The Impact of Mandatory Central Clearing on Interest Rate Swaps Pricing

By Arnob L. Alam *

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Mandatory central clearing was the keystone derivatives market reform in the Dodd-Frank era. This paper examines the impact of the mandate on interest rate swaps pricing. Using data from Depository Trust & Clearing Corporation's Swaps Data Repository around the time of the central clearing mandate implementation and using Canadian-dollar denominated contracts, which were not subject to the clearing mnadate as a comparison group, a 13-14 bps increase in swap premia is observed for US-dollar denominated contracts as a result of the mandate. A similar increase of 7-8 bps is observed comparing contracts denominated in British Pounds (subject to clearing mandate) against contracts denominated in Swiss Francs (not subject to the clearing mandate). Since the central clearing mandate was implemented in phases, the cleared volume and impact on pricing can be examined per phase. Phase 1 of the mandate resulted in a 16 percentage point increase in cleared volumes and 5 bps increase in prices; phase 2 resulted in 12 percentage point increase in cleared volumes and an additional 3 bps increase in prices; although there was no increase in cleared volume in phase 3 prices increased 16 bps. The results are robust to additional controls for contract characteristics and alternative functional forms of the regression model.

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The 2006-2008 financial crisis, the most severe economic downturn since the Great Depression, led to the passage of the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA). A key provision of the DFA required certain financial contracts to be cleared through a central counterparty (CCP). This paper investigates the causal impact of this clearing mandate on prices in the interest rate (IR) swaps market, a major derivatives market used for hedging or speculating on interest rate risk. Despite extensive theoretical literature on central clearing, empirical studies are limited. Earlier research focused on the credit default swaps (CDS) market using event studies. Event studies cannot isolate causal impacts due to potential confounding factors. This paper addresses the gap in the literature by (1) examining the IR swaps market, which is larger and more widely used than the CDS market and (2) using a diff-in-diff approach to identify causal effects of the clearing mandate. Leveraging the fact that initial central clearing rules targeted IR swaps in the four largest currencies traded in the US but did not apply to contracts denominated in other currencies, this paper plausibly identifies the causal impact of the regulation on swaps pricing using a difference-in-differences approach.

The paper is organized as follows: section I provides background on the IR swaps market, the financial crisis, and the clearing mandate's role in post-crisis market reforms; section II reviews the literature; section III develops the theory of interest rate swaps pricing; section IV details my data; section V reviews the identification strategy; section VI discusses the results and section VII concludes.

I. Background

A. *Interest Rate Swaps and Central Clearing*

IR swaps are financial derivatives used to hedge or speculate on interest rate movements. The three most common types of IR swaps include "vanilla" fixed-for-floating swaps, basis swaps, and cross-currency basis swaps, with vanilla fixed-for-floating swaps being the most prevalent (*OTC derivatives statistics at end-*

June 2024 2024). In this type of swap, one party exchanges fixed-rate coupon payments for floating-rate payments on a notional principal (Skarr and Szakaly-Moore 2007).[1] Firms can use these instruments to convert floating-rate risk to fixed-rate risk, and vice versa.

An example of a typical swaps arrangement is depicted in fig. 1. In this example, suppose firm A can borrow $1M at the London Interbank Offer Rate (LIBOR, a common variable interest rate used by banks when lending money to each other) or a fixed rate of 2.0%, while firm B can borrow $1M at LIBOR + 0.25% or a fixed rate of 1.75%. Suppose firm A prefers borrowing at a fixed rate and firm B prefers borrowing at a floating rate.[2] Despite their preferences, firm A has a comparative advantage in borrowing at a floating-rate, and firm B in borrowing at a fixed-rate. To achieve their preferred arrangements, the firms can enter into an IR swap agreement with a $1M notional principal, where firm A receives a floating rate of LIBOR from firm B and pays a fixed rate of 1.75% to firm B. This transforms firm A's floating-rate liability into a fixed-rate one and vice versa for firm B. The IR swaps market allows firms to borrow in the market they have a comparative advantage in and trade for their preferred interest rate arrangement.

Figure 1. : Figure about here

IR swaps can be bespoke contracts, customizable to individual economic needs (Loon and Zhong 2016). As the largest over-the-counter (OTC) swaps market, it accounted for $465 trillion of the $601 trillion global OTC swaps market in 2010 (Kleist and Mallo 2011).[3] For many currencies, there are "standardized" contracts, which have common features and are the most heavily traded (Haynes,

[1] The principal is notional because unlike a real bond it is never exchanged. It is only used to scale fixed and floating rat payments.

[2] This could be because firm A owns fixed-income securities while firm B owns assets that pay a variable rate, and the firms would like to match the duration of their assets with their liabilities.

[3] The IR swaps market had increased to $715 trillion by June 2023 according to an updated version of the same report

Lau, and Tuckman 2020). During the period studied in this paper, the standard US Dollar (USD)-denominated IR swaps contract had semiannual payments for one leg and quarterly payments for the other leg, with the 3-month USD-LIBOR curve used both as the floating-rate reference and for discounting future cash flows (see section III for further explanation). The standard Canadian Dollar (CAD)-denominated contract used 3-month Canadian Dollar Offer Rate (CDOR) as the reference floating rate. In addition to the currency, reference rates and payment frequencies, there are many other contract details, such as day-count conventions, settlement rules and termination rules that need to be specified, and these are listed in more detail in appendix A. The CAD- and USD-denominated standard contracts use the ISDA Master Agreement, which details these contract specifications (Minton 1997). Although contract specifications can be customized to meet the requirements of the counterparties, such non-standard contracts are likely to be less liquid than the standard contracts. Standard contracts denominated in other currencies (e.g. Euro [EUR], British Pound [GBP], and Japanese Yen [JPY]) have their own conventions as well (these conventions are also documented in appendix A).

The IR swaps market is dealer-dominated, with dealer-customer and dealer-dealer trades accounting for 80% of notional value (Bolandnazar 2020). 50% of trades (by notional value) are executed by the largest seven dealers, indicating market concentration among a few dealers. This concentration can impact pricing and market stability in several ways. Larger dealers might be able to reduce search costs by easily finding a counterparty from their large client base. They could also reduce costs by economizing over administrative and warehousing costs of contracts. However, because of their market position, they might have market power and be able to charge a premium over the price that would prevail in competitive markets. The failure of a large dealer (or a dealer's major counterparty) could also drastically reduce liquidity in the system and increase transactions costs.

When a swap is cleared, the initial contract between the two parties is replaced (novated) by two contracts between each party and a central clearinghouse/derivative clearing organization (CCP, DCO or clearinghouse) (Duffie, Scheicher, and Vuillemey 2015; Duffie and Zhu 2011). The clearinghouse becomes the counterparty for each leg (that is, receiving the fixed-rate payments from one party and paying it floating-rate payments, while also receiving the floating-rate payments from the other party and paying it the fixed-rate payments). Under ordinary circumstances, the clearinghouse is a sort of "pass-through" organization that transmits payments from one counterparty to the other. However, if one party fails to meet their contractual obligation, the clearinghouse can still make sure the other party gets paid (Pirrong 2011). For this purpose, CCPs practice risk-control measures and have additional resources to make a counterparty whole in case of default.[4] When counterparties clear their trade through a clearinghouse, they must put up collateral (initial margin) and contribute to a default fund. In case the risk position of the counterparty changes, it can be required to put up additional collateral (variation margin). The CCP also has default fund contributions from other members, its own equity (CCP capital), and access to other lines of credit (such as the Federal Reserve discount window). The combination of these resources makes it unlikely that the failure of one counterparty would drastically affect the whole market. Since clearing members can lose their contribution to the default fund in case of the failure of a counterparty, clearing mutualizes counterparty risk among the members of the CCP.

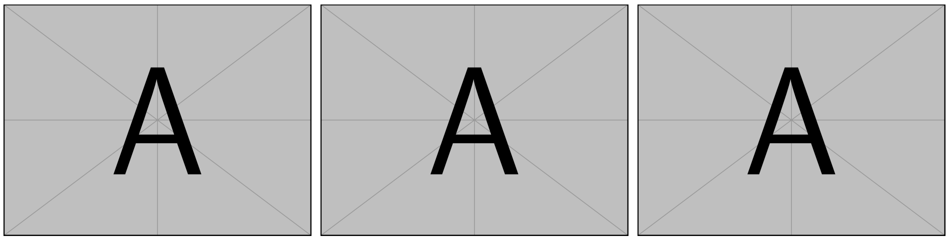
In addition to financial resources, CCPs exercise prudent risk-control measures. These include monitoring members trading positions, requiring risk-adjusted margin contributions and liquidating distressed assets in an orderly fashion when a clearing member fails (Pirrong 2011). Since the CCP can observe all trades that

[4]The clearing counterparty is usually a dealer who is a clearing member at the CCP. "A clearing member is usually a trade intermediary that can deal directly with the CCP. Trade intermediaries that are not clearing members must clear their trades through a trade intermediary that is a clearing member" (McPartland 2009). Trade intermediaries that are clearing members will collect collateral from their non-clearing member clients and pass it on to the CCP.

it is clearing, it has a better picture of overall riskiness than market participants in a bilateral OTC markets have.

Clearing can reduce demand for collateral through a practice called netting (Duffie, Scheicher, and Vuillemey 2015). There are two types of netting practices common in the industry: cross-product netting and multilateral netting. For a CCP that clears multiple types of contracts (e.g., IR swaps, forward rate agreements, overnight-index swaps, credit default swaps, etc.) cross-product netting involves netting across different derivatives products. For example, if firm A owes the CCP \$10 million in collateral for IR swaps, but the CCP owes firm A \$8 million for CD swaps, then firm A can just pay the CCP \$2 million in net collateral.

Multilateral netting involves netting payments across multiple firms. Consider the following example involving 3 firms (illustrated in fig. 2). The set of obligations between the firms are as follows: firm A owes firm B \$100 million and firm C \$200 million; firm B owes firm A \$50 million and firm C \$150 million; firm C owes firm A \$100 million and firm B \$100 million. The total collateral demand in the system is \$700 million. This initial set of obligations is visualized in fig. 2a, where the arrows indicate the direction of the obligation (which firm owes who). Without multilateral netting, the firms can still engage in bilateral netting, as shown in fig. 2b. In a bilateral netting regime, the firms "subtract" or "net out" their payment to each counterparty. Thus, the following payments would be made: firm A would pay firm B (\$100 - \$50) = \$50 million and firm C (\$200 - \$100) =\$100 million; firm B would pay firm C (\$ 150 - \$100) = \$50 million. The total collateral demand would be \$200 million. As shown in the figure, under this arrangement, firm B acts like a pass-through entity that collects payment from firm A and transmits it to firm C. However, if firm B is unable to make the collateral payment, firm C loses some of the collateral it is due. Multilateral netting can eliminate this payment from firm B to firm C (with the CCP now acting as the pass-through entity). Under central clearing and netting firm A would pay the CCP \$150 million and the CCP would pay firm C \$150 million (while firm B would not make any payments at all). The total collateral demand would be \$150 million. Figure 2c graphically depicts this multilateral netting scenario.



(a) subfig about here (b) subfig about here (c) subfig about here

Figure 2. : Figure about here

Originally created for members of futures and equities exchanges (Bernstein, Hughson, and Weidenmier 2019), clearinghouses became more significant with regulations like the DFA (2010) and European Market Infrastructure Regulation (EMIR) (Regulation (EU) No 648/2012 on OTC derivatives, central counterparties and trade repositories 2012) mandating central clearing of derivatives (Menkveld and Vuillemey 2021). Mandated clearing can have macro and micro effects on the swaps market (Pirrong 2011). At the macro level, clearing could reduce volatility but also strain the market through collateral demand during volatile or illiquid periods (especially if margin policies are procyclical). Large enough losses could threaten clearinghouse solvency, transmitting effects to all members. At the micro level, central clearing may change the types of trades firms enter, potentially leading to riskier trades due to mutualized default risk (adverse selection) and riskier post-trade activities (moral hazard). Clearing is subject to economies of scale and scope, which could lead to natural monopolies. However, regulators are likely to prevent this through antitrust regulations and "local clearinghouse" requirements (that is, even though a single clearinghouse for both the US and Europe might have lower costs, US and EU regulators might require separate clearinghouses in each jurisdiction) (Benos et al. 2019). While clearinghouses can reduce default risk and collateral demand, they also require resources for risk management activities, which may increase trading costs.

B. Regulatory Background

Following the 2008 financial crisis, Congress passed the DFA to reform the entire US financial system. Since the OTC derivatives markets played a large role in the crisis, DFA aimed to significantly change how these markets worked. Besides central clearing, key objectives included improving trade data availability for regulators and market participants, standardized trading on electronic platforms, business conduct and capital requirements for major market participants and collateral requirements for non-standard, uncleared swaps (Dodd-Frank Wall Street Reform and Consumer Protection Act 2010). To reduce default risk for large swaps dealers, DFA requires dealers to register with the Commodities Futures Trading Commission (CFTC) or the Securities and Exchange Commission (SEC), adhere to internal business conduct standards and maintain adequate capital (*Dodd-Frank Act,* n.d.). To enhance liquidity, price discovery and transparency, it encourages trading to take place in centralized Swaps Execution Facilities (SEFs, usually electronic trading venues) or Designated Contract Markets (DCMs). To make trade data more readily available, it requires near real-time reporting and dissemination of price information to Swaps Data Repositories (SDRs) and submitting additional data (called primary economic terms) to SDRs and regulators in a timely fashion. Furthermore, the DFA mandates most contracts be centrally cleared (and for uncleared contracts, requires parties to post regulatory margin/collateral to mitigate the effects of default). Table 1 summarizes key CFTC rule-making related to DFA.

Table 1—: Table about here

I now discuss how some of the other regulations (besides clearing) in table 1 could impact swaps pricing. One of the provisions of the DFA that the CFTC implemented at the earliest was the data-reporting/record-keeping requirement. This required certain characteristics of swaps trades, such as the agreed upon rates and prices, to be reported in near real-time through SDRs. The OTC IR swaps market was previously relatively opaque (where quotes were usually obtained on a bilateral basis). The greater price transparency available to market participants after the implementation of the data-reporting regulation is likely to affect pricing and volatility (for example, see Tarbert and Grimm (2021) who study the impact of reporting requirement changes on swaps pricing).

The CFTC also encouraged standardization of swaps contracts by requiring parties to put up additional collateral for non-standard contracts, and for standardized contracts to be traded on electronic swaps execution facilities (SEF)/ exchanges. Since they route request for quotes to multiple dealers and make bids/asks known to all participants, SEFs are likely to increase competition[5], pricing transparency[6] and liquidity.[7] (Mateus and Faltoni 2015; McAlley 2024)

CFTC rule-making also targeted the business conduct of swaps dealers and major swaps participants. This included requiring such entities to register with the CFTC, develop and maintain internal business conduct standards, set aside capital or require margining for trades they enter, segregate customer funds and have plans for unwinding trades in case of bankruptcy. These regulations are likely to reduce the risk/impact of a dealer default and to affect pricing through the reduced counterparty-risk channel.

Regulators collaborated internationally to harmonize regulatory requirements. The US and EU acted nearly simultaneously in enacting the central clearing requirement. EU regulations also affected trading in the UK (London is a major financial center of swaps trading). In Japan and Australia, authorities enacted

[5]because requests for quotes are transmitted to multiple dealers simultaneously
[6]because it would give market participants access to price history, market depth and other market statistics
[7]because it will allow more participants, both dealers and end-users to participate in the market

mandatory central clearing slightly before the US and EU, for contracts designated in their respective local currencies. Other financial centers, such as Hong Kong, Singapore and Switzerland enacted central clearing requirements around the 2016-2017 period. Importantly, Canada implemented a central clearing requirement in May 2017, creating a period between 2013-2017 where IR swaps contracts denominated in Canadian dollars did not need to be cleared either in the US or in Canada. Table 2 summarizes clearing requirements internationally. Note that the table focuses only on the central clearing mandate in a global context, although other regulations (like those described in table 1 for the US) were also enacted internationally as well.

Table 2—: About here

II. Literature Review

A. Interest Rate Swaps

Formal swap agreements were first seen in financial markets in 1981/1982. Bicksler and Chen (Bicksler and Chen 1986) find four uses of IR swaps in the market: (1) to manage mismatches in duration of assets and liabilities, [8] (2) to lower fixed-rate borrowing costs, [9] (3) to restructure a firm's debt mix, and (4) to manage basis risk. The primary economic rationale for the existence of IR swaps is differences between firms' costs to borrow at fixed vs. variable rates arising due to market imperfections. [10]

Smith, Smithson, and Wakeman (1988) present two models of pricing swaps. One model replicates the payoff of a swap through a portfolio of forward or futures contracts. The other model replicates the payoff through a portfolio of floating rate and fixed rate corporate bonds. They note that for a portfolio of bonds, there is an exchange of the principal at the end of the bond term, while for an IR swap the principal is usually not exchanged (that is, it is a notional principal). Thus, the impact of a default is greater for a corporate bond than for an IR swap. Futures contracts on the other hand are exchange-traded, cleared, and settled daily, so the risk of loss due to counterparty default is close to zero. For forwards, the contract value is realized only at the end of the contract period and has greater potential for counterparty default than for futures. An IR swap is somewhere in-between: it is periodically settled (on the payment dates).

Minton (1997) examines these valuation models. He finds that the fixed rate of the IR swap is discounted by 4 bps compared to a replicating portfolio of Eurodollar futures (Eurostrips) and that movements in swap rates and Eurodollar futures rates are highly correlated. When evaluating the portfolio of bonds model,

[8] For example, depository institutions hold long-term fixed rate assets such as mortgages and short-term liabilities such as demand deposits; on the other hand, insurance companies often invest in short term assets that pay a variable rate, such as money market funds, and have long-term fixed-rate liabilities

[9] Borrowers with poor credit can often borrow at a lower cost in the floating rate market

[10] Differences in regulations or credit market imperfections can give firms comparative advantage in borrowing in one market over another

he finds that actual swap rates fall between the rate derived from a portfolio of corporate bonds and the rate derived from Eurodollar futures. Proxies for counterparty credit quality also have a statistically significant impact on pricing, suggesting counterparty risk is a factor in observed swaps pricing.

B. Central Clearing

The policy and market implications of a central clearing mandate are discussed extensively by Pirrong (2011). Per Pirrong, CCPs should clear liquid, standardized products, as illiquid products can pose substantial risks to the CCP. CCP's can reduce the disruptive effect of defaults by drawing on additional sources of capital and facilitating orderly liquidation of positions. However, they can also increase systemic risk by requiring additional margin during periods of financial stress. In addition, by mutualizing the risk of default, they can induce market participants to take more risks (moral hazard and adverse selection issues). CCPs are subject to economies of scale and scope (that is, the market will converge to one or a few large CCPs that can economize over warehousing costs and take advantage of multilateral and multi-product netting.). Since CCPs arelikely to become systemically important financial institutions, regulators must monitor them closely and have prudent measures (to prevent failure or ensure a orderly wind down in case of failure.).

Duffie and Zhu (2011) show that theoretically, concentrating clearing to one CCP can economize on collateral. Benos et al. (2019) explore the issue of economies of scale/scope among CCPs. Regulators in Europe and United States have required "local CCPs" to clear contracts that originate in their jurisdiction. They find that the same contracts trade at different prices when cleared through two different clearinghouses (LCH in the UK/Europe and CME Clearing in the US) and suggest that this difference arises due to increased collateral costs when clearing is fragmented.

Bernstein, Hughson, and Weidenmier (2019) look at the impact of central clearing on equities pricing by examining the prices of the same stocks traded on New York Stock Exchange (NYSE) and Consolidated Stock Exchange (CSE). The NYSE established a clearinghouse in 1892 while the CSE did not. They find that the same stocks on the NYSE traded for 90-173 premium over the CSE price. This result is in line with what I observe for the IR swaps market where mandatory clearing causes a rise in swap premia.

III. Theory

A. Pricing Without Credit Risk

An IR swap can be thought of as an exchange of a series of fixed-rate payments by one party for a series of variable (floating) rate payments by the other party involved in the swap. For the fixed leg, the present value of the payments is given by (Darbyshire 2022):

$$PV_{fixed\,leg} = \sum_{i=0}^{T} \frac{CF}{(1+r_i)^{t_i}} \tag{1}$$

where: CF is the (fixed) cash flow, r_i is the risk-free rate for period i, t_i is the time at which CF will be received and T is the tenor (total length of the contract).

The present value of the floating leg is:

$$PV_{floating\,leg} = \sum_{i=0}^{T} \frac{CF_i}{(1+r_i)^{t_i}} \tag{2}$$

where: CF_i is the floating leg payment for period i, and all the other variables are as defined previously. The present value of the contract for the counterparty paying the fixed leg and receiving the floating leg is[11]

$$PV = PV_{floating\,leg} - PV_{fixed\,leg} \tag{3}$$

Floating rate payments are not known in advance but are usually forecasted by a relevant yield curve (Darbyshire 2022). For example, if the floating leg payment is based on USD LIBOR, a USD LIBOR curve, constructed by interpolating short-term deposit rates, medium-term Eurodollar futures, and long-term instruments like forward rate agreements and existing swaps, is used (Bloomberg L.P. 2024). At the outset of the contract, its value (PV) is zero. This is achieved

[11] (The counterparty's value is given by a similar formula, but with the signs reversed on the right-hand side.)

by determining the present value of the floating leg using the forecasted payments (e.g. using the USD LIBOR yield curve) and then setting the fixed rate payment CF in eq. (1) such that the present values of both legs are equal. The payments are discounted using the same LIBOR yield curve.

B. Pricing With Counterparty Risk

The IR swap market is dominated by a handful of substantial swap dealers (SDs) and Major Swap Participants (MSPs) rather than many small market participants (Bolandnazar 2020). These SDs and MSPs provide buy (bid) and sell (ask/offer) quotes for swaps, potentially finding other participants to balance their swap exposures. Figure 3 depicts a hypothetical network model of such a market. In the figure, three dealers (D) each trade with their set of customers (C). Dealers might engage in inter-dealer trading and bulk futures markets trading (not shown) for cash flow or risk management purposes. Customers can trade with multiple dealers or occasionally engage in bilateral trades among themselves (indicated by arrows going from C to C). Bilateral trades between clients typically have low volume. The Dealer-centric network structure lowers search costs compared to a direct customer-to-customer market (Bolandnazar 2020).

Figure 3. : About here

In practice, customers and dealers must account for the risk associated with counterparties defaulting. The "risk-free" present value pricing in eq. (1) - eq. (3) needs to be adjusted for this risk. If S_i represents the survival probability of the counterparty up to period i the expected present value of the fixed leg is:

$$PV_{floating\,leg} = \mathbb{E}\left[\sum_{i=0}^{T} \frac{CF_i \cdot S_i}{(1+r_i)^{t_i}}\right] \tag{4}$$

The fixed rate payment CF needs to account for the modified PV of the floating leg.[12]

C. Pricing Under Central Clearing

The structure of a dealer-dominated market means that a dealer's failure (possibly due to inadequate risk management or correlated customer defaults) could affect other dealers and potentially the entire market. To counter this, regulators introduced central counterparties (clearinghouses). These clearinghouses void (novate) the initial swap contract and establish two new contracts, mirroring the original, with each counterparty. Now participants only need to be concerned about the clearinghouse's potential default, rather than their counterparties'. Owing to their robust capitalization, regulation, and sound risk management, clearinghouses are perceived to decrease default and contagion risks. Figure 4 visualizes a hypothetical market structure with mandated central clearing. In this picture, the bilateral obligations between dealers (D) and customers (C) have been replaced by contracts between the dealer, customer, and the CCP.

Figure 4. : About here

If clearinghouses can reduce or eliminate counterparty risk, swaps values should be closer to the risk-free case rather than the case with counterparty risk. However, even if clearinghouses are successful at eliminating counterparty risk, additional cost of compliance (such as clearing fees and margin requirements) could keep swaps prices from reaching the risk-free valuation.

I discuss a limitation of the theoretical model. The pricing model assumes risk-neutral valuation of future cash flows. For example, in the case of valuation with counterparty default eq. (4), cash-flows are discounted by the probability of

[12] Swap valuation with counterparty risk requires two adjustments. Only the credit valuation adjustment (CVA) is shown. However, if one defaults on their counterparty, one no longer has to make one's obligated payments, which would increase the value of the contract. This adjustment is called the Debit Value Adjustment (DVA) and not shown above

receiving said cash-flow, captured by the counterparty survival probability up to period i: S_i. Risk-averse investors would require additional discounts to purchase a contract with default risk. If clearing is able to reduce or eliminate counterparty risk, this should enhance the observed results (that is, prices should increase by even more than what risk-neutral models would predict). The pricing model also ignores other risks such as liquidity risk and focuses on credit risk alone. In the empirical section, additional controls (such as contract tenor and notional) are added to capture different liquidity effects for different contracts, but this is not explored in the basic pricing model . Finally, other costs such as margin/collateral are ignored.

IV. Data

A. Data Sources and Collection

The primary dataset used in this analysis consists of trade-level information on IR swaps obtained from Bloomberg's Swaps Data Repository (SDR) screen. Bloomberg compiles and disseminates this data from the Depository Trust and Clearing Corporation's Swaps Data Repository (DTCC SDR), one of the largest repositories designated by the Commodity Futures Trading Commission (CFTC) to collect and maintain records of swap transactions.

The data collection process is governed by the reporting requirements introduced under the DFA. Specifically, the CFTC mandated that swap counterparties report detailed transaction-level data to registered SDRs, such as DTCC, shortly after trade execution (Swap Data Recordkeeping and Reporting Requirements 2012). These reporting obligations, which became effective starting in late 2012, aimed at increasing market transparency and improving regulatory oversight by providing near real-time access to key trade characteristics.

The DTCC SDR dataset from Bloomberg captures detailed trade information, including trade date and time, swap currency, notional value, fixed and floating rates, contract tenor, payment frequency, capped notional indicators, and clearing status. To identify the causal impact of the central clearing mandate, I need to examine a period when other regulations are not varying. The CFTC implemented DFA regulations piecemeal between 2010-2016, leaving only small windows where the impact of the clearing mandate can be studied in isolation (this is discussed further in section V). The dataset spans 20-day windows around the phased implementation of the CFTC's central clearing mandate.

In order to find the fair value fixed rate of a swap, I need to construct relevant yield curves. I also obtain the data for this from the Bloomberg Terminal (YC function). I detail the exact curve building methodology (including the specific curves used) in the next section.

B. Yield Curve Construction and Swaps Pricing

To calculate the theoretical counterparty-riskless price (fair fixed rate) of IR swaps, I forecast future floating rate payments and discount the payments using the appropriate yield curve (that is, the swaps yield curve pertaining to the currency and reference rate that the swap is denominated in). I use a single curve method, the prevalent pricing method during the study period (subsequently, the market switched to a dual-curve method of pricing swaps, not detailed here). For USD swaps, I obtain the USD semiannual fixed-floating rate curve (curve S23) for each trading day from Bloomberg. I similarly obtain the Canadian yield curve (curve S11) from the Bloomberg Terminal for pricing Canadian swaps. I use curve S45 for EUR denominated contracts, curve S10 for GBP denominated contracts and S12 for CHF denominated contracts.

I use the QuantLib-python library to construct the forward curve (Ametrano and Ballabio 2003). Table 3 shows sample data for CAD and USD yield curves on September 11, 2013. For the USD swaps curve, the short-end (3M or less) of the curve is anchored by LIBOR rates; the medium-end (6M – 18M) of the curve is anchored by Eurodollar futures; and the long-end (24M onward) of the curve is anchored by US swap rates (Bloomberg L.P. 2024). For the CAD swaps curve, the short-end (less than 3 months) is anchored by deposit rates (the Canadian Call Loan Rate [CCLR] and the Canadian Dollar Overnight Rate [CDOR]). The medium-end of the curve (3M - 18M) is anchored by Banker's Acceptance Futures and the long-end of the curve (24M onwards) is anchored by observed swap rates. Futures rates need to have a convexity adjustment applied to them due to daily settlement (Bloomberg L.P. 2024). The values reported in the table have this convexity adjustment already applied.

Observable market rate instruments are used to create the "pillars" of the swap curve. Payments that occur between the pillars need to be estimated (and discounted) using some form of curve interpolation.[13] I use piecewise linear interpolation. I verify the curve by pricing contracts using my constructed curve and comparing against calculations by Bloomberg SWPM function. I can match the output of Bloomberg's SWPM up to 4 decimal places.

Table 3—: About here

C. Raw Data Description

The raw dataset is comprised of individual trade-level observations of IR swaps from the DTCC SDR, accessed via Bloomberg's terminal. Each trade observation includes detailed contract characteristics used in my analysis:

- Trade date and time: minute-by-minute timestamp indicating when each swap trade was executed.
- Effective and maturity dates: when the swap agreement begins and terminates.
- Swap currency: denomination currency of the swap (primarily USD and CAD in this paper).
- Notional value: the principal amount used to calculate payments exchanged by counterparties.
- Other payment: whether an initial (upfront) payment is made and if so, how much is this payment amount.
- Fixed and floating rates: the fixed interest rate agreed upon in the swap contract, and the reference rate for floating payments (e.g., LIBOR for USD

[13]for example, at the long-end of the yield curve, market instruments are only observable in one-year intervals (e.g. 10-year forward rate agreements, 11-year forward rate agreements, etc.). But payments usually occur more frequently, such as 10 years, 10.25 years, 10.50 years, etc. The floating rate payments between the pillars and the discount rate need to be interpolated between the two observed pillar dates

swaps and CDOR for CAD swaps). Also, any adjustments to the floating rate reference (e.g. LIBOR + 25 bps).

- Contract tenor: duration of the swap contract from effective date to maturity.
- Payment frequency: interval at which payments are exchanged (e.g. semi-annual for fixed leg and quarterly for floating leg).
- Capped notional indicator: indicator specifying if swaps have capped notional amounts.
- Clearing status: indicator specifying whether a swap was centrally cleared or uncleared.
- SEF indicator: indicator specifyling whether a swap was traded on a swaps execution facility.

The dataset covers trades conducted around the three implementation phases of the CFTC's central clearing mandate: Phase 1 (March 11, 2013), Phase 2 (June 10, 2013), and Phase 3 (September 9, 2013). The periods included in the dataset are the ten trading days before and after each implementation phase, ensuring comparability across pre- and post-regulatory environments.

Table 4 shows the counts and total notional values by floating leg reference. LIBOR was the most common floating leg reference for USD denominated contracts, used for more than 95% of all USD contracts (by both transaction count or total notional value). CDOR was the reference rate for more than 95% of CAD-denominated contracts. Other reference rates for USD contracts included the Fed Funds Rate, Prime Rate, OIS Rate, and several municipal rate indices. A few contracts use a foreign reference rate (COOVIBR is the Colombian overnight rate, IBR is the Colombian equivalent of LIBOR, CLP-TNA is a Chilean rate, CLICP is a Chilean price index). These are likely contracts that are hedging or speculating foreign interest rate or inflation risk but want to be paid in USD. For

CAD-denominated contracts, besides the CDOR, the other reference rate was the Canadian Overnight Repo Rate Average (CORRA, an overnight rate). For USD-denominated swaps, clared conracts trended from 61% of nall contracts prior to implementation of phase 1, to 78% after phase 1, and 89% after phase 2. It stayed at 89% following the implementation of phase 3. For CAD-denominated swaps, clearing hovered between 48%-59%.

Examining total trade volume (measured by summing notional contract amounts across all contracts), USD swaps trading volume increased by about 62% (from \$334B prior to clearing to \$543 after phase 3), while volumes in Canada decreased by 25% (from \$39B to \$29B). Such declines in Canadian trading could be due to seasonal variation, due to traders switching to USD contracts because of safer cleared markets, or due to other reasons. An increase in USD swaps trading volume would be consistent with an increased demand for safer products narrative. Note that there is a dip in uncleared volume following the implementation of phase 1 and 2, not made up fully by the increase in cleared volumes. This suggests that some market participants had difficulty switching from uncleared to cleared markets and may have simply stopped trading . By implementation of phase 3, total volume for USD swaps had increased significantly.

Table 4—: About here

D. Data Filtering and Cleaning

To ensure accuracy and comparability, several filtering and cleaning steps were applied to the raw dataset:

Pricing Threshold Trades with a price (fixed rate) outside ±50 bps relative to Bloomberg's fair valuation of a similar swap contract were excluded. These outliers likely involve unique or non-standard swaps whose relevant features are not captured in the dataset.

Currency and Reference Rate Only contracts denominated in USD and CAD with USD LIBOR (for USD) or CDOR (for CAD) as the floating reference rates were retained, as these are most relevant for the paper.

Other Contract Characteristics Single-payment (zero-coupon) swaps and contracts with non-standard payment frequencies were excluded due to significant pricing differences compared to standard contracts.

Voluntary Clearing Status Contracts that were voluntarily cleared before the central clearing mandate or remained uncleared due to specific exemptions after the mandate were excluded to isolate the causal impact of mandatory clearing.

Trade Delay Contracts whose effective dates were more than 90 days after the trade date were excluded. These contracts have a lower volume than contracts that either execute within 2 days of the trade date or the next international money market date. They have less liquidity and might be priced differently.[14].

In addition, the following data cleaning steps were taken: (1) if the original rates were expressed in basis points,[15] they were converted to percentages by dividing by 100 and (2) usually 'Rate 1' is the fixed leg and 'Rate 2' is the variable leg in the dataset; in some records these legs are "flipped" and corrections were made to account for this.[16]

After data filtering the final population used in the analysis are swaps whose fixed rates are within 50 bps of the fair rate of that contract (as defined by eq. (1)-

[14] There are two types of standardized plain-vanilla interest rate swaps contracts commonly traded on the market. Spot-starting swaps become effective within two business after the trade date (T+2), following standard market conventions for USD swaps. Market Agreed Coupon (MAC) swaps have standardized pricing (for example 5Y swaps have a tick size of 25 bps, so you won't observe rates like 4.3%), standardized tenors (e.g. 2Y, 5Y, 10Y up to 30Y) and standardized coupon payment schedules. They become effective at the next International Money Market (IMM) date. Since the next IMM date can be up to a quarter (about 90 days) away, I only keep swaps that become effective within 90 days of the trade date. Non-standard contracts often have trade dates out into the future (these are called forward starting swaps). For further discussion, see Haynes, et al.(Haynes, Lau, and Tuckman 2020)

[15] Detected by the rate being greater than 10

[16] This flip is identified by the "leg 1" field having a value of "LIBOR" for these contracts, instead of "fixed" as it is ordinarily

eq. (3)), which become effective within 90 days of the trade date and which are not voluntarily cleared prior to the clearing mandate and do not have a clearing exemption after the clearing mandate. In a robustness check (appendix B), I add back contracts that are beyond the 50 bps and show this does not affect the results qualitatively.

E. Descriptive Statistics

Table 5 shows summary statistics of the control variables used in the regressions (see section V). Wednesday was the most active trading day and Monday and Friday were the least active trading days. The dataset includes two trading holidays (Monday May 27, 2013, was Memorial Day and Monday, September 2, 2013, was Labor Day). Data from these days are included in the analysis, but trading volume is low. I split the trading day into 4 sessions based on the reported trade time: 8:00 AM – 10:59 AM (Morning), 11:00 – 1:59 PM (Mid-Day), 2:00 PM – 4:59 PM (Afternoon) and 5:00 PM – 7:59 AM (After Hours). The midday trading session was the most active, but all on-hour (i.e. during business hours) trading sessions have similar levels of activity. Trading in the off-hour trading session was lighter and accounted for about 16% of all contracts that were traded (contrast with 8:00 AM – 5:00 PM trading that accounted for 84% of the volume). The median notional value of the contract was $50M (with a range between $1,000 and $260M). The median tenor was about 7 years (with a range between 2 months and 43 years).

A note on covariate balance: CAD-denominated swaps have important differences for some important contract characteristics. For example, a smaller portion of CAD-denominated contracts (about 8%) are traded during off-hours, compared to about 16% for USD-denominated contracts. That means that there is more liquidity in the USD market for off-hours trading. The average contract size (notional) is about 12% larger for CAD contracts (63.6 million CAD vs. 56.1 million USD) and CAD contracts have significantly shorter tenors (average tenor of

4 years, 10 months vs. 10 years for USD contracts). Tenor, contract size and trade time have significant impact on pricing. If the impact of central clearing remains the same regardless of contract characteristic, the classical difference-in-differences method is an unbiased estimator of the effect of central clearing. However, if this assumption is violated (for example, if pricing has different impacts on contracts of different tenors), the difference-in-differences method is no longer an unbiased estimator. One approach to deal with this issue is to introduce additional controls into the difference-in- differences model. Therefore, contract characteristics are added to the two-way fixed-effects (TWFE) regressions to reduce bias and improve precision.

Table 5—: About here

V. Identification Strategy

This paper aims to analyze the impact of a policy intervention (a change in central clearing rules) on an outcome (interest rate swaps prices) . Adapting the notation of Rubin (1976), let $Y_i(1)$ denote the outcome for unit i when treated, and $Y_i(0)$ denote the outcome when untreated. The causal effect on unit i is represented by $Y_i(1) - Y_i(0)$. I focus on estimating the Average Treatment Effect on the Treated (ATT), $\mathbb{E}[Y_i(1) - Y_i(0) | Treatment_i = 1]$. Since both outcomes cannot be observed at once, I use an appropriate method to estimate the counterfactual $Y_i(0)$.

Modern causal inference offers several methods to estimate this ATT, including randomized control trials (RCT), natural experiments, regression discontinuity designs (RDD), instrumental variables (IV), matching, and difference-in-differences (diff-in-diff) (Angrist and Pischke 2009; Cunningham 2021). I briefly discuss the challenges of applying some of these methods to the research question at hand. In an RDD, units above a threshold value of a covariate receive treatment, while those below do not (e.g., scholarships granted to students above a specific test score). If units cannot precisely control their position relative to the threshold, assignment is "as good as random" close to the threshold, allowing for causal inference (Lee and Lemieux 2010). However, in the context of the clearing mandate, the contract characteristics (e.g., currency, notional value, floating rate index, tenor) can be precisely controlled by market participants. Thus, the assumptions necessary for RDD are not met. The IV approach relies on an instrument that affects the likelihood (or intensity) of treatment assignment. When the treatment variable is endogenous, a straightforward comparison between treated and untreated units could yield biased results. For a valid IV approach, the instrument must be relevant , independent, and satisfy the exclusion restriction (Angrist and Pischke 2009). This approach is also unsuitable here, as CFTC-defined criteria determine clearing, and no external instrument influences clearing likelihood.

The approach adopted in this paper is the diff-in-diff method. In this method, an appropriate comparison group (e.g. Canadian Dollar-denominated contracts) is used to stand in for the counterfactual untreated units. Since this comparison group may differ from the treatment group in important ways an initial pre-treatment difference of the outcome variable between the two groups is calculated. This difference is then compared to the difference after treatment to estimate the causal effect. A key assumption in this approach is that of parallel trends— that, in the absence of treatment, both groups would have followed similar trends and the gap between the outcomes would remain constant (Angrist and Pischke 2009). This is generally not true for Canadian and U.S. swaps markets, given Canada's export-oriented economy, distinct market participants, and independent monetary and fiscal policies, all of which influence swaps pricing. However, I argue that for short periods (e.g., the 20-day windows studied in this paper), the U.S. and Canadian swaps markets are highly coupled. This is supported both by visual inspection of parallel pre-treatment trends, as well as formal statistical tests for parallel trends.

I investigate the causal impact of the central clearing mandate on IR swap prices by comparing the premium over the fair rate[17] on USD denominated swaps versus the premium on CAD denominated swaps before and after the mandate. I employ a diff-in-diff identification strategy, with the CAD denominated swaps acting as the comparison group, which allows me to plausibly isolate the causal effect of the mandate on the swap premiums by exploiting the variation in timing of policy implementation. I begin by selecting a sample of IR swaps denominated in both USD and CAD from the ten trading days before and after the central clearing mandate was implemented. I create two groups based on the currency of denomination: the treatment group, consisting of USD denominated swaps that were affected by the central clearing mandate, and the comparison group,

[17]that is, the difference between the risk-less fixed rate described in section III and the observed fixed rate on an actual contract

consisting of CAD denominated swaps that were not subject to the mandate during the same period. By comparing the swap premiums between these two groups before and after the mandate, I can plausibly identify the causal effect of the policy on swap premiums if both groups would have followed parallel trends in the absence of the clearing mandate.

To estimate the causal effect of the central clearing mandate on swap premiums, I employ a TWFE regression model, which takes the following form:

(5)
$$Y_{i,t} = \alpha + \beta_1 \cdot Treatment_i + \beta_2 \cdot Post_t + \delta(Treament_i \times Post_t) + X_i'\Gamma + \epsilon_{i,t}$$

where $Y_{i,t}$ is the swap premium for swap i at time t, $Treatment_i$ is an indicator variable equal to 1 if the swap is denominated in USD (treatment group) and 0 otherwise (comparison group), $Post_t$ is an indicator variable equal to 1 for the period after the mandate was implemented, and X_i is a vector of control variables. The control variables included in X_i are the day of the week in which the contract is traded, the time (categorized as morning, mid-day, afternoon or off-hours) at which the contract is traded, the logarithm of the notional amount, whether the variable rate is capped, and the tenor of the contract (measured in months). β_1, β_2, δ are coefficients and Γ is a vector of coefficients. The coefficient of interest is δ, which captures the causal effect of the central clearing mandate on swap premiums.

The trading day variable is included because there is some discussion in the asset pricing literature of pricing differences on certain days (e.g., the "Monday effect" for equities. See Cross (1973) and French (1980)). Trading time is also similarly included to account for differences in pricing behavior during certain trading sessions during the day. For example, trading is often concentrated to the 9 AM - 5 PM period, with less trading activity happening in off-hours sessions (see section IV). The lack of liquidity during those sessions can affect pricing. The logarithm of the notional value is included, as there is some discussion in the literature (see Fock (2024) and Randall (2015)) that market participants prefer larger contracts (perhaps to economize over fixed costs) and due to the higher liquidity of these larger contracts, they may be priced differently than smaller contracts. If the notional amount is capped, the true nominal value of the contract is not reported. These are usually for large block trades and often involve large counterparties (*SDR View, Capped Notional Changes* 2013). Finally, the tenor (length of the contract) is included as some tenors (e.g., 10-year contracts) have more liquidity than others.

To ensure the validity of the identification strategy, I test the parallel trends assumption both by visually inspecting and statistically verifying the pre-treatment trends of swap premiums for both treatment and comparison groups and conducting placebo tests. I formally test the parallel trends assumption by regressing the fixed rate against the treatment indicator (i.e. the currency of the contract), time (trade date) and *treatment* × *time* interaction effect, for the two-week period prior to the period of study for phase 1 (that is, from Jan 28, 2013 to Feb 22, 2012). I also include some controls for contract characteristics (a subset of the control variables discussed earlier). I run the regression:

$$Y_i = \alpha + \beta_1 \cdot Treatment_i + \beta_2 \cdot Time + \delta(Treatment_i \times Time) + X_i'\Gamma + \epsilon_i \tag{6}$$

where: $Treatment_i$ is an indicator variable of whether the contract is in the comparison group (currency is CAD) or treatment group (currency is USD) and *time* is a continuous variable (the trade date). This regression is run separately for each tenor of contract (since pricing for different tenors are different). Table 6 shows the results of such a regression for the two-year, five-year, and ten-year contracts. The interaction term ($Currency : USD{*}TradeDate$) is not significant, suggesting the two groups were following parallel trends prior to the implementation of the mandatory clearing policy. Note that there is a 30-88 bps difference between USD and CAD swaps prices (with the Canadian swaps being priced higher; statistically significant). However, the two groups followed parallel during this pre-trend period. The control variables were generally not statistically significant, except for Log Notional for the 10-year contract, which showed a 3 bps increase in price for every 1% increase in the notional value. Although statistically significant, the effect is not large. I defer further discussion of the control variables until section VI.

Table 6—: About here

I also examine whether the parallel trends assumption holds by visually inspecting the swap rate (fixed rate of the IR swaps contract) prior to each phase of the implementation of the clearing mandate. I examine the three most common tenors of USD and CAD IR swaps (2-year, 5-year and 10-year swaps). The data are reported by Bloomberg and are usually the average of 11 or more contracts that meet contract specifications traded around 11:00 AM Eastern Time of the trading day. Figure 5 shows a sample of these trends, specifically the trends for pre-phase 1 for 10-year swaps and the pre-phase 2 for 2-year swaps. Other periods and phases show similar parallel trends but are not included here for brevity. The swaps rates show a parallel pre-trend prior to the implementation of the clearing mandate, with the Canadian swaps rate always higher than the US rate. This is likely due to differences in key policy rates between the US (Fed Funds low target rate 0%) and Canada (key policy rate target 1%). There was no change to these policy rates in 2013.

Figure 5. : About Here

Finally, I test the validity of the parallel trends assumption by performing a placebo diff-in-diff. I pick the 20 trading days before the study period. I create a "placebo" treatment, as if there was a transition to mandatory clearing mandate on the 11th trading day. That is, I run the same type of diff-in-diff described earlier but pick a period when no treatment actually took place. Table 7 shows the results. The placebo diff-in-diff does not show an increase in premia (coefficient of the $Group * Period$ term), further strengthening my belief that the increase in premia discussed in section VI is real. I again defer discussion of the control variables until a later section.

Table 7—: About here

VI. Results

For analyzing the impact of the clearing mandate on prices, I compare USD denominated contracts using LIBOR as the floating rate index, against CAD denominated contracts using the CDOR as the floating rate index. The USD LIBOR contracts are subject to the CFTC clearing mandate while the CAD CDOR contracts are not. Table 8 lists the diff-in-diff results for the swap premium, pooling data from all phases. Column 1 shows a basic model without any controls for contract characteristics. Column 2 (full model) shows the effects additional controls, such as the (log) notional value of the contract, day of the week, and period of trading and whether the notional value was "capped" (i.e., the exact value was not reported to the trade repository).

Per the basic model, the clearing mandate causes an approximately 14 bps rise in premia across the three phases in this model. In the full model with additional controls for contract characteristics, premia rise by approximately 13 bps. These results are qualitatively in line with the theoretical model that reducing the riskiness of the contract increases its price (see section III).

Examining the control variables, beginning with the trading day, and using Wednesday as the reference level, I note that there is a 1.0-3.0 bps increase in the premium depending on the trading day. There is also a 1.0-1.3 bps decrease in the premium for trading in morning, afternoon or off hours trading sessions (as compared to midday). Both results contrast with assumptions of "efficient markets," where there should be no arbitrage opportunities by trading during special days or times. A one percent increase in the notional value is associated with a 0.77 bps increase in the premium. Again, this contrasts with expectations from "efficient market" assumptions because arbitrage opportunities exist (for example, a dealer can make a riskless profit by agreeing to receive a fixed rate on a higher-priced "large" contract and agreeing to pay the fixed-rate for two lower-priced "small" contracts). Finally, a one-year increase in the tenor is associated with a 0.03 bps increase in the premium. Although many of the covariates are statistically significant, the magnitudes of the effects are small, ranging from 0.03 to 3 bps.

Table 8—: About Here

Table 9 shows the result of a diff-in-diff analysis on each phase separately. In phase 1, there is an approximately 5.3 bps increase in premia after the implementation of the mandate. As noted previously, there was a 16% increase in the cleared volume following implementation of phase 1. In phase 2, there was an additional approximately 2.6 bps increase in premia. In phase 3, premia increased by approximately 16 bps. These results generally hold to the idea that as more of the market is cleared, there is a perceived reduction in counterparty risk and swap premia rise. The results are consistent with the pooled diff-in-diff, with most of the effect occurring during the third phase of the mandate.

A note on the R^2 and adjusted R^2 metrics reported in table 8 and table 9. Table 8 pools data from all three periods (covering a time-span from March through September 2013). Other macroeconomic conditions that varied over this time-span could lead to differences in pricing but are not present in the model. In addition, the identities and perceived riskiness of counterparties are not available in the dataset (trades reports are anonymized). A trader's identity (and more importantly, riskiness) likely plays an important role in the pricing of these contracts but cannot included in the model due to lack of data. If we suppose that the identity and riskiness of the trader is less important in a centrally cleared market, we expect this omitted variable to be less of an issue as the central clearing mandate becomes more stringent. We see some evidence of this in table 9. The R^2 and adjusted R^2 are particularly low for phase 1 but improve in phase 2 and 3. If the identity of the trader is more important in a non-centrally cleared market (phase 1), this is exactly what we would expect to see.

Table 10 shows the results of a similar diff-in-diff using an alternative currency

Table 9—: Caption

pair. The CFTC clearing mandate also affected contracts denominated in GBP using the LIBOR as the reference rate (with the same implementation dates as the USD clearing mandate). These contracts now serve as the treatment group. The clearing mandate did not apply to Swiss Franc (CHF) denominated contracts, and these contracts now serve as the comparison group. The clearing mandate had a similar (but smaller) impact on prices of GBP-denominated swaps, further strengthening my belief that clearing reduces counterparty risk and increases contract premia.

Table 10—: About here

VII. Conclusion

This paper investigated the causal impact of the central clearing mandate on the IR swaps market, focusing on pricing. Using a diff-in-diff approach, I isolated the effects of the clearing mandate on swaps prices, observing a 13-14 bps increase in swap premia due to the mandate, in line with theoretical expectations.

The findings suggest that central clearing plays a significant role in reducing counterparty risk. This is reflected an increased valuation for cleared contracts, indicating market participants place a premium on reduced risk exposure.

These results can be important for regulators and market participants to consider, as they highlight both the strengths and unintended consequences of central clearing in maintaining market stability. Regulators could further study the market structure of the IR swaps market, and the impact of market concentration (a few dealers accounting for most trading in the market) on posted quotes and on volatility.

Future research could delve deeper into the long-term effects of central clearing, particularly in crisis periods, and explore whether different market structures or alternative clearing mechanisms might enhance both liquidity and stability in the IR swaps market. In addition, researchers could explore the general equilibrium and welfare implications of central clearing. For example, central clearing did not emerge in the IR swaps market voluntarily (or at least voluntary clearing was limited). Does the top-down central clearing mandate reflect some sort of coordination problem or other market failure mechanism? Central clearing mutualizes risk. Does this lead to moral hazard problems? Under what circumstances would market participants want to voluntarily enter into an institution such as central clearing?

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Appendix: Contract Characteristics

This appendix details the common market conventions for interest rate swaps. It first defines key terms and then lists the conventions for each market.

A1. Definitions

Settlement Settlement refers to the number of business days after the trade date when the swap contract is finalized, and payments are made (Hull, 2022). The most common conventions are T+0, T+2, and T+3, where "T" represents the trade date, and the number indicates how many business days after the trade date settlement occurs. For example, in a T+2 settlement, the settlement occurs two business days after the contract is executed.

Fixed Leg The fixed leg of an interest rate swap refers to the portion of the swap where the payer makes periodic payments at a fixed interest rate, which is predetermined and remains constant throughout the life of the swap (Hull, 2022). The characteristics below describe various conventions associated with this leg.

Payment Frequency This defines how often payments are made on the fixed leg. For instance, "semiannual" means payments are made twice a year, while "annual" means once a year.

Business Day Adjustment Convention When a payment date falls on a non-business day, this convention dictates how the date is adjusted. All the contracts in this paper use a "modified following" convention. A modified following convention means payments are pushed to the next business day unless that day falls in the next month, in which case payments are moved backward to the preceding business day.

Adjustment Type Adjustment type refers to which dates are adjusted when a business day adjustment is necessary. For example, in "Accrual and Payment Dates" adjustment, both the accrual period and the payment date will be adjusted if necessary.

Roll Convention The roll convention specifies how payment dates are set relative to a reference date, typically whether payments move forward or backward when adjusting for business days. A "backward" roll moves the date to the nearest preceding business day, while "Backward (EOM)" additionally ensures payments align with end-of-month periods.

Accrual Calculation Calendar This calendar determines which set of business days are considered in calculating the accrual of interest payments. For example, the "US Federal Reserve" calendar includes only U.S. federal holidays, while the "England" calendar takes U.K. public holidays into account.

Pay Delay Pay delay refers to the number of days between the payment due date and the actual date the payment is made. For instance, "0 days" means payments are made on the due date.

Day Count Convention This convention determines how interest accrues over time, using fractions of a year based on the number of days between two dates . Common conventions include:

- **30I/360** Assumes each month has 30 days and a year has 360 days. It simplifies calculations but may deviate slightly from actual time. If the start date of the day count is on 31st, it is treated as if it is the 30th. If the end date is on the 31st, then it can either be treated as the 30th or the 31st depending on the start date. It also includes special rules for when either the start or end date of the day count convention is Feb 28/29.
- **30E/360** Like the 30I/360 convention, but if either the start or end dates are on the 31st, they are treated as if they are on the 30th. February 28/29 is always treated as 30th.

ACT/365.FIXED Uses the actual number of days in a period, divided by a fixed 365-day year for calculating partial year interest rate accrual.

Actual/360 Uses the actual number of days between dates, but assumes the year has 360 days when calculating partial year interest payments.

Floating Leg The floating leg of the swap is the leg where payments are made based on a variable interest rate, which changes over time based on a reference index (Hull, 2022). Besides the floating leg counterpart of the definitions/conventions discussed for the fixed leg, the additional conventions/definitions below describe how these payments are structured.

Reference Index The reference index is the benchmark interest rate that dictates the floating payments. Common indices include: USD LIBOR 3M, CDOR 3M, GBP LIBOR 6M, CHF LIBOR 6M

Reset Frequency This determines how often the floating rate is recalculated or "reset." For example, a quarterly reset means the floating rate is updated every three months.

Fixing Calendar This refers to the calendar used to determine when the floating rate is fixed or set. For example, the "England" fixing calendar means rates are set according to U.K. business days.

Fixing Lag Fixing lag defines how many days in advance the floating rate is determined before the payment period begins. For instance, a "2 business days" fixing lag means the floating rate is set two days before the payment is due.

Reset Position "Advance" reset position means the floating rate is set at the beginning of the interest period and applied throughout the period.

A2. Contract Characteristics

Table A1—: About here

Appendix: Robustness Checks

This appendix provides several robustness tests to my analysis. Firstly, in the main body of the paper, in the analysis of the clearing mandate on swap pricing, I filtered out observations that were +/- 50 bps from the Bloomberg terminal calculated fair rate. I now present an alternate version of tables table 8 and table 9, now including these outliers. Overall, there were 1,101 such outliers (representing about 4% of the overall dataset). Results continue to be very similar to the results found in the main body. In this broader dataset, clearing causes a 12-bps rise in swaps prices for USD contracts in the overall dataset. Most control variables also show similar results to what is found in the main body. The notable exceptions are tenor (where a one-year increase in the tenor is now associated with a 0.03 bps increase in the premium instead of a 4-bps decrease) and Friday trading (which is now associated with a 0.95 bps increase in the premium rather than a -0.78-bps decrease). The group difference (that is the difference in baseline premium for USD over CAD contracts) also becomes not statistically significant. Note that the effect of these control variables is small (less than 1 bps).

Table B1—: About here

Table B2—: About here

Also, as is sometimes done in literature, I drop observations on the first trading day of each phase that the clearing mandate went into force (to mitigate the effects of program implementation effects). Results continue to show similar patterns as found in the main body of the paper. The mandate causes a 12-bps rise in premiums for US-contracts after implementation. Control variables show similar signs and magnitude as is discussed in the main body of the essay.

Table B3—: About here

The diff-in-diff in the main body of the paper is a restrictive model that assumes that central clearing has the same effect on all tenor of contracts. I remove this restriction in the table below by interacting the tenor with the group and treatment indicators. The parameters of interest are $Group * Period$ and $Group * Period * Tenor$. These parameters indicate the baseline treatment effect is 20 bps, with the effect diminishing for longer tenor contracts (by about 1.43 bps/year).

Table B4—: About Here

Finally, given the low R^2 values of some of the regression results, I try alternative regression specifications. Table B5 shows the results of a model with second-order terms for the continuous control variables tenor and notional. Although these higher order terms are statistically significant, the model still suffers from the same low R^2 as the model used in the main body of the paper. The overall conclusion remains the same (clearing causes a 13-bps increase in premium for USD contracts). Control variables also show similar signs and magnitudes as in the main body of the essay.

Table B5—: About Here

Figures and Tables

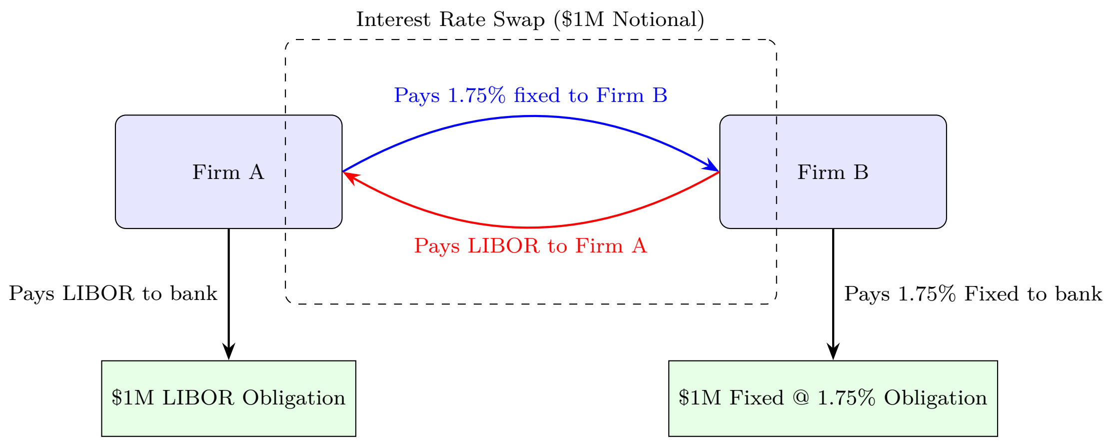
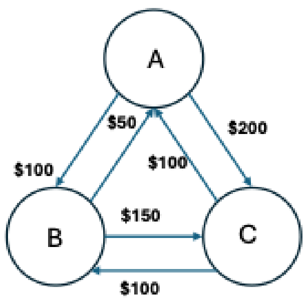
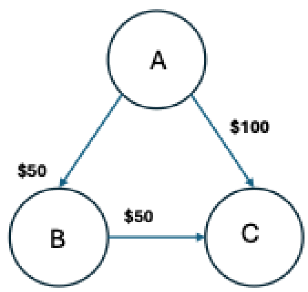


Figure C1. : Example of an interest rate swap between two firms.

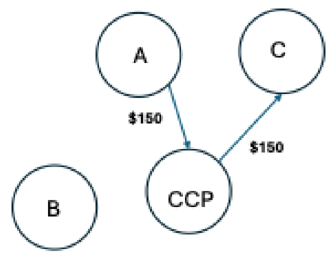
Note: Firm A wants to convert $1M worth of fixed rate obligations to floating rate obligations. Firm B wants to convert $1M floating rate obligations to fixed rate obligations. The firms enter into a plain-vanilla fixed-for -floating interest rate swap to transform their obligations.



(a) A market with no netting or clearing

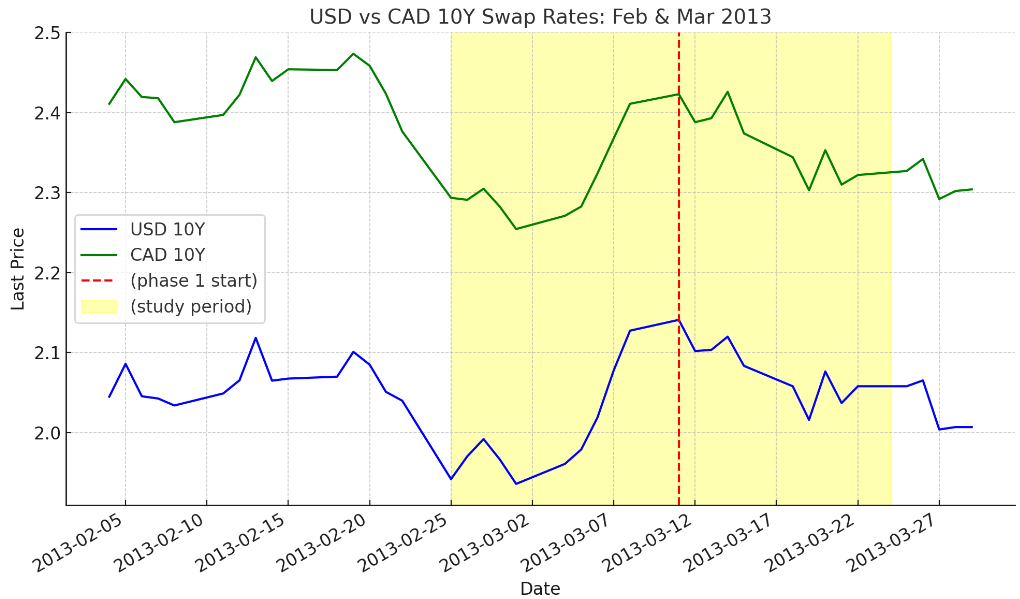


(b) A market where participants bilaterally net obligations

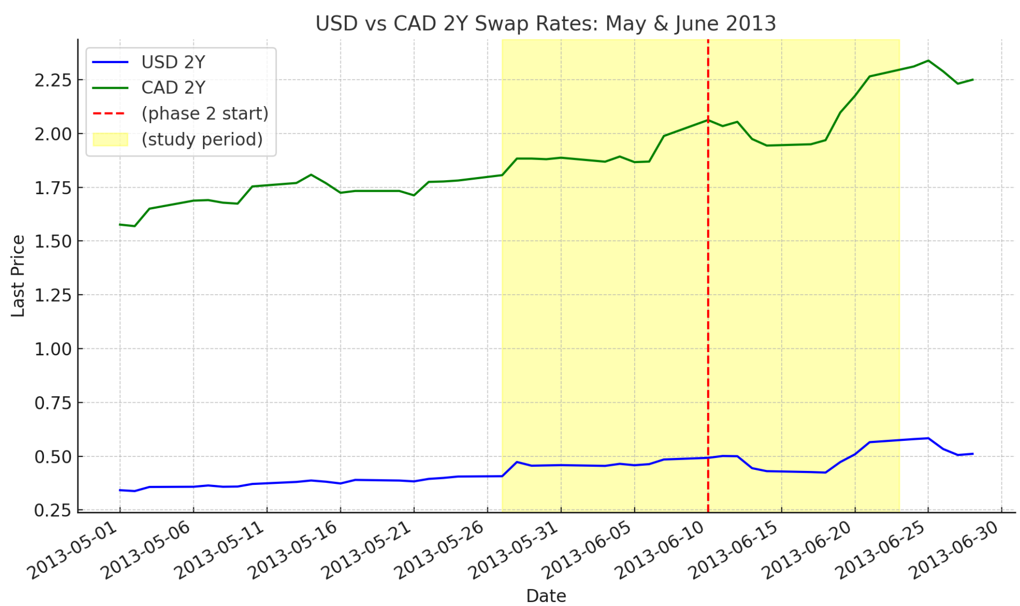


(c) A market where a clearinghouse (CCP) nets obligations multilaterally

Figure C2. : Example of obligations and netting between three firms under different institutional arrangements



(a) 10-year swaps during phase 1



(b) 2-year swaps during phase 2

Figure C3. : Pre-trends for swap pricing.

Note: Red, dashed vertical line indicates when the clearing mandate went into effect. Highlighted area is the period of study, and the pre-trend is to the left of the highlighted area. If the lines to the left of the vertical, red-dashed line look parallel (as it does in this case), it indicates that the two markets were following parallel trends. Specifically, we see that in the 30-days captured to the left of the red-dashed line, CAD and USD swaps were following parallel pricing trends.

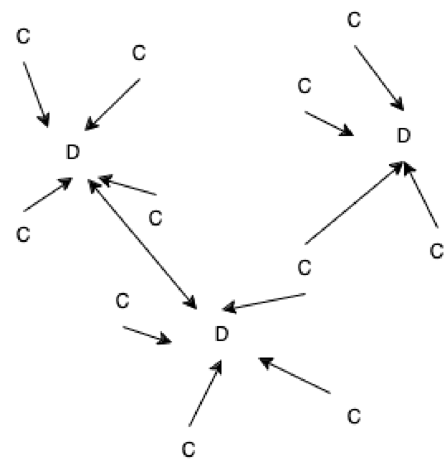


Figure C4. : A dealer-intermediated market without central clearing

Note: Three dealers (labeled *D*) trade with many customers (labeled C). Dealers can engage in inter-dealer trades (indicated with arrows between D and D), and customers can trade with multiple dealers (indicated with arrows from one C to multiple D) or with other customers directly (indicated by arrows from C to C).

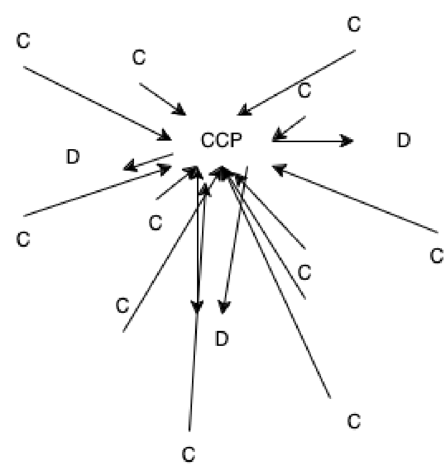


Figure C5. : Dealer-based Market with Central Clearing

Note: The obligations between customers and dealers, customers and customers, and between dealers are replaced by obligations between the CCP and the counterparty (dealer/customer).

Table C1—: Major Rule-Making Areas of the Dodd-Frank Act.

Rule-making Area	**Major Rules**
Swaps Dealers & Major Swaps Participants	Registration (Mar 2012); Internal Business Conduct Standards (Jun 2012); Capital and Margin for non-banks (2016; Sep–Nov 2020); Segregation (Apr 2012) and Bankruptcy (Feb 2012)
Data Requirements	Data record-keeping and reporting requirements (Oct 2010, Dec 2010, Mar 2012); Swap Data Repositories (SDR) Registration (Oct 2011); Real Time Reporting (Mar 2012); Large Swaps Trader Reporting (Sep 2011)
Clearing Requirements	Establishment of Derivatives Clearing Organizations (DCO/CCP) (Jan 2012); Clearing requirement for most common swaps (Mar–Sep 2013); Margining requirements for uncleared swaps (Apr 2016)
Trading Requirements	Establishment of Swaps Execution Facilities (SEF) (Jun 2013); Made Available for Trade (MAT) designation/requirement (Jun 2013)
Position Limits	Position Limits and Aggregation of Positions (Jan 2012)
Enforcement	Disruptive Trading Practices (Mar 2011); Anti-Manipulation (Aug 2011); Whistleblowers (Aug 2011)
Other	Reliance on Credit Ratings (Jul 2011); Fair Credit Reporting Act (Jul 2011); Investment Adviser Reporting (Nov 2011); Volcker Rule (Jan 2014); Cross-Border Applications (Jan 2013)

Note: The CFTC interpreted the DFA to contain six major rule-making areas (as well as a seventh, "other" area for miscellaneous rules). Specific rules within each rule-making area are listed on the right.

Table C2—: Summary of Central Clearing Requirements in Major Financial Centers.

Jurisdiction	**Relevant Laws and Regulations**
North America	DFA (2010) and CFTC and SEC rulemaking require mandatory clearing of IR swaps contracts denominated in USD LIBOR, GBP LIBOR, EURIBOR, and JPY LIBOR by Sep 2013. Additional currencies and classes of contracts are added in 2016 to harmonize regulations across jurisdictions. Canada requires certain CAD-denominated swaps to be cleared starting in May 2017.
Europe	EMIR passes in 2012, requiring clearing of certain IR swaps contracts. Regulations come into effect in Mar 2013. Bank of England issues guidance in Apr 2013, reiterating EMIR applicability to UK-based traders. Additional currencies and swaps added in 2016. Switzerland established a clearing mandate in 2017.
Asia	JFSA requires JPY IR swaps referencing JPY LIBOR to be cleared by end of 2012. Hong Kong requires HKD swaps to be cleared starting Jul 2017. MAS requires SGD contracts to be cleared by Dec 2017.
Australia	CFR passes legislation requiring mandatory clearing of AUD IR swaps by end of 2012.

Note: Japan and Australia required mandatory clearing of JPY-denominated and AUD-denominated contracts traded in their jurisdictions starting at end of 2012. The US and EU required mandatory clearing (for contracts in various currencies) starting in the first half of 2013. Other countries enacted similar requirements between 2013 and 2017.

Table C3—: Number of contracts and notional values by clearing status and reference rate for USD and CAD interest rate swaps (unfiltered data set). Data are presented for each phase separately; within each phase, pre- and post-implementation periods are shown.

CUR	Floating Leg	Cleared Count	Cleared Notional	Uncleared Count	Uncleared Notional	% Cleared
Pre Phase 1 Implementation (Feb 25 – Mar 8)						
USD	LIBOR	3,518	203,345.90	3,071	131,242.01	61%
	USD-Federal Funds-H.15	0	0.00	16	2,183.00	0%
	USD-PRIME-H.15	0	0.00	2	6.00	0%
	USD-PRIME-H15	0	0.00	2	4.00	0%
	USD SPRDL MANUAL	0	0.00	1	100.00	0%
	USD-AAA_MUNI-	0	0.00	4	31.00	0%
	USD-OIS-3	0	0.00	1	6.00	0%
	IBR	0	0.00	2	200.00	0%
	CLICP	0	0.00	1	100.00	0%
	TIS	0	0.00	1	1.00	0%
	USD-USPSA-BLOOMBERG	0	0.00	1	4.00	0%
CAD	CAD-BA-CDOR	225	18,811.40	308	20,363.10	48%
	CAD-REPO-CORRA	0	0.00	3	410.00	0%
Post Phase 1 Implementation (Mar 11 – Mar 22)						
USD	LIBOR	4,342	262,257.70	2,125	76,649.65	77%
	USD-Federal Funds-H.15	0	0.00	24	3,353.00	0%
	IBR	0	0.00	6	1,050.00	0%
	USD-SIFMA Municipal Swap Index	0	0.00	6	60.00	0%
	USD-PRIME-H.15	0	0.00	2	6.00	0%
	USD-PRIME-H15	0	0.00	2	3.00	0%
	USD-Prime-H.15	0	0.00	1	2.00	0%
	USD-USPSA-BLOOMBERG	0	0.00	2	20.00	0%
	CLICP	0	0.00	3	450.00	0%
	USD-AAA_MUNI-	0	0.00	2	25.00	0%
	USD-BMA Municipal Swap Index	0	0.00	2	6.52	0%
CAD	CAD-BA-CDOR	126	9,578.00	140	11,137.31	46%
	CAD-REPO-CORRA	0	0.00	3	780.00	0%
	CDOR	0	0.00	5	105.60	0%

Note: Notional values are in millions of currency units.

CUR	Floating Leg	Cleared Count	Cleared Notional	Uncleared Count	Uncleared Notional	% Cleared
Pre Phase 2 Implementation (May 27 – Jun 7)						
USD	LIBOR	6,870	426,753.26	2,954	118,388.28	78%
	USD-Federal Funds-H.15	0	0.00	29	4,463.00	0%
	COOVIBR	0	0.00	9	1,800.00	0%
	CLP-TNA	0	0.00	6	1,200.00	0%
	USD FORM 3750	0	0.00	1	100.00	0%
	USD-AAA_MUNI-	0	0.00	2	13.00	0%
	USD-BMA Municipal Swap Index	0	0.00	1	7.00	0%
	USD-PRIME-H.15	0	0.00	12	62.90	0%
CAD	CAD-BA-CDOR	180	14,726.00	169	14,290.70	51%
Post Phase 2 Implementation (Jun 10 – Jun 21)						
USD	LIBOR	7,975.00	461,124.51	1,449.00	53,548.33	90%
	USD-Federal Funds-H.15	0.00	0.00	33.00	5,068.00	0%
	USD-PRIME-H.15	0.00	0.00	5.00	26.00	0%
	USD-PRIME-H15	0.00	0.00	1.00	9.00	0%
	USD-Prime-H.15	0.00	0.00	1.00	2.00	0%
	COOVIBR	0.00	0.00	21.00	3,750.00	0%
	CLP-TNA	0.00	0.00	7.00	700.00	0%
	USD BMA MANUAL	0.00	0.00	1.00	45.00	0%
	USD-AAA_MUNI-	0.00	0.00	3.00	20.00	0%
	USD-BMA Municipal Swap Index	0.00	0.00	2.00	10.00	0%
CAD	CAD-BA-CDOR	176.00	11,322.08	174.00	7,969.50	59%

Note: Notional values are in millions of currency units.

CUR	Floating Leg	Cleared Count	Cleared Notional	Uncleared Count	Uncleared Notional	% Cleared
Pre Phase 3 Implementation (Aug 26 – Sep 6)						
USD	LIBOR	6,112.00	396,744.28	1,398.00	47,355.82	89%
	USD-Federal Funds-H.15	0.00	0.00	36.00	4,539.00	0%
	USD-PRIME-WEIGHTED-AVERAGE	0.00	0.00	2.00	200.00	0%
	USD-PRIME-H.15	0.00	0.00	5.00	7.00	0%
	USD-PRIME-H15	0.00	0.00	8.00	35.56	0%
	USD-AAA_MUNI-	0.00	0.00	1.00	10.00	0%
	USD-SIFMA Municipal Swap Index	0.00	0.00	1.00	5.00	0%
CAD	CAD-BA-CDOR	128.00	9,697.20	134.00	7,487.11	56%
	CAD-REPO-CORRA	0.00	0.00	1.00	35.00	0%
Post Phase 3 Implementation (Sep 9 – Sep 20)						
USD	LIBOR	7,481	485,507.61	1,461	58,912.20	89%
	USD-Federal Funds-H.15	0	0.00	19	3,606.00	0%
	TREASURY_DTCC_GCF_REPO_INDEX	0	0.00	4	850.00	0%
	USD FORM 3750	0	0.00	1	30.00	0%
	USD-AAA_MUNI-	0	0.00	9	56.00	0%
	USD-BMA Municipal Swap Index	0	0.00	3	13.00	0%
	USD-BMA-BMA	0	0.00	1	22.00	0%
	USD-BMA-REFB	0	0.00	2	12.75	0%
	USD-PRIME-H.15	0	0.00	7	17.00	0%
	USD-PRIME-H15	0	0.00	7	64.00	0%
	USD-Prime-H.15	0	0.00	1	1.00	0%
	USD-SIFMA Municipal Swap Index	0	0.00	5	52.75	0%
CAD	CAD-BA-CDOR	210	14,099.00	354	15,561.41	48%
	CDOR	0	0.00	1	5.00	0%
	CDOR.CAD	0	0.00	4	106.00	0%

Note: Notional values are in millions of currency units.

Table C4—: Sample data for construction of USD and CAD swaps curves.

Tenor	Bloomberg CUSIP	Yield	Data Source
3M	EDU13 Comdty	0.2575	BGN
6M	EDZ13 Comdty	0.294	BGN
9M	EDH14 Comdty	0.3574	BGN
12M	EDM14 Comdty	0.4402	BGN
15M	EDU14 Comdty	0.5675	BGN
18M	EDZ14 Comdty	0.7341	BGN
2Y	USSWAP2 BGN Curncy	0.5957	BGN
3Y	USSWAP3 BGN Curncy	1.0014	BGN
4Y	USSWAP4 BGN Curncy	1.4500	BGN
5Y	USSWAP5 BGN Curncy	1.8650	BGN
6Y	USSW6 BGN Curncy	2.2145	BGN
7Y	USSWAP7 BGN Curncy	2.5010	BGN
8Y	USSW8 BGN Curncy	2.7305	BGN
9Y	USSW9 BGN Curncy	2.9190	BGN
10Y	USSWAP10 BGN Curncy	3.0765	BGN
11Y	USSWAP11 BGN Curncy	3.2103	BGN
12Y	USSWAP12 BGN Curncy	3.3220	BGN
15Y	USSWAP15 BGN Curncy	3.5510	BGN
20Y	USSWAP20 BGN Curncy	3.7315	BGN
25Y	USSWAP25 BGN Curncy	3.8150	BGN
30Y	USSWAP30 BGN Curncy	3.8565	BGN

*Note: U*SD Swaps Curve. Last Updated 9/11/13.
The "short end" is based on deposit rates; the "medium leg" uses futures (with convexity adjustment to reconcile swap vs. futures settlement); and the "long end" uses observed IR swaps.
The "Data Source" column is the Bloomberg terminal-reported methodology/source for the yields. BGN refers to *Bloomberg Generic* and CMPN refers to *Composite of Real-Time Contributed Prices.* BGN is derived from market-participant contributions, executable quotes, and Bloomberg pricing models. CMPN is based on actual dealer contributions (e.g., bid/ask and indicative prices).

Tenor	CUSIP	Yield	Data Source
1D	CCLR Index	1.00	CMPN
1M	CDOR01 Index	1.22	CMPN
2M	CDOR02 Index	1.2475	CMPN
3M	BAU13 Comdty	1.2750	BGN
6M	BAZ13 Comdty	1.2997	BGN
9M	BAH14 Comdty	1.3491	BGN
12M	BAM14 Comdty	1.4584	BGN
15M	BAU14 Comdty	1.6275	BGN
18M	BAZ14 Comdty	1.8164	BGN
2Y	CDSW2 BGN Curncy	1.6195	BGN
3Y	CDSW3 BGN Curncy	1.9372	BGN
4Y	CDSW4 BGN Curncy	2.2350	BGN
5Y	CDSW5 BGN Curncy	2.4855	BGN
6Y	CDSW6 BGN Curncy	2.6885	BGN
7Y	CDSW7 BGN Curncy	2.8595	BGN
8Y	CDSW8 BGN Curncy	3.0030	BGN
9Y	CDSW9 BGN Curncy	3.1335	BGN
10Y	CDSW10 BGN Curncy	3.2540	BGN
12Y	CDSW12 BGN Curncy	3.4570	BGN
15Y	CDSW15 BGN Curncy	3.6713	BGN
20Y	CDSW20 BGN Curncy	3.7915	BGN
25Y	CDSW25 BGN Curncy	3.7555	BGN
30Y	CDSW30 BGN Curncy	3.6930	BGN

Note: CAD Swaps Curve. Last Updated 9/11/13.

Table C5—: Selected contract characteristics.

	Overall	USD	CAD
Trading Day			
Monday	4,096 (15.1%)	3,859 (14.8%)	237 (20.3%)
Tuesday	5,372 (19.7%)	5,147 (19.8%)	225 (19.2%)
Wednesday	6,733 (24.7%)	6,491 (24.9%)	242 (20.7%)
Thursday	6,001 (22.1%)	5,814 (22.3%)	187 (16.0%)
Friday	5,008 (18.4%)	4,730 (18.2%)	278 (23.8%)
Trading Session			
Morning	7,193	6,734 (25.9%)	459 (39.3%)
Mid-Day	7,845	7,504 (28.8%)	341 (29.2%)
Afternoon	7,684	7,411 (28.5%)	273 (23.4%)
After Hours	4,488	4,392 (16.9%)	96 (8.2%)
Capped			
Capped	8,373 (30.8%)	8,087 (31.1%)	286 (24.5%)
Not Capped	18,837 (69.2%)	17,954 (68.9%)	883 (75.5%)
Tenor			
Min	2 months	2 months	9 months
1st Quartile	5 years	5 years	1 year
Median	7 years	7 years	3 years
3rd Quartile	10 years	10 years	5 years
Max	43 years	43 years	30 years
Mean	9 yrs., 9 mos.	10 years	4 yrs., 10 mos.
Notional			
Min	1,000	1,000	10,000
1st Quartile	16,000,000	16,000,000	7,000,000
Median	50,000,000	50,000,000	42,000,000
3rd Quartile	100,000,000	100,000,000	100,000,000
Max	260,000,000	250,000,000	260,000,000
Mean	56,426,143	56,103,848	63,605,689

Note: The dataset is filtered to only include observations that use USD LIBOR or CAD CDOR as the reference rate, are not voluntarily cleared, are not zero-coupon swaps, and are within 50 bps of the "fair rate" reported by Bloomberg.
Source: Bloomberg L.P. and author's own calculation.

Table C6—: Parallel Trends Pre-Trend Tests for Pricing

	Dependent variable: Fixed Rate		
	2-year contracts	5-year contracts	10-year contracts
Currency USD * Trade Date	0.001	0.004	0.002
	(0.008)	(0.004)	(0.004)
Currency: USD	-0.882***	-0.675***	-0.309***
	(0.122)	(0.053)	(0.053)
Trade Date	-0.002	-0.0004	-0.0003
	(0.002)	(0.001)	(0.003)
Log Notional	0.0004	-0.009	0.035***
	(0.016)	(0.036)	(0.013)
Capped	0.178	0.173*	0.084
	(0.167)	(0.098)	(0.052)
Constant	1.392***	1.915***	1.846***
	(0.299)	(0.589)	(0.210)
Observations	158	635	921
R^2	0.338	0.064	0.031
Adjusted R^2	0.316	0.057	0.026
Residual Std. Error	0.530 (df = 152)	0.740 (df = 629)	0.521 (df = 915)
F Statistic	15.513*** (df = 5; 152)	6.751*** (df = 5; 629)	5.950*** (df = 5; 915)

Note: Standard errors clustered by Trade Date in parentheses.
*** p<0.01; ** p<0.05; * p<0.1

Note: The period of data are from contracts traded between Jan 28 – Feb 22, 2013 (i.e., twenty trading days prior to the study period of phase 1). If parallel trends hold, we expect the interaction term (Currency*Trade Date) to be not statistically significant.

Table C7—: Placebo Diff-in-Diff

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
Group * Period	0.1694	0.1696
	(0.5975)	(0.5952)
Group	1.6566***	1.4077***
	(0.4343)	(0.4357)
Period	−0.5706	−0.4838
	(0.5826)	(0.5799)
Tenor		0.0301***
		(0.0077)
Log Notional		−0.0219
		(0.0595)
Capped		−0.8827***
		(0.1572)
Morning Session		0.2761*
		(0.1520)
Afternoon Session		0.3836**
		(0.1600)
Off Hours		0.0617
		(0.1802)
Monday		0.7955***
		(0.1954)
Tuesday		0.5999***
		(0.1800)
Thursday		1.7587***
		(0.1744)
Friday		1.7827***
		(0.1822)
Constant	−1.2876***	−1.9215*
	(0.4197)	(1.1216)
Observations	20,794	20,794
R^2	0.0020	0.0136
Adjusted R^2	0.0019	0.0130
Residual Std. Error	8.4872 (df = 20790)	8.4398 (df = 20780)
F Statistic	13.8615*** (df = 3; 20790)	22.0214*** (df = 13; 20780)
Note:		*p<0.1; **p<0.05; ***p<0.01

Note: I conduct a placebo diff-in-diff using data from the 20 trading days prior to each phase studied in table 8. I perform a placebo analysis as if the central clearing mandate had been implemented on the the eleventh trading day. If the diff-in-diff method is sound, we should not see the interaction term $Group * Period$ be significant.

Table C8—: Diff-in-Diff results with all phases pooled together

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
Group * Period	14.2183***	13.4103***
	(0.6833)	(0.6839)
Group	−0.8889*	−0.7683
	(0.4917)	(0.4900)
Period	−13.6369***	−13.2955***
	(0.6641)	(0.6610)
Tenor		0.0362***
		(0.0086)
Log Notional		0.7755***
		(0.0671)
Capped		−0.9311***
		(0.1849)
SEF		0.6922
		(2.5197)
Morning Session		−1.0238***
		(0.1843)
Afternoon Session		−1.2368***
		(0.1814)
Off Hours		−1.2907***
		(0.2125)
Monday		1.5672***
		(0.2244)
Tuesday		2.3944***
		(0.2070)
Thursday		2.7672***
		(0.2005)
Friday		0.9566***
		(0.2124)
Constant	−0.2415	−14.1707***
	(0.4718)	(1.2407)
Observations	27,210	27,210
R^2	0.0283	0.0444
Adjusted R^2	0.0282	0.0440
Residual Std. Error	11.3530 (df = 27206)	11.2607 (df = 27195)
F Statistic	264.3342*** (df = 3; 27206)	90.3482*** (df = 14; 27195)
Note:		*p<0.1; **p<0.05; ***p<0.01

Note: Column 1 shows results for a basic model without controlling for any covariates. Column 2 shows controls for contract characteristics. The parameter of interest is the interaction term $Group * Period$, which shows an effect of $13.4 - 14.2$ *bps* increase in premia for the treatment group once clearing is enacted.

Table C9—: Diff-in-Diff results by each implementation phase separately

	Dependent variable: Premium		
	Phase 1	Phase 2	Phase 3
	(1)	(2)	(3)
Group * Period	5.308***	2.658**	16.277***
	(0.899)	(1.336)	(1.408)
Group	−2.789***	2.327***	3.139***
	(0.525)	(0.886)	(1.205)
Period	−4.898***	−4.150***	−12.360***
	(0.875)	(1.309)	(1.338)
Tenor	−0.050***	0.064***	0.086***
	(0.013)	(0.013)	(0.016)
Log Notional	−0.489***	0.685***	1.506***

	(0.094)	(0.109)	(0.125)
Capped	−0.727***	−0.583**	−1.575***
	(0.268)	(0.287)	(0.345)
Morning Session	−0.387	0.788***	−2.375***
	(0.265)	(0.292)	(0.340)
Afternoon Session	−1.170***	−0.571**	−0.538
	(0.264)	(0.280)	(0.342)
Off Hours	−1.196***	1.594***	−5.542***
	(0.309)	(0.334)	(0.392)
Monday	2.017***	6.666***	−5.821***
	(0.323)	(0.367)	(0.409)
Tuesday	0.741**	8.913***	−3.854***
	(0.312)	(0.326)	(0.377)

Thursday	2.025***	8.909***	−3.700***
	(0.306)	(0.306)	(0.376)
Friday	1.642***	5.832***	−4.480***
	(0.325)	(0.320)	(0.402)
Constant	11.804***	−22.064***	−27.840***
	(1.654)	(2.101)	(2.446)
Observations	7,561	10,856	8,793
R^2	0.025	0.109	0.179
Adjusted R^2	0.024	0.108	0.178
Residual Std. Error	8.635 (df = 7547)	11.002 (df = 10842)	11.861 (df = 8779)
F Statistic	15.068*** (df = 13; 7547)	102.336*** (df = 13; 10842)	147.232*** (df = 13; 8779)

Note: *p<0.1; **p<0.05; ***p<0.01

Table C10—: Diff-in-Diff results for an alternative currency pair

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
Group * Period	7.4610***	8.2859***
	(1.5404)	(1.5143)
Group	−0.2734	−0.9492
	(1.2232)	(1.2023)
Period	−6.6242***	−8.2303***
	(1.4576)	(1.4435)
Tenor		0.0974***
		(0.0193)
Log Notional		0.6572***
		(0.1811)
Capped		−0.4361
		(0.5052)
Morning Session		−0.9820**
		(0.4967)
Afternoon Session		−2.5981***
		(0.4186)
Off Hours		−2.4152***
		(0.7555)
Monday		3.1430***
		(0.5643)
Tuesday		3.5697***
		(0.5050)
Thursday		3.0135***
		(0.4984)
Friday		1.5464***
		(0.5515)
Constant	−3.7350***	−15.0964***
	(1.1343)	(3.1718)
Observations	3,522	3,522
R^2	0.0168	0.0580
Adjusted R^2	0.0159	0.0546
Residual Std. Error	10.3965 (df = 3518)	10.1905 (df = 3508)
F Statistic	20.0170*** (df = 3; 3518)	16.6288*** (df = 13; 3508)
Note:		*p<0.1; **p<0.05; ***p<0.01

Note: This table uses GBP denominated contracts as the treatment group and CHF denominated contracts as the comparison group. GBP-denominated contracts were subject to the clearing mandate during the same time period as the USD-denominated contracts in table 8 while CHF denominated contracts were not.

Table C11—: Diff-in-diff results without filtering for outliers (all phases pooled).

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
Group	6.4783***	7.1186***
	(1.2754)	(1.2786)
Period	−16.8364***	−16.6251***
	(1.6893)	(1.6921)
Tenor		−0.0552**
		(0.0226)
Log Notional		0.5606***
		(0.1730)
Capped		−0.3432
		(0.4880)
SEF		−4.2437
		(6.5996)
Morning Session		−2.6170***
		(0.4843)
Afternoon Session		−2.4587***
		(0.4762)
Off Hours		−3.5615***
		(0.5589)
Monday		2.8288***
		(0.5910)
Tuesday		1.6594***
		(0.5454)
Thursday		1.1212**
		(0.5274)
Friday		−0.7841
		(0.5581)
Group * Period	12.8246***	12.1513***
	(1.7395)	(1.7539)
Constant	−3.4148***	−11.6213***
	(1.2252)	(3.1911)
Observations	28,311	28,311
R^2	0.0139	0.0182
Adjusted R^2	0.0138	0.0177
Residual Std. Error	30.2838 (df = 28307)	30.2239 (df = 28296)
F Statistic	133.0846*** (df = 3; 28307)	37.4453*** (df = 14; 28296)
Note:		*p<0.1; **p<0.05; ***p<0.01

Note: This table does not filter out contracts whose fixed rate is more than $\pm 50bps$ than the calculated fair rate for the fixed leg.

Table C12—: Diff-in-Diff results without filtering for outliers (per phase results)

	Dependent variable: Premium		
	Phase 1	Phase 2	Phase 3
	(1)	(2)	(3)
Group	7.200***	6.368***	12.806***
	(2.241)	(2.151)	(2.331)
Period	−2.813	−16.738***	−5.274**
	(3.751)	(2.926)	(2.617)
Tenor	−0.305***	0.021	0.039
	(0.055)	(0.031)	(0.035)
Notional	−2.382***	0.653**	2.108***
	(0.391)	(0.257)	(0.257)
Capped	1.164	0.031	−1.834**
	(1.141)	(0.689)	(0.729)

Morning Session	-5.318^{***}	0.581	-2.231^{***}
	(1.121)	(0.702)	(0.716)
Afternoon Session	-3.678^{***}	-1.300^{*}	-0.882
	(1.110)	(0.673)	(0.718)
Off Hours	-6.020^{***}	0.474	-6.191^{***}
	(1.311)	(0.803)	(0.826)
Monday	-0.927	9.518^{***}	-4.437^{***}
	(1.361)	(0.883)	(0.866)
Tuesday	-2.788^{**}	8.744^{***}	-3.307^{***}
	(1.315)	(0.787)	(0.794)
Thursday	-2.880^{**}	9.627^{***}	-5.501^{***}
	(1.292)	(0.736)	(0.790)
Friday	-2.307^{*}	4.595^{***}	-4.177^{***}

	(1.373)	(0.768)	(0.848)
Group * Period	−3.568	11.873***	11.274***
	(3.848)	(3.007)	(2.755)
Constant	50.354***	−21.877***	−50.813***
	(6.877)	(4.958)	(4.895)
Observations	7,819	11,233	9,259
R^2	0.025	0.036	0.073
Adjusted R^2	0.023	0.035	0.071
Residual Std. Error	37.150 (df = 7805)	26.916 (df = 11219)	25.619 (df = 9245)
F Statistic	15.137*** (df = 13; 7805)	32.443*** (df = 13; 11219)	55.763*** (df = 13; 9245)

Note: *p<0.1; **p<0.05; ***p<0.01

	USD	CAD	GBP	CHF
Settlement	T+2	T+0	T+0	T+2
Fixed Leg				
Day Count Convention	30I/360	ACT/365.FIXED	ACT/365.FIXED	30E/360
Payment Frequency	Semiannual	Semiannual	Semiannual	Annual
Business Day Adjustment	Modified Following	Modified Following	Modified Following	Modified Following
Adjustment Type	Accrual and Payment Dates	Accrual and Payment Dates	Accrual and Payment Dates	Accrual and Payment Dates
Roll Convention	Backward	Backward	Backward (EOM)	Backward
Accrual Calendar	US Federal Reserve and Bank of England	Canada	Bank of England	Switzerland
Pay Delay	0 days			
Floating Leg				
Day Count Convention	Actual/360	ACT/365.FIXED	ACT/365.FIXED	Actual/360
Payment Frequency	Quarterly	Semiannual	Semiannual	Semiannual
Reference Index	USD LIBOR 3M	CDOR 3M	GBP LIBOR 6M	CHF LIBOR 6M
Reset Frequency	Quarterly	Quarterly	Semiannual	Semiannual
Business Day Adjustment	Modified Following	Modified Following	Modified Following	Modified Following
Adjustment Type	Accrual and Payment Dates	Accrual and Payment Dates	Accrual and Payment Dates	Accrual and Payment Dates
Roll Convention	Backward	Backward	Backward (EOM)	Backward
Accrual Calendar	US Federal Reserve and Bank of England	Canada	Bank of England	Switzerland
Fixing Calendar Bank of Englang	Canada	Bank of England	Bank of England	
Fixing Lag	2 business days	0 days	0 days	0 days
Pay Delay	0 days	0 days	0 days	0 days

Table C13—: Contract characteristics for common contracts (Source: Bloomberg L.P.)