4 Data

The Commodity Futures Trading Commission's (CFTC) clearing mandate on IR swaps became effective on March 11, 2013. The regulation was implemented in three phases. Phase 1, which started on March 11, mandated clearing for certain IR swaps involving swap dealers (SD), major swap participants (MSP), or active funds. Phase 2, which started on June 10, extended the mandate to additional entities, including commodity pool operators, banks and other financial institutions, while Phase 3, which started on September 9, covered all remaining entities (unless exempted, for example if the swap user is a non-financial entity that uses swaps to hedge commercial risk). The CFTC defined contract specifications for swaps that must be cleared. These specifications included the currency (USD, GBP, EUR, JPY), the contract tenor (28 days to 50 years for USD, GBP and EUR based contracts, 28 days to 30 years for JPY bases contracts), and the floating leg reference (LIBOR or EURIBOR). It also specified “negative” characteristics (that is, swaps having these characteristics do not need to be cleared) including no dual currencies, no conditional notional amount and no optionality. The IR swaps covered by the mandate were the largest categories by volume.

I compare prices, price volatility, and liquidity before in each of the three phases, comparing USD and CAD denominated swaps – the largest regulated and unregulated markets, respectively. To minimize the impact of interest rate policy and other macroeconomic variables, I analyze a small ten-day trading window before (Feb 25 – Mar 8, May 27 – Jun 7 and Aug 26 – Sep 6) and after (Mar 11 – Mar 22, Jun 10 – Jun 21 and Sep 9 – Sep 20) the regulation's effective date in each phase. The data are reported by the Depository Trust and Clearing Corporation Swaps Data Repository (DTCC SDR) and obtained using the SDR screen of the Bloomberg terminal. For the main part of the dissertation, I restrict my dataset to observations where the premium is within ±50 bps of the Bloomberg reported price of a swap with similar characteristics. Swaps that have a much higher premia are likely to have unseen characteristics (such as early termination clauses, conditional notional amounts, etc.) that are not observable in the dataset. In an appendix, I show that my results are robust to including these outliers.]

Note that before the regulation is passed, (voluntary) clearing in USD-denominated swaps is a little less than 61%. After phase 1 implementation, clearing increases to around 78%. After phase 2 implementation, clearing jumps to 89% and remains at that level after phase 3. The CAD-denominated market is much smaller (both in number of trades, and notional value). Clearing in Canadian IR swaps hovers around 48% prior to Phase 1. It reaches a high of around 56% in phase 2 and diminishes back to 48% after phase 3. Clearing for CAD denominated swaps is voluntary.

To calculate the theoretical counterparty-riskless price of IR swaps, I forecast future floating rate payments and discount the payments using the appropriate yield curve. 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, where one curve was used to calculate future floating-rate payments, and another curve to discount those payments to their present value). 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 the QuantLib-python library to construct the forward curve. 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.

Table 3 shows sample data for CAD and USD yield curves on September 11, 2013. Note that futures rates need to have a convexity adjustment applied since futures payoffs differ from payoffs for other instruments. The values reported in the table have this convexity adjustment applied. Values between the “pillars” (data points) of the yield curve need to be interpolated. 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 SWPM up to 4 decimal places.

The contract characteristics reported in the DTCC SDR include swap currency, trade date and time, effective date, maturity date, fixed rate, payment frequencies, clearing status, notional value, and capped notional indicator. For USD swaps, USD LIBOR is the floating rate index for 98% of swaps, while for CAD swaps, CDOR is the index for 99% of swaps. I exclude certain swaps that make a single payment at maturity (i.e., payment frequency is 1T), which should actually be classified as an FRA. Table 4 shows the notional value and number of trades captured in my data, by clearing status and reference floating leg rate.

Table 5 shows summary statistics of the control variables used in the regression. Only contracts using LIBOR as the floating reference leg are included. Additionally, contracts that were "voluntarily cleared" prior to the mandate or "exempt from clearing" after the mandate are excluded. The leftmost column (unfiltered dataset) shows the statistics from this dataset. For the main part of the paper, I further filter this data to swaps whose fixed rate is within 50 bps of the Bloomberg calculated fixed rate. The rightmost column shows the statistics for this filtered dataset. Note that this filtering does not substantially alter the characteristics of the control variables. 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). I split the trading day into 4 sessions (corresponding roughly to the trading times on the NYSE) 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 mid-day trading session was most active. About 16% of contracts were traded during the off-hour trading session. 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).

There are several limitations to the DTCC SDR dataset. Firstly, the dataset does not identify the counterparties. The identity of the counterparty (and more importantly, its creditworthiness) could have a significant impact on the swap price. In addition, the dataset does not mark which counterparty is the dealer (that is, whether the dealer is receiving the fixed rate or paying the fair rate). When receiving the fixed rate (and paying the floating leg), the dealer is likely to require a premium over the fair price. When paying the fixed rate, the dealer is likely to pay a discount below the fair price. I am also unable to observe non-standard contract characteristics such early termination previsions, collateral arrangements and day-count and settlement conventions. The standard-version of the interest rate swaps contract uses the International Swaps and Derivatives Association (ISDA) Master Agreement for specifying these contract terms. Deviations from the ISDA master agreement could affect the liquidity of the contract.

Table 3 Sample data for USD and CAD yield curves

Period	Bloomberg CUSIP	Yield	Data Source	Date Last Updated
3M	EDU13 Comdty	0.2575	BGN	09/11/13
6M	EDZ13 Comdty	0.294	BGN	09/11/13
9M	EDH14 Comdty	0.3574	BGN	09/11/13
12M	EDM14 Comdty	0.4402	BGN	09/11/13
15M	EDU14 Comdty	0.5675	BGN	09/11/13
18M	EDZ14 Comdty	0.7341	BGN	09/11/13
2Y	USSWAP2 BGN Curncy	0.5957	BGN	09/11/13
3Y	USSWAP3 BGN Curncy	1.0014	BGN	09/11/13
4Y	USSWAP4 BGN Curncy	1.45	BGN	09/11/13
5Y	USSWAP5 BGN Curncy	1.865	BGN	09/11/13
6Y	USSW6 BGN Curncy	2.2145	BGN	09/11/13
7Y	USSWAP7 BGN Curncy	2.501	BGN	09/11/13
8Y	USSW8 BGN Curncy	2.7305	BGN	09/11/13
9Y	USSW9 BGN Curncy	2.919	BGN	09/11/13
10Y	USSWAP10 BGN Curncy	3.0765	BGN	09/11/13
11Y	USSWAP11 BGN Curncy	3.2103	BGN	09/11/13
12Y	USSWAP12 BGN Curncy	3.322	BGN	09/11/13
15Y	USSWAP15 BGN Curncy	3.551	BGN	09/11/13
20Y	USSWAP20 BGN Curncy	3.7315	BGN	09/11/13
25Y	USSWAP25 BGN Curncy	3.815	BGN	09/11/13
30Y	USSWAP30 BGN Curncy	3.8565	BGN	09/11/13

Tenor	CUSIP	Yield	Source	Date Last Updated
1D	CCLR Index	1.00	CMPN	09/11/13
1M	CDOR01 Index	1.22	CMPN	09/11/13
2M	CDOR02 Index	1.2475	CMPN	09/11/13
3M	BAU13 Comdty	1.275	BGN	09/11/13
6M	BAZ13 Comdty	1.2997	BGN	09/11/13
9M	BAH14 Comdty	1.3491	BGN	09/11/13
12M	BAM14 Comdty	1.4584	BGN	09/11/13
15M	BAU14 Comdty	1.6275	BGN	09/11/13
18M	BAZ14 Comdty	1.8164	BGN	09/11/13
2Y	CDSW2 BGN Curncy	1.6195	BGN	09/11/13
3Y	CDSW3 BGN Curncy	1.9372	BGN	09/11/13
4Y	CDSW4 BGN Curncy	2.235	BGN	09/11/13
5Y	CDSW5 BGN Curncy	2.4855	BGN	09/11/13
6Y	CDSW6 BGN Curncy	2.6885	BGN	09/11/13
7Y	CDSW7 BGN Curncy	2.8595	BGN	09/11/13
8Y	CDSW8 BGN Curncy	3.003	BGN	09/11/13
9Y	CDSW9 BGN Curncy	3.1335	BGN	09/11/13
10Y	CDSW10 BGN Curncy	3.254	BGN	09/11/13
12Y	CDSW12 BGN Curncy	3.457	BGN	09/11/13
15Y	CDSW15 BGN Curncy	3.6713	BGN	09/11/13
20Y	CDSW20 BGN Curncy	3.7915	BGN	09/11/13
25Y	CDSW25 BGN Curncy	3.7555	BGN	09/11/13
30Y	CDSW30 BGN Curncy	3.693	BGN	09/11/13

Table 4 Number of contracts and notional values by Clearing Status and reference rate for USD and CAD IR swaps contracts

Pre Phase 1

Currency	Floating Leg	Cleared (Count)	Cleared (Notional Value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
USD	**LIBOR**	3,518	203,345.90	3,071	131,242.01	61%
	USD-Federal Funds-H.15	0	0.0	16	2,183.00	0%
	USD-PRIME-H.15	0	0.0	2	6.00	0%
	USD-PRIME-H15	0	0.0	2	4.00	0%
	USD SPRDL MANUAL	0	0.0	1	100.00	0%
	USD-AAA_MUNI-	0	0.0	4	31.00	0%
	USD-OIS-3	0	0.0	1	6.00	0%
	IBR	0	0.0	2	200.00	0%
	CLICP	0	0.0	1	100.00	0%
	TIS	0	0.0	1	1.00	0%
	USD-USPSA-BLOOMBERG	0	0.0	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

Currency	Floating Leg	Cleared (Count)	Cleared (Notional Value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
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%

Pre Phase 2

Currency	Floating Leg	Cleared (Count)	Cleared (Notional Value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
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

Currency	Floating Leg	Cleared (Count)	Cleared (Notional Value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
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%

Pre Phase 3

Currency	Floating Leg	Cleared (Count)	Cleared (Notional value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
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

Currency	Floating Leg	Cleared (Count)	Cleared (Notional Value)	Uncleared (Count)	Uncleared (Notional Value)	Percent Cleared
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%

Table 5 Selected Charactersitics of Control Variables

	<u>**Unfiltered Dataset**</u>	<u>**Main Dataset**</u>
	Trading Day	**Trading Day**
Monday	4,246	4,096
Tuesday	5,558	5,372
Wednesday	**7,020**	**6,733**
Thursday	6,243	6,001
Friday	5,244	5,008
	Trading Session	**Trading Session**
Morning	7,419	7,193
Mid-Day	**8,266**	**7,845**
Afternoon	7,974	7,684
After Hours	4,652	4,488
	Capped	**Capped**
Capped	19,727	18,837
Not Capped	8,584	8,373
	Tenor	**Tenor**
Min	2 months	2 months
1st Quartile	5 years	5 years
Median	7 years	7 years
3rd Quartile	10 years	10 years
Max	43 years	43 years
Mean	9 years, 9 months	9 years, 9 months
	Notional	**Notional**
Min	1,000	1,000
1st Quartile	15,000,000	16,000,000
Median	50,000,000	50,000,000
3rd Quartile	100,000,000	100,000,000
Max	260,000,000	260,000,000
Mean	55,650,025	56,426,143

5 Results

5.1 Prices

For analyzing the impact of the clearing mandate on prices, I compare USD LIBOR denominated contracts against CAD CDOR contracts. USD LIBOR contracts are subject to the CFTC clearing mandate (note that USD denominated contracts using another floating rate index such as the Federal Funds Rate are not subject to the clearing mandate, but these contracts can be voluntarily cleared.

Table 6 lists the DiD results for the swap premium. Column 1 shows a basic model without any controls for contract characteristics. The clearing mandate causes a ~14 bps rise in premia. As expected, reducing the riskiness of the contract increases its price. Column 2 shows the effects additional controls, such as the (log) notional value of the contract, day and period of trading and whether the notional value was "capped" (i.e. the exact value was not reported to the trade repo). In this model, premia rise by ~ 13 bps. Thus, the results are robust to such controls.

Using Wednesday as the reference level, I note that there is a 1-3 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 mid-day). Note that both results contrast with assumptions of "efficient markets", where there should be no arbitrage opportunities by trading during special days or times. A one-year increase in the tenor is associated with a 0.03 bps increase in the premium. A one percent increase in the notional value is associated with a 0.77 bps increase in the premium. Again, these result contrast 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 a "large" contract and agreeing to pay the fixed-rate for two lower-priced "small" contracts). However, these differences could be related to liquidity, counterparty risk, or other contract characteristics of larger and longer swaps, which is not observable in our data. Although statistically significant, the magnitudes of the effects are small, ranging from 0.03 to 3 bps.

Table 7 shows the result of running the model on each phase of the data separately. In phase 1, there is a ~5 bps increase in the premium after the mandate. As noted previously, there was a 16% increase in the cleared volume following implementation of phase 1. There was an additional 12% increase in the cleared volume following phase 2, and the premium rose by another ~3 bps. In phase 3, a larger set of market participants fell under the mandate (although the cleared volume did not change), and the premium increased by ~16 bps. This suggests that when almost all contracts (>90%) are cleared, premia rise due to less severe consequences of counterparty default.

Table 8 shows the results from a placebo difference-in-differences regression. I pick the 20 trading days before the periods studied above (60 trading days in total across three phases). I create a "placebo" difference-in-differences, as if there was a transition to clearing mandate on the 11th trading day (i.e. Feb 11, May 13 and Aug 12). The results do not show any effect from this placebo DiD, further strengthening our belief that the increase in premia seen in the actual DiD is real.

Table 9 shows the results of a similar regression using an alternative currency pair. The CFTC clearing mandate also affected contracts denominated in GBP using the LIBOR as the reference rate (with implementation dates the same as the USD LIBOR clearing mandate). These contracts serve as the treatment group. The clearing mandate did not apply to CHF denominated contracts, and this serves as the control group. The clearing mandate had a similar (but smaller) impact on prices of GBP-denominated swaps, further strengthening our belief that clearing reduces counterparty risk and increases contract premia.

Table 6 Difference-in-Difference Results for Prices

Difference-in-Differences Regression Results

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
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)
Group * Period	14.2183***	13.4103***
	(0.6833)	(0.6839)
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**p***p<0.01

Table 7 Difference-in-Dfferences results for prices by phase

By Phase Results: Advanced Model

	Dependent variable: Premium		
	Phase 1	Phase 2	Phase 3
	(1)	(2)	(3)
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)
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)
Group * Period	5.308^{***}	2.658^{**}	16.277^{***}
	(0.899)	(1.336)	(1.408)
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**p***p<0.01

Table 8 Placebo DiD Results

Placebo Difference-in-Difference Results

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
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)
Group * Period	0.1694	0.1696
	(0.5975)	(0.5952)
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

Table 9 Alternative Currency Pair (GBP denominated contracts serve as the treatment group and CHF denominated contracts serve as the control group)

Alternative Currencies Difference-in-Differences Results (GBP vs. CHF)

	Dependent variable: Premium	
	Basic Model	Advanced Model
	(1)	(2)
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)
Group * Period	7.4610***	8.2859***
	(1.5404)	(1.5143)
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:		$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 10 shows the results of difference-in-difference regression for the relative bid-ask spreads. Note that since the period of study is short (ten trading days before and ten trading after the clearing mandate implementation), and since liquidity is a "market wide", rather than an individual contract-based measure, the opportunity to control for variables that impact liquidity is limited to market-wide metrics. If a longer period were being studied, variables that impact liquidity, such as monetary policy and credit availability could be added as controls. However, since these variables do not vary during the short period studied, they cannot be controlled for. Two control variables that proxy financial market conditions are added to the more complex model: a measure of equity market volatility and a measure for equity market return. For the volatility measure, I use the CBOE VIX Index, which measures the 30-day expected realized variance of the S&P 500 index and its Canadian equivalent (the S&P TSX VIX). For

The clearing mandate does not impact the liquidity as measured by relative bid-ask spreads. As noted in the theory section, we should expect reductions in counterparty risk of interest rate swaps to cause a narrowing of the bid-ask spread (the spread is charged by dealers to offset their expected losses from holding inventory). However, the spread is also driven by supply and demand conditions in the market. As explored in the pricing section, a reduction in riskiness of IRS increases their demand. If the swaps market is monopolistic (that is, new swaps dealers face barriers to entry), then incumbent dealers can choose not to lower their bid-ask spreads and pocket the additional profits from the high demand.

Table 11 and Table 12 show the results for the Roll and Amihud measure respectively. These measures also do not show any impact of the clearing mandate on liquidity. As described earlier, in monopolistic markets, increase in demand due to less counterparty risk can be captured as increases in premia by the dealers, without improving liquidity. The relative bid-ask spread, Roll measure and Amihud measures all consistently show no change in market liquidity due to the clearing mandate.

Table 10 Relative Bid-Ask Spread DiD

Relative Bid-Ask Spread DiD Analysis

	Dependent variable:
	Relative Spread
Group	-0.005***
	(0.001)
Period	0.0001
	(0.001)
Tenor (2Y)	0.007***
	(0.001)
Tenor (5Y)	0.003***
	(0.001)
Group*Period	-0.001
	(0.001)
Constant	0.011***
	(0.001)
Observations	360
R^2	0.406
Adjusted R^2	0.398
Residual Std. Error	0.005 (df = 354)
F Statistic	48.406*** (df = 5; 354)
Note:	*p**p***p<0.01

Table 11 Roll Measure DiD

	Dependent variable:
	\`Roll Measure\`
Group	0.363***
	(0.078)
Period	0.010
	(0.086)
Tenor (5 years)	0.118**
	(0.055)
Tenor (10 years)	-0.087
	(0.058)
Stock market index	4.385
	(3.401)
Volatility index	0.027*
	(0.015)
Group*Period	-0.087
	(0.101)
Constant	-0.370*
	(0.212)
Observations	236
R^2	0.219
Adjusted R^2	0.195
Residual Std. Error	0.345 (df = 228)
F Statistic	9.137*** (df = 7; 228)
Note:	*p**p***p<0.01

Table 12 Amihud Measure DiD

	Dependent variable:
	Amihud Measure
Group	-10.347***
	(3.305)
Period	3.890
	(3.486)
Tenor (5 years)	3.011
	(2.399)
Tenor (10 years)	-0.478
	(2.551)
Stock market index	37.435
	(148.396)
Volatility index	0.217
	(0.665)
Group*Period	-3.878
	(4.238)
Constant	6.710
	(9.409)
Observations	254
R^2	0.138
Adjusted R^2	0.113
Residual Std. Error	15.659 (df = 246)
F Statistic	5.622*** (df = 7; 246)
Note:	*p**p***p<0.01

Table 13 shows the results of the price volatility difference-in-difference regression. Price volatility (as measured by realized volatility) does not appear to be affected by the clearing mandate. During “normal” trading periods, the clearing mandate might not be as impactful as during periods of market stress. To test whether the clearing mandate had a “calming effect” on US markets (as compared to Canadian markets) I compare realized volatility around the time of the (second) “Grexit” vote. Caution should be exercised when interpreting these results, as the “control group” (CAD contracts) have different exposure to the Greek economy than the “treatment” group. The referendum on the second Greek bailout package was announced on June 26 with the vote taking place on July 5. An alternative arrangement between Greece and the Eurozone was reached on July 13. Thus, the period between June 27 and July 13 might be taken as a period of enhanced market stress. Figure 9 shows the realized volatility of USD and CAD interest rate swaps contracts between June 1 and July 31, with important dates marked. We do not observe any consistent pattern of volatility for either the US or Canadian markets. Table 14 shows the results of a “diff-in-diff” using the post-June 26 time frame as the treatment period and using the US market as the treatment group. There is no significant difference in volatility between US and Canadian contracts in either the pre- or post-treatment time period.

Table 13 Volatility Difference in Differences

Volatility Diff-in-Diff

	Dependent variable: Realized Volatility
Group	0.1733***
	(0.0277)
Period	0.0029
	(0.0347)
Group * Period	0.0016
	(0.0391)
Constant	0.0277
	(0.0245)
Observations	861
R^2	0.0849
Adjusted R^2	0.0817
Residual Std. Error	0.2346 (df = 857)
F Statistic	26.5000*** (df = 3; 857)
Note:	*p<0.1; **p<0.05; ***p<0.01

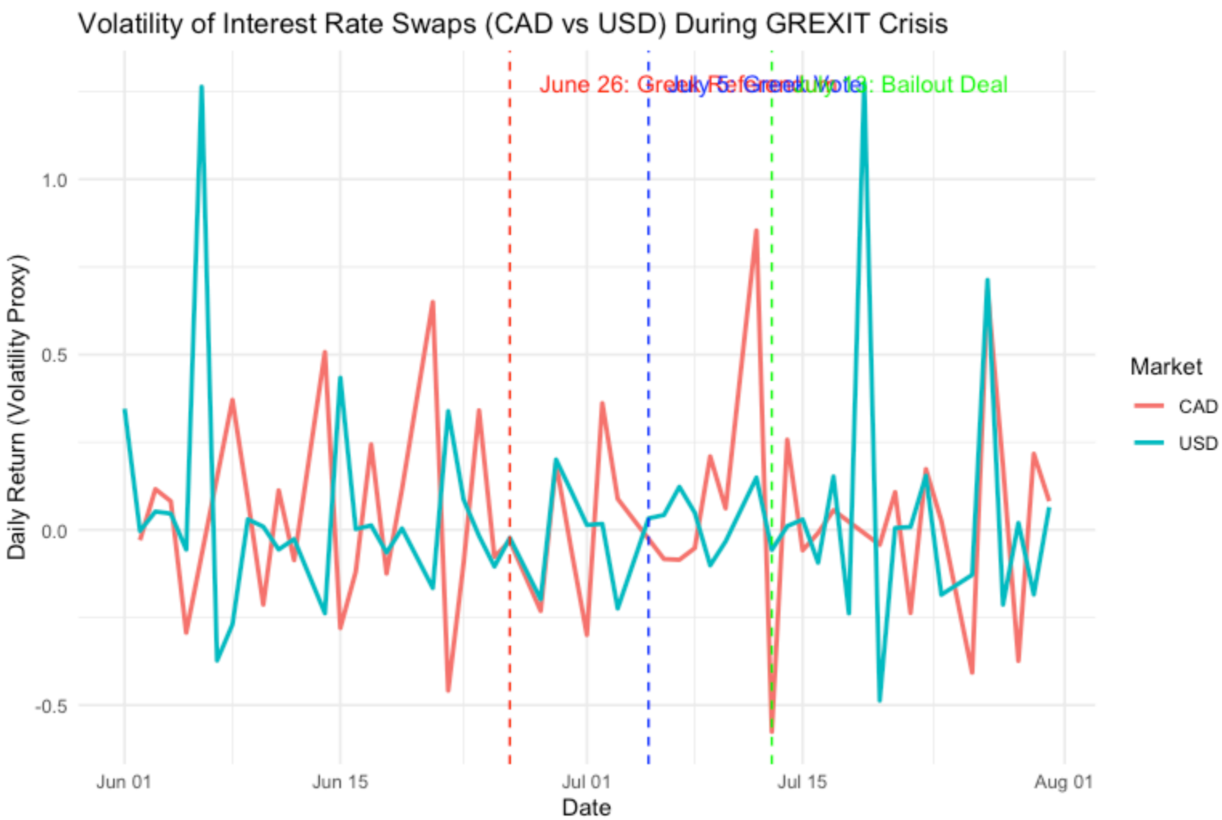

Figure 9 Realized Volatility around GREXIT

Table 14 Volatility diff-in-diff during GREXIT time period

Difference-in-Differences Analysis of Volatility During GREXIT

	Dependent variable:
	Volatility (Daily Return)
Post Period	-0.002
	(0.087)
USD Market	0.012
	(0.090)
Post Period x USD Market	-0.016
	(0.119)
Constant	0.039
	(0.065)
Observations	104
R^2	0.001
Adjusted R^2	-0.029
Residual Std. Error	0.300 (df = 100)
F Statistic	0.018 (df = 3; 100)
Note:	*p**p***p<0.01

6 Conclusion

This study investigates the causal impact of the central clearing mandate on the interest rate swaps (IRS) market, focusing on key outcomes such as pricing, liquidity, and volatility. Using a difference-in-differences approach, I can isolate the effects of the clearing mandate, providing a comprehensive view of its influence on market dynamics.

The findings suggest that central clearing plays a significant role in reducing counterparty risk, as evidenced by the consistent rise in swap premia following the mandate. This reflects an increased valuation for cleared contracts, indicating market participants place a higher premium on reduced risk exposure. However, the anticipated improvements in liquidity were not observed. Measures such as the bid-ask spread, Roll measure, and Amihud liquidity measure show no substantial change in liquidity as a result of the clearing mandate. This suggests that in monopolistic or concentrated dealer markets, the demand for cleared contracts does not necessarily lead to narrower spreads or improved liquidity conditions.

Regarding price volatility, the results indicate that under normal market conditions, the mandate has little to no effect on volatility. The realized volatility measures reveal that prices generally follow a random walk during stable periods, making it difficult to detect significant changes due to the clearing requirement. However, during episodes of market stress, such as the event surrounding the second “Grexit” vote, cleared contracts experienced lower volatility compared to their uncleared counterparts, implying that central clearing may enhance stability in more turbulent times.

While the mandate has succeeded in reducing counterparty risk, its impact on liquidity and volatility appears more nuanced. The clearinghouse structure has not necessarily resulted in a more liquid market, and its effect on volatility is more pronounced during periods of financial stress rather than regular market conditions. These results are crucial for regulators and market participants, as they highlight both the strengths and limitations of central clearing in maintaining market stability.

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 IRS market.

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Appendix: Contract Characteristics

This appendix lists the detailed characteristics of the "standard" (most liquid) interest-rate swaps contract for the currencies studied in this paper.

Currency	*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 Convention	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 Calculation Calendar	US Federal Reserve, England	Canada	England	Switzerland
Pay Delay	0 days	0 days	0 days	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 Business Day	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
Calculation Calendar	US Federal Reserve, England	Canada	England	Switzerland
Fixing Calendar	England	Canada	England	England
Fixing Lag	2 business days	0 days	0 days	2 business days
Pay Delay	0 days	0 days	0 days	0 days
Reset Position	Advance	Advance	Advance	Advance

Defintions

Settlement

Settlement refers to the number of business days after the trade date when the swap contract is finalized and payments are made. 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. The characteristics below describe various conventions associated with this leg.

- 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.
  - ACT/365.FIXED: Uses the actual number of days in a period, dividing by a fixed 365-day year.
- 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. 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.

Floating Leg

The floating leg of the swap is where payments are made based on a variable interest rate, which changes over time based on a reference index. The conventions 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: U.S. Dollar London Interbank Offered Rate for a 3-month period.
  - CDOR 3M: Canadian Dollar Offered Rate for 3 months.

  - GBP LIBOR 6M: British Pound LIBOR for 6 months.
  - CHF LIBOR 6M: Swiss Franc LIBOR for 6 months.
- 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.

Appendix: Alternative Utility Functions and Bid-Ask spreads

In the main body of the paper, I derive expressions for bid-ask spread using a Constant Relative Risk Aversion (CRRA) utility function for all market participants. In this appendix, I derive expressions for the bid-ask spread using Constant Relative Risk Aversion (CRRA) utility and show the results are qualitatively similar.

Consider the same game-theoretic setup as described in the main body of the paper. However, now players have utility function:

$$u(w) = \begin{cases} \frac{w^{1-\gamma}}{1-\gamma}, \gamma \neq 1 \\ \ln w, \gamma = 1 \end{cases}$$

The final wealth of the liquidity trader is given by:

$$w(Q) = Q \cdot p_b + (L - Q) \cdot (1 + z) = Q(p_b - 1) + (L + Q)z$$

Let $\mu_w = \mathbb{E}[w(Q)]$ be the expected wealth. A second-order Taylor series approximation of the utility function around μ_w is given by:

$$u(w) \approx u(\mu_w) + (w - \mu_w)u'(\mu_w) + \frac{1}{2}(w - \mu_w)^2 u''(\mu_w)$$

Then

$$\mathbb{E}[u(w)] \approx u(\mu_w) + \frac{1}{2}u''(\mu_w)\mathbb{E}[(w - \mu_w)^2]$$

Where I have used $\mathbb{E}[w - \mu_w] = 0$

Since $\mathbb{E}[(w - \mu_w)^2] = (L - Q)^2\sigma^2$. We have:

$$\mathbb{E}[u(w)|w = \mu_w] \approx \frac{\mu_w(Q)^{1-\gamma} - 1}{1-\gamma} - \frac{\gamma}{2}\mu_w(Q)^{-\gamma-1}(L - Q)^2\sigma^2$$

where I write $\mu_w = \mu_w(Q)$ to emphasize that the liquidity trader's expected wealth is a function of the liquidity trader's order quantity. To find the optimal order quantity, we can set the derivative of the expected utility to zero:

$$d\frac{\mathbb{E}\left[u\left(w(Q)\right)\right]}{dQ} = 0$$

We can solve this to obtain:

$$Q^* = L + \frac{(p_b - 1)\mu_w(Q)^{2\gamma+1}}{\gamma\sigma^2}$$

This is like the optimal order quantity we derived under CARA

$$Q_{CARA} = \frac{1}{\alpha\sigma^2}(p_b - 1) + L$$

With an additional $\mu_w^{2\gamma+1}$ term in the numerator, showing the order quantity is sensitive to the expected level of wealth of the trader.

We can similarly derive the reservation prices for the dealers. For simplicity, I work through the reservation bid price for dealer 1.

If dealer 1 receives a random inventory position I_1, $I_1 \sim Unif(-R, R)$. If s/he posts the best bid price, his/her wealth at the end of the period is:

$$w = (I_1 + Q)(1 + z) - p_b^1 Q$$

If s/he does not trade, his/her wealth will be:

$$w^{NT} = I_1(1 + z)$$

At some price $p_{b,r}^1$ the dealer will be indifferent between trading and not trading. This will occur when $u\left(w(p_{b.r}^1)\right) = u(w^{NT})$.

Let μ_w be the expected wealth $\mathbb{E}\left[(1 + Q)(1 + z) - p_{b,r}^1 Q\right] = I_1 + Q\left(1 - p_{b,r}^1\right)$

The second order Taylor-series expansion about μ_w is:

$$u(w)|w = \mu_w \approx u(\mu_w) + (w - \mu_w)u'(\mu_w) + \frac{1}{2}(\mu_w - w)^2 u''(\mu_w)$$

Taking expectations:

$$\mathbb{E}[u(w)|w = \mu_w] \approx \mathbb{E}[u(\mu_w)] + \frac{1}{2}(w - \mu_w)^2 u''(\mu_w)$$

Using the fact that $\mathbb{E}[w - \mu_w]^2 = (I_1 + Q)^2\sigma^2$ we obtain:

$$\mathbb{E}[u] \approx \frac{I_1 + Q\left(1 - P_{b,r}^1\right)^{1-\gamma} - 1}{1 - \gamma} + \frac{1}{2}(I_1 + Q)^2\sigma^2(-\gamma(I_1 + Q\left(1 - p_{b,r}^1\right)^{-\gamma-1}$$

We can similarly take the Taylor Series approximation of the utility function at the no-trade level of wealth:

$$\mathbb{E}[u(w_{NT})] \approx \frac{\left(w_{NT}^{1-\gamma} - 1\right)}{1 - \gamma} - \frac{\gamma}{2} I_1^2 \sigma^2 w_{NT}^{-\gamma-1}$$

We can substitute $w_{NT} = I_1(1 + z)$ and $w = (I_1 + Q)(1 + z) - p_b^1 Q$ into the expressions above and set $\mathbb{E}[u(w)|w = \mu_w] = \mathbb{E}[u(w_{NT})]$. We obtain the reservation price:

$$p_{b,r}^1 \approx \frac{\gamma\sigma^2}{2}\mu_w(p_{r,b}^1)$$

We cannot solve for $p_{b,r}^1$ explicitly, but note it has a similar form to the CARA reservation price.

In competitive markets, the dealer's markup will tend to zero and prices will tend to the reservation prices.

Thus we find that using CRRA utility function (or with an utility function which is at least as concave as a CRRA utility function), the optimal order quantity and bid-ask spreads are qualitatively similar to the CARA utility case, except quantities and spreads are sensitive to the level of expected wealth of the players.

Appendix: Results from unfiltered dataset

This appendix presents an alternate version of tables Table 6 and Table 7, removing filters for outliers (contracts with premium (discount) more than +/- 50 bps). Note that the rise in premium for the treatment group remains large and statistically significant even after including these outliers.

Difference-in-Differences Regression Results

	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**p***p<0.01

By Phase Results: Advanced Model

	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**p***p<0.01