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Interactions between Exchange Traded Derivatives and OTC Derivatives: Evidence for the Canadian Dollar Futures vs. OTC Markets

Lorne N. Switzer[a] and Haibo Fan[b]

[a] *Van Berkom Endowed Chair of Small Cap Equities, Finance Department, John Molson School of Business, Concordia University, 1455 De Maisonneuve Blvd. W., Montreal, Quebec, CANADA H3G 1M8*
switz@jmsb.concordia.ca

[b] *Research Associate, John Molson School of Business, Concordia University, 1455 De Maisonneuve Blvd. W., Montreal, Quebec, CANADA H3G 1M8*
haibofan@yahoo.com

ABSTRACT

The OTC market, which is dominated by commercial banks, has been alleged to pose a considerable barrier to the growth of exchange traded derivatives. If banks substitute OTC products to their captive clients, transactions costs for hedging could be excessive relative to those of exchange traded products. The dominant position of OTC currency derivatives products relative to exchange traded derivatives could be troublesome for a number of other reasons including lack of transparency, with insufficient disclosure at the entity level. Lower transactions costs and trader anonymity provide relative advantages to futures markets for conveying information of informed traders/speculators. This paper tests the informational advantage hypothesis for foreign exchange futures contracts relative to OTC contracts using actual OTC foreign exchange derivative trading data. In addition, we test for substitutability vs. complementarity of OTC products against foreign exchange futures products. We examine monthly trading volume and volatility estimates of the OTC market and the futures market for the Canadian Dollar over the period January 1998 to September 2005. Futures trading activity is shown to provide leading information to the OTC markets, suggesting that there are informational advantages to futures markets. Trading volume in the OTC (exchange traded) market shows uni-(bi-) directional Granger causality to the volatility to both spot and futures markets, consistent with greater responsiveness of the exchange traded (OTC) market to changes in market-wide (idiosyncratic)risk. Regression tests support substitutability between the foreign exchange futures market and the OTC derivatives market.

JEL: *F31, G13, G15*

Keywords: *OTC and exchange traded derivatives; Foreign exchange; Volume and volatility causality; Substitutability vs. complementarity*

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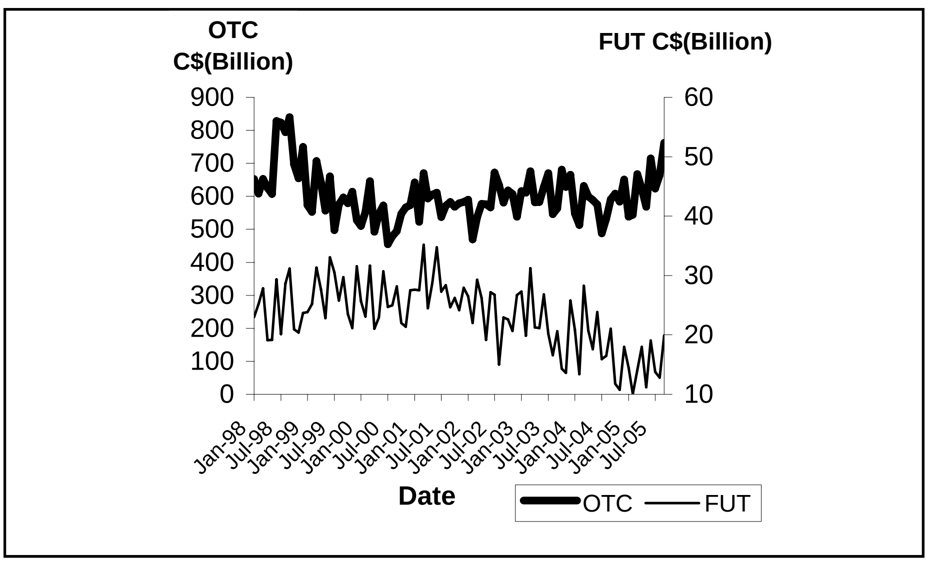
I. INTRODUCTION

In recent years, the growth in trading volume of exchange-traded derivatives contracts has been rapid, exceeding 20% per year globally, based on estimates of the Bank for International Settlements (BIS). However, the primary trading venue for currency derivatives is the OTC market, which is dominated by commercial banks. According to the 2004 BIS Triennial survey, the average daily volume in exchange traded currency products totalled 23 billion compared to \$1,345 billion in over-the-counter products.[1] Figure 1 highlights the size differential of OTC market vs. the Futures market for Canadian dollars. Over the period 1998-2005, the notional value of exchange traded Canadian dollar futures represents less than 5% of their OTC derivative counterparts.

Figure 1
Trading Volume: OTC vs. Futures



*In the figure, OTC is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C\$ Billion); FUT is the total of the daily notional values of the nearby contract in a month (in C\$ Billion). Monthly Trading Volumes are from January 1998 to September 2005.

The pre-eminent position of OTC derivative products relative to exchange traded derivatives could be troublesome for a number of reasons. First, such products lack transparency, with insufficient disclosure at the entity level. Insufficient transparency and surveillance in OTC products could give rise to manipulation of markets, or greater departures from fair value of trades. Commercial banks may steer their clients to OTC products with higher relative transactions costs for their captive clients.[2] Furthermore, counterparty risk exposures are far greater for OTC products than for exchange traded products, owing to daily variation settlements by exchange clearing houses for the latter. Greenspan (1999) suggests that such risk may represent as much as 6% of banks' total assets. Transactions cost advantages, however, would favor futures markets as the optimal venue for conveying information of informed traders/speculators.

Due to a lack of data, assessing the interactions between OTC and exchange traded derivative products has been difficult, at best. Some work has been done on the relationships between exchange traded *futures* vs. *spot* markets (for example, Chan et al. (1991); Chan (1992), Ng and Pirrong, (1996), Koutmos and Tucker (1996), and Min and Najand (1999)).[3] The few extant studies on the links between the OTC derivatives market and exchange traded futures ignore trade flows and are typically based on implied prices, rather than transaction prices.[4]

Rosenberg and Traub (2006) state that informed traders may prefer the futures market to the OTC market because of the anonymity of trader identity or higher speed of transaction execution. Huang (2002), Barclay, Hendershott and McCormick (2003), Hasbrouck (2003), and Kurov and Lasser (2004) provide evidence for the choice of anonymous markets by informed traders.

Nystedt (2004) provides a more general theoretical framework for examining the interactions between exchange traded markets and derivative markets, extending the incomplete market models of Duffie and Jackson (1989) and Tashjian and Weissman (1995). In this model, trading venues differ by the diverse types of risk that they are suited to hedge against, dissimilar risk aversions of their particular clients, and how they handle credit risk. In particular, the OTC has relative advantages in hedging idiosyncratic risk, and disadvantages in dealing with credit risk and credit risk aversion. On balance, whether or not the OTC market substitutes for or complements the exchange traded derivatives market remains an empirical matter.

This paper tests for whether or not the foreign exchange futures market displays informational advantages relative to the OTC market, in terms of conveying information of informed traders. In addition, we examine whether or not there are differences in the markets' responses to market wide (systematic) volatility changes. Finally we look at the overall substitutability vs. complementarity of OTC vs. foreign exchange futures products. Rather than looking at proxies for market activity or implied prices, this study uses *actual* monthly trade volume data which we combine with volatility estimates of the OTC market and futures markets for the Canadian dollar over the period January 1998 to September 2005. We find that futures trading activity leads trading activity in the OTC markets, but not vice versa, suggesting that there are informational advantages to futures markets. Trading volume in the OTC (exchange traded) market shows uni-(bi-) directional Granger causality to the volatility to both spot and futures markets, consistent with higher responsiveness of the exchange traded (OTC) market to changes in market-wide (idiosyncratic) risk. Regression tests are consistent with substitutability between the futures market and the OTC market.

The remainder of the paper is organized as follows. In Section II, we describe the data. Section III presents the empirical results. The paper concludes in Section IV with a summary of the findings.

II. DATA

Data for spot and OTC markets are obtained from a unique source of information: the annual reports on activities by the Canadian Foreign Exchange Committee (CFEC). The CFEC is composed of senior representatives from financial institutions actively involved in the foreign exchange market in Canada and in the U.S. Dollar/Canadian Dollar market globally. The CFEC regularly collects exchange traded and OTC derivative positions from approximately 60 major global dealers in the Group of 10 (G10) countries, as part of a directive by the Euro-currency Standing Committee of the Bank for International Settlements.[5] Major Canadian financial institutions participate in this reporting; consolidated amounts outstanding were collected by the CFEC for the first time as of June 30, 1998. The Bank of Canada coordinates, on behalf of market participants, the compilation of regular reports on the volume of foreign exchange business against Canadian Dollar. The historical spot exchange rates of the Canadian Dollar against U.S. Dollar are from the Bank of Canada.

The exchange traded futures data are from the Chicago Mercantile Exchange (CME) Canadian Dollar contracts, which were purchased from Norman's Historical Database.[6] The CME is the main exchange trading venue for Canadian Dollar futures contracts. Canadian Dollar futures on the CME first started trading in 1972. They are listed for six months in the March quarterly cycle: Mar, Jun, Sep, and Dec. The last trading day is the business day before the third Wednesday of the maturity month. Futures contracts are quoted in U.S. Dollars per Canadian Dollar, and call for physical delivery at expiration. The contract's trading unit is 100,000 Canadian dollars.

The CFEC annual reports provide monthly data for the OTC market from January 1998 through September 2005. We build our data set for the spot rate and the CME futures accordingly. The test dataset covers ninety three monthly observations from January 1998 through September 2005. Since the nearby contract accounts for 90.3 percent of the trading volume on all Canadian Dollar futures in term of the number of contracts traded in the CME on each day for our sample period, we focus on the nearby contract, rolling over to the next contract in the maturity month of the old contract on the day that the volume of the next contract exceeds that of the expiring contract. Our empirical analyses focus on the interactions between trading volume between the OTC and exchange traded derivatives markets and on measures of trading activity and market volatility.

Trading volume has been widely used to study the effects of competition between exchanges/trading venues (e.g. Silber (1981), Pirrong (1996) and Holder et al. (2002)). In addition, researchers have paid increasing attention to the relationship between trading volume and volatility. Clark (1973) states that volume and volatility are both driven by a common unobservable factor, which is determined by the arrival of new information to the market. His model predicts a positive correlation of volatility and unexpected trading volumes. In Tauchen and Pitts (1983), the comovement of volatility and trading volume depends on whether the number of traders is fixed or is growing. Lyons (1996) shows that trade quantity (volume) can impact prices. Using data for four currencies, Brandt and Kavajecz (2004) find that the orderflow imbalances account for up to 26% of the day-to-day variation in yields on normal trading days in the U.S. Treasury market. Chae (2005) reports that the trading volume has informational value in the U.S. equity market. Lee and Rui (2002) find feedback relationships between trading volume and return volatility in New York, Tokyo, and London. Daigler and Wiley (1999) find that large changes in volume are an important factor in explaining volatility in the futures market.

The basic variables that we use in our analyses are defined as follows: OTCVolume is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. FuturesVolatility is the monthly standard deviation of closing prices on each day of the nearby Canadian Dollar futures contracts traded in the CME for that month. SpotVolatility is the monthly standard deviation of the closing exchange rate on each day from Bank of Canada

Table 1 provides descriptive statistics for the variables used in the tests. It is clear that the notional value of futures contracts traded is much less than the respective OTC value.

Table 1
Descriptive statistics

	OTCVolume	**FuturesVolume**	**NotionalFront**	**NotionalAll**
Mean	603.70	158982.5	23.13	27.34
Median	590.00	159258.0	23.52	26.27
Maximum	840.00	227601.0	35.18	46.80
Minimum	455.00	81294.0	10.07	10.98
Std. Dev.	75.6081	34113.3	5.7501	8.9063
	SpotVolatility	**VolatilitySpot**	**FuturesVolatility**	**VolatilityFut**
Mean	0.0103	0.0004	0.0052	0.0004
Median	0.0098	0.0003	0.0048	0.0003
Maximum	0.0241	0.0012	0.0116	0.0014
Minimum	0.0040	0.0001	0.0019	0.0001
Std. Dev.	0.0040	0.0003	0.0023	0.0003

Summary measures of the variables used in the tests are shown. OTCVolume is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. NotionalFront is the total of the daily notional values of the nearby contract in a month (in C$ Billion).The daily notional value is calculated as the product of the contract size, the number of the front contract traded and the average of the opening and closing prices of that contract for each day. NotionalAll is the total of the daily notional values of all Canadian Dollars futures contract in a month (in C$ Billion). The daily notional value is calculated as the product of the contract size, the number of all contracts, and the average of the opening and closing price of all contracts traded on each day. SpotVolatility is the monthly standard deviation of the exchange rate at close from Bank of Canada. VolatilitySpot is the monthly variance calculated by Eq.6 on the exchange rate at close from Bank of Canada. FuturesVolatility is the monthly standard deviation of closing prices on each day of the nearby Canadian Dollar futures contracts traded in the CME for that month. VolatilityFut is the monthly variance of the nearby Canadian Dollar futures contracts traded in the CME for that month; and is calculated by Eq.6. A total of 93 monthly data from January 1998 to September 2005 is used.

Table 2 shows the contemporaneous correlations for these measures.

Table 2
Contemporaneous correlation between series

	OTCVolume	**FuturesVolume**	**FuturesVolatility**	**SpotVolatility**
OTCVolume	1			
FuturesVolume	0.150346	1		
FuturesVolatility	0.189609*	-0.31431*	1	
SpotVolatility	0.184389*	-0.12193	0.8811**	1

This table reports the contemporaneous Pearson correlation coefficients between market activity measures for the OTC, Futures and Spot market. OTCVolume is the the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. FuturesVolatility is the monthly standard deviation of closing prices on each day of the nearby Canadian Dollar futures contracts traded in the CME for that month. SpotVolatility is the monthly standard deviation of the exchange rate at close from Bank of Canada. The sample period is from January 1998 to September 2005.
*significant at .05 level; ** significant at .01 level.

Trading activity in the OTC markets is not significantly related to trading in the futures markets, based on the bi-variate correlations. Interestingly, greater activity in the OTC (futures) markets is associated with greater (rediced) volatility of the spot and futures prices. This is consistent with the view that futures markets help to stabilize market risk. However, these correlations need to be interpreted with caution, and need not reflect causality. To the extent that OTC volume and market volatility are trending over time, even if they are actually unrelated variables, they may appear to be positively correlated simply because of the shared directionality. To establish causality between the variables is a matter to which we now turn.

III. CAUSALITY TESTS

To examine the lead-lag relationships of market activities between the OTC and futures market and between the futures market and the spot market, we perform a series of pair-wise Granger causality tests (Granger, 1969). For two variables x, and y, and for autoregressive lags of length p and k, we estimate:

$$y_t = \alpha_0 + \sum_i^p \beta_i x_{t-i} + \sum_i^k \alpha_i y_{t-i} + \varepsilon_{1t} \tag{1}$$

$$x_t = \alpha_0 + \sum_i^p \beta_i x_{t-i} + \sum_i^k \alpha_i y_{t-i} + \varepsilon_{2t} \tag{2}$$

where ε_{1t} and ε_{2t} are the error terms. The subscripts stand for the date with appropriate lags. Significance of the causality results are based on F-tests of the null hypotheses:

$$H_0: \beta_1 = \beta_2 = \ldots = \beta_p = 0 \text{ for Eq.1} \tag{3}$$
$$H_0: \alpha_1 = \alpha_2 = \ldots = \alpha_k = 0 \text{ for Eq.2} \tag{4}$$

The *F*-value for testing the null hypothesis computed as:

$$F = \frac{(RSS_0 - RSS_1)/p}{RSS1/(T-2p-1)} \tag{5}$$

where RSS_1 is the sum of squared residuals of Equation (1) or Equation (2), and RSS_0 is the sum of the squared residuals with the restriction that $\beta_1 = \beta_2 = \ldots = \beta_p = 0$ or $\alpha_1 = \alpha_2 = \ldots = \alpha\, B_k = 0$. The F-value is asymptotically distributed as F (p, T – 2p – 1) or F (k, T – 2k – 1) for equation 1 and 2 respectively. When the null hypothesis of (3) is rejected, then x is said to have Granger-caused y. When the null hypothesis of (3) is rejected and null hypotheses of (4) cannot be rejected, then x is said to have one directional Granger-causation to y.

Table 3
Unit root tests

	OTCVolume		**FuturesVolume**	
	Intercept	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
t-Stat ADF	-5.4251	-5.3944	-2.0218	-3.8942
p-Value ADF	0.0000**	0.0001**	0.2772	0.0162*
t-Stat PP	-5.8741	-5.8758	-8.7565	-9.8660
p-Value PP	0.0000**	0.0000**	0.0000	0.0000**
	FuturesVolatility		**SpotVolatility**	
	Intercept	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
t-Stat ADF	-2.6834	-8.0560	-7.8706	-8.1872
p-Value ADF	0.0809	0.0000**	0.0000**	0.0000**
t-Stat PP	-6.5379	-8.1850	-8.1174	-8.3271
p-Value PP	0.0000**	0.0000**	0.0000**	0.0000**

* significant at .05 level; ** significant at .01 level.

t-statistics and MacKinnon (1996) one-sided p-values of Augmented Dickey-Fuller test (ADF) and Phillips and Perron test (PP) with automatic selection of lags on monthly measures of activities in the Canadian Dollar markets are presented. The maximum lag is set at 11in the tests. Column Intercept, Trend & Intercept are the results of the models with an intercept term and with both a trend and intercept term, respectively. OTCVolume is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. FuturesVolatility is the monthly standard deviation of closing prices on each day of the nearby Canadian Dollar futures contracts traded in the CME for that month. SpotVolatility is the monthly standard deviation of the exchange rate at close from Bank of Canada. The sample period is from January 1998 to September 2005.

As a first step in the analysis, we test the series for unit roots using Augmented Dickey–Fuller (ADF, 1981) and Phillips and Perron (PP, 1988) tests. For non-stationary series, classical causality tests could lead to spurious results, with classical significance tests incorrectly identifying significant relationships between the variables. In both ADF and PP tests, we report results for two models: estimated with an intercept, as well as with an intercept and trend. The null hypothesis is that the series to be tested has a unit root. The test results are reported in Table 3. As shown in the table, all series reject the unit root hypothesis, and are hence treated as stationary in the causality tests.

We use the AIC or BIC benchmark to select the optimum autoregressive lags of length p and k for each variable. Three lags were determined as optimal for these variables.

IV. CAUSALITY TEST RESULTS

The results for the Granger-causality tests are shown in Table 4. Test 1 and Test 2 show that the OTC volumes have one directional Granger causality with volatility of both the spot and futures markets. Test 4 and Test 5 show bi-directional feedback between futures trading volume and volatility of the spot or futures market. These results are consistent with Nysted (2004)'s hypothesis of the greater responsiveness of the exchange traded (OTC) market to changes in market-wide (idiosyncratic) risk. The bi-directional feedback results are also consistent with Min and Najand (1999) who show that trading volume has significant explanatory power for volatility changes in both spot and futures markets.

The informational advantage of futures markets is shown in Test 3. As is evident, futures trading activity leads trading activity in the OTC markets, but not vice versa. This suggests that there are informational advantages to exchange traded futures markets which provide required anonymity for informed traders (Rosenberg and Traub (2006), Huang (2002), Barclay et al. (2003), Hasbrouck (2003), Kurov and Lasser (2004), Reiss and Werner (2005) and Bjonnes and Rime (2005)).[7]

Table 4
Pair-wise Granger causality tests

Test	Pair	Granger-causality Test: Null Hypothesis	F-Stat	p-Value
1	OTC Volume & SpotVolatility	Spot measure does not cause OTC measure	1.5364	0.2112
		OTC measure does not cause Spot measure	4.4732	0.0058**
2	OTC Volume & FuturesVolatility	Futures measure does not cause OTC measure	1.0837	0.3607
		OTC measure does not cause Futures measure	4.8724	0.0036**
3	OTC Volume & FuturesVolume	Futures measure does not cause OTC measure	3.9076	0.0116*
		OTC measure does not cause Futures measure	1.0858	0.3598
4	FuturesVolume & SpotVolatility	Spot measure does not cause Futures measure	2.4043	0.0733
		Futures measure does not cause Spot measure	5.3974	0.0019**
5	FuturesVolume & FuturesVolatility	Futures Volatility does not cause Futures Volume	2.7428	0.0483*
		Futures Volume does not cause Futures Volatility	6.1985	0.0007**

* significant at .05 level; ** significant at .01 level.
Granger Causality results are reported in this Table. The test models and hypotheses are from Eq.1 to Eq.5 in the text. OTCVolume is the the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. FuturesVolatility is the monthly standard deviation of closing prices on each day of the nearby Canadian Dollar futures contracts traded in the CME for that month. SpotVolatility is the monthly standard deviation of the exchange rate at close from Bank of Canada. The sample period is from January 1998 to September 2005.

Holder et al. (2002) characterize complementary (as opposed to substitute) markets as those in which prices reflect information flows, with no significant relationship between trading volume between the two markets. The significant result reported for Test 3, that futures trading volume causes OTC trading volume, is consistent with the substitutability of the markets. To further explore this issue, in Table 5 we report regression estimates of the causality model. On the left (right) hand side of the equation, we show the results with the OTC Derivatives (Futures Market) Trading Volume as the dependent variable. No significant relationship between the lagged values of the OTC Volume measures in the futures volume regression is observed; however, a negative and significant relationship is shown between the lagged futures volume and OTC trading activity. Higher trading activity in futures markets reduces the trading volume in the OTC market, consistent with substitutability as opposed to complementarity between the markets.

Cox, Ingersoll and Ross (1981) demonstrate that volatile interest rates may affect the pricing of forwards vs. futures, and in turn the choice of market venue for participants. This may be more of a concern for long term contracts. To test for an interest effect, we also included the contemporaneous monthly average of squared daily interest differences between three month T-bill rates of U.S. and Canada as a regressor in the causality equations. The results are shown in Panel B of Table 5. The results do not show any significant interest volatility effect.[8]

Table 5
Trading volume regression for OTC and futures market

Dependent Variable: OTCVolume				Dependent Variable: FuturesVolume			
Independent Variable	**Coefficient**	**t-Statistic**	**Prob.**	**Independent Variable**	**Coefficient**	**t-Statistic**	**Prob.**
Panel A							
C	230.74	2.7786	0.0068	**C**	27862.25	0.7845	0.4350
OTCVolume (-1)	0.4181	3.8041	0.0003**	**FuturesVolume (-1)**	0.1466	1.6619	0.1003
OTCVolume (-2)	0.0484	0.3954	0.6936	**FuturesVolume (-2)**	-0.0500	-0.5247	0.6012
OTCVolume (-3)	0.2664	2.4368	0.0170*	**FuturesVolume (-3)**	0.6558	7.1796	0.0000**
FuturesVolume (-1)	-0.0006	-2.8625	0.0053**	**OTCVolume (-1)**	-69.0416	-1.4687	0.1457
FuturesVolume (-2)	-0.0002	-0.7397	0.4616	**OTCVolume (-2)**	67.7337	1.2924	0.1998
FuturesVolume (-3)	0.0003	1.4974	0.1381	**OTCVolume (-3)**	18.5289	0.3963	0.6929
Adjusted R-squared			0.3752	**Adjusted R-squared**			0.4347
Durbin-Watson stat			1.9318	**Durbin-Watson stat**			1.6700
F-statistic			9.9065	**F-statistic**			12.4049
Prob(F-statistic)			0.0000	**Prob(F-statistic)**			0.0000

* significant at .05 level;** significant at .05 level.

Table 5 (continued)

Trading volume regression for OTC and futures market

Dependent Variable: OTCVolume				Dependent Variable: FuturesVolume			
Independent Variable	**Coefficient**	**t-Statistic**	**Prob.**	**Independent Variable**	**Coefficient**	**t-Statistic**	**Prob.**
Panel B							
C	230.6457	2.7490	0.0074	**C**	28565.80	0.7963	0.4282
OTCVolume (-1)	0.4181	3.7781	0.0003**	**FuturesVolume (-1)**	0.1453	1.6339	0.1061
OTCVolume (-2)	0.0484	0.3929	0.6954	**FuturesVolume (-2)**	-0.0511	-0.5323	0.5960
OTCVolume (-3)	0.2664	2.4218	0.0176	**FuturesVolume (-3)**	0.6544	7.1049	0.0000*
FuturesVolume (-1)	-0.0006	-2.8378	0.0057**	**OTCVolume (-1)**	-68.6726	-1.4515	0.1505
FuturesVolume (-2)	-0.0002	-0.7336	0.4653	**OTCVolume (-2)**	67.7676	1.2856	0.2022
FuturesVolume (-3)	0.0003	1.4854	0.1413	**OTCVolume (-3)**	18.6424	0.3964	0.6928
InterestDif	0.0671	0.0121	0.9903	**InterestDif**	-503.7643	-0.2132	0.8317
Adjusted R-squared			0.3676	**Adjusted R-squared**			0.4281
Durbin-Watson stat			1.9317	**Durbin-Watson stat**			1.6709
F-statistic			8.3890	**F-statistic**			10.5170
Prob(F-statistic)			0.0000	**Prob(F-statistic)**			0.0000

* significant at .05 level;** significant at .05 level.

Regression results of the Granger test 3 of Table 4, relating OTC Trading Volumes to Exchange Traded Futures Trading volumes are reported. OTCVolume is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. InterestDif is monthly average of squared daily interest differences between three month T-bill rates of U.S. and Canada. C is constant term in regressions. The numbers in parenthesis are the lags of the variables. The sample period is from January 1998 to September 2005.

V. ROBUSTNESS TESTS

Similar to French, Schwert, and Stambaugh (1987), in addition to looking at monthly volatility of exchange rates, we also consider the volatility of **monthly rates of return** (see also Andersen, Bollerslev, Diebold, and Labys, (1999)).

Suppose that we are interested in the monthly volatility of an asset for which daily returns are available. Assume there are n trading days in month t ; if $r_{t,i}$, defined as the log returns of the asset on day i is a white noise series, the estimated monthly volatility is then:

$$\sigma_m^2 = \frac{n}{n-1}\sum_{i=1}^{n}(r_{t,i} - \bar{r}_t)^2 \quad (6)$$

Table 6 shows that two volatility series for spot and futures estimated by Eq.6 reject the unit root hypothesis, and are hence treated as stationary in the causality tests.

Table 6
Unit root tests

	VolatilityFut		VolatilitySpot		NotionalFront	
	Intercept	**Trend & Intercept**	**Intercept**	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
t-Stat ADF	-3.538	-4.176	-3.566	-5.762	-1.1458	-3.1398
p-Value ADF	0.009	0.007	0.008	0.000	0.6946	0.1037
t-Stat PP	-4.670	-5.458	-4.961	-5.839	-7.0163	-8.8736
p-Value PP	0.000	0.000	0.000	0.000	0.0000	0.0000

t-statistics and MacKinnon (1996) one-sided p-values of Augmented Dickey-Fuller test (ADF) and Phillips and Perron test (PP) with automatic selection of lags on monthly volatility in the Canadian Dollar markets are presented. The maximum lag is set at 11in the tests. Column Intercept, Trend & Intercept are the results of the models with an intercept term and with both a trend and intercept term, respectively. VolatilityFut is the monthly variance of the returns of the nearby Canadian Dollar futures contract traded in the CME for that month (Eq.6). VolatilitySpot is the monthly variance calculated by Eq.6 on the exchange rate at close from Bank of Canada. NotionalFront is the total of the daily notional values of the nearby contract in a month (in C$ Billion). The sample period is from January 1998 to September 2005. All tests are significant at .01 levels.

Moreover, we also used NotionalFront as a measure of transaction volume of the futures market. NotionalFront is the total of the daily notional values of the nearby contract in a month (in C$ Billion).The daily notional value is calculated as the product of the contract size, the number of the front contracts traded on each day, and the average of the opening and the closing price of that contract for the day. Three lags were determined as optimal autoregressive lags with the AIC or BIC benchmarks for these variables in our tests.

The bi-directional feedback results for both the spot and futures markets persist when new measures of volatility are used in the tests (Test 4 and Test 5 in Table 7).

Table 7

Pair-wise Granger causality tests

Test	Pair	Granger-causality	F-Stat	p-Value
1	OTCVolume & VolatilitySpot	Spot measure does not cause OTC measure	0.4443	0.7220
		OTC measure does not cause Spot measure	1.0957	0.3557
2	OTCVolume & VolatilityFut	Futures measure does not cause OTC measure	0.5655	0.6393
		OTC measure does not cause Futures measure	1.5519	0.2073
3	OTCVolume & NotionalFront	Futures measure does not cause OTC measure	3.5846	0.0172*
		OTC measure does not cause Futures measure	1.1150	0.3478
4	FuturesVolume & VolatilitySpot	Spot measure does not cause Futures measure	2.4586	0.0685
		Futures measure does not cause Spot measure	2.8099	0.0445*
5	FuturesVolume & VolatilityFut	Futures volatility measure does not cause Futures volume	3.2799	0.0249*
		Futures volume does not cause futures volatility measure	2.8767	0.0410*

* significant at .05 level.

Granger Causality results are reported in this table. The test models and hypotheses are from Eq.1 to Eq.5 in the text. OTCVolume is the sum of monthly Canadian Dollar foreign exchange OTC Forward and Swap Market volumes (in C$ Billion). FuturesVolume is the number of nearby Canadian Dollar futures contracts traded in the CME for that month. VolatilityFut is the monthly variance of the nearby Canadian Dollar futures contracts traded in the CME for that month; (from Eq.6). VolatilitySpot is the monthly return variance (calculated by Eq.6) on the exchange rate at close from Bank of Canada. NotionalFront is the total of the daily notional values of the nearby contract in a month (in C$ Billion). The sample period is from January 1998 to September 2005.

In addition, when the volatility is estimated by Eq.6, the significance of the one directional Granger causality for the OTC Volume with the volatility of both the spot and futures markets disappears (Test 1 and Test 2 in Table 7). Most important, the informational rule of futures markets is still significant with the notional value as the measure of trading volume in futures market (Test 3)[9].

Although recent studies have suggested that transaction volume provides information, there does not seem to be a consensus on its effects (Karpoff, 1987). To provide evidence that trading volume in derivative markets affects information flows for our sample, we also investigated the relationship between price changes and trading volume. Similar to Schwert (1989), a distributed lag regression of futures market volatility (estimated by Eq.6) in month t on the growth rate of futures trading volume (VolGrowth) is performed:

$$\sigma_t^2 = C_0 + \sum_{i=0}^{L} \beta_i * \text{VolGrowth}_{t-i} \tag{7}$$

where $\text{VolGrowth}_t = \text{FuturesVolume}_t / \text{FuturesVolume}_{t-1}$

Table 8 shows that the positive relationship between the variance of futures returns and market trading volume are maintained. The results are also robust to specifications with and without ARMA terms.

Table 8
Estimates of the relation between the variance of futures returns and market trading volume

Model 1				**Model 2**			
Dependent Variable: VolatilityFut				**Dependent Variable: VolatilityFut**			
Independent Variable	Coefficient	t-Statistic	Prob.	**Independent Variable**	Coefficient	t-Statistic	Prob.
C	-0.0008	-1.9934	0.0494	**C**	-0.0005	-1.2928	0.1997
VolGrowth	0.0004	2.5162	0.0137*	**VolGrowth**	0.0003	2.1786	0.0322*
VolGrowth(-1)	0.0004	2.9942	0.0036**	**VolGrowth(-1)**	0.0003	2.7233	0.0079**
VolGrowth(-2)	0.0004	2.7005	0.0083**	**VolGrowth(-2)**	0.0003	2.3229	0.0226*
				AR(1)	0.5145	4.9003	0.0000**
				MA(2)	0.2472	2.0630	0.0422*
Adjusted R-squared			0.0689	**Adjusted R-squared**			0.4022
Durbin-Watson stat			0.8517	**Durbin-Watson stat**			1.9818
F-statistic			3.1946	**F-statistic**			12.8408
Prob(F-statistic)			0.0275	**Prob(F-statistic)**			0.0000
Residuals				**Residuals**			
Q-Stat(6)	65.0260	**Prob**	0.0000	**Q-Stat(6)**	4.3745	**Prob**	0.3580

* significant at .05 level;** significant at .05 level.

Distributed lag regression results on the relationship between the variance of futures returns and market trading volume (Eq.7). Model 1 (2) shows estimates of Eq.7 without (with) ARMA terms. VolatilityFut is the monthly variance of the returns on the nearby Canadian Dollar futures contract traded on the CME for that month. VolGrowth in month t is the growth rate of volume for the nearby Canadian Dollar futures trading contract. Q-Stat is the Ljung-Box Q-statistics. The sample period is from January 1998 to September 2005.

VI. CONCLUSIONS

This paper examines the interactions between OTC derivative markets and exchange traded markets using actual trading data for the respective markets. Specifically we examine the monthly trading volume and volatility estimates of the OTC market and futures markets for the Canadian dollar over the period January 1998 to September 2005. Futures trading activity is shown to provide leading information to the OTC markets, consistent with informational advantages for futures markets. In addition, the exchange traded (OTC) market shows greater responsiveness to changes in market-wide (idiosyncratic) risk. Regression tests support substitutability between the foreign exchange futures market and the OTC derivatives market.

ENDNOTES

1. The notional principle of foreign exchange OTC derivatives (forwards, forex swaps, currency swaps, and currency options) amounted to $31.609 trillion and only $107.6 billion for exchange traded derivatives of foreign exchange products in December 2005 according to the BIS. See BIS, Quarterly Review, September 2006.
2. Alternatively, as a precondition for a loan, a bank may require a client to undertake a short currency hedge using its own vehicles. For example, a bank may require that a short forward foreign exchange position on a loan covenant be covered with simultaneous short call option and long put option positions at (bank) set prices, rather than providing a choice for the client to use exchange traded futures or options contracts to provide the same cash flow risk profile.
3. Chatrath and Song (1998) test for volatility spillover relationships between the spot and futures markets for the Japanese Yen versus the US Dollar. Rosenberg and Traub (2006) find that the amount of information contained in currency futures prices is much greater than one would expect based on relative market size, based on order flows for the Deutsche Mark/Euro, Japanese Yen, Swiss Franc and the Pound.
4. For example, Grinblatt and Jegadeesh (1996) investigate the timing of the flow of information across the Eurodollar forward and futures markets. They find that there is a two or three-week delay in information flow from the futures market to the forward market. They find no evidence of informational delays from the forward market to the futures market. Park and Switzer (1997) show that forecasts from futures prices tend to outperform forward prices for U.S. T-bills, T-Notes and Treasury bonds. Gupta and Subrahmanyam (2000) report no delays in the flow of information from the Eurocurrency futures market to the swap market. Kavussanos and Vivikis (2004) is one of the only studies that we are aware of that uses actual OTC data. They investigate the lead-lag relationship in returns and volatilities between spot and forward prices in the OTC Forward Freight Agreement market. They report a bi-directional lead-lag relationship between the spot and the forward markets. The OTC contracts are shown to provide more rapid information discovery relative to the spot markets.
5. The proposal was approved by the governors of the central banks of the G10 countries in January 1997.
6. The CME also trades Canadian dollar option contracts. On September 26, 2005 the Montreal exchange launched currency options on the US dollar. Trading of these contracts has been limited, however.
7. According to the third annual survey of European asset managers by Financial News, fund managers consider the anonymity and mandate restrictions as important factors in using exchange-traded instruments. http://www.efinancialnewsnetwork.com/financialnews//attachments/7111388230203034/6361029043020303.pdf
8. We also tried various lags of InterestDif (calculated as the monthly average of squared daily interest differences between three month T-bill rates of U.S. and Canada) in the estimation; the results for these variants are all insignificant.
9. We also perform Engle ARCH/GARCH tests on the four measures for futures and spot volatility. We found no ARCH effects for these four series.

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