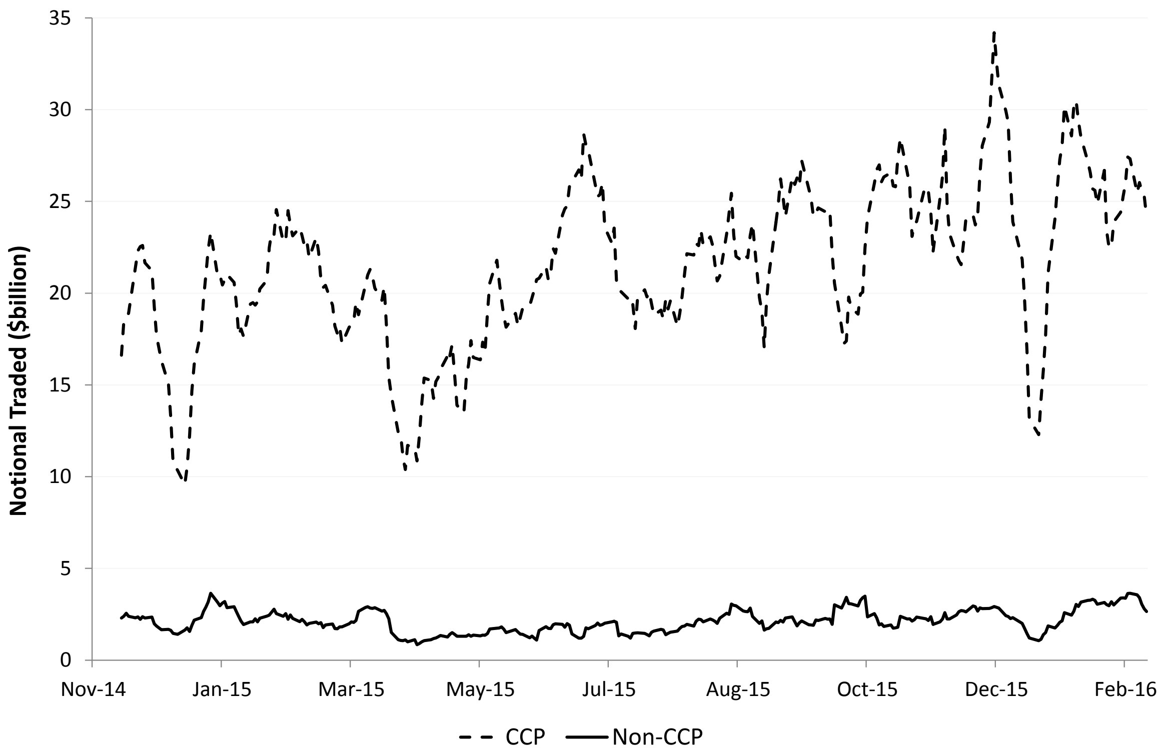

Table 1: Trading activity by segment and counterparty type. This table reports the number of trades (N trades) and notional traded (Notional) throughout our sample period by segment and counterparty type. CCP denotes trades cleared through a central counterparty, while Non-CCP denotes non-centrally cleared trades. The latter segment consists of collateralised (Non-CCP with margin) and uncollateralised (Non-CCP no margin) trades. The exchanged collateral can be variation margin or/and initial margin. Counterparties are classified into asset managers (AM), banks (Bank), dealers (Dealer), hedge funds (HF), insurance companies and pension funds (Ins), other financial companies (Other fin), and non-financial companies (Non-fin). Panel B excludes trades from entities that could not be classified. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016.

Panel A. Breakdown by segment

	N trades	**Notional ($m)**
CCP	85,810	6,801,165
Non-CCP	15,241	669,346
Total	101,051	7,470,511

Panel B. Breakdown by segment and counterparty type

	AM	**Bank**	**Dealer**	**HF**	**Ins**	**Other fin**	**Non-fin**
CCP							
N trades	3,324	33,387	114,733	8,057	300	171	26
Notional ($m)	132,823	1,831,592	9,084,860	1,074,940	21,561	11,100	1,216
Non-CCP with margin							
N trades	1,045	4,869	11,966	610	797	696	113
Notional ($m)	35,133	132,296	560,238	81,574	70,474	44,364	9,573
Non-CCP no margin							
N trades	635	980	3,717	56	270	177	28
Notional ($m)	14,192	37,631	149,484	5,904	17,787	21,621	7,365

Table 2: 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. The latter segment consists of collateralised (Non-CCP with margin) and uncollateralised (Non-CCP no margin) trades. Notional is the dollar amount (in $m) 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 credit rating is the average credit rating of the receiver (seller) or payer (buyer) of fixed rate from three different sources (S&P, Moody's, and Fitch). It has been converted to a scale from 0 to 20, where 0 denotes the worst rating and 20 the maximum rating (see Table 2 in the Appendix). The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016.

	N	**Mean**	**Std. Dev.**
Panel A. CCP			
Notional ($m)	85,810	79.26	152.23
Log-notional	85,810	17.36	1.40
Maturity (years)	85,810	9.48	8.31
Swap return (bps)	85,803	1.78	16.67
Credit rating of Buyer	57,593	14.66	1.20
Credit rating of Seller	57,593	14.73	1.25
Panel B. Non-CCP			
Notional ($m)	15,241	43.92	126.82
Log-notional	15,241	16.27	1.80
Maturity (years)	15,241	8.23	6.76
Swap return (bps)	15,237	2.27	20.70
Credit rating of Buyer	3,823	14.55	1.77
Credit rating of Seller	3,823	14.13	1.75
Panel C. Non-CCP with margin			
Notional ($m)	11,658	45.05	122.85
Log-notional	11,658	16.40	1.68
Maturity (years)	11,658	8.20	6.77
Swap return (bps)	11,654	2.19	19.32
Credit rating of Buyer	3,267	14.49	1.74
Credit rating of Seller	3,267	14.20	1.74
Panel D. Non-CCP no margin			
Notional ($m)	3,583	40.22	138.93
Log-notional	3,583	15.86	2.12
Maturity (years)	3,583	8.31	6.73
Swap return (bps)	3,583	2.52	24.69
Credit rating of Buyer	556	14.94	1.92
Credit rating of Seller	556	13.72	1.75

Table 3: Determinants of (de)centralised clearing — contract characteristics This table reports the results of a probit regression, where the dependent variable is one for non centrally cleared trades and zero otherwise. Log-notional is the logarithm of the dollar amount on which the contract's exchanged interest payments are based. Maturity refers to the number of years between the effective and maturity date of the swap contract. Standardised maturity is a dummy variable that is one when the contract's maturity is 1Y, 2Y, 3Y, 4Y, . . . , 50Y and zero otherwise. Standardised price is a dummy variable that is one when the contract's price last digit is 5 or 0. For example, a 5Y swap with 1.05 fixed rate has a standardised maturity and price. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. Robust t-statistics are shown in brackets. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	(1)	**(2)**	**(3)**
Log-Notional	-0.281***		-0.282***
	(-73.17)		(-73.07)
Maturity	-0.028***		-0.028***
	(-36.54)		(-35.98)
Standardised maturity		-0.216***	-0.267***
		(-13.63)	(-16.14)
Standardised price		-0.143***	-0.089***
		(-14.25)	(-8.42)
Constant	3.985***	-0.785***	4.264***
	(59.02)	(-51.94)	(61.19)
Pseudo R^2	0.092	0.005	0.096
Obs	101051	101051	101051

Table 4: Determinants of (de)centralised clearing — counterparty characteristics This table reports the results of a probit regression, where the dependent variable is one for non centrally cleared trades and zero otherwise. The regression is run at the trade and counterparty level for specifications (1) to (4) and trade only level for specifications (5) to (6). Log-notional is the logarithm of the dollar amount on which the contract's exchanged interest payments are based. Maturity refers to the number of years between the effective and maturity date of the swap contract. The next seven regressors are dummy variables that capture the different counterparty types. For example, Asset manager equals one if the counterparty is an asset manager and zero otherwise. CM/CCP client is one if the counterparty is either a clearing member or has an client account with a CCP and zero otherwise. CCP client is one if the counterparty has a client account with a CCP and zero otherwise. D2C is a dummy variable that is one if the transaction is executed in the dealer-to-client segment and zero otherwise. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. Robust t-statistics are shown in brackets. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log-Notional		-0.271***		-0.255***		-0.237***
		(-97.22)		(-91.52)		(-62.88)
Maturity		-0.028***		-0.027***		-0.023***
		(-50.52)		(-47.90)		(-28.46)
Asset manager	0.158***	-0.037				
	(7.50)	(-1.59)				
Bank	-0.458***	-0.420***				
	(-35.11)	(-30.38)				
Dealer	-0.591***	-0.475***				
	(-51.79)	(-38.64)				
Hedge fund	-0.848***	-0.510***				
	(-37.80)	(-21.05)				
Insurance	1.356***	1.562***				
	(34.53)	(35.59)				
Non-financial	1.595***	1.764***				
	(13.53)	(13.75)				
Other financial	1.561***	1.656***				
	(32.85)	(33.24)				
CM/CCP client			-1.267***	-1.195***		
			(-133.66)	(-120.35)		
CCP client			0.173***	0.134***		
			(15.97)	(11.67)		
D2C					1.227***	1.089***
					(78.55)	(67.01)
Constant	-0.582***	4.168***	0.003	4.511***	-1.998***	2.320***
	(-55.49)	(84.11)	(0.36)	(90.26)	(-136.59)	(33.96)
Pseudo R^2	0.057	0.137	0.104	0.176	0.104	0.164
Obs	202102	202102	202102	202102	101051	101051

Table 5: Determinants of (de)centralised clearing — counterparty credit risk This table reports the results of a probit regression, where the dependent variable is one for non centrally cleared trades and zero otherwise. The regression is run either at the trade and counterparty level (columns 1,3, and 5) or only the trade level (columns 2, 4, 6, 7). Log-notional is the logarithm of the dollar amount on which the contract's exchanged interest payments are based. Maturity refers to the number of years between the effective and maturity date of the swap contract. Credit rating is the counterparty's credit rating from three different sources (S&P, Moody's, and Fitch). It has been converted to a scale from 0 to 20, where 0 denotes the worst rating and 20 the maximum rating (see Table 2 in the Appendix). 15Jan2015 (15-23Jan2015) is a dummy that equals one on the Swiss National Bank event day (week, 15-23 January 2015) and zero otherwise. VIX is the volatility implied by S&P 500 index options. Libor-OIS spread is the difference between the three-month USD Libor rate and the federal funds rate, which is commonly used as a proxy for the cost of funding. The changes in the last two variables are used to capture market stresses. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. Robust t-statistics are shown in brackets. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Log-Notional	-0.294***	-0.281***	-0.294***	-0.281***	-0.293***	-0.281***	-0.282***
	(-83.72)	(-73.13)	(-83.63)	(-73.12)	(-83.54)	(-73.17)	(-73.17)
Maturity	-0.031***	-0.028***	-0.031***	-0.028***	-0.031***	-0.028***	-0.028***
	(-44.78)	(-36.53)	(-44.77)	(-36.50)	(-44.73)	(-36.52)	(-36.55)
Credit rating	-0.024***		-0.023***		-0.020***		
	(-6.69)		(-6.42)		(-5.60)		
15Jan2015		0.137*	2.564***				
		(1.82)	(2.98)				
15Jan2015 × Credit rating			-0.168***				
			(-2.82)				
15-23Jan2015				0.163***	2.530***		
				(5.05)	(6.43)		
15-23Jan2015 × Credit rating					-0.162***		
					(-5.99)		
VIX changes						0.238***	
						(4.37)	
Libor-OIS spread changes							0.428***
							(4.08)
Constant	4.416***	3.983***	4.398***	3.981***	4.353***	3.985***	3.988***
	(54.83)	(58.97)	(54.54)	(58.93)	(53.76)	(59.01)	(59.02)
Pseudo R^2	0.093	0.092	0.093	0.092	0.094	0.092	0.092
Obs	162348	101051	162348	101051	162348	101051	101051

Table 6: OTC premium in dealer-to-client segment. 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. We only include trades executed in the dealer-to-client segment. 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. Non-CCP with IM is a dummy that equals one for non-centrally cleared trades that involve the exchange of initial margin by the two counterparties and zero otherwise. The rest of variables are defined in Equations (1) and (2). Columns (1)-(4) show the results when the dealer sells interest rate protection (receives fixed), while columns (5)-(8) show the results when the dealer buys protection (pays fixed). The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties reported to DTCC between December 1, 2014 and February 19, 2016. All specifications include time, buyer ID, and seller ID fixed effects. We report t-statistics calculated using clustered standard errors (by quarter and dealer ID) in parentheses. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	Dealer receiving fixed				Dealer paying fixed			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non-CCP dummy	**8.116****	**8.424*****	**9.189*****	**8.621*****	**1.840**	**6.426**	**1.817**	**6.615**
	(2.52)	**(2.73)**	**(2.65)**	**(2.78)**	**(0.88)**	**(1.46)**	**(0.84)**	**(1.39)**
Non-CCP with IM			-3.800**	-9.369***			0.729	-2.828
			(-2.22)	(-3.82)			(0.21)	(-0.51)
Log-Notional	0.113	-0.022	0.104	-0.021	-0.288	-0.206	-0.287	-0.206
	(0.78)	(-0.12)	(0.72)	(-0.11)	(-1.41)	(-0.64)	(-1.41)	(-0.63)
Maturity	0.024	0.023	0.022	0.023	0.033	0.063	0.033	0.063
	(0.91)	(0.70)	(0.85)	(0.68)	(1.20)	(1.56)	(1.20)	(1.56)
Credit rating of buyer	0.431	0.684	0.425	0.685	-0.381	-0.592	-0.382	-0.586
	(1.17)	(1.10)	(1.16)	(1.10)	(-0.66)	(-0.75)	(-0.66)	(-0.74)
Credit rating of seller	0.375	0.275	0.393	0.268	0.203	0.542	0.204	0.541
	(0.79)	(0.45)	(0.84)	(0.44)	(0.78)	(0.74)	(0.78)	(0.74)
CR of dealer (payer)						-0.846***		-0.848***
						(-3.43)		(-3.44)
CR of dealer (receiver)		0.006		0.012				
		(0.03)		(0.06)				
LR of dealer (payer)						0.226		0.227
						(0.97)		(0.97)
LR of dealer (receiver)		0.254		0.260				
		(1.49)		(1.56)				
Time, Buyer ID, Seller ID FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.177	0.163	0.178	0.163	0.267	0.279	0.267	0.279
Obs	12092	7119	12092	7119	16193	8093	16193	8093

Table 7: OTC premium in dealer-to-client segment, when clients are not banks. The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for non-centrally cleared trades and zero otherwise, and a number of other variables and controls. We only include trades executed in the dealer-to-non-bank-client segment. Non-banks consist of hedge funds, asset managers, insurance and non-financial firms. 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. Non-CCP with IM is a dummy that equals one for non-centrally cleared trades that involve the exchange of initial margin by the two counterparties and zero otherwise. The rest of variables are defined in Equations (1) and (2). Columns (1)-(4) show the results when the dealer sells interest rate protection (receives fixed), while columns (5)-(8) show the results when the dealer buys protection (pays fixed). The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. All specifications include time, buyer ID, and seller ID fixed effects. We report t-statistics calculated using clustered standard errors (by quarter and dealer ID) in parentheses. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	Dealer receiving fixed				Dealer paying fixed			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non-CCP dummy	**4.148***	**4.190**	**4.159***	**3.739***	**-0.081**	**-2.762***	**-0.028**	**-0.005**
	(2.03)	**(1.44)**	**(2.03)**	**(1.77)**	**(-0.08)**	**(-1.74)**	**(-0.03)**	**(-0.01)**
Non-CCP with IM			-1.933	-1.467			-5.714	-5.796
			(-1.50)	(-1.37)			(-0.73)	(-0.75)
Log-Notional	0.356**	0.200	0.356**	0.360**	0.246	-0.054	0.247	0.287
	(2.11)	(0.84)	(2.10)	(2.04)	(1.26)	(-0.20)	(1.27)	(1.48)
Maturity	0.029	0.029	0.029	0.023	0.036	0.142***	0.037	0.037
	(0.86)	(0.52)	(0.86)	(0.64)	(0.65)	(2.81)	(0.65)	(0.66)
Credit rating of buyer						-1.359		-0.604
						(-0.87)		(-0.71)
Credit rating of seller		0.956		1.462**				
		(0.80)		(2.41)				
CR of dealer (buyer)						-0.246		-0.440
						(-0.32)		(-1.15)
CR of dealer (seller)		0.554		0.779				
		(1.02)		(1.60)				
LR of dealer (buyer)						0.252		
						(0.80)		
LR of dealer (seller)		0.166						
		(0.79)						
Time, Buyer ID, Seller ID FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.260	0.276	0.260	0.260	0.286	0.359	0.286	0.253
Obs	17651	10566	17651	16979	13394	5264	13394	13016

Table 8: OTC premium in dealer-to-client segment — determinants. The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for non-centrally cleared trades and zero otherwise, and a number of interaction variables and controls. We report separate results for the dealer-to-client and the dealer-to-non-bank-client segment and for when the dealer sells (receives fixed) or buys (pays fixed) interest rate protection. 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 rest of variables are defined in Equation (1). The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. All specifications include time, buyer ID, and seller ID fixed effects. We report t-statistics calculated using clustered standard errors (by quarter and dealer ID) in parentheses. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	Dealer-to-client				Dealer-to-client (non-bank)			
	Dealer receiving fixed		Dealer paying fixed		Dealer receiving fixed		Dealer paying fixed	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non-CCP dummy	11.798	-36.498	-29.896	-91.455	-8.231	-13.610	-0.335	-1.250
	(0.41)	(-0.88)	(-0.79)	(-1.13)	(-1.37)	(-1.61)	(-0.05)	(-0.18)
Non-CCP × Log-notional	**1.033**	**2.492**	-1.267	-0.338	**0.697****	**1.027****	0.051	-0.026
	(1.30)	**(1.61)**	(-0.95)	(-0.15)	**(2.12)**	**(2.21)**	(0.14)	(-0.08)
Non-CCP × Maturity	**0.494**	**1.255****	0.500	2.220***	0.040	0.013	-0.077	-0.124
	(1.55)	**(2.14)**	(1.25)	(3.16)	(0.58)	(0.11)	(-1.01)	(-1.51)
Non-CCP × Credit rating of buyer	**-2.054***	**-1.764***	2.030	2.923				
	(-1.73)	**(-1.72)**	(0.89)	(0.73)				
Non-CCP × Credit rating of seller	**0.651**	**1.572**	**1.374****	**2.899***				
	(0.90)	**(1.38)**	**(2.22)**	**(1.73)**				
Log-notional	0.019	-0.119	-0.158	-0.195	0.200	-0.044	0.242	-0.033
	(0.13)	(-0.73)	(-1.03)	(-0.84)	(0.96)	(-0.15)	(1.09)	(-0.11)
Maturity	0.000	-0.011	0.019	0.013	0.017	0.018	0.046	0.161**
	(0.02)	(-0.44)	(0.93)	(0.44)	(0.43)	(0.28)	(0.73)	(2.65)
Credit rating of buyer	0.433	0.778	-0.608	-0.762				-1.359
	(1.16)	(1.24)	(-1.02)	(-1.05)				(-0.86)
Credit rating of seller	0.222	0.097	0.242	0.497		0.951		
	(0.45)	(0.16)	(0.88)	(0.69)		(0.79)		
CR of dealer (payer)				-0.841***				-0.260
				(-3.23)				(-0.34)
CR of dealer (receiver)		-0.049				0.537		
		(-0.22)				(0.99)		
LR of dealer (payer)				0.244				0.251
				(1.11)				(0.80)
LR of dealer (receiver)		0.236				0.168		
		(1.48)				(0.79)		
Time, Buyer ID, Seller ID FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.182	0.174	0.271	0.298	0.261	0.277	0.286	0.359
Obs	12092	7119	16193	8093	17651	10566	13394	5264

Table 9: OTC premium in dealer-to-client segment — liquidity and relationships. The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for non-centrally cleared trades and zero otherwise, and a number of other variables and controls. We only include trades executed in the dealer-to-client segment. 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 rest variables are defined in Equation (1). Columns (1)-(4) show the results when the SEF variable, which equals one for centrally cleared trades executed on swap execution facilities and zero otherwise, is included. SEF captures differences in market liquidity. Columns (5)-(8) show the results when buyer ID and seller ID fixed effects are replaced by their interaction. Intuitively, this fixed effect captures bilateral relationship effects. We report results for when the dealer sells (receives fixed) or buys (pays fixed) interest rate protection. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. Unless otherwise stated, specifications include time, buyer ID, and seller ID fixed effects. We report t-statistics calculated using clustered standard errors (by quarter and dealer ID) in parentheses. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	Liquidity				Relationships			
	Dealer receiving fixed		Dealer paying fixed		Dealer receiving fixed		Dealer paying fixed	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Non-CCP dummy	**7.991****	**7.786****	**1.167**	**5.495**	**10.445*****	**12.993*****	**0.120**	**5.137**
	(2.49)	**(2.54)**	**(0.57)**	**(1.29)**	**(2.67)**	**(2.82)**	**(0.05)**	**(0.87)**
SEF	-3.580***	-4.896***	-4.556***	-5.755***				
	(-5.20)	(-4.62)	(-6.26)	(-5.02)				
Log-notional	0.155	0.070	-0.163	-0.046	0.054	-0.054	-0.275	-0.163
	(1.07)	(0.38)	(-0.81)	(-0.15)	(0.33)	(-0.31)	(-1.32)	(-0.52)
Maturity	0.033	0.037	0.051*	0.081**	0.001	0.015	0.035	0.068*
	(1.29)	(1.15)	(1.97)	(2.20)	(0.04)	(0.45)	(1.30)	(1.75)
Credit rating of buyer	0.446	0.843	-0.560	-0.813	0.331	0.645	-0.565	-1.046
	(1.19)	(1.32)	(-0.96)	(-1.02)	(0.77)	(0.95)	(-0.84)	(-1.11)
Credit rating of seller	0.247	0.118	0.188	0.545	0.198	0.009	0.273	1.491**
	(0.52)	(0.19)	(0.72)	(0.75)	(0.40)	(0.01)	(0.97)	(2.51)
CR of dealer (payer)				-0.853***				-0.850***
				(-3.42)				(-2.84)
CR of dealer (receiver)		0.023				-0.059		
		(0.10)				(-0.24)		
LR of dealer (payer)				0.212				0.136
				(0.96)				(0.52)
LR of dealer (receiver)		0.246				0.265		
		(1.43)				(1.59)		
Time, Buyer ID, Seller ID FE	Yes	Yes	Yes	Yes	No	No	No	No
Time, (Buyer ID × Seller ID) FE	No	No	No	No	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.185	0.177	0.274	0.289	0.236	0.188	0.353	0.332
Obs	12092	7119	16193	8093	12092	7119	16193	8093

Table 10: OTC premium in dealer-to-client segment — bilateral exposures. The table reports the results of trade-level panel regressions of the swap return on the Non-CCP dummy that equals one for non-centrally cleared trades and zero otherwise, and a number of other variables and controls. We only include trades executed in the dealer-to-client segment. 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 rest variables are defined in Equation 1. We show results when the buyer ID and seller ID fixed effects are replaced by a month × buyer ID × seller ID fixed effect. Intuitively, this fixed effect captures bilateral dealer-client exposures that are assumed to change monthly. We report results for when the dealer sells (receives fixed) or buys (pays fixed) interest rate protection. The sample covers every USD-denominated spot vanilla interest rate swap by non-US-based counterparties, which was reported to DTCC between December 1, 2014 and February 19, 2016. We report t-statistics calculated using clustered standard errors (by quarter and dealer ID) in parentheses. *, **, *** denote significance at 1%, 5%, and 10% confidence level, respectively.

	Bilateral Exposures (monthly)			
	Dealer receiving fixed		Dealer paying fixed	
	(1)	**(2)**	**(3)**	**(4)**
Non-CCP dummy	**13.294****	**15.390****	**-0.862**	**1.657**
	(2.13)	**(2.10)**	**(-0.20)**	**(0.18)**
Log-Notional	0.094	0.080	-0.446**	-0.560
	(0.54)	(0.35)	(-2.19)	(-1.68)
Maturity	0.000	0.001	0.003	0.017
	(0.00)	(0.04)	(0.10)	(0.41)
Credit rating of Buyer	0.762	-0.346	0.363	-8.054
	(0.45)	(-0.27)	(0.28)	(-0.24)
Credit rating of Seller	-0.940	-5.348*	0.333	3.211
	(-0.38)	(-1.68)	(0.39)	(0.23)
CR of Dealer (buyer)				-1.150
				(-0.47)
CR of Dealer (seller)		-1.814*		
		(-1.79)		
LR of Dealer (buyer)				1.727
				(1.05)
LR of Dealer (seller)		-0.132		
		(-1.60)		
Time, (Month x Buyer ID x Seller ID) FE	Yes	Yes	Yes	Yes
$\overline{R}^2$	0.432	0.361	0.505	0.490
Obs	12092	7119	16193	8093

7 Appendix

Table 1: Trading activity by counterparty location. The sample covers every USD-denominated spot vanilla interest rate swap which was reported to DTCC between December 1, 2014 and February 19, 2016.

Location	N trades		Notional ($m)	
GB	153,594	45%	13,519,559	48%
US	68,988	20%	6,600,735	23%
FR	39,726	12%	2,862,393	10%
DE	23,142	7%	1,778,758	6%
KY	11,125	3%	1,152,804	4%
CA	4,828	1%	388,484	1%
CH	4,285	1%	325,520	1%
JP	3,892	1%	188,485	1%
HK	1,855	1%	123,084	0%
AU	2,801	1%	100,424	0%
Other	25,756	8%	1,098,609	4%

Table 2: Ratings conversion.

Rating			Conversion Scale
S&P	Moody's	Fitch	
AAA	Aaa	AAA	20
AA+	Aa1	AA+	19
AA	Aa2	AA	18
AA-	Aa3	AA-	17
A+	A1	A+	16
A	A2	A	15
A-	A3	A-	14
BBB+	Baa1	BBB+	13
BBB	Baa2	BBB	12
BBB-	Baa3	BBB-	11
BB+	Ba1	BB+	10
BB	Ba2	BB	9
BB-	Ba3	BB-	8
B+	B1	B+	7
B	B2	B	6
B-	B3	B-	5
CCC+	Caa1	CCC+	4
CCC	Caa2	CCC	3
CCC-	Caa3	CCC-	2
CC	Ca	CC	1
C	Ca	C	0.5
	C	DDD	0
D		DD	0
		D	0