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Centralized trading, transparency and interest rate swap market liquidity: evidence from the implementation of the Dodd-Frank Act

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Abstract

We use proprietary transaction data on interest rate swaps to assess the effects of centralized trading, as mandated by Dodd-Frank, on market quality. Contracts with the most extensive centralized trading see liquidity metrics improve by between 12% and 19% relative to those of a control group. This is driven by a clear increase in competition between dealers, particularly in US markets. Finally, centralized trading has caused inter-dealer trading in EUR swap markets to migrate from the US to Europe. This evidence is consistent with swap dealers attempting to avoid being captured by the trade mandate in order to maintain market power.

Key words: Interest rate swaps, pre-trade transparency, market power, liquidity, swap execution facilities.

JEL classification: G10, G12, G14.

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1 Introduction

A key regulatory response to the 2008 Global Financial Crisis has been to improve the resilience and transparency of Over The Counter (OTC) markets for derivative securities. To this end, over the last decade these markets have seen the introduction of clearing and margining and also increases in pre- and post-trade transparency, via centralized trading requirements and the creation of repositories containing information on completed trades.

This study focusses on a particular aspect of this regulatory change, an increase in pre-trade transparency in OTC markets, and we investigate how this has affected the competitive structure and liquidity of interest rate swap (IRS) markets. The global swap market is by far the largest OTC derivatives market[1], and this is the first study of the impact of post-crisis regulation on that market. Historically, global swap trading was decentralized and relatively opaque. However, a centralized trading requirement was introduced in the US in 2014 via the "Dodd-Frank Act", which required that *any* trade in a sufficiently liquid IRS contract involving a US counter-party *must* take place on a Swap Execution Facility (SEF). SEFs are multi-lateral trading venues, featuring open limit order book (LOB) and request for quote (RFQ) functionalities, allowing customers to solicit quotes from multiple dealers and/or an order book simultaneously. Thus SEFs introduced pre-trade transparency to a previously dark market and reduced customers' costs of searching for liquidity.

We show that the introduction of SEF trading had several important effects on IRS markets. First, swaps that were subject to the SEF-trading mandate saw significant improvements in liquidity. For example, relative to EUR mandated swaps (where SEF trading is much less prevalent), measures of liquidity for USD mandated swaps improve by between 12% and 19%. This translates to *daily* execution costs for end-investors in USD mandated swaps falling by about $3 - $6 million relative to EUR mandated swaps.

Second, we provide evidence that links this improvement in liquidity to more intense competition between swap dealers. Following the introduction of the SEF trading mandate,

[1]BIS, November 2016: `http://www.bis.org/publ/otc_hy1611.pdf`

the number of active participants in swap trading rose and we show that active US clients (i.e. those clients most strongly affected by the regulation) traded with a significantly larger number of dealers.

Finally, we document an effect consistent with dealers attempting to retain their market power in the new regulatory landscape. In particular, we show that upon the introduction of centralized trading in the US, the global EUR swap market fragmented geographically, as the percentage of average daily trading volume between US and non-US domiciled dealers in EUR swaps declined markedly and abruptly from 20% to 5%. This decline in trans-Atlantic volume for EUR contracts was entirely driven by those swap dealers with trading desks in multiple locations migrating the bulk of their inter-dealer activity to their non-US (primarily European) branches.[2] This is consistent with dealers in EUR swaps attempting to retain their market power by blocking access to the inter-dealer market to potential entrants. This is because, by transferring activity outside of the scope of US rules and avoiding SEF trading, dealers retain the ability to exclude specific counter-parties, something that is not possible (or easy) under the trade mandate. No similar pattern exists for trades between dealers and clients or trades in USD swaps.[3]

Our results are derived from proprietary data from the London Clearing House (LCH) between January 2013 and September 2014, supplemented with public data from the Depository Trust & Clearing Corporation (DTCC). SEF trading was introduced to the US in October 2013 and SEF trading became mandatory for a list of liquid contracts in February 2014. Thus, our data cover the trading activity in the Global IRS market for a reasonable period before and after the regulatory changes. Both data sources contain standard information on executed swap transactions. The LCH data additionally contain counterparty information from which we can infer traders' geographic locations (e.g. US- versus non-US-based entities) and trader type (e.g. dealer versus client). The DTCC data also tell us

[2]For related press coverage, see also 'Big US banks make swaps a foreign affair' in the Wall St Journal (`http://www.wsj.com/articles/SB10001424052702304788404579520302570888332`).

[3]The USD market is dominated by US persons who are subject to the trade mandate and as such, migrating its entire inter-dealer segment outside the US would likely be impractical.

whether a trade was executed on a SEF.

We employ a difference-in-differences technique to isolate the effects of the introduction of SEF trading on liquidity and competition. The treatment group of assets in our difference-in-differences tests is the set of USD swaps that were required to trade on a SEF after February 2014. Our control group is either the USD swaps that were not captured by the SEF trading mandate or the EUR swaps that were mandated, but which are mostly traded by non-US persons who, in turn, are not captured by the SEF trading requirement. We measure liquidity using various price dispersion measures based on the metric proposed by Jankowitsch et al. (2011), complemented with Amihud's price impact measure (Amihud (2002)), plus a bid-ask spread derived from swap quote data.

To place our analysis within the context of recent theory work on transparency, our result that centralized trading has improved liquidity and increased dealer competition for mandated swaps lends support to the research of Duffie et al. (2005) and Yin (2005). They argue that pre-trade quote transparency is a necessary condition for competitive liquidity provision and lowers transaction costs for customers, as it reduces search frictions. Along similar lines, Foucault et al. (2013) argue that in the presence of positive search costs, a unique Nash equilibrium exists where dealers quote monopolist prices i.e. prices that equal end-users' reservation values. Thus, reducing search costs allows customers to access keener pricing.[4] Hendershott and Madhavan (2015) examine the efficacy of electronic venues at facilitating trading in OTC markets. They show that periodic one-sided electronic auction mechanisms, similar to the RFQ mechanism we see on SEFs, encourage dealer competition and result in better prices while limiting information leakage. Our results run counter to the intuition in de Frutos and Manzano (2002) and Foucault et al. (2007). The former argue that risk-averse dealers price less keenly in transparent markets, since, to induce trades that correct an inventory imbalance, they only need to marginally improve the quote on the

[4]Vayanos and Wang (2012) survey the literature and explain how illiquidity is related to various market imperfections. They show that participation costs, imperfect competition and search frictions all have a detrimental effect on liquidity.

relevant side of the market relative to their competitors. Foucault et al. (2007) show that when informed trading intensities are low, lower transparency (in the form of hiding trader identity information) can lead to higher liquidity.

The empirical work on the link between transparency and liquidity contains some mixed results. Boehmer et al. (2005) show that NYSE stocks experienced a significant increase in liquidity when the exchange began to publish the limit order book to traders not located on the exchange floor. Green et al. (2007) study municipal bond dealers. They argue that opacity in this market increases dealer market power and they then show how dealer market power increases execution costs. Goldstein et al. (2007), Edwards et al. (2007) and Bessembinder et al. (2006) show that introducing post-trade transparency to US corporate bond markets had, on balance, a positive effect on liquidity (exceptions were found for very thinly-traded bonds and for the largest trades).[5]. In contrast, Foucault et al. (2007) show that imposing anonymity on trading activity, i.e. reducing transparency, increased liquidity in Euronext stock trading. Friederich and Payne (2014) find the same result in data from the London Stock Exchange, attributing the finding to the possibility of predatory trading under transparency (i.e. when identities are revealed). Our results chime with those above that suggest a positive link between transparency and liquidity.[6]

Our work is also related to other recent studies focusing on regulatory developments in OTC derivative markets markets (see Spatt (2017) and Acharya et al. (2009) for an overview of the post-crisis derivatives reform agenda). Loon and Zhong (2014) and Loon and Zhong (2015) study the effects of centralized clearing and post-trade reporting on CDS markets. Both of these reforms, mandated by Dodd-Frank, are shown to improve liquidity, while the former also reduces credit risk. Our focus is different, in that we study the impact of pre-trade transparency as related to the third pillar of the Dodd-Frank OTC derivatives regulation (i.e. the mandate for centralized trading) and we also examine the IRS market,

[5]Other evidence that links transparency with liquidity can also found in Harris and Piwowar (2006), Naik et al. (1999) and Boehmer et al. (2005).

[6]Our results are also in line with the experimental evidence in Flood et al. (1999).

which is much larger than the CDS market. It is worth noting that Loon and Zhong (2015) include a SEF dummy variable in their panel regressions but as their sample period ends before the introduction of the CFTC trading mandate in February 2014 they cannot say anything about the impact of the centralized trading requirement on liquidity.

Our result that EUR swap markets have fragmented as a result of the US SEF trading mandate ties into a recent regulatory literature on the efficacy of the reform and its impact on markets (see Giancarlo (2015), Massad (2016), Powell (2016)). The result suggests that there are costs, pecuniary or otherwise, to trading on SEFs that dealers wish to avoid. As mentioned earlier, one possibility is that dealers move activity from their US desks to their European desks in order to retain control over who they deal with. This could allow them to exclude new entrants from the inter-dealer EUR swap market which, in turn, would preclude those new entrants from trading effectively in the client market.[7] Thus, the observed geographic fragmentation is consistent with dealers attempting to maintain entry barriers to (EUR) swap trading.

Overall, our analysis highlights the importance of dealer market power in understanding how financial markets react to changes in their transparency regimes. This remains an area of policy interest. As of January 2018 Europe has adopted new centralized trading rules for swaps as part of the Markets in Financial Instruments Regulation (MiFIR). This has the potential to improve conditions for customers and also to remove the imbalance in regulation that has led to the geographical fracture in swaps markets. At the same time, in the US, there is uncertainty as to whether all parts of the Dodd-Frank Act will be retained as law with the new CFTC trading rules being at the heart of this discussion among policy makers and practitioners.[8]

The rest of the paper is organized as follows. Section 2 sets out the regulatory changes that affected swap markets as a result of Dodd-Frank and gives a detailed description of SEFs.

[7]This would not be feasible for USD swaps as the inter-dealer market is well established, geographically, in the US, while the bulk of EUR swap trading already happens in Europe.

[8]See, for example, related reporting by Bloomberg: `https://www.bloomberg.com/gadfly/articles/2017-02-23/wall-street-girds-for-regulatory-battles-loud-and-quiet`

Section 3 describes our data sources and presents summary statistics. Section 4 presents the difference-in-differences tests of the impact of the SEF trading mandate on market activity and liquidity. Section 5.1 shows how the mandate has changed the relationships between dealers and customers. Section 5.2 describes the changes in the geography of swap trading and how those changes may be linked to market power. Section 6 concludes.

2 Policy Context and Institutional Details

2.1 OTC derivatives and the Dodd-Frank Act

A major pillar of the US Wall Street Reform and Consumer Protection Act (the "Dodd-Frank Act") concerns OTC derivatives markets. In particular, owing to concerns that insufficient collateralization and opacity in these markets contributed to systemic risk during the crisis, Title VII of the Act implemented a series of reforms aimed at mitigating counterparty risk and improving pre- and post-trade transparency in swaps markets. It mandates centralized clearing for eligible contracts, requires real-time reporting and public dissemination of transactions and also requires that eligible contracts should be traded on a SEF, a form of multilateral electronic trading venue. SEF trading brings about a marked increase in the level of *pre-trade* transparency for the affected swap contracts.

The Dodd-Frank trading mandate was implemented by the CFTC in two phases. First, on October 2, 2013, SEF trading became available for OTC derivatives on a voluntary basis. As of that date, newly authorized trading venues had to comply with a number of principles and requirements. A principal one of these requirements was the obligation to operate a limit order book (LOB).[9] In the second phase, specific contracts were explicitly

[9] This does not mean that there were no electronic venues in operation or that no swaps were being traded on limit order books or other multilateral trading platforms before October 2, 2013. It only means that after this date, any venue that was officially recognized as a SEF had to comply with the specific CFTC minimum requirements mentioned above. Unfortunately, we have no data on the methods of execution prior to October 2, 2103. Nevertheless, if swaps were already being traded on pre-trade transparent electronic platforms before this date, this should bias us against finding any differences in market conditions when making a "before versus after" comparison. Our analysis shows that the differences were actually substantial.

required to be executed on SEFs. The mandate captured a wide range of interest rate swap (IRS) contracts of various currencies and maturities as well as several credit default swap (CDS) indices. The determination of the mandated contracts was (and still is) primarily SEF-driven, through the Made Available to Trade (MAT) procedure. A SEF can submit a determination that a swap is available for trade to the CFTC, which then reviews the submission. Once a swap is certified as available to trade, all other SEFs that offer this swap for trading must do so in accordance with the requirements of the trade mandate. The criteria for MAT determination include the trading volume of the swap and the frequency of transactions. Table 1 shows the mandated maturities along with the mandate date for the plain vanilla USD- and EUR-denominated IRS contracts which we use in our analysis. Most maturities were mandated on February 15 2014 with a couple more maturities following suit a few days later on the 26th.

The SEF trading mandate only captures "US persons", with that definition being relatively broad.[10] Importantly, the mandate affects the trades of US persons regardless of who their counterparty is. In other words, if a US person is to trade a mandated contract with a non-US person, the trade has to be executed on a SEF.

2.2 Swap Execution Facility (SEF) Characteristics

SEFs are electronic trading platforms where, according to the CFTC, "multiple participants have the ability to execute swaps by accepting bids and offers made by multiple participants in the platform". In practice, SEFs have two different functionalities to facilitate this. The first is a fully fledged central limit order book which allows any market participant

[10] Apart from US-registered swap dealers and major participants, the definition of a US person also includes foreign entities that carry guarantees from a US person (e.g. the foreign branch of a US dealer) and also any entities with personnel on US soil which is substantially involved in arranging, negotiating or executing a transaction. According to market reports this created initially some uncertainty as to who is captured. See for example: http://www.risk.net/risk-magazine/news/2256600/broader-us-person-definition-could-cause-clearing-avalanche-participants-warn

to supply liquidity by posting bids and offers.[11] All SEFs must offer an order book and, theoretically, this functionality allows end-users to bypass dealers altogether in concluding a trade, assuming of course that the order book has sufficient liquidity.

The second functionality is a modification of the existing request-for-quote (RFQ) dealer-centric model. The innovation, relative to pre-existing single-dealer platforms, is that a client's request for a quote is disseminated simultaneously and instantly to multiple dealers instead of just one. Thus clients can easily compare prices across dealers and this promotes competition for client order flow between dealers. Up until October 2014, the law required that a RFQ be communicated to no less than two market participants and, after that date, to no less than three. Having received a RFQ, dealers respond by posting their quotes to the client.[12] Importantly, dealers cannot see each others' quotes nor do they know which other dealers have received the request. In addition, the market participants responding to the RFQ cannot be affiliated with the RFQ requester and may not be affiliated with each other. This arrangement makes it hard for dealers to collude and effectively renders the bidding process a first-price, sealed bid auction.

The two trading functionalities are designed to operate in conjunction for swaps that are subject to the trade execution mandate.[13] This means that a SEF must provide a RFQ requester with any resting bid or offer on the SEF's order book alongside any quotes received by the dealers from whom quotes have been requested. The requester retains the discretion to execute either against the resting quotes on the LOB or against the RFQ responses.[14] After

[11]For swaps that are subject to the trade mandate, SEF regulation also requires that broker-dealers, who have the ability to execute against a customer's order or execute two customers against each other, be subject to a 15-second timing delay between the entry of the two orders on the LOB. This is intended to limit broker-dealer internalization of trades and to incentivize competition between market participants.

[12]It is worth noting that CFTC did not impose any requirement that the identity of the RFQ requester be disclosed. This was due to concerns expressed by market participants that the disclosure of the RFQ requester identity would cause information leakages about future trading intentions. See Foucault et al. (2007) and Nolte et al. (2015) for a discussion on the implications of the disclosure of counterparty identities.

[13]Any trades of swap contracts that are not subject to the mandate can still be executed on a SEF and the SEF must offer an order book. However, the SEF is also free to offer any other method of execution (including bilateral trading and voice-based systems) for these trades.

[14]In their analysis of SEF trading of Index CDS, Collin-Dufresne et al. (2016) demonstrate that the majority of dealer to customer trades use the RFQ mechanism, while inter-dealer trades use several different execution mechanisms, with work-ups and mid-market matches being important.

a LOB or RFQ trade, the SEF can establish a short work-up session open to all market participants. During the work-up, market participants can trade an additional quantity of the same swap at the same price as the initial trade, with first priority in execution given to counterparties who initiated the first trade. Duffie and Zhu (2015) show that work-up protocols can enhance price discovery and liquidity.

Many SEFs are available for trade in the interest-rate swaps that we study. Data from the London Clearing House for April to September 2014 identifies the venues on which trades occurred and they show that, for USD swaps, the most active SEFs were Tradeweb (with a market share of 20.6%), ICAP (19.8%), Tullet Prebon (17.2%) and Bloomberg (15%). Total USD trading activity for this period was at $4,770bn. For trading in EUR swaps, ICAP had the largest market share (at 34.8%), followed by BGC Partners (25.0%), Tullet Prebon (15.0%) and Tradeweb (10.6%). Total trading volume in the EUR contracts was €4,444bn. In both cases, no other SEF has a market share above 10%. Thus, some of the most active SEFs are operated by brokers while others are run by firms specializing in operating electronic markets and information systems. We have little data on how much of the SEF trading in interest rate swaps occurs on limit order books and how much occurs via RFQ. However, Riggs et al. (2018) look at detailed data on SEF trading of index CDS and indicate that limit order book usage is very limited.

Overall, SEFs change the microstructure of the market in two important ways. First, they increase pre-trade transparency by allowing market participants to observe prices quoted by dealers much more easily. Second, SEFs increase competition between swap liquidity suppliers. SEFs make comparison of dealer quotes much more straightforward, they allow new entrants to the swap dealing business to start supplying liquidity on LOBs and they allow end-users to trade directly with each other and to bypass dealers completely. While, in practice, most of the liquidity provision is still being done by traditional dealers, we will see that SEFs have eroded their market power and increased competitive pressures.

3 Data and Summary Statistics

3.1 Swap Transaction Data

In our analysis we use transaction data for USD and EUR denominated vanilla spot interest rate swaps, which we obtain from the LCH and the DTCC.

LCH clears approximately 50% of the global interest rate swap market and more than 90% of overall cleared interest rate swaps through its SwapClear platform. Its services are used by almost 100 financial institutions from over 30 countries, including all major dealers. We obtain reports of all new trades that were cleared by LCH between January 1, 2013 and September 15, 2014.

Each LCH report contains information on the trade date, effective date, maturity date, notional, swap rate, and other contract characteristics. In addition, a report includes the identities of the counterparties, which allows us to categorize trades by type of counterparty (dealer vs. non-dealer) and location (US, EU etc).[15] As is standard in this market, we classify the top 16 banks by volume in our sample as dealers, while any other counterparty is classified as a client.[16] Since April 2014 LCH reports also contain information on whether a transaction is executed on a trading venue, the name of the venue, as well as whether the venue is authorized as a SEF.

We apply a number of filters to clean the data. First, we keep only spot starting swaps, by removing any reports whose effective date is more than 2 business days from the trade date. Next, we remove duplicate reports, which arise because one report is generated for each side of a cleared trade. We also remove any portfolio or compression trades as they are

[15]Identities are reported in Business Identifier Codes (BIC). BIC is a unique identification designation for financial institutions approved by the International Organization for Standardization (ISO). It has typically 8 characters made up of (i) 4 letters that identify the bank, (ii) 2 letters that identify the country, and (iii) 2 letters or digits that identify the city.

[16]This choice is not arbitrary as these 16 banks are 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`

not price-forming.[17] Finally, to remove any inaccurate or false reports we keep only trades where the percentage difference between the reported swap rate and Bloomberg's end-of-day rate for the same currency and maturity is less than 5% in absolute value.

Although LCH is the global leader in clearing interest rate swaps, there are other clearing houses that offer competing services, e.g. the Chicago Mercantile Exchange (CME). To ensure that our results are representative of the whole market, we complement the LCH data with data from the DTCC, a trade repository (TR) operator. The DTTC was the first to begin operating a TR on December 31, 2012. We extract all transactions that were reported to them between January 1, 2013 and September 15, 2014. DTCC reports contain information on many contract characteristics, including whether a trade is centrally cleared or executed on a SEF. We filter the DTCC data in a similar way to the LCH data. Finally, we remove of any trades that were reported to both LCH and DTCC, via an algorithm that matches LCH and DTCC reports based on contract characteristics that are common to both data sets.

After filtering the data, we are left with a sample of 628,896 trade reports which account for a total $58.17 trillion in notional. In Figure 1 we show the time series of trading volume by currency. This figure illustrates the sheer size of the swap market with volumes hovering around $70-80 billion for each currency on a daily basis. We can also see that total volume is roughly equally split between USD and EUR denominated swaps.

In Figure 2 we present the shares of volume by type of counterparty. The majority of trades are inter-dealer, consistent with the commonly held view that a small number of dealers dominates the OTC swap market. Dealer-to-client trades account for about one-third of the market in both currencies. One difference between the two currencies is that the share of client-to-client trading activity for USD-denominated swaps is twice as large as that in EUR-denominated swaps.

[17] Compression trades are used in order to reduce the total notional amounts outstanding of participating institutions, while leaving their net notional amounts unchanged. The purpose of this is to reduce the amount of counterparty risk (which is a function of gross notional) while maintaining the same level of exposure to market risk.

With regard to location, we split trading activity into (i) trades between US financial institutions, (ii) trades between US and non-US financial institutions, and (iii) trades between non-US financial institutions. Figure 3 presents these data. About 50% of trading in USD-denominated swaps involves a US and a non-US counterparty, 30% two US counterparties, and 20% two non-US counterparties. For EUR-denominated swaps, US to non-US trading activity is only 14% of the sample, with the vast majority of trades, about 80%, between non-US counterparties. This means that the CFTC does not have the power to enforce the SEF trading mandate in EUR swap markets, as they are dominated by non-US counterparties. This observation motivates part of the empirical strategy employed later in the paper.

4 SEF Trading and Market Quality

4.1 Liquidity Variables

We measure liquidity using 5 metrics that are drawn from either transactional data or intraday bid-ask quotes provided by Thomson Reuters. One limitation of the trade reports is that they are not time-stamped. As a result we cannot construct liquidity metrics that rely on transaction sequencing. Instead, we mainly use metrics that only require executed trades and bid-ask quotes.

We first use three price dispersion measures to proxy for execution costs. The first is that proposed by Jankowitsch et al. (2011):

$$DispJNS_{i,t} = \sqrt{\sum_{k=1}^{N_{i,t}} \frac{Vlm_{k,i,t}}{Vlm_{i,t}} \left(\frac{P_{k,i,t} - m_{i,t}}{m_{i,t}} \right)^2} \tag{1}$$

where $N_{i,t}$ is the total number of trades executed for contract i on day t, $m_{i,t}$ is the end-of-day t mid-quote for contract i, as reported by Bloomberg, $P_{k,i,t}$ is the execution price of transaction k, $Vlm_{k,i,t}$ is the volume of transaction k and $Vlm_{i,t} = \sum_k Vlm_{k,i,t}$ is the total volume for contract i on day t. Jankowitsch et al. (2011) derive this measure from a market microstructure model where it is shown to capture inventory and search costs. Low dispersion of prices around the benchmark indicates low trading costs and high liquidity, and vice versa.

The use of end-of-day midquotes as a benchmark for a contract's *fair value* might be problematic in days of high intra-day volatility. For example, the value of a contract might be very different before and after a macroeconomic announcement. For this reason, we also employ a variation of the Jankowitsch et al. (2011) measure that uses the average execution price on a day as the price benchmark and is less susceptible to intraday volatility bias:

$$DispVW_{i,t} = \sqrt{\sum_{k=1}^{N_{i,t}} \frac{Vlm_{k,i,t}}{Vlm_{i,t}} \left(\frac{P_{k,i,t} - \bar{P}_{i,t}}{\bar{P}_{i,t}} \right)^2} \tag{2}$$

where notation is as above and $\bar{P}_{i,t}$ is the average execution price on contract i and day t. We require at least four intraday observations to determine the average execution price.

While the second dispersion metric reduces the intra-day volatility bias, it does not eliminate it. The same average execution price can be obtained from both extremely volatile and relatively stable intra-day paths for the mid-quote. Thus, we also employ the spread estimator proposed in Benos and Žikeš (2018) which, subject to weak assumptions about prices, is bias-free.[18] The estimator is a function of equally weighted versions of the two dispersion metrics above and equals:

$$DispBZ_{i,t} = \sqrt{\max\{2(3DispEW_{i,t}^2 - DispJNS\_EW_{i,t}^2), 0\}} \tag{3}$$

where $DispEW$ and $DispJNS\_EW$ are given by the formulas for the previous dispersion metrics but where $\frac{Vlm_{k,i,t}}{Vlm_{i,t}}$ is replaced by $\frac{1}{N_{i,t}}$.

To further account for any mechanical effect of intra-day volatility on liquidity, contract-specific daily realized variance is included as an explanatory variable in all empirical specifications. Note that all dispersion metrics are comparable across contracts with different base

[18] Žikeš (2017) explores the asymptotic properties of this estimator.

currencies and maturities as they are percentage deviations from a price benchmark.

We also use the Amihud (2002) price impact measure, defined as:

$$Amihud_{i,t} = \frac{|R_{i,t}|}{Vlm_{i,t}} \tag{4}$$

where $R_{i,t}$ is the price change for contract i on day t and $Vlm_{i,t}$ is the total volume expressed in \$ trillions. All of these liquidity measures have been used before in the context of OTC derivatives markets and are shown to strongly relate to other conventional liquidity proxies, see for example the evidence in Goyenko et al. (2009), Friewald et al. (2012), Friewald et al. (2014), Loon and Zhong (2014), Loon and Zhong (2015) and Benos and Žikeš (2018) among others.

Finally, we also measure liquidity with the relative quoted spread based on intra-day data obtained from Thomson Reuters. Bid and ask quotes for each contract are sampled every 10 minutes across the trading day and, assuming N intervals in a day, we calculate the daily average quoted spread for contract i on day t as:

$$QSpread_{i,t} = \frac{1}{N}\sum_{k=1}^{N} \frac{2(Ask_{k,i,t} - Bid_{k,i,t})}{Ask_{k,i,t} + Bid_{k,i,t}} \tag{5}$$

This liquidity measure is included to ensure robustness since it is not dependent on execution prices, which are used for all other liquidity metrics.

4.2 Panel diff-in-diff specifications

To assess the impact of SEF trading on market liquidity and activity, we estimate two panel difference-in-differences models. We wish to see if the introduction of SEF trading for a treatment group of IRS contracts causes their liquidity to diverge from that of a control group after our event dates. These dates are the 2nd of October 2013 when SEFs were officially authorized by the CFTC (and trades could be executed on them on a voluntary basis) and the CFTC mandate effective dates shown in Table 1. On these dates (which vary across contract maturities) it became mandatory for US persons to trade the specific maturities on SEFs.[19] Table 2 summarizes the main variables used in the models that follow.

Before presenting the results of our estimations, it is worth noting that a problem with our simple diff-in-diff approach is that the set of contracts mandated for SEF trading is not necessarily exogenous. In fact, as detailed in Section 2.1, SEFs themselves determine which contracts they trade through the MAT procedure. Then, if the set of contracts made available to trade are precisely those that are most likely to benefit (in liquidity terms) from SEF trading, any evidence of liquidity improvement that we obtain will be a biased estimate of the true liquidity benefit associated with SEF trading. However, while it is clear that SEFs made available for trade contracts that were already the most liquid, this is not the same as saying that they chose contracts that were most likely to benefit in liquidity terms from SEF trading. Thus, while it worth acknowledging there has been selection on average liquidity in this setting, we suspect that any bias might not be too severe.

Another possible issue with our diff-in-diff estimation technique is that, if SEF trading causes liquidity to improve for mandated swaps, this liquidity improvement might spill over to non-mandated swaps. For example, if dealers quote tighter spreads for the mandated 10 year USD swap, this may lead to tighter spreads in the (non-mandated) 9 year USD swap that is only a short distance away on the curve. If anything, though, this should create a bias towards us finding no significant effects and, in addition, it is a problem that should not contaminate the comparison of USD and EUR swaps.

Test 1: USD vs. EUR mandated contracts

For our first diff-in-diff test we use the mandated USD-denominated contracts as a treatment group and the mandated EUR-denominated contracts as a control group. The USD segment of the IRS market has a substantially higher proportion of U.S. participants who are captured

[19] These event dates are well after the implementation of the trade reporting mandate on December 31, 2012 and the clearing mandate on March 11, 2013. The clearing mandate implementation date occurs during our pre-event sample period, but excluding data prior to this date does not change our results in any important way.

by the CFTC mandate. The EUR contracts, however, may be mandated but they are mainly traded by non-US persons who are not required to trade on a SEF (e.g. Figure 3 tells us that over 80% of trading in the EUR contracts does not involve a US person and thus, for these trades, the SEF trading mandate can be ignored). Thus, if transparency improves liquidity, we would expect the liquidity of USD contracts to improve relative to that of EUR contracts.[20] An advantage of using the mandated EUR contracts as a control group is that the treatment and control groups have similar liquidity profiles, which implies that our results are not subject to the selection bias mentioned above. On the other hand, liquidity and activity in the EUR segment of the market might be driven by different fundamentals. We control for this by including a number of contract and currency specific control variables in our specifications.

We implement this test by estimating the following panel specification:

$$L_{it} = \alpha_i + \beta_1 Date_t^{(1)} + \beta_2 Curr_i Date_t^{(1)} + \beta_3 Date_t^{(2)} + \beta_4 Curr_i Date_t^{(2)} + \gamma Swap\_RV_{it} + \delta' X_t + \epsilon_{it} \tag{6}$$

where i indexes the set of swap contracts (defined by maturity and currency) such that the α_i are contract-specific fixed effects and t denotes days. L_{it} is a liquidity or market activity variable. The liquidity variables are defined in equations (1) to (5) whereas our activity variables include daily volume traded, the daily number of trades executed and the number of unique market participants active on a given day. $Date_t^{(j)}$, $j = 1, 2$ are dummies for the two event dates equalling one after the respective events and zero otherwise, $Curr_i$ is a currency dummy that is equal to one for USD contracts and zero for EUR contracts. $Swap\_RV$ is the contract-specific realized variance, which is calculated using Thomson Reuters' intraday quote data. Specifically, we compute 10-minutely squared mid-quote returns, sum them across a day to give a daily realized variance and then compute a 30-day rolling average of the

[20]Of course, to the extent that SEFs are also used by those trading in EUR mandated contacts, albeit to a lower degree, we might expect (small) improvements in their liquidity too.

daily variances. It is included so as to ensure that our results are not driven by any differences in the volatility of the EUR- and USD-denominated contracts. X_t is a vector of aggregate currency-specific control variables which includes stock market returns, stock index implied volatilities as proxies for overall market uncertainty, overnight unsecured borrowing rate spreads for both markets as proxies for dealer funding costs and yield curve slopes intended to capture differences in fundamentals between the USD and EUR market segments. Our specification explicitly disentangles liquidity/activity in the two currency groups as well as any changes in liquidity after the two events. The coefficients β_1 and β_3 capture any effects that are common to both market segments and coefficients β_2 and β_4 capture incremental effects that are particular to the USD segment. We cluster the standard errors by both maturity and currency.

The left-column of plots in Figure 4 displays time-series of cross-swap mean values of our key dependent variables, separately for the EUR MAT and USD MAT samples, in the window prior to the SEF mandate date. These are displayed to shed light on the 'parallel trends' assumption that underlies our difference-in-differences analysis. The assumption appears to be a reasonable one for these data as the liquidity variables all evolve in rather similar fashion in the period of time before the SEF trading mandate came into force.

Tables 3 and 4 show the results of these estimations for the liquidity and activity variables respectively. The models are estimated with and without the control variables. A first result to note is that after SEF trading became available on 2 October 2013 ($Date^{(1)}$ dummy) there is an improvement in liquidity for both market segments as the significantly negative coefficients on $Date^{(1)}$ and the insignificant interaction terms indicate. The only exception to this is for the quoted spreads, where a small but significant reduction in liquidity for USD contracts can be seen. Following the enforcement of the SEF trading mandate there is a clear differential effect between the USD and EUR segments of the market with the USD contracts showing a significant further liquidity improvement relative to the EUR contracts. This improvement is visible across all liquidity measures, with 11 of the 12 interaction terms being significantly negative at a 5% level and the other coefficient significantly negative at 10%. Also, for USD quoted spreads, the second event date interaction is negative and much larger in magnitude than the positive interaction on the first event date, implying that overall USD quoted spreads fall relative to EUR spreads.

Regarding the activity variables, the results suggest that there was a reduction in activity for EUR contracts and a respective increase in USD contracts mainly after the first event date, i.e. when SEF trading became available. It is interesting here that, although activity in EUR mandated contracts declined, liquidity actually improved, as the market became more transparent. We do not observe any significant difference in trading activity between the USD and EUR contracts after the second event (February 2014). Another noteworthy effect is that after both events, the number of parties trading in USD markets rose significantly relative to the number of traders in EUR markets. Thus breadth of participation in USD markets rose.

In the activity and liquidity regressions, there are few consistently signed and consistently significant regressors. The realized volatility variable ($Swap\_RV$) is always positive in the liquidity regressions (and is significant in half of the specifications). The VIX and VDAX are also often positive and significant (except in the quoted spread regressions) in the liquidity regressions. In the activity regressions, the control variables are only occasionally significant.

Test 2: USD mandated vs. USD non-mandated contracts

For the second diff-in-diff test we concentrate exclusively on USD contracts and use the mandated maturities as a treatment group and non-mandated USD swaps as the control group.[21] This test has the advantage of looking at contracts whose prices are driven by the same set of fundamentals and also cleanly compares mandated versus non-mandated

[21] The mandated maturities are: 2Y, 3Y, 4Y, 5Y, 6Y, 7Y, 10Y, 12Y, 15Y, 20Y and 30Y. The non-mandated maturities are: 1Y, 8Y, 9Y and 25Y.

contracts. We estimate the following panel regression:

$$L_{it} = \alpha_i + \beta_1 Date_t^{(1)} + \beta_2 MAT_i Date_t^{(1)} + \beta_3 Date_t^{(2)} + \beta_4 MAT_i Date_t^{(2)} + \gamma Swap\_RV_{it} + \delta' X_t + \epsilon_{it} \tag{7}$$

where now i denotes maturities and t denotes days. The α_i terms are again contract-specific fixed effects. The key right-hand side variables used are the same as before with the only difference being that we now have a dummy variable (MAT_i) indicating whether a given contract maturity has been mandated by the CFTC.

The right-column of plots in Figure 4 gives our 'parallel trends' analysis for the USD MAT versus non-MAT samples. Again, there is evidence that the dispersion measures are neither diverging nor converging across the two samples. For the quoted spread data, there is a small level shift in MAT spreads around 4 months before the first event date, which is subsequently and gradually eroded as we approach the mandate event date. For the Amihud measure, the trend on USD non-MAT contracts is rather noisy although it does not show any signs of divergence (or convergence) with that of USD MAT contracts. For this reason, we are inclined to place less weight on the difference-in-differences results when using this variable.

Tables 5 and 6 show the results of these estimations for the liquidity and activity variables and for specifications with and without controls. There is evidence of liquidity improvements for both mandated and non-mandated contracts after SEF trading became available on 2 October 2013. This is particularly clear in the dispersion metrics, but not for the Amihud measures or the quoted spread data. Focussing on the dispersion-based liquidity measures, after the second event date the liquidity of the mandated contracts tends to increase again while, if anything, that of non-mandated contracts deteriorates slightly. The picture is less clear for quoted spreads and the Amihud measure. On the second event date, the coefficients on the interaction terms for these dependent variables are always negative, but they are not quite significant at conventional levels (with t-statistics between -1.30 and -1.50).

Overall, though, the broad picture here is one of increased liquidity for both mandated and non-mandated USD contracts with the increase being significantly greater for the former. It is fair to say, however, that the evidence of a liquidity improvement for mandated contracts from these estimations is less strong than the evidence obtained from the comparison of USD and EUR mandated contracts (especially for quoted spreads).

One interpretation of this finding is that the liquidity improvements in the mandated contracts spilled over - to some extent - to non-mandated contracts. This is possible because market participants might also have chosen to trade non-mandated contracts on SEFs as soon as the functionality became available, and presumably also because, as discussed above, more transparency for some quoted prices on the USD maturity curve gives market participants a better idea of what a fair quote is for other USD maturities.

As far as activity and participation are concerned, 6 shows that, as for the estimations using the EUR control sample, there are positive effects only for the mandated contracts occurring in the period after 2 October 2013.

Economic Significance of Liquidity Improvement

We next assess the economic significance of the observed improvements in liquidity. For this, we calculate the dollar reduction in execution costs for market end-users. The market value of an IRS is set to zero at initiation by selecting the fixed rate such that the present values of the fixed and floating legs are the same. However, a bid-ask spread charged by a dealer on top of the fixed rate, would affect the value of the swap and thus introduce an additional cost incurred by the end-user. The total dollar value of this cost can be approximated by:

$$Cost(\$) \approx ESpread\_Adj \times P \times m \times Trade\_Size$$

where $ESpread\_Adj$ is the effective spread of a transaction in an IRS contract with a maturity of m years, P is the prevailing swap rate and $Trade\_Size$ is the amount of notional traded. Intuitively, this formula is estimating the change in the market value of the fixed leg of a swap when the swap rate has increased by the effective spread. [22]

We follow the same approach in order to calculate the *reduction* in execution costs as a result of the trade mandate. We base our economic significance calculations on Test 1, i.e. the comparison of USD versus EUR mandated contracts, because mandated contracts are the most heavily traded and are the largest segment of the market. Since our difference-in-differences specifications in (6) are estimated on a daily basis and across all contract maturities, we approximate the daily dollar *incremental reduction* in execution costs for USD mandated contracts relative to EUR mandated contracts by:

$$Cost\_reduction(\text{USD MAT vs EUR MAT}) \approx (\hat{\beta}_2+\hat{\beta}_4)\times\bar{P}\times\overline{Maturity}\times\overline{Vlm}\times D2C(\%) \quad (8)$$

where $\hat{\beta}_2, \hat{\beta}_4$ are the estimated coefficients of the date-currency interaction terms in model (6), $\bar{P}$ is the average volume-weighted price of the USD mandated contracts (1.7%), $\overline{Maturity}$ is their average volume-weighted maturity (7 years) and $\overline{Vlm}$ is their average daily volume ($75 billion). Finally, we multiply with the average fraction of dealer-to-client volume (33%) to estimate the reduction in execution costs that accrues to market end-users. Similarly, the *total reduction* in execution costs that accrues to USD mandated contracts is given by:

$$Cost\_reduction(\text{USD MAT}) \approx \Big(\sum_{i=1}^{4}\hat{\beta}_i\Big) \times \bar{P} \times \overline{Maturity} \times \overline{Vlm} \times D2C(\%) \qquad (9)$$

where here we include the sum of all estimated dummy coefficients $\hat{\beta}_i$ from model (6).[23]

This basic calculation suggests that the effects of the trade mandate are economically significant. The coefficients for the $Curr \times Date^{(1)}$ and $Curr \times Date^{(2)}$ interaction terms

[22]The swap rate, P, is being multiplied by the adjusted spread and then by notional so as to yield a dollar figure. The cost is also a multiple of contract maturity since an end-user pays the fixed rate (and the effective spread) every year for the duration of the contract lifespan. In this calculation, the annual dollar costs are just summed aross years without any discounting which, given the historically low interest rates over our sample period, should not change the result very much.

[23]Notice however that it is only the incremental reduction in execution costs that can be causally attributed to the trade mandate.

in the dispersion specifications suggest that the incremental reduction in execution costs of the USD mandated versus the EUR mandated contracts is between 12% and 19% of previous cross-currency average dispersion levels. This amounts to a reduction of roughly $3-$6 million *daily* for market end-users. The total reduction in execution costs for USD mandated contracts is larger, at between 22% to 32% of previous dispersion levels, which amounts to roughly $7-$11 million daily for end-users. The effect on the EUR contracts is also substantial, despite the fact that fewer participants are captured by the mandate. The reduction in execution costs there is about 10% to 14% or $3-$5 million daily.

4.3 Liquidity in D2D versus D2C trades

Thus far, we have presented evidence that liquidity improves for SEF-traded instruments after the mandate date in February 2014. It would be interesting to know, however, whether these improvements are felt both in dealer-to-client (D2C) trades and inter-dealer (D2D) trades. Does SEF trading allow dealers to rebalance inventories more cheaply or are end-users able to enter positions more cheaply or both?

In Tables 7 to 10, we re-run our liquidity panel regressions, but where the dependent variable is now constructed either from D2D trades only or from D2C trades only. Unfortunately we cannot separate either the quoted spread data or the Amihud measure into D2D and D2C components (as they are not based on individual trades) and so for this analysis we can only use the dispersion-based measures of liquidity.

Tables 7 and 8 indicate that, after the SEF mandate date, D2C trades in the treated group of swaps always experience a liquidity improvement (i.e. dispersion falls), regardless of which control group we use and regardless of the dispersion measure used to approximate liquidity. This increase in liquidity is significant in 10 of the 12 regressions we report. There is no consistent movement in D2C trade liquidity for treated group relative to control group swaps on the first event date (i.e. the date that SEFs opened for trade). Only one of the first event date interactions is significant and that too suggests an improvement in liquidity when SEF trading is available.

For D2D trading, the picture is much less clear. Comparing D2D trades in mandated USD contracts versus those in mandated EUR swaps, Table 9 shows that there is a liquidity improvement for the former relative to the latter after the SEF mandate date for all of the dispersion measures. However, Table 10 shows that there is no improvement in D2D liquidity for mandated USD contracts relative to non-mandated USD contracts. The results suggest that D2D liquidity improves for both mandated and non-mandated USD contracts, in particular on the first event date (with results for one of our liquidity proxies showing that the liquidity improves more for non-mandated contracts than for mandated contracts on the first event date).

Thus, overall, our regressions show that end-users of swaps have experienced consistent liquidity benefits from mandated SEF trading. The picture for inter-dealer trades is less clear, in that we do not see uniform evidence that their trading has become less expensive.

4.4 SEF flag panel specifications

We next test how the *fraction* of SEF trading affects liquidity and market activity. For this, we utilize the DTCC segment of our data which contains a flag indicating whether a given trade was executed on a SEF. We estimate the following panel specification for mandated USD and EUR-denominated contracts only, on a daily frequency:

$$L_{it} = \alpha_i + \beta_1 SEF_{it} + \beta_2 Date_t^{(1)} + \gamma Swap\_RV_{it} + \delta' X_t + \epsilon_{it} \tag{10}$$

where L_{it} is one of the previously defined liquidity or market activity variables for contract i on day t, SEF_{it} is the percentage of SEF trading, $Date_t^{(1)}$ is a date dummy taking the value of 1 after the authorization of SEFs on 2 October 2013 and X_t is the usual vector of controls. We include the date dummy in the specification so as to see if the time and cross-sectional variation in SEF trading, conditional on SEF trading being available, has incremental explanatory power.[24] Because it is possible that SEF trading is itself caused by market liquidity, we also estimate this model by IV, instrumenting SEF_{it} with its own lags.

Tables 11 and 12 show the results of these estimations. The coefficients on the percentage of SEF trading are significant in 14 of the 16 regressions and consistent with the previous findings. A higher fraction of SEF trading is associated with increased levels of liquidity as captured by reduced values for both the dispersion metrics as well as the Amihud and quoted spread variables. Similarly, SEF trading is positive and statistically significant in the regressions for activity variables: a higher fraction of SEF trading is associated with higher volumes, more trades and a larger number of market participants. Overall, these results suggest that SEF trading is associated with robust and measurable improvements in market quality.

5 SEFs and Dealer Market Power

5.1 Relationships between Dealers and Clients

Duffie et al. (2005) and Yin (2005) argue that the beneficial effects of pre-trade transparency on liquidity come via the effect of transparency on dealer competition. More intense dealer competition leads to better prices for customers. We have already seen, in Tables 4 and 6, that the introduction of SEF trading increased the number of parties trading swaps, potentially making these markets more competitive. In this section we explore whether the trading relationships between individual customers and dealers have changed as a result of the CFTC trade mandate. If SEF trading has led to more intense competition between dealers, we would expect the number of dealers that the average customer trades with to have risen for securities subject to the SEF trading mandate.

Thus we create a variable that we call $Ndealers_{it}$. This variable is a count of the number

[24] We also estimate model (10) only using data after the introduction of SEF trading. The results for the liquidity variables are similar to those reported below and for this reason they are omitted.

of unique dealers with whom customer i trades in month t. It is based on completed trades across all EUR and USD mandated swaps.[25] As a first pass, we aggregate $Ndealers_{it}$ across months and end-users for the period before mandatory SEF trading and then do the same for the period after the mandate came into force and in Figure 5 display the frequency distributions of those two samples. It is clear that SEF trading is associated with a dramatic rightwards shift in the distribution, with the fraction of clients trading with only a few dealers being substantially reduced and the fraction of clients trading with more dealers rising correspondingly. For example, prior to the cutoff date, around 28% of customers dealt only with a single dealer. With the introduction of the SEF trading mandate, this number dropped to 8%. Similarly, prior to February 2014, over 50% of customers dealt with 3 or fewer dealers, while after this date the corresponding number was around 20%.

These numbers immediately suggest that there have been profound changes in the nature of the interactions between swap dealers and customers. Prior to the trading mandate strong ties existed between individual customers and particular dealers. With the improvements in pre-trade transparency, customer search costs have fallen and it has become easier for customers to trade with the dealer showing the best price. Thus, effective competition between dealers has risen and, as we have shown above, this has led to lower execution costs.

Given that the CFTC trade mandate only captures US persons (i.e. US legal entities), one would further expect that any changes in the dealer-client relationships should be more pronounced for US persons. To test this, we estimate a difference-in-differences specification using the cross-section of all clients in our sample. In particular, we build our $Ndealers_{it}$ variable for every customer and every month and estimate the following model:

[25] Another interesting measure would be the number of unique dealers that a particular customer contracted through requests for quotes in a particular period, but unfortunately we do not observe the RFQ process and thus cannot build such a variable.

$$
\begin{aligned}
Ndealers_{it} \;=\;& a_i + bUS_i + c_1\, Date_t^{(1)} + c_2\,(Date_t^{(1)} \times US_i) + c_3\,(Date_t^{(1)} \times ACTIVE_i) \\
& + d_1\, Date_t^{(2)} + d_2\,(Date_t^{(2)} \times US_i) + d_3\,(Date_t^{(2)} \times ACTIVE_i) \\
& + f_1\, ACTIVE_i + f_2\,(US_i \times ACTIVE_i) + f_3\,(Date_t^{(1)} \times US_i \times ACTIVE_i) \\
& + f_4\,(Date_t^{(2)} \times US_i \times ACTIVE_i) + \gamma'\, X_{it} + u_{it} \qquad (11)
\end{aligned}
$$

where t denotes months, i indexes end-users and a_i is a fixed effect for end-user i. $Date^{(1)}$ is the October 2013 SEF introduction dummy, $Date^{(2)}$ is the February 2014 SEF mandate dummy and the $X_{i,t}$ vector contains a set of end-user specific trading activity variables (including number of trades and total volume executed). US is a dummy for any client that is a US-person, while $ACTIVE_{it}$ is a dummy that identifies a client who trades at least 20 times per month on average (i.e. roughly once a day or more). In our data, there are a large number of end-users who trade very infrequently (e.g. once a week or less) and, thus, for whom our dependent variable is always likely to be low regardless of the trading environment. Thus, in order to avoid focussing on those clients and to shift attention towards clients for whom increased dealer competition and greater liquidity is going to be most valuable, we separate the active from the less active clients in the dummy specification in the regression

Table 13 shows the results of this estimation. The implementation of the SEF trading mandate leads to the active set of US clients executing against a significantly larger number of dealers. Prior to the mandate date, and focussing on the results without control variables for clarity of interpretation, the significant coefficients indicate that those active US clients dealt with around 9 dealers per month on average and afterwards this increases by around 17%, or 1.6 dealers, on average. This change is statistically significant, while there are no significant shifts for non-US or inactive clients. The specification with control variables yields qualitatively similar findings, although in that case the less active US clients see a small, marginally significant drop in the number of dealers they trade with after the mandate date.

Thus, our graphical and econometric evidence is consistent. After the introduction of mandatory SEF trading competition between dealers intensified, particularly for the set of active US clients, and this likely contributes to the fall we observe in clients' trading costs.

5.2 The Geography of Trading and Dealer Market Power

Shortly after the SEF trading mandate took effect, one concern among market participants and regulators was that it might lead the global swaps market to fragment along geographical lines (ISDA (2014)). Since the mandate only applied to US persons it was conceivable that, for example, European counterparties who wished to avoid trading on a SEF might do so by trading exclusively with other European counterparties. Indeed, some reports released after the implementation of the mandate suggested that the market was becoming fragmented and that this was causing market quality to deteriorate (e.g. Giancarlo (2015)).

In this section, we exploit our knowledge of counterparty identities in the LCH data and investigate this issue in detail. First, we classify all market participants in the LCH data as US or non-US-based and calculate the percentage of trading volume executed between US and non-US counterparties (US-to-non-US).

Figure 6 plots this percentage for USD and EUR-denominated contracts. It is evident that whereas no substantial effect takes place in USD-denominated contracts, after the introduction of SEF trading there is a clear reduction in the fraction of US-to-non-US volume in EUR-denominated swaps, from around 20% to 5%. More formally, the first two columns of Table 14 show the results of time-series regressions of the fractions of US-to-non-US volumes in USD and EUR contracts on the SEF introduction event dummy and a number of controls. The dummy coefficient is highly significant and negative for the EUR contracts and insignificant for USD contracts. Thus the EUR segment of the swap market did become significantly more geographically fragmented following the introduction of SEF trading.

It is likely that the observed difference between the two market segments is because of the much smaller proportion of US market participants in the EUR-denominated segment of the market: if a non-US counterparty wants to trade with another non-US counterparty and avoid executing on a SEF, this is much simpler for a EUR-denominated contract than for a USD-denominated one. Given the preponderance of US persons trading USD swaps, it is hard to avoid trading with a US person and thus on a SEF.

However, given the beneficial effects of SEF trading, the obvious question is why any (and which) counterparties might want to avoid trading on SEFs. Figure 7 shows a breakdown of the fraction of US-to-non-US volume in the EUR-denominated contracts according to the type of counterparties. It is clear that the observed fragmentation is entirely driven by inter-dealer trading and the last two columns of Table 14 confirm this. Thus, it appears that it is swap dealers who are trying to avoid using SEFs where possible. There is no observable fragmentation for EUR trades that involve at least one non-dealer. This might have been expected, as there is no incentive for customers to avoid trading on SEFs given the liquidity improvements they offer.

The question that remains is why cross-border activity by EUR swap dealers dropped so clearly when the SEF trading mandate was introduced in the US. One possibility is that inter-dealer trading between US-based and non-US-based dealers could genuinely have exogenously declined and could have been replaced by local (intra-US and intra-European) trading. Alternatively, inter-dealer trades between US and non-US firms could have been executed by the non-US branches of swap dealers who happen to have trading desks in multiple jurisdictions. For example, a trade in EUR between a US and a European dealer that was being executed by the US desk of the former, could now be executed by the European desk of the same dealer. In this case, it would be registered as an intra-European trade and would not be subject to the SEF trade mandate.

To see if this is the case, we plot in Figure 8 the fraction of inter-dealer trading in EUR contracts done by the US and non-US trading desks of only those swap dealers who have desks in multiple jurisdictions and who execute more than 10% of their swap volumes from a desk located in the United States. The figure shows that there is a sharp shift in inter-dealer activity from the US desks to the non-US ones. The fraction of non-US desk trading increases from a daily average of 75% prior to the introduction of SEFs, to an average of 95% after (with the corresponding fraction of US desk trading dropping from 25% to 5%). Additionally, Figure 9 shows that there is virtually no change in the amount of inter-dealer trading done exclusively by dealers who regularly trade the bulk (i.e. more than 90%) of their derivatives from their European desks. We interpret this as implying that the observed geographical fragmentation is artificial in the sense that it is entirely driven by EUR swap dealers in large institutions using their non-US desks to do business that would previously have passed through their US desk.

These results are consistent with (although not direct proof of) swap dealers strategically choosing the location of the desk executing a particular trade in order to avoid trading in a more transparent and competitive setting. A potential explanation for this lies in attempts to maintain market power. By shifting the location of the inter-dealer market in EUR swaps to Europe and using European entities to execute, the SEF trading mandate and the associated CFTC impartial access requirements are avoided.[26] This allows dealers to retain power, in that they retain control over who they trade with and how, which in turn would allow them to exclude any potential new competitors from inter-dealer trading. If a potential competitor cannot access inter-dealer markets to manage inventory, their quotes are likely to be less tight and thus they are less likely to attract business in the customer market.

6 Summary and Conclusion

One of the pillars of the G20 reform agenda for OTC derivatives markets is the requirement to migrate trading activity to more centralized, more transparent venues. In response, as part of Dodd-Frank, US regulators have mandated that US persons should trade certain interest rate swap contracts on swap execution facilities (SEFs). These venues improve

[26]The CFTC guidance is available at:
www.cftc.gov/idc/groups/public/@newsroom/documents/file/dmostaffguidance111413.pdf

transparency by automatically disseminating requests for quotes to multiple dealers and by featuring an electronic order book which allows any market participant to compete with dealers for liquidity provision by posting quotes. Thus, SEFs induce competition between existing dealers and also lower the barriers to potential entrants to the dealing community.

Using transaction data from the IRS market we assess the impact of SEF introduction on swap market activity and liquidity. We find that the move from an OTC to a more centralized, competitive market structure leads to a substantial reduction in execution costs. This is clearest for the mandated USD contracts, which are the most directly affected as they are primarily traded by US persons who are captured by the trade mandate, and is also most prominent for trades between dealers and clients. For these contracts, dispersion-based liquidity measures for mandated USD swaps show that liquidity improves by between 12% and 19% relative to that of EUR mandated contracts. This amounts to daily savings in execution costs of as much as \$3 - \$6 million for end-users of USD swaps.

We then demonstrate that the introduction of centralized trading resulted in a sharp increase in competition between swap dealers. The average active US client in this market trades with a significantly greater number of dealers after the centralized trading mandate. Thus, dealer competition rises and liquidity improves, as one would expect.

Additionally, we find that, for the EUR-denominated swap market, the bulk of inter-dealer trading previously executed between US and non-US trading desks is now largely executed by the non-US (mostly European) trading desks of the same institutions (i.e. banks have shifted inter-dealer trading of their EUR swap positions from their US desks to their European desks). We interpret this as an indication that swap dealers wish to avoid being captured by the SEF trading mandate and the associated impartial access requirements. Migrating the EUR inter-dealer volume off-SEFs enables dealers to choose who to trade with and (more importantly) who not to trade with. This might allow them to erect barriers to potential entrants to the dealing community. Thus this fragmentation of the global market may be interpreted as dealers trying to retain market power, where possible. Importantly, we find no evidence that customers in EUR swap markets try to avoid SEF trading and the improved liquidity it delivers.

While our analysis suggests that so far there has been no incremental negative impact on EUR contract liquidity as a result of this market fragmentation, it may have negated the liquidity gains experienced in the USD segment of the market. Therefore, given the global nature of OTC derivatives markets, our findings suggest that extending the scope of the trading mandate to cover other sufficiently liquid swap markets would be desirable. Such regulation has been implemented at the start of 2018 in the EU as part of MiFIR.

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Figure 1: Total traded volume (in $ billion) by currency. In this figure we plot the total volume of EUR-denominated and USD-denominated plain vanilla swaps. The sample covers every spot vanilla interest rate swap which was either cleared by LCH or reported to DTCC between January 1, 2013 and September 15, 2014.

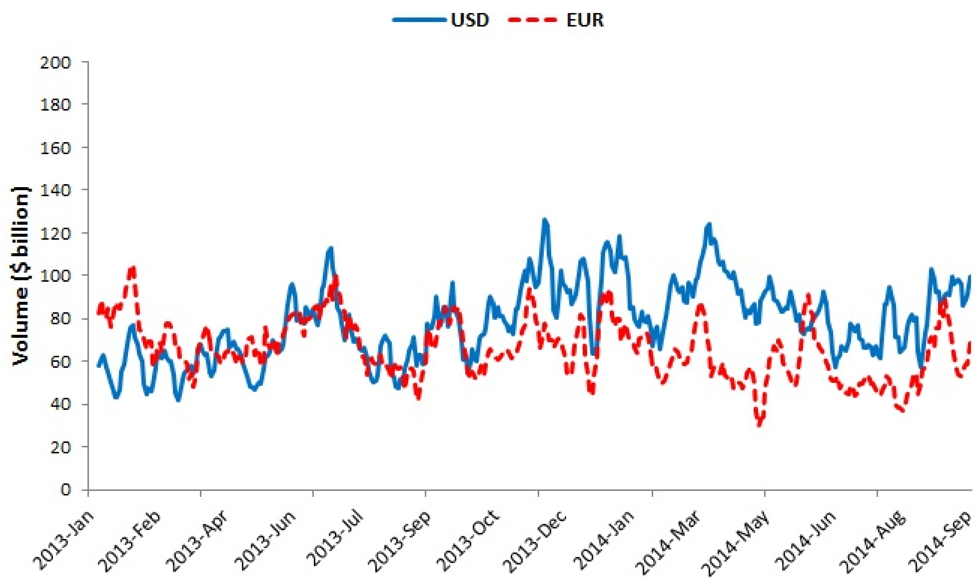


Figure 2: Volume shares by type of counterparty: In this figure we decompose the total volume into dealer-to-dealer (*d2d*), dealer-to-client (*d2c*), and client-to-client (*c2c*) trading. The inner circle presents the volumes of USD-denominated swaps, while the outer circle presents the volumes of EUR-denominated swaps. The sample covers every spot vanilla interest rate swap which was cleared by LCH between January 1, 2013 and September 15, 2014.

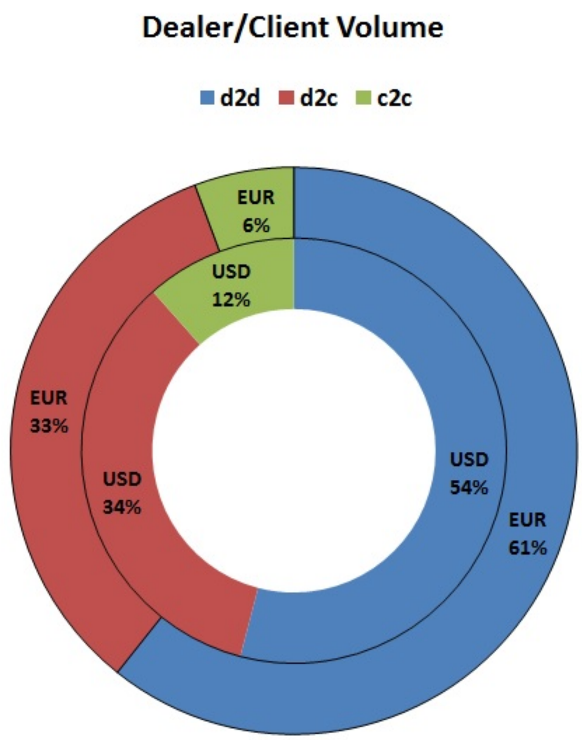


Figure 3: Volume shares by location. In this figure we decompose the total volume into US-to-US, US-to-non-US, and non-US-to-non-US trading. The inner circle presents the volumes of USD-denominated swaps, while the outer circle presents the volumes of EUR-denominated swaps. The sample covers every spot vanilla interest rate swap which was cleared by LCH between January 1, 2013 and September 15, 2014.

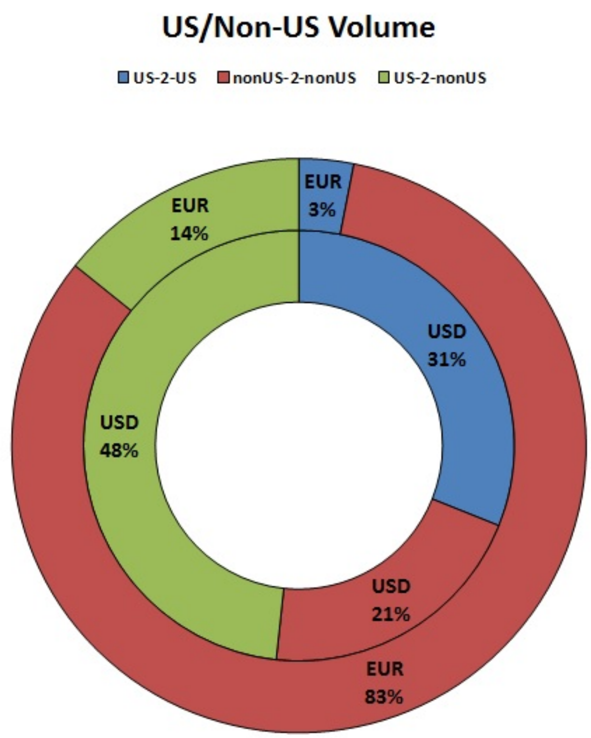
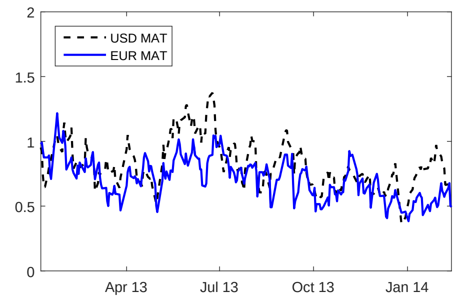
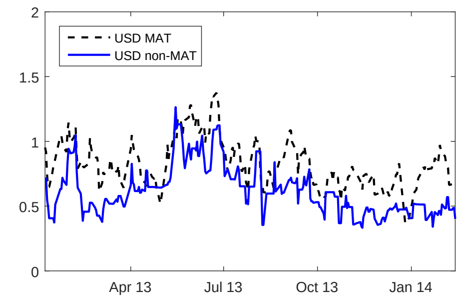


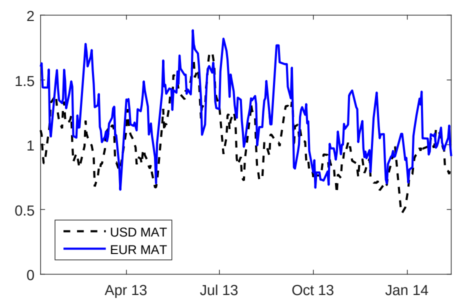
Figure 4: Parallel trends: this figure shows the evolution of our key liquidity measures, for treated and control samples, prior to the second event date. The liquidity measures shown are smoothed price dispersions, quoted spreads and the Amihud measure and they have been averaged across the members of the relevant set of contracts on each date.



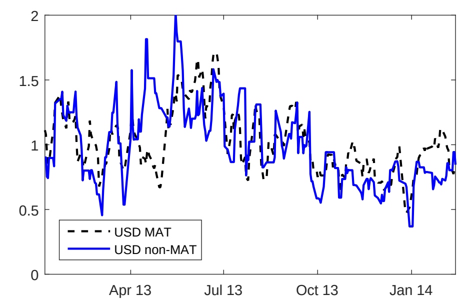
(a) Disp(vw): USD MAT vs EUR MAT



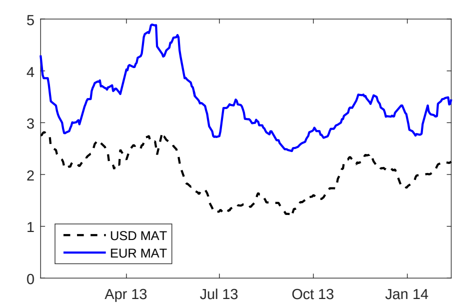
(b) Disp(vw): USD MAT vs non-MAT



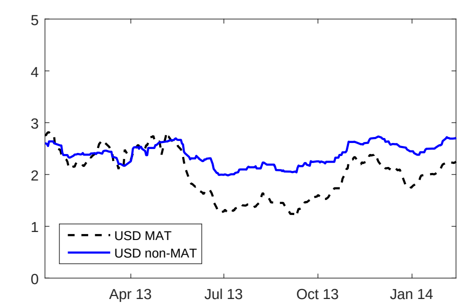
(c) Disp(JNS): USD MAT vs EUR MAT



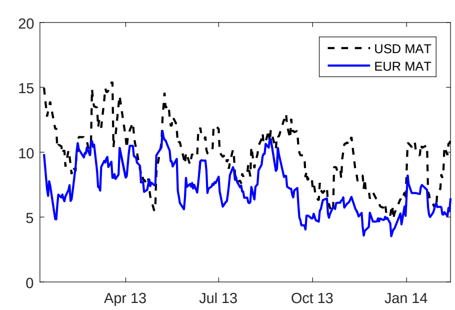
(d) Disp(JNS): USD MAT vs non-MAT



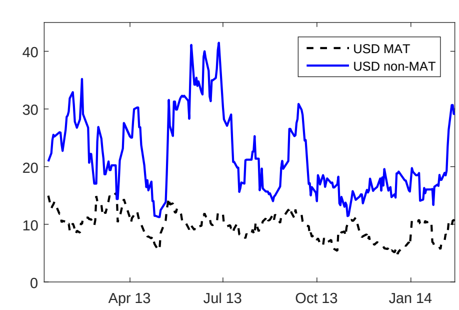
(e) Qspread: USD MAT vs EUR MAT



(f) Qspread: USD MAT vs non-MAT



(g) Amihud: USD MAT vs EUR MAT



(h) Amihud: USD MAT vs non-MAT

Figure 5: Frequency distribution of the number of dealers with whom end-users trade before and after February 2014, when SEF trading becomes mandatory for all US persons trading any mandated IRS contracts.

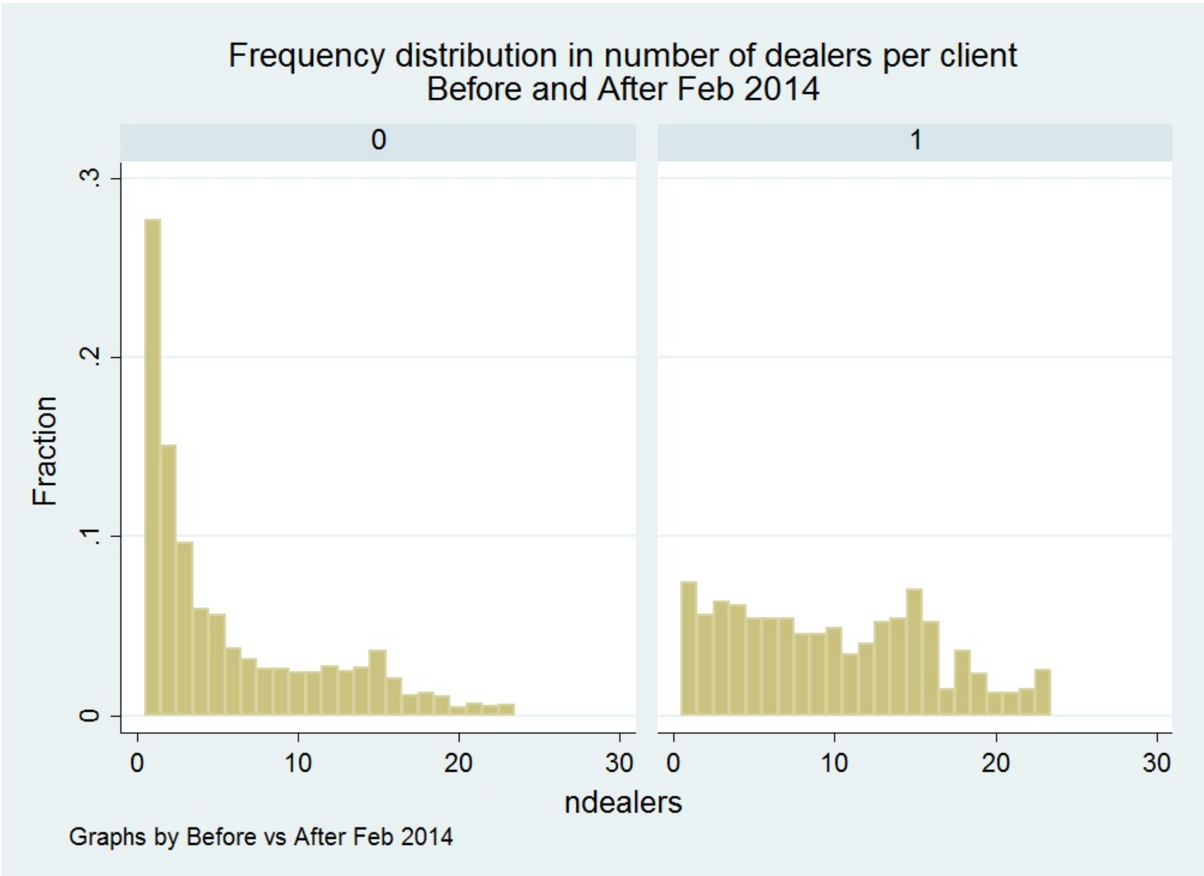


Figure 6: Fraction of US-to-non-US trading. This figure shows the percentage of US-to-non-US trading in USD- and EUR-denominated swaps. The sample covers every spot vanilla interest rate swap transaction reported to LCH. The vertical line marks the introduction of SEFs (October 2, 2013). The time period is January 1, 2013 to September 15, 2014.

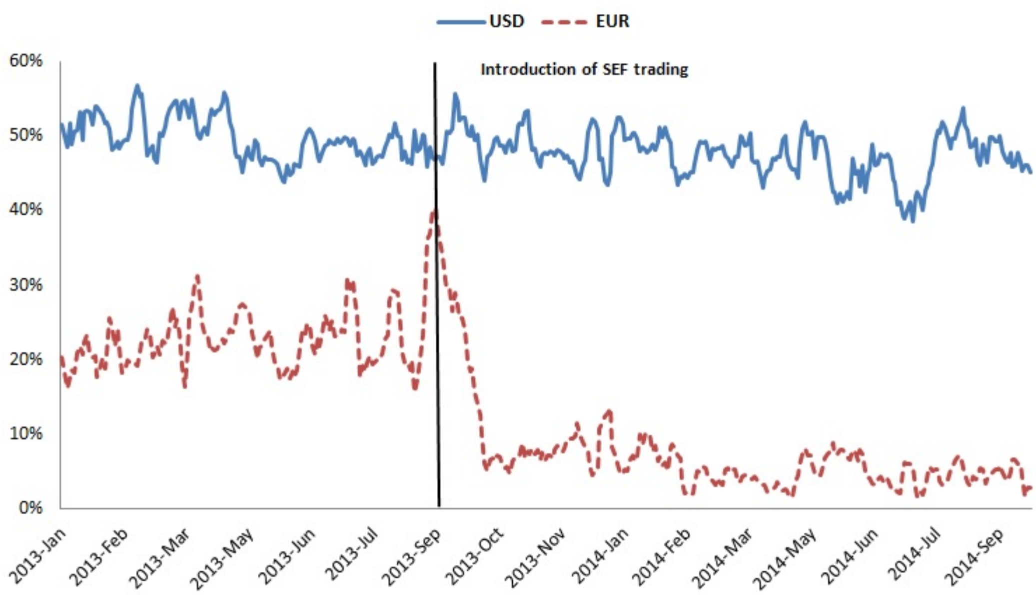


Figure 7: Breakdown of US-to-non-US trading. This figure shows the breakdown of US-to-non-US trading volume in EUR-denominated swaps into inter-dealer volume and all other trading volume. The sample covers every spot vanilla interest rate swap transaction reported to LCH. The vertical line marks the introduction of SEFs (October 2, 2013). The time period is January 1, 2013 to September 15, 2014.

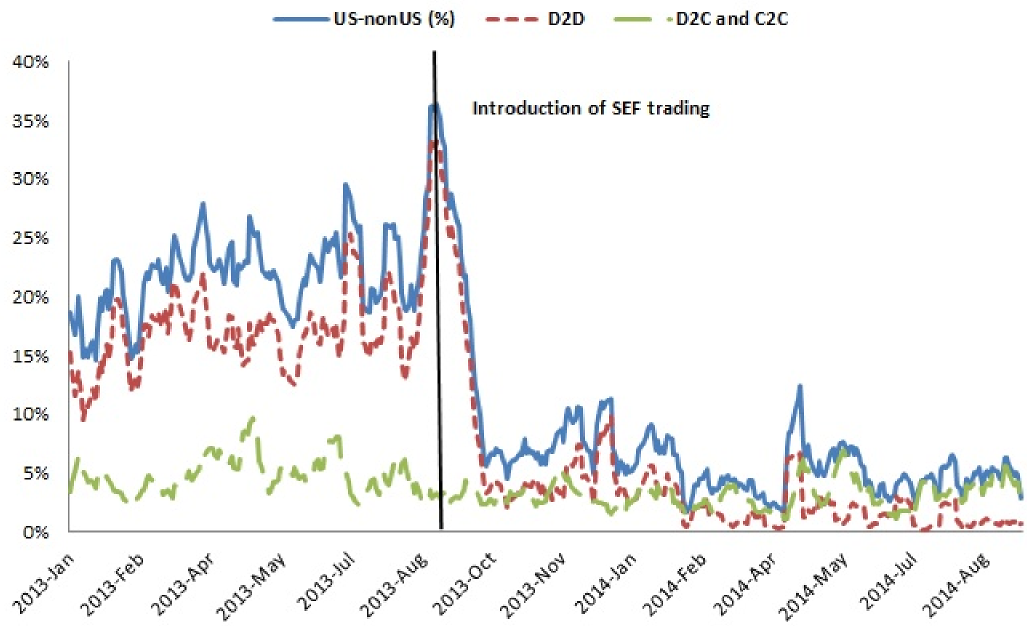


Figure 8: Breakdown of inter-dealer volume by trading desk location. This figure plots the fractions of inter-dealer trading in EUR-denominated swaps executed by US and non-US trading desks, for all swap dealers that have trading desks in the US and at least one more jurisdiction. The sample covers every spot vanilla interest rate swap transaction reported to LCH. The vertical line marks the introduction of SEFs (October 2, 2013). The time period is January 1, 2013 to September 15, 2014.

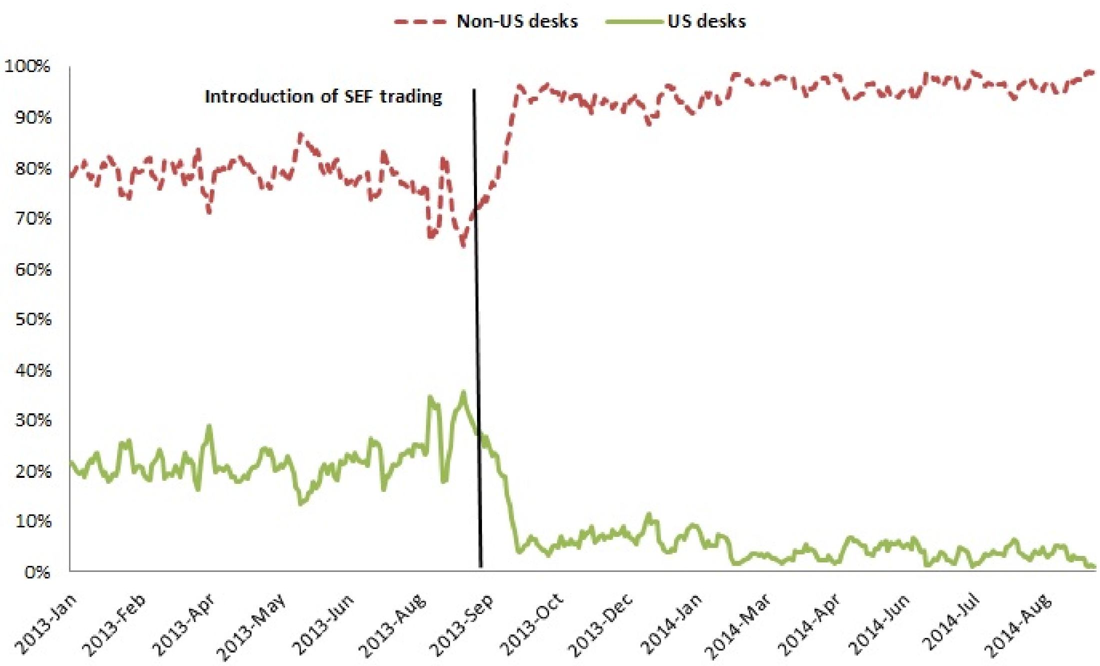


Figure 9: This figure plots the amount of inter-dealer trading in EUR-denominated swaps executed exclusively by swap dealers that have no trading desks in the US. The sample covers every spot vanilla interest rate swap transaction reported to LCH. The vertical line marks the introduction of SEFs (October 2, 2013). The time period is January 1, 2013 to September 15, 2014.

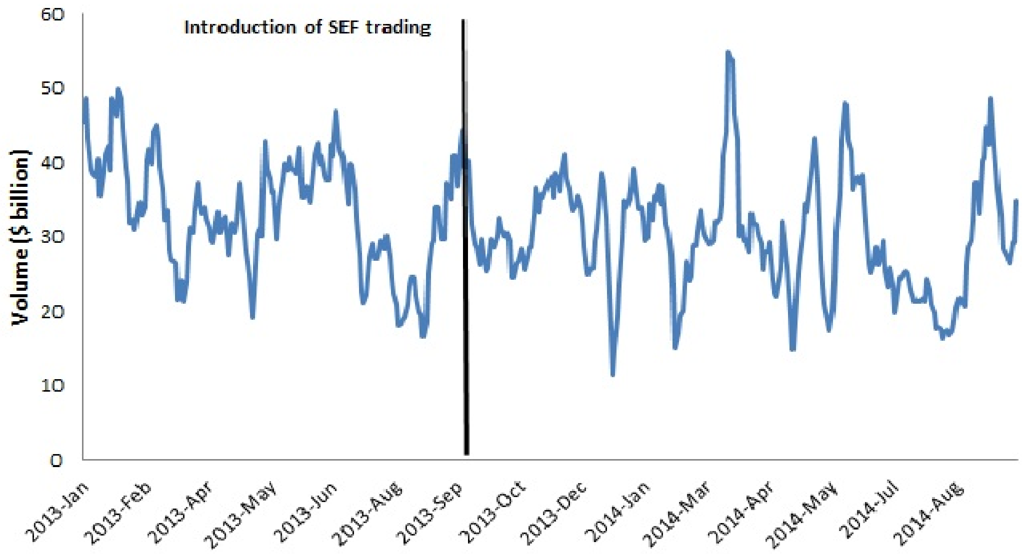


Table 1: SEF trading mandate dates by currency and maturity for plain vanilla IRS contracts used in our study.

Currency	*Maturity*	*Effective date*
USD	2,3,5,7,10,12,15,20,30	15/02/2014
EUR	2,3,5,7,10,12,15,20,30	15/02/2014
USD	4,6	26/02/2014
EUR	4,6	26/02/2014

Table 2: Summary statistics of daily values of the key variables, by currency. The table shows statistics on trading volume (*Vlm*) measured in $ billions; daily number of trades (*Ntrades*); daily unique number of active counterparties (*Nparties*); the fraction of SEF (*SEF*), dealer-to-dealer (*D2D*), and US to non-US (*US-to-non-US*) trading. It also shows statistics on the three dispersion measures, the Amihud price impact measure and the quoted spread as described in Section 4.1. The data consists of all LCH and DTCC reported transactions for USD- and EUR-denominated plain vanilla swaps. The time period is January 1, 2013 to September 15, 2014.

	USD					EUR				
	Mean	*Sd*	*Min*	*Max*	*N*	*Mean*	*Sd*	*Min*	*Max*	*N*
Liquidity variables										
Disp(vw)(%)	0.72	0.47	0	4.16	5875	0.66	0.46	0	3.67	5463
Disp(JNS)(%)	0.91	0.58	0.05	4.29	5875	1.16	0.82	0.07	4.60	5463
Disp(BZ)(%)	1.15	0.90	0	5.67	5875	0.68	0.87	0	6.10	5463
Amihud	14.52	42.03	0.00	1031.75	5870	9.50	17.49	0.00	447.32	5817
QSpread(%)	2.11	1.89	0.39	9.95	5742	3.68	3.48	0.55	42.68	5817
Activity variables										
Vlm ($ billion)	5.66	7.36	0.02	64.58	5875	4.44	4.49	0.06	44.90	5463
Ntrades	72.88	95.18	4	676	5875	39.82	45.36	4	346	5463
Nparties	22.04	12.25	2	61	5740	19.68	8.59	2	49	5791
Market structure										
SEF (%)	0.48	0.44	0	1	5820	0.20	0.32	0	1	5072
D2D (%)	0.54	0.24	0	1	5740	0.61	0.21	0	1	5791
US-to-non-US (%)	0.48	0.21	0	1	5740	0.14	0.16	0	0.96	5791

Table 3: Panel difference-in-difference specification for liquidity variables. We show estimation results of equation (6), where the treatment group are the USD mandated contracts and the control group are the EUR mandated contracts. The liquidity metrics are defined in equations (1)- (5). $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. *Curr* is a dummy that takes the value 1 for USD-denominated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised vartiance of each swap contract calculated using a 30-day rolling window. *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

USD mandated vs. EUR mandated - Liquidity variables

	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**	**QSpread**	**QSpread**	**Amihud**	**Amihud**
$Date^{(1)}$	-0.2121***	-0.2202***	-0.3284***	-0.3435***	-0.2734***	-0.2406***	-0.0033***	0.0015	-2.0908***	-0.4027
	(-10.98)	(-7.16)	(-12.44)	(-6.87)	(-6.28)	(-5.82)	(-3.09)	(1.34)	(-5.86)	(-0.49)
$CURR \times Date^{(1)}$	0.0162	-0.0067	0.0711*	0.0472	-0.0154	-0.0715	0.0038***	0.0038**	-0.1595	-0.0472
	(0.50)	(-0.21)	(1.84)	(1.08)	(-0.25)	(-1.36)	(3.06)	(2.17)	(-0.14)	(-0.04)
$Date^{(2)}$	0.1061***	0.0274	0.2056***	0.0550	0.1155***	0.0908**	0.0110***	0.0049**	2.8727***	1.6492***
	(4.40)	(0.97)	(5.05)	(1.11)	(3.39)	(2.57)	(3.39)	(2.55)	(5.56)	(3.02)
$CURR \times Date^{(2)}$	**-0.1345*** **	**-0.0958** **	**-0.2178*** **	**-0.1514** **	**-0.2152*** **	**-0.1674*** **	**-0.0120*** **	**-0.0074*** **	**-2.5622***	**-2.2233***
	(-4.85)	**(-2.71)**	**(-4.94)**	**(-2.00)**	**(-4.68)**	**(-3.62)**	**(-3.39)**	**(-3.12)**	**(-2.00)**	**(-1.81)**
Swap_RV		34.3884*		55.9020*		45.4654***		4.0545***		323.0161*
		(1.89)		(1.82)		(2.91)		(4.39)		(1.82)
VIX		0.0106**		0.0092*		0.0234***		-0.0003***		-0.3149
		(2.78)		(1.84)		(3.69)		(-3.51)		(-1.71)
VDAX		0.0105**		0.0218***		0.0061		-0.0006*		0.0485
		(2.39)		(3.41)		(0.78)		(-1.95)		(0.71)
$logR_{SP500}$		-2.5999**		-3.2044***		-3.8063*		-0.0036		-73.9144**
		(-2.81)		(-3.22)		(-1.73)		(-0.50)		(-2.40)
$logR_{DAX}$		1.2973*		-2.2878*		6.0851***		0.0158**		-54.2685**
		(2.05)		(-1.81)		(5.59)		(2.66)		(-2.09)
Slope_USD		-0.1114***		-0.1412**		-0.2107***		-0.0118***		-0.3990
		(-3.15)		(-2.75)		(-4.42)		(-5.03)		(-0.32)
Slope_EUR		0.0147		-0.0030		0.1283		-0.0021		-1.3469
		(0.26)		(-0.04)		(1.59)		(-0.82)		(-0.89)
O/N_Spread_USD		-0.4118**		-0.0678		-1.3549***		-0.0014		-9.0355
		(-2.44)		(-0.30)		(-3.69)		(-0.68)		(-0.75)
O/N_Spread_EUR		0.3761***		0.6027***		0.3735***		0.0088***		-3.4391
		(6.09)		(5.82)		(4.92)		(3.39)		(-0.98)
Constant	0.8362***	0.8365***	1.2040***	1.2242***	1.1541***	0.9887***	0.0275***	0.0671***	9.5040***	14.1409***
	(91.65)	(7.60)	(107.22)	(7.70)	(71.52)	(5.30)	(39.65)	(5.99)	(51.45)	(7.93)
Within-R^2	0.054	0.077	0.040	0.067	0.032	0.044	0.078	0.313	0.003	0.005
N	8821	8205	8821	8205	8821	8205	8688	8073	8818	8202

Table 4: Panel difference-in-difference specification for activity variables. We show estimation results of equation (6), where the treatment group are the USD mandated contracts and the control group are the EUR mandated contracts. Vlm is the amount of gross notional traded in US dollars, $Ntrades$ is the number of trades executed and $Nparties$ is the number of unique counterparties active on a given day. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. *Curr* is a dummy that takes the value 1 for USD-denominated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific volatility of each swap contract calculated using a 30-day rolling window. *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

USD mandated vs. EUR mandated - Activity variables

	Vlm	**Vlm**	**Ntrades**	**Ntrades**	**Nparties**	**Nparties**
$Date^{(1)}$	-0.3433**	-0.4270**	-4.2991***	-6.3279***	0.0583	-0.4482
	(-2.61)	(-2.56)	(-2.91)	(-3.46)	(0.27)	(-1.06)
$CURR \times Date^{(1)}$	**2.4496*** **	**2.1238*** **	**22.4662*** **	**18.7042*** **	**1.4968** **	**0.8772**
	(3.15)	**(2.85)**	**(3.29)**	**(2.95)**	**(2.26)**	**(1.39)**
$Date^{(2)}$	-0.7535**	-0.6740	-6.4935**	-10.7412**	-1.1243***	-1.4809***
	(-2.74)	(-1.69)	(-2.37)	(-2.32)	(-3.06)	(-3.70)
$CURR \times Date^{(2)}$	**0.3077**	**0.3333**	**4.0289**	**4.0268**	**1.1234** **	**1.0083***
	(0.77)	**(0.77)**	**(1.16)**	**(1.08)**	**(2.11)**	**(1.91)**
Swap_RV		20.8778		-141.3714		-121.3896
		(0.20)		(-0.16)		(-0.63)
VIX		-0.0227		0.2091		0.0460
		(-0.79)		(0.68)		(0.90)
VDAX		0.1549***		1.6553***		0.2651***
		(3.23)		(3.12)		(4.54)
$logR_{SP500}$		-6.0106		-48.2967		4.5398
		(-1.13)		(-0.90)		(0.54)
$logR_{DAX}$		-4.2459		-119.4527**		-11.2663
		(-1.12)		(-2.10)		(-1.66)
Slope_USD		-0.3819		-3.2920		0.6334
		(-0.96)		(-0.89)		(0.97)
Slope_EUR		1.2889**		3.0552		0.2681
		(2.83)		(0.59)		(0.31)
O/N_Spread_USD		-0.8503		-1.8934		-0.5551
		(-0.78)		(-0.17)		(-0.19)
O/N_Spread_EUR		2.1692***		28.1735***		3.1105***
		(3.83)		(3.54)		(3.36)
Constant	5.6516***	2.9138**	64.8541***	51.1500***	23.0793***	18.1139***
	(25.80)	(2.24)	(30.44)	(3.92)	(100.95)	(11.02)
Within-R^2	0.042	0.049	0.033	0.043	0.013	0.028
N	8821	8205	8821	8205	8821	8205

Table 5: Panel difference-in-difference specification for liquidity variables. We show estimation results of specification (7), where the treatment group consists of the USD mandated contracts and the control group of the USD non-mandated contracts. The liquidity metrics are defined in equations (1)- (5). $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. MAT is a dummy that takes the value 1 for mandated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised variance of each swap contract calculated using a 30-day rolling window. *VIX* is the S&P 500 volatility index and $\log R_{SP500}$ is the log daily return on the index itself. *O/N_Spread_USD* is the difference between the overnight unsecured borrowing rate and the respective central bank rate. *Slope_USD* is the spreads between the 10-year and 3-month Treasury securities. The model is estimated using maturity fixed effects. Standard errors are clustered by maturity. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

USD mandated vs. USD non-mandated - Liquidity variables

	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**	**QSpread**	**QSpread**	**Amihud**	**Amihud**
$Date^{(1)}$	-0.2220***	-0.2362***	-0.3372***	-0.3269***	-0.2520***	-0.3097***	0.0017	0.0052***	-12.6410*	-9.5547
	(-3.87)	(-4.72)	(-6.37)	(-6.91)	(-3.60)	(-5.21)	(0.94)	(3.09)	(-1.89)	(-1.75)
$MAT \times Date^{(1)}$	0.0261	0.0273	0.0799	0.0694	-0.0367	-0.0091	-0.0012	0.0002	10.3859	12.1055
	(0.41)	(0.47)	(1.33)	(1.25)	(-0.44)	(-0.12)	(-0.64)	(0.10)	(1.53)	(1.55)
$Date^{(2)}$	0.0304	0.0140	0.0582**	0.0023	-0.0171	0.0137	0.0012***	0.0019***	8.7194	5.2508
	(1.73)	(0.64)	(2.18)	(0.06)	(-0.74)	(0.40)	(4.52)	(3.19)	(1.37)	(1.09)
$MAT \times Date^{(2)}$	**-0.0589****	**-0.0611****	**-0.0704****	**-0.0742****	**-0.0827***	**-0.0764***	**-0.0022**	**-0.0010**	**-8.4310**	**-8.6509**
	(-2.63)	**(-2.65)**	**(-2.23)**	**(-2.26)**	**(-2.12)**	**(-2.08)**	**(-1.50)**	**(-1.30)**	**(-1.30)**	**(-1.35)**
Swap_RV		4.0546		3.4620		29.2650*		2.6261***		172.3148
		(0.44)		(0.28)		(1.83)		(11.41)		(0.88)
VIX		0.0091*		0.0067		0.0209**		-0.0002**		-0.8607
		(2.01)		(1.30)		(2.54)		(-2.52)		(-1.33)
VDAX		0.0212***		0.0307***		0.0294**		-0.0003***		0.7018
		(4.31)		(4.11)		(2.78)		(-3.70)		(1.10)
$logR_{SP500}$		-5.9413***		-5.5260***		-10.8943***		0.0001		-36.4589
		(-7.76)		(-4.34)		(-4.42)		(0.02)		(-0.41)
$logR_{DAX}$		1.8209***		0.5032		5.2805***		0.0014		-203.7765*
		(3.04)		(0.62)		(3.62)		(0.48)		(-1.92)
Slope_USD		-0.3664		-0.6720***		-0.6065		0.0017		-19.8318
		(-1.74)		(-3.12)		(-1.54)		(0.93)		(-0.98)
Slope_EUR		0.3598***		0.4618***		0.4900***		0.0065***		-4.9971
		(5.48)		(6.12)		(5.28)		(5.14)		(-0.81)
O/N_Spread_USD		-0.1404***		-0.2023***		-0.1637**		-0.0122***		-2.5034
		(-4.83)		(-5.38)		(-2.75)		(-4.03)		(-0.95)
O/N_Spread_EUR		0.1176**		0.1080		0.2354**		0.0064**		-3.6189
		(2.78)		(1.64)		(2.88)		(2.33)		(-1.32)
Constant	0.8441***	0.6170***	1.0916***	0.9398***	1.3402***	0.6650**	0.0208***	0.0403***	16.4692***	26.7056***
	(65.67)	(5.07)	(69.89)	(5.73)	(71.15)	(2.50)	(51.41)	(8.37)	(34.91)	(3.80)
Within-R^2	0.065	0.098	0.065	0.092	0.044	0.072	0.014	0.397	0.004	0.009
N	5875	5453	5875	5453	5875	5453	5742	5321	5090	5041

Table 6: Panel difference-in-difference specification for activity variables. We show estimation results of specification (7), where the treatment group consists of the USD mandated contracts and the control group of the USD non-mandated contracts. Vlm is the amount of gross notional traded in US dollars, $Ntrades$ is the number of trades executed and $Nparties$ is the number of unique counterparties active on a given day. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. MAT is a dummy that takes the value 1 for mandated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific volatility of each swap contract calculated using a 30-day rolling window. *VIX* is the S&P 500 volatility index and $\log R_{SP500}$ is the log daily return on the index itself. *O/N_Spread_USD* is the difference between the overnight unsecured borrowing rate and the respective central bank rate. *Slope_USD* is the spreads between the 10-year and 3-month Treasury securities. The model is estimated using maturity fixed effects. Standard errors are clustered by maturity. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

USD mandated vs. USD non-mandated - Activity variables

	Vlm	**Vlm**	**Ntrades**	**Ntrades**	**Nparties**	**Nparties**
$Date^{(1)}$	0.1963	-0.2287	0.5327	-6.1345***	-0.5161***	-1.9857***
	(1.64)	(-1.12)	(1.24)	(-3.05)	(-3.91)	(-6.32)
$MAT \times Date^{(1)}$	**1.9100****	**1.7259****	**17.6343****	**15.1957****	**2.0712*****	**1.6324****
	(2.43)	**(2.29)**	**(2.61)**	**(2.33)**	**(3.20)**	**(2.73)**
$Date^{(2)}$	-0.0645	0.2186	0.2127	-3.4326	-0.1081	-0.3922
	(-0.30)	(0.56)	(0.41)	(-0.75)	(-0.45)	(-0.83)
$MAT \times Date^{(2)}$	-0.3813	-0.5056	-2.6773	-3.8244	0.1072	-0.1751
	(-1.05)	(-1.41)	(-1.20)	(-1.69)	(0.23)	(-0.41)
Swap_RV		-225.4282		-1824.3714		-548.4686***
		(-1.55)		(-1.46)		(-3.73)
VIX		-0.0023		0.3802		0.1052
		(-0.06)		(0.88)		(1.76)
VDAX		0.1501**		1.5821*		0.1283*
		(2.29)		(2.11)		(1.79)
$logR_{SP500}$		-17.6012**		-123.1580		-7.8017
		(-2.79)		(-1.65)		(-0.92)
$logR_{DAX}$		-5.7087		-165.8872*		-24.8985***
		(-1.23)		(-2.14)		(-3.55)
Slope_USD		2.0095		20.1599		5.0426
		(1.57)		(1.56)		(1.55)
Slope_EUR		2.0631**		32.4400***		3.2482***
		(2.97)		(2.99)		(3.52)
O/N_Spread_USD		-0.0608		-0.2133		1.4658**
		(-0.17)		(-0.05)		(2.37)
O/N_Spread_EUR		1.4410**		3.0573		-0.1475
		(2.54)		(0.46)		(-0.21)
Constant	4.6513***	1.2543	62.1412***	47.1781**	20.9446***	17.4549***
	(14.97)	(0.69)	(20.93)	(2.57)	(62.82)	(7.66)
Within-R^2	0.049	0.061	0.031	0.045	0.013	0.033
N	5875	5453	5875	5453	5875	5453

Table 7: Panel difference-in-difference specification for liquidity variables built from D2C trades. We show estimation results of equation (6), where the treatment group are the USD mandated contracts and the control group are the EUR mandated contracts. The liquidity metrics are defined in equations (1)- (5) but the measures are constructed only from dealer-to-client trade prices. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. *Curr* is a dummy that takes the value 1 for USD-denominated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised vartiance of each swap contract calculated using a 30-day rolling window. *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	USD mandated vs. EUR mandated - Liquidity variables - D2C					
	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**
Date(1)	-0.1683***	-0.1605***	-0.3275***	-0.3344***	-0.2048***	-0.1253***
	(-10.41)	(-5.68)	(-9.25)	(-6.00)	(-5.30)	(-2.94)
Curr × *Date*(1)	-0.0089	-0.0370	0.0672	0.0392	-0.0554	-0.1066*
	(-0.32)	(-1.18)	(1.41)	(0.69)	(-0.97)	(-2.00)
Date(2)	0.0845***	0.0329	0.1912***	0.0545	0.0812**	0.0777*
	(2.86)	(0.94)	(3.96)	(0.89)	(2.24)	(1.76)
Curr × *Date*(2)	**-0.1033*** **	**-0.0679***	**-0.1895*** **	**-0.1264***	**-0.1507** **	**-0.1005***
	(-3.17)	**(-1.80)**	**(-3.54)**	**(-1.96)**	**(-2.83)**	**(-1.95)**
Swap_RV		29.2816**		52.9601*		46.5183***
		(2.37)		(2.07)		(4.30)
VIX		0.0121**		0.0111**		0.0211**
		(2.75)		(2.20)		(2.13)
VDAX		0.0081		0.0216***		0.0086
		(1.67)		(3.45)		(1.00)
*logR_SP*500		-0.8544		-1.6085		-2.3369
		(-0.68)		(-1.53)		(-0.95)
logR_DAX		-0.2588		-4.0102**		2.1912*
		(-0.34)		(-2.73)		(2.03)
Slope_USD		-0.0967**		-0.1177**		-0.1878***
		(-2.66)		(-2.77)		(-2.90)
Slope_EUR		0.0359		-0.0002		0.1464*
		(0.72)		(-0.00)		(1.74)
O/N_Spread_USD		-0.3949**		0.2389*		-1.3315***
		(-2.81)		(1.74)		(-4.23)
O/N_Spread_EUR		0.2905***		0.5729***		0.2035**
		(5.09)		(5.51)		(2.31)
Constant	0.7533***	0.6626***	1.1932***	1.1258***	1.0046***	0.6634***
	(95.34)	(6.59)	(96.84)	(8.52)	(66.20)	(3.59)
R^2	0.035	0.050	0.033	0.056	0.021	0.029
N	8694	8086	8694	8086	8694	8086

Table 8: Panel difference-in-difference specification for liquidity variables for D2C trades. We show estimation results of specification (7), where the treatment group consists of the USD mandated contracts and the control group of the USD non-mandated contracts. The liquidity metrics are defined in equations (1)- (5) but are constructed from dealer-to-client trade prices only. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. *MAT* is a dummy that takes the value 1 for mandated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised variance of each swap contract calculated using a 30-day rolling window. *VIX* is the S&P 500 volatility index and $\log R_{SP500}$ is the log daily return on the index itself. *O/N_Spread_USD* is the difference between the overnight unsecured borrowing rate and the respective central bank rate. *Slope_USD* is the spreads between the 10-year and 3-month Treasury securities. The model is estimated using maturity fixed effects. Standard errors are clustered by maturity. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	USD mandated vs. USD non-mandated - Liquidity variables - D2C					
	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**
$Date^{(1)}$	-0.1979***	-0.1757***	-0.2903***	-0.2757***	-0.2326***	-0.1961**
	(-5.93)	(-5.63)	(-4.52)	(-4.40)	(-3.79)	(-2.70)
$MAT \times Date^{(1)}$	0.0207	0.0134	0.0300	0.0264	-0.0276	-0.0198
	(0.51)	(0.37)	(0.42)	(0.37)	(-0.37)	(-0.30)
$Date^{(2)}$	0.0518***	0.0447	0.0359***	-0.0233	0.0515	0.0983*
	(6.68)	(1.63)	(3.17)	(-0.67)	(1.29)	(1.81)
$MAT \times Date^{(2)}$	-0.0706***	-0.0713***	-0.0342	-0.0393	-0.1210**	-0.1108*
	(-4.44)	(-4.50)	(-1.32)	(-1.59)	(-2.16)	(-2.10)
Swap_RV		7.7447		6.1456		38.8071***
		(1.22)		(0.68)		(3.32)
VIX		0.0104		0.0090		0.0209
		(1.67)		(1.65)		(1.49)
VDAX		0.0176**		0.0267***		0.0254*
		(2.69)		(4.29)		(2.13)
$logR\_SP500$		-3.7757**		-3.8327*		-7.4619**
		(-2.73)		(-2.14)		(-2.24)
logR_DAX		0.4674		-0.1334		1.2727
		(0.50)		(-0.12)		(0.79)
Slope_USD		-0.2546		-0.2468		-0.7301*
		(-1.59)		(-1.51)		(-1.98)
Slope_EUR		0.2419***		0.4442***		0.2265*
		(3.60)		(4.67)		(1.77)
O/N_Spread_USD		-0.1193***		-0.1956***		-0.1436*
		(-4.15)		(-5.36)		(-1.86)
O/N_Spread_EUR		0.0913		0.0726		0.1983*
		(1.69)		(1.04)		(2.03)
Constant	0.7463***	0.4960***	1.0699***	0.9949***	1.1369***	0.3963
	(70.02)	(3.67)	(68.05)	(4.82)	(60.88)	(1.60)
R^2	0.044	0.063	0.047	0.064	0.029	0.047
N	5740	5329	5740	5329	5740	5329

Table 9: Panel difference-in-difference specification for liquidity variables built from D2D trades. We show estimation results of equation (6), where the treatment group are the USD mandated contracts and the control group are the EUR mandated contracts. The liquidity metrics are defined in equations (1)- (5) but the measures are constructed only from inter-dealer trade prices. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. *Curr* is a dummy that takes the value 1 for USD-denominated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised vartiance of each swap contract calculated using a 30-day rolling window. *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

USD mandated vs. EUR mandated - Liquidity variables - D2D

	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**
$Date^{(1)}$	-0.2073***	-0.2077***	-0.3200***	-0.3253***	-0.2745***	-0.2277***
	(-10.57)	(-6.46)	(-12.72)	(-6.52)	(-6.78)	(-4.75)
$Curr \times Date^{(1)}$	0.0194	0.0002	0.0509	0.0240	0.0336	-0.0148
	(0.61)	(0.01)	(1.30)	(0.59)	(0.54)	(-0.27)
$Date^{(2)}$	0.0815***	0.0021	0.1895***	0.0263	0.1039***	0.0521
	(3.43)	(0.08)	(4.56)	(0.50)	(3.95)	(1.29)
$Curr \times Date^{(2)}$	-0.1326***	-0.0923**	-0.2232***	-0.1441**	-0.2137***	-0.1707***
	(-4.40)	(-2.47)	(-4.75)	(-2.29)	(-5.58)	(-3.80)
Swap_RV		34.0819*		64.3465*		36.6113
		(1.75)		(1.89)		(1.67)
VIX		0.0083*		0.0043		0.0180*
		(1.81)		(0.91)		(2.07)
VDAX		0.0124**		0.0260***		0.0113
		(2.57)		(4.04)		(1.28)
$logR_{SP500}$		-2.9483***		-4.1101***		-4.0304*
		(-2.93)		(-3.96)		(-1.81)
$logR_{DAX}$		1.4921**		-1.5449		6.3466***
		(2.18)		(-1.33)		(5.34)
Slope_USD		-0.1337***		-0.1579**		-0.2190***
		(-3.09)		(-2.41)		(-3.80)
Slope_EUR		0.0353		0.0196		0.0962
		(0.52)		(0.21)		(0.93)
O/N_Spread_USD		-0.3408		-0.0427		-1.0397***
		(-1.70)		(-0.18)		(-2.83)
O/N_Spread_EUR		0.4028***		0.6490***		0.4054***
		(5.89)		(6.16)		(3.90)
Constant	0.7820***	0.8072***	1.1886***	1.2133***	1.0276***	0.9657***
	(81.73)	(5.73)	(97.67)	(6.78)	(64.51)	(4.41)
R^2	0.050	0.068	0.039	0.064	0.026	0.034
N	8694	8086	8694	8086	8694	8086

Table 10: Panel difference-in-difference specification for liquidity variables for D2D trades. We show estimation results of specification (7), where the treatment group consists of the USD mandated contracts and the control group of the USD non-mandated contracts. The liquidity metrics are defined in equations (1)- (5) but are constructed from inter-dealer trade prices only. $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading on 2 October 2013 and $Date^{(2)}$ is a dummy variable that takes the value of 1 after the mandate effective dates as per Table 1. MAT is a dummy that takes the value 1 for mandated contracts and is zero otherwise. *Swap_RV* is the daily maturity/currency-specific realised variance of each swap contract calculated using a 30-day rolling window. *VIX* is the S&P 500 volatility index and $\log R_{SP500}$ is the log daily return on the index itself. *O/N_Spread_USD* is the difference between the overnight unsecured borrowing rate and the respective central bank rate. *Slope_USD* is the spreads between the 10-year and 3-month Treasury securities. The model is estimated using maturity fixed effects. Standard errors are clustered by maturity. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	USD mandated vs. USD non-mandated - Liquidity variables - D2D					
	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**
$Date^{(1)}$	-0.2206***	-0.2378***	-0.3670***	-0.3557***	-0.2648***	-0.3111***
	(-5.22)	(-4.58)	(-10.79)	(-10.16)	(-4.75)	(-3.75)
$MAT \times Date^{(1)}$	0.0327	0.0342	0.0979**	0.0843*	0.0239	0.0338
	(0.66)	(0.61)	(2.15)	(2.14)	(0.33)	(0.40)
$Date^{(2)}$	-0.0475*	-0.0618*	0.0050	-0.0448	-0.0388	-0.0239
	(-1.98)	(-2.07)	(0.12)	(-1.03)	(-0.87)	(-0.40)
$MAT \times Date^{(2)}$	-0.0036	-0.0064	-0.0386	-0.0402	-0.0709	-0.0739
	(-0.12)	(-0.21)	(-0.84)	(-0.82)	(-1.34)	(-1.35)
Swap_RV		-0.9503		5.4553		3.1516
		(-0.11)		(0.35)		(0.20)
VIX		0.0086*		0.0045		0.0200*
		(1.80)		(0.99)		(1.88)
VDAX		0.0205***		0.0351***		0.0252**
		(3.73)		(4.12)		(2.24)
$logR\_SP500$		-5.4071***		-4.0018**		-10.6833***
		(-4.94)		(-2.20)		(-4.62)
logR_DAX		1.4733**		-0.3310		4.8861***
		(2.73)		(-0.29)		(3.95)
Slope_USD		-0.0251		-0.4298		-0.3192
		(-0.13)		(-1.55)		(-0.85)
Slope_EUR		0.4794***		0.5890***		0.6621***
		(6.05)		(7.06)		(5.10)
O/N_Spread_USD		-0.2032***		-0.2575***		-0.2880***
		(-5.38)		(-4.70)		(-4.11)
O/N_Spread_EUR		0.1680***		0.1799**		0.2756**
		(3.19)		(2.87)		(2.57)
Constant	0.7450***	0.6464***	1.0580***	0.9113***	1.0981***	0.8199**
	(66.76)	(3.84)	(63.32)	(4.01)	(64.10)	(2.89)
R^2	0.065	0.090	0.062	0.084	0.036	0.057
N	5740	5329	5740	5329	5740	5329

Table 11: Liquidity panel regressions utilizing the SEF variable. We show the estimation results of specification (10) for USD and EUR-denominated mandated contracts and where liquidity variables are the dependent ones. The liquidity metrics are defined in equations (1)- (5). *SEF* is the percent of the total trading volume executed on a SEF, $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading (2 October 2013), *Swap_RV* is the daily maturity/currency-specific realised variance of each swap contract calculated using a 30-day rolling window, *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. The top panel shows the results of fixed effects specifications and the bottom panel shows the results of instrumental variable fixed effects specifications where *SEF* is treated as endogenous and is instrumented using own lags. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	Disp(vw)	**Disp(vw)**	**Disp(JNS)**	**Disp(JNS)**	**Disp(BZ)**	**Disp(BZ)**	**QSpread**	**QSpread**	**Amihud**	**Amihud**
SEF	**-0.1029*****	**-0.2905*****	**-0.0866***	**-0.3367*****	**-0.1993*****	**-0.4126*****	**-0.0011**	**-0.0037****	**-1.0228*****	**-3.2738*****
	(-3.53)	**(-4.69)**	**(-2.06)**	**(-3.45)**	**(-5.24)**	**(-3.26)**	**(-0.64)**	**(-2.37)**	**(-2.85)**	**(-7.75)**
$Date^{(1)}$	-0.1668***	-0.0421	-0.2689***	-0.1110*	-0.1584***	-0.0179	0.0046**	0.0062***	-0.6295	0.5515**
	(-5.74)	(-1.04)	(-6.14)	(-1.74)	(-5.43)	(-0.22)	(2.58)	(6.01)	(-1.61)	(2.05)
Swap_RV	36.7326*	28.8136***	58.5807*	50.1179***	50.8243***	37.2267***	4.2579***	4.1662***	307.1833**	216.7732***
	(2.06)	(5.66)	(1.97)	(6.26)	(3.27)	(3.58)	(4.30)	(32.76)	(2.19)	(6.45)
VIX	0.0104**	0.0091*	0.0076	0.0063	0.0248***	0.0240**	-0.0004***	-0.0003***	0.0788	0.0981***
	(2.61)	(1.95)	(1.36)	(0.86)	(3.74)	(2.53)	(-5.85)	(-2.92)	(1.36)	(3.21)
VDAX	0.0105**	0.0126***	0.0226***	0.0232***	0.0069	0.0100	-0.0005*	-0.0005***	0.0125	0.0018
	(2.53)	(2.66)	(4.00)	(3.11)	(0.86)	(1.03)	(-1.87)	(-4.45)	(0.18)	(0.06)
$logR_{SP500}$	-2.8081***	-3.8429***	-3.6104***	-5.3726***	-4.0848*	-6.0128***	-0.0089*	-0.0163	5.0503	7.5303
	(-3.23)	(-4.38)	(-3.79)	(-3.89)	(-1.84)	(-3.35)	(-2.07)	(-0.74)	(1.10)	(1.28)
$logR_{DAX}$	1.5643**	1.8304***	-1.6442	-0.9388	6.1359***	6.6646***	0.0129**	0.0165	2.9507	0.8081
	(2.45)	(2.96)	(-1.39)	(-0.97)	(5.43)	(5.28)	(2.66)	(1.06)	(0.82)	(0.19)
Slope_USD	-0.1191***	-0.1005***	-0.1434***	-0.1131**	-0.2154***	-0.1888***	-0.0114***	-0.0113***	0.5225	0.5694***
	(-3.59)	(-3.33)	(-2.84)	(-2.38)	(-4.48)	(-3.06)	(-5.35)	(-14.98)	(0.79)	(2.87)
Slope_EUR	0.0348	0.0242	0.0138	-0.0177	0.1151	0.1202*	-0.0034	-0.0037***	-2.7621**	-2.9485***
	(0.68)	(0.74)	(0.16)	(-0.34)	(1.69)	(1.79)	(-1.14)	(-4.54)	(-2.57)	(-13.72)
O/N_Spread_USD	-0.4395**	-0.2934	-0.1624	-0.0694	-1.2867***	-1.0384**	-0.0010	0.0017	0.0271	1.5344
	(-2.44)	(-1.45)	(-0.79)	(-0.22)	(-3.29)	(-2.52)	(-0.42)	(0.33)	(0.03)	(1.16)
O/N_Spread_EUR	0.3808***	0.3620***	0.5816***	0.5575***	0.4126***	0.3934***	0.0093***	0.0097***	-1.4174**	-0.9933***
	(6.39)	(6.67)	(5.90)	(6.53)	(5.18)	(3.55)	(3.51)	(7.07)	(-2.52)	(-2.82)
Constant	0.8235***	0.7988***	1.1915***	1.1929***	1.0237***	0.9509***	0.0684***	0.0692***	10.5183***	10.8236***
	(7.04)	(9.47)	(6.63)	(8.99)	(5.62)	(5.52)	(5.85)	(32.78)	(7.82)	(19.72)
R^2	0.0786	0.0687	0.0664	0.0591	0.0438	0.0415	0.2956	0.2882	0.1281	0.0953
N	7795	7074	7795	7074	7795	7074	7663	6947	7387	6714
Specification	FE	FE& IV	FE	FE& IV	FE	FE& IV	FE	FE& IV	FE	FE& IV

Table 12: Activity panel regressions utilizing the SEF variable. We show the estimation results of specification (10) for USD and EUR-denominated mandated contracts and where activity variables are the dependent ones. Vlm is the amount of gross notional traded in US dollars, $Ntrades$ is the number of trades executed and $Nparties$ is the number of unique counterparties active on a given day. *SEF* is the percent of the total trading volume executed on a SEF, $Date^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading (2 October 2013), *Swap_RV* is the daily maturity/currency-specific realised variance of each swap contract calculated using a 30-day rolling window, *VIX* and *VDAX* are the S&P 500 and DAX volatility indices and $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns on the indices themselves. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. The model is estimated using maturity and currency fixed effects. The top panel shows the results of fixed effects specifications and the bottom panel shows the results of instrumental variable fixed effects specifications where *SEF* is treated as endogenous and is instrumented using own lags. Standard errors are clustered by maturity and currency. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	Vlm	**Vlm**	**Ntrades**	**Ntrades**	**Nparties**	**Nparties**
SEF	**1.0991****	**3.5368*****	**12.5107****	**36.0019*****	**1.1922****	**1.0802**
	(2.39)	**(6.00)**	**(2.46)**	**(5.92)**	**(2.37)**	**(1.20)**
$Date^{(1)}$	-0.1474	-1.5360***	-6.6839**	-20.3018***	-0.9629**	-0.8962
	(-0.83)	(-3.98)	(-2.55)	(-5.11)	(-2.69)	(-1.52)
Swap_RV	-23.0222	52.3171	-486.6971	186.9327	-159.5672	-193.2745***
	(-0.20)	(1.08)	(-0.51)	(0.37)	(-0.83)	(-2.61)
VIX	-0.0002	-0.0135	0.6743*	0.4919	0.0693	0.0403
	(-0.01)	(-0.31)	(1.94)	(1.08)	(1.22)	(0.60)
VDAX	0.1266***	0.1226***	1.1320***	1.0597**	0.2241***	0.2593***
	(3.52)	(2.71)	(2.92)	(2.27)	(3.53)	(3.76)
$logR_{SP500}$	-6.3167	-16.0204*	-30.8376	-134.0619	2.0093	-6.4599
	(-1.32)	(-1.92)	(-0.61)	(-1.55)	(0.30)	(-0.51)
$logR_{DAX}$	-3.3225	-2.2498	-116.5080*	-99.9945*	-9.8547	-9.5957
	(-0.76)	(-0.38)	(-1.92)	(-1.65)	(-1.35)	(-1.07)
Slope_USD	-0.6096	-0.6815**	-7.0445*	-9.0652***	0.3229	0.5465
	(-1.35)	(-2.37)	(-1.73)	(-3.06)	(0.47)	(1.25)
Slope_EUR	1.9408***	2.4542***	14.4390***	20.5942***	1.2597	1.2872***
	(3.81)	(7.84)	(3.15)	(6.38)	(1.58)	(2.70)
O/N_Spread_USD	-0.8207	0.3127	-2.2228	3.8232	-0.5797	2.1097
	(-0.69)	(0.16)	(-0.19)	(0.19)	(-0.19)	(0.72)
O/N_Spread_EUR	2.1873***	2.4904***	27.8625***	32.3748***	2.9634***	3.1571***
	(3.88)	(4.82)	(3.85)	(6.08)	(3.40)	(4.01)
Constant	2.5937*	2.2338***	42.7607***	42.8665***	17.7379***	17.7182***
	(1.90)	(2.78)	(3.37)	(5.18)	(12.67)	(14.47)
R^2	0.0273	0.0122	0.0272	0.0151	0.0237	0.0256
N	7795	7074	7795	7074	7795	7074
Specification	FE	IV & FE	FE	IV & FE	FE	IV & FE

Table 13: Difference-in-differences regression of the number of unique dealers per client. We show the estimation results of model (11). $Ndealers_{it}$ is the number of unique dealers with whom client i trades in month t. $Date_t^{(1)}$ is a dummy variable that takes the value of 1 after the introduction of SEF trading (2 October 2013) and $Date_t^{(2)}$ is the February 2014 mandated trading dummy. US_i is a dummy for clients that are US legal entities and $USACTIVE_i$ is a dummy for US clients who trade more than 20 times a month (on average). Vlm_{it}, $Ntrades_{it}$ and $Ncontracts_{it}$ are the volume traded (in £billions), the number of trades executed and the number of different contracts traded respectively by client i in month t. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	Ndealers	**Ndealers**
$Date^{(1)}$	0.3557*	0.1572
	(1.94)	(1.04)
$Date^{(2)}$	-0.0161	0.0965
	(-0.06)	(0.46)
$US \times Date^{(1)}$	0.1904	0.1875
	(0.59)	(0.68)
$US \times Date^{(2)}$	-0.6695	-0.7345*
	(-1.44)	(-1.92)
$ACTIVE$	**3.6733*** **	**1.9699*** **
	(8.28)	**(5.85)**
$Date^{(1)} \times ACTIVE$	-0.0479	0.3396
	(-0.18)	(1.58)
$Date^{(2)} \times ACTIVE$	0.0066	-0.2495
	(0.02)	(-0.74)
$US \times ACTIVE$	0.6325	0.6239
	(0.95)	(1.17)
$US \times Date^{(1)} \times ACTIVE$	-0.3178	-0.2169
	(-0.59)	(-0.49)
$US \times Date^{(2)} \times ACTIVE$	**1.5754*** **	**1.8168*** **
	(2.62)	**(3.29)**
Ntrades		0.0064***
		(5.83)
Trade size		0.2022
		(0.25)
Ncontracts		0.4966***
		(14.94)
Constant	5.3342***	2.7448***
	(37.99)	(13.32)
Fixed Effects	Yes	Yes
R^2	0.620	0.841
N	2633	2633

Table 14: Time series regressions of the percentage of US-to-non-US volume in the USD and EUR-denominated contracts in our sample. *Date*$^{(1)}$ is a time dummy that takes the value 1 after the introduction of SEF trading on 2 October 2013, *Avg_Swap_RV* is the daily cross-maturity average currency-specific swap realised variance calculated using a 30-day rolling window, $\log R_{SP500}$ and $\log R_{DAX}$ are the daily log returns of the S&P 500 and DAX indices and *VIX* and *VDAX* are estimates of the implied volatility of these indices. *O/N_Spread_USD* and *O/N_Spread_EUR* are the differences between the overnight unsecured borrowing rates and the respective central bank rates. *Slope_USD* and *Slope_EUR* are the spreads between the 10-year and 3-month government securities of the US and the investment grade Eurozone countries respectively. Robust *t-statistics* are shown in the parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. The time period is January 1, 2013 to September 15, 2014.

	US-to-nonUS, % (USD)	**US-to-nonUS, % (EUR - All)**	**US-to-nonUS, % (EUR - D2D)**	**US-to-nonUS, % (EUR - D2C & C2C)**
Date$^{(1)}$	**0.0140**	**-0.1685*** **	**-0.1669*** **	**-0.0009**
	(0.89)	**(-9.40)**	**(-9.47)**	**(-0.13)**
Avg_Swap_RV	-19.1248	-3.0357	-9.2632*	6.3420
	(-0.89)	(-0.46)	(-1.78)	(1.33)
VIX	0.0002	0.0011	0.0037	-0.0027*
	(0.08)	(0.36)	(1.30)	(-1.88)
VDAX	0.0043	-0.0017	-0.0050	0.0036**
	(1.40)	(-0.51)	(-1.56)	(2.28)
$logR_{SP500}$	-0.4936	0.5239	0.7324	-0.2146
	(-0.78)	(0.84)	(1.27)	(-0.79)
$logR_{DAX}$	0.1700	-0.3264	-0.1077	-0.2103
	(0.37)	(-0.82)	(-0.29)	(-1.27)
Slope_USD	-0.0052	0.0059	0.0367	-0.0308**
	(-0.16)	(0.22)	(1.50)	(-2.41)
Slope_EUR	0.0245	0.0251	0.0028	0.0226*
	(0.76)	(1.08)	(0.13)	(1.86)
O/N_Spread_USD	0.1027	-0.2739	-0.2029	-0.0709
	(0.52)	(-1.41)	(-1.34)	(-0.67)
O/N_Spread_EUR	-0.0764	-0.0609	-0.0728**	0.0106
	(-1.63)	(-1.62)	(-2.35)	(0.56)
Constant	0.3749***	0.1589***	0.1078*	0.0469
	(5.60)	(2.61)	(1.88)	(1.47)
R^2	0.080	0.744	0.745	0.153
N	285	285	285	285