Three Essays on Derivatives Markets

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ABSTRACT

Three Essays on Derivatives Markets

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This thesis consists of three essays. The first essay (chapter two) looks at the impact of derivatives regulation on liquidity and mispricing of US derivatives markets. In particular, we test the hypothesis that Dodd Frank derivative provisions may improve the efficiency of the exchange traded markets due to an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. We examine the impact of key Dodd Frank events on market activity for financial derivatives (futures and option contracts on US T bonds, Eurodollar futures and options, and S&P 500 Futures contracts) and on foreign exchange derivatives (futures and options contracts on EUROs, British Pounds, and Canadian dollars). First, we look at how liquidity on the markets has been affected. Next, we test for mispricing of derivatives contracts. We find that measured liquidity does fall for US financial futures and options but rises for foreign exchange futures and options subsequent to the introduction of the Treasury guidelines for OTC trading. We also find that the efficiency of the U.S. exchange traded futures markets has improved, as reflected by a reduction in mispricing in the S&P futures contracts; some improvement in pricing efficiency is also shown for nearby Eurodollar futures contracts. These results are consistent with an increase of arbitrage by

traders on the exchange traded markets, as opposed to the OTC markets, in contrast to the "noise" model.

The second essay (chapter three) provides a description and comparison between OTC and exchange-traded derivatives market activity. It compares the turnover in OTC derivatives among three regions: Americas, Europe, and Asia/Pacific. Similar analysis is also conducted for non-financial customers. The empirical results show that the growth rate of exchange-traded derivatives leads growth rate of OTC derivatives. The conclusion still holds for derivatives of different risk categories.

The third essay (chapter four) examines the futures market efficiency of the VIX and the relative merits of the VIX and VIX futures contracts in forecasting future S&P 500 excess returns the future Russell 2000 excess returns, and the future small-cap premium. We find that the current VIX is significantly negatively related to S&P 500 index excess returns and positively related to the Russell 2000 index excess returns. These results suggest that the VIX predicts asset returns based on size based portfolios asymmetrically – with higher (lower) values of the VIX associated with lower (higher) values of small-cap (large cap) returns in the future. However, the VIX and VIX modeled by an ARIMA process are not significantly related to future values of the small-cap premium. In contrast, VIX futures show forecasting prowess for the S&P 500 excess return, the Russell 2000 excess return and the small-cap premium. VIX futures are significantly negatively related to these series. The results for the speculative efficiency of the VIX futures contracts are mixed, however. Overall, the analyses support the hypothesis of informational advantages of the futures markets relative to the spot market in the price discovery process not just for size based asset returns, but on the size premium as well.

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I would like to dedicate this thesis to my family back in China for their encouragement and support.

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CHAPTER 1

INTRODUCTION

My dissertation explores the impact of derivatives regulations on the exchange traded derivatives by examining the market liquidity and price discovery efficiency pre and post the events surrounding key Dodd Frank regulations. The interactions of position growth rates between exchange traded derivatives and OTC derivatives across different risk categories are studied. It also examines the futures market efficiency of the VIX and the relative merits of the VIX and VIX futures contracts in forecasting not only future size based asset returns, but future size premium as well.

As a response to the late 2000s recession, the Dodd-Frank Wall Street Reform and Consumer Protection Act was passed by the United States government. It brought the most significant changes to financial regulation in the U.S. The section 13 of the Bank Holding Company Act (the "Volcker Rule") prohibits any banking entity from engaging in proprietary trading. This type of trading activity includes the buying and selling of securities, derivatives, bonds or other financial products to earn returns. Banks involved in proprietary trading are acting like hedge funds in seeking high returns on investments. Financial firms will need to create comprehensive record-keeping and reporting systems to provide both company-wide and segment-specific trading and financial data to comply with the regulations, which have not been finalized. A variety of critics have attacked the law. One of the criticisms is the uncertainty of its provisions. My first essay studies how the regulatory changes can affect the behaviour of market participants by examining the liquidity of US financial derivatives markets and pricing efficiency of the US exchange traded futures markets.

Trades in the OTC derivatives market are typically much larger than trades in the exchange-traded derivatives market. In the OTC derivatives market, dealers negotiate directly with each other to tailor the amount and expiration date to their own needs. There is no exchange or central clearing house to support the OTC transactions. Therefore, each counterparty takes the credit risk that the contract might not be honoured. In the exchange-traded derivatives market, the contracts are highly liquid with standardized unit size and fixed expiration date. The execution of the contract is guaranteed by marking to market mechanism. According to the triennial global central bank surveys of foreign exchange and derivatives market activity by Bank for International settlements, growth in the notional amounts outstanding in OTC derivatives market and exchange-traded derivatives market has been rapid. My second essay examines the interaction between the growth rates of positions between these two markets across different risk categories.

Substantial work has tested the relationship between volatility and returns with mixed results. Most of them focus on the contemporaneous relationship between realized volatility and the risk premium. Since 2000, economically and statistically significant abnormal performance is observed for small cap stocks in the United States and Canada. The riskiness of the market might explain the differential performance for size based asset portfolios. We hypothesize that VIX may contain information in forecasting future portfolio returns. My third essay examines the futures market efficiency of the VIX and the information quality of the VIX and VIX futures in forecasting future size based portfolio excess returns and small-cap premium.

CHAPTER TWO

IMPACT OF DERIVATIVES REGULATIONS ON THE LIQUIDITY OF EXCHANGED TRADED DERIVATIVES

2.1 INTRODUCTION

The financial crisis has given rise to increased regulatory activism around the world. In the United States, policy makers responded to widespread calls for regulatory reform to address perceived supervisory deficiencies with the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank). One of the criticisms of Dodd-Frank is that the uncertainty of its provisions, such as section 13 of the Bank Holding Company Act (the "Volker Rule"), will increase volatility and adversely affect market efficiency. Some commentators, for example Greenspan (2011) and Duffie (2012), have suggested that Dodd-Frank will have undesirable implications to the markets in general, by lowering the quality of information about fundamentals, which would reduce efficient price discovery as well as through a reduction of liquidity. However, this may be offset through a migration of market making and investment activities to other trading venues. Duffie (2012) discusses problems associated with migration to non-bank firms such as hedge funds and insurance companies. We look at the implications of another possible conduit for trade migration***: the redirection of trades from the OTC markets to that of exchange traded derivatives.*** Such a redirection could be expected to the extent that the exchange traded markets substitute for the OTC markets (see e.g. Switzer and Fan (2007)). A migration from the OTC markets that increases activity in exchange traded derivatives in general, which benefit from volatility, might be posited to improve the efficiency of the latter.

How regulatory changes *per se* affect market liquidity and efficiency remain open questions in the literature. The events surrounding key Dodd Frank regulations provide a useful setting to add to the literature on how the regulatory process can affect the behavior of market participants, as reflected in trading volume or open interest and efficient pricing of exchange traded derivatives. The remainder of this paper is organized as follows. In the next section, we look at the impact of key Dodd Frank event dates on the liquidity of US financial derivatives markets. In section 2.3 we look at pricing efficiency based on the cost-of carry for S&P futures contracts. In section 2.4, we look at deviations of futures from implied forward prices for Eurodollar contracts. The paper concludes with a summary in section 2.5.

2.2 DODD-FRANK AND THE LIQUIDITY OF DERIVATIVES MARKETS

In this section, we look at the impact of Dodd Frank on the liquidity US derivatives markets. A key driver in previous studies of market liquidity is volatility, which as mentioned previously, might be expected to increase, given the uncertainty in the implementation of Dodd-Frank regulations. Clark (1973) asserts that an unobservable factor that reflects new information arrival affects both volume and volatility. Tauchen and Pitts (1983) propose two theoretical explanations for the co-movement of volatility and trade volume in markets. Chen, Cuny, and Haugen (1995) examine how volatility affects the basis and open interest of stock index futures. When examining the relationship between volatility and open interest, they include lags of the open interest variable to take into account the time-series behavior of open interest and find that much of today's open interest comes from the "carry over" from yesterday's open interest. In their model, an increase in volatility entices more traders into the market to share the risk. Rather than reducing risk exposure through selling stocks, investors take advantage of the derivatives markets –e.g. they share risk by selling the S&P 500 futures, which causes open interest to increase. Their results are consistent with this model. When there is a large positive shift in volatility, a strong positive relation between volatility and open interest is observed. Bhargava and Malhotra (2007) use both volume and open interest to distinguish between speculators and hedgers. They examine the relationship between trading activity in foreign currency futures and exchange rate volatility. They find that speculators and day traders destabilize the market for futures with lower demand for futures in response to increased volatility. Whether hedgers stabilize or destabilize the market is inconclusive since the demand from hedgers shows mixed results.

Our model re-examines the linkages for volume and volatility extending the Chen, Cuny, and Haugen (1995) and Bhargava and Malhotra (2007) studies using more recent data. We also incorporate structural shifts associated with key Dodd Frank announcement days for a wider variety of derivative products into the models. We look at financial derivatives: futures and option contracts on US T bonds and Eurodollars as well as S&P 500 futures contracts. We also look at foreign exchange derivatives: futures and options contracts on EUROs, British Pounds, and Canadian Dollars. Our objective is to look at a full range of market derivative products as they might be affected by Dodd-Frank. We chose to look at the derivative products separately, which allows us to abstract from possible distortionary effects that may affect specific instruments. For example futures contracts would not be subject to "moneyness" biases such as are typically found in exchange traded options.

The basic regression of open interest extends Chen, Cuny, and Haugan (1995) and Bhargava and Malhotra (2007) and is as follows:

$$OpenInterest_t = \alpha_0 + \alpha_1 HistoricalVar_t + \alpha_2 DoddFrank_t + \varepsilon_t \qquad (2.1)$$

where *OpenInterest* is the sum of open interest across the relevant contracts, and *HistoricalVar* is the historical variance of the underlying asset. *DoddFrank* is a dummy variable equal to one at the date of and subsequent to three "watershed" Dodd-Frank announcement dates[1]. We use open interest, rather than trading volume as our measure of liquidity to capture how restrictions on OTC markets entice new participants to migrate to the exchange traded markets. This is in the same spirit as Chen, Cuny and Haugen (1995) who focus on the role of volatility in inducing new market participants. Using volume as a measure of liquidity would not necessarily capture market migration effects. Trading volume could increase in a market due to entry or exit, which would not allow us to isolate the direction of the migration effect. The selection of key announcement dates involved the consideration of a number of issues relevant to testing for the impact of financial regulations. First, we wanted to ensure that the announcement dates do not coincide with any other major regulatory announcements, or financial industry specific announcements. In addition, we wanted to identify major events in which specific measures by which regulatory intent will be implemented. Dodd-Frank follows standard procedure in the development of US financial regulation: its promulgation is a consideration for politicians, while its implementation is the

[1]The Dodd-Frank dummy variables are equal to one beginning on the date of each announcement until the end of the sample period. This allows us to test if the announcements have separate effects, as well as to identify when the Dodd-Frank measures get imparted into the markets. For example, if each of the breakpoint dummy variables is significant, this would suggest that Dodd-Frank is a continuous process with distinct episodes.

responsibility of the regulatory agencies mandated by the legislation itself (Fullenkamp and Sharma (2012)). As a result one must draw a distinction between regulatory events relating to Dodd-Frank, which we will refer to as "mandates", i.e. those which specify what regulatory deficiency is to be addressed and by whom, versus "implementation" related events which specify actions which will be taken, or specify measures to be included in rules enforced by regulators. We choose as announcement events" implementation" date events, since they are most relevant to market participants.

Our first event occurs on ***August 11, 2009***, when the Treasury formally submitted to Congress, a "Proposed OTC Derivatives Act" which, called for central clearing and more strict oversight of OTC markets through stricter recordkeeping and data-reporting requirements. In addition, the Treasury proposal outlined the need for greater capital and margin requirements for OTC market participants, with the intention of increasing the overall stability of the financial system. This event represents an important moment in defining the shape of OTC legislation, and was the basis for much of what would later become the OTC portion of HR 4173 (the House version of what would later become Dodd-Frank). This proposal was highly implementation-related, and provided financial institutions around the world a foretaste of forthcoming OTC regulation, and the concomitant compliance costs.

The second selected event occurs on ***June 25, 2010*** with the completion of the reconciliation of the House and Senate versions of the bill. By the afternoon of the 25th an outline of the final version of Dodd-Frank was released to the public. The implementation of the Act was widely expected to have a negative impact on the operation of many financial institutions. However, the impact of the announcement on the markets might be expected to be somewhat muted, given the advanced scrutiny of market participants of the House and

Senate proposals. Furthermore, many components of the reconciled version of the bill were considered as *favorable news*, since they were less harsh than initially proposed in the original House and Senate versions (Paletta, 2010.)

Our third selected event is ***October 6, 2011***, which is the first trading day following the leak of a memorandum containing a draft of the Volcker Rule, ahead of the scheduled (October 11) FDIC conference (McGrane and Patterson (2011)). The Volcker Rule prohibits banks or institutions that own banks from engaging in proprietary trading on their own account – i.e. trading that that is not at the behest of clients. Furthermore, banks are proscribed from, owning or investing in hedge funds or private equity funds. From a financial economics perspective, the rule may seem to undermine market completeness, by potentially eliminating arbitrage activities by important financial agents. The Volker rule leak event is a surprise that contains salient material information that was confirmed at the formal release date. In an efficient market, one might expect the market response to this event subsumes the effects of the formal release date announcement. Switzer and Sheahan-Lee (2013) show that this is indeed the case in their study of bank stock price reactions to the Volker rule.

2.2.1 Data Description

Daily data of open interest for futures and options are collected from Bloomberg. The data cover the period from January 2007 to June 2012 (1436 observations). The underlying assets include Eurodollar, 10 year Treasury Bond, S&P 500, and three foreign currencies (the EUROs, the British Pounds, and the Canadian dollars). The variances are estimated by historical 90 day and 10 day volatility of the underlying assets and are obtained from Bloomberg.

2.2.2 Empirical Results and Discussion

Table 2.1 below shows the estimation results for three variants of (2.1) for the futures contracts. The panels denoted: Treasury Date, Conference Date, and Volker Date provide the results when the Dodd-Frank announcement date is Aug.11, 2009, Jun.25, 2010, and Oct. 6, 2011, respectively.

Three variants of (2.1) are estimated:

Model1:

$$OpenInterest_t = \alpha_0 + \alpha_1 DoddFrank_t + \varepsilon_t \tag{1a}$$

Model 2:

$$OpenInterest_t = \alpha_0 + \alpha_1 HistoricalVar_t + \alpha_2 DoddFrank_t + \varepsilon_t \tag{1b}$$

Model3:

$$OpenInterest_t = \alpha_0 + \alpha_1 HistoricalVar_t + \alpha_2 Lag(OI) + \alpha_3 DoddFrank_t + \varepsilon_t \tag{1c}$$

[Please insert Table 2.1 about here]

On the whole, the results show some variation in the goodness of fit of the models across the different derivatives products examined, with better fits observed for the initial US treasury proposal on derivatives (August 11, 2009), so our discussion will focus on these results. Similar to Chen, Cuny, and Haugen (1995), we observe a positive effect of volatility on open interest for the S&P 500 futures contracts, when including lagged open interest in the equation (Model 3). This is consistent with the hypothesis that market volatility helps to induce participation in the S&P 500 futures contracts. However the result is not statistically significant. In addition, it does not hold for the other futures contracts. On the contrary, volatility appears to reduce open interest for Eurodollar futures, T bond futures, and the three currencies examined.

The Dodd Frank structural breakpoints appear to be negatively associated with open interest, but only for the financial futures, i.e. Eurodollar futures contract, T-bond future contracts and the S&P futures contracts. However, this relationship is not significant for the Eurodollar contracts and the T-bond contracts.[2] For two of the foreign currency futures contracts - the EUROs and British pounds, open interest actually increases significantly subsequent to Dodd-Frank dates. For the Canadian dollar futures contracts, the open interest enhancing effects of Dodd Frank are not significant, after taking into account historical

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2 It may be the case that the Dodd Frank variable should not be expected to be the most significant factor underlying the secular decline in liquidity of the Eurodollar futures contract, which we further document in section 4 below. This decline may be related to other important but extraneous factors, including the extremely low Federal funds rate (approximately zero) since January 2009. This may explain why, as we show in Table 1, the Dodd-Frank dummy variable becomes insignificant when we include historical volatility and lagged open interest as regressors. Another extraneous factor that may be important is the impact of LIBOR manipulation (the LIBOR scandal). In this vein Park and Switzer (1995) document evidence of market manipulation through private information in LIBOR settlement over the period June 1982-June 1992, many years before the formal exposure of the LIBOR scandal. If such manipulation is persistent through time, its effects along with any secular decline in open interest would be internalized in the lagged open interest variable, which is significant. We explore this issue further in section 4 below The first fines imposed concerning the LIBOR scandal occur on June 27, 2012 after our event date and estimation period date, when by Barclays Bank was fined $200 million by the Commodity Futures Trading Commission, $160 million by the United States Department of Justice and £59.5 million by the UK Financial Services Authority. Awareness of the breadth of the scandal accelerated in July 2010 when the US congress began its investigation into the case.

volatility and lagged open interest effects. In sum, the results suggest that the assertion that Dodd-Frank has detrimental liquidity effects across all exchange traded derivatives products is not sustained.

Table 2.2 provides the estimates of the open interest regressions for the call option contracts. The results for call options are for the most part, qualitatively similar to those of the futures contracts, with some exceptions. Historical volatility is positively associated with open interest for the S&P 500 contracts, as in Chen, Cuny, and Haugen (1995), but this effect is not significant when lagged open interest is included. Lagged open interest also appears to subsume volatility effects for the other contracts. Dodd-Frank dummy variables remain significantly negative, but only for the financial futures contracts. They are positive for the currency call options.

[Please insert Table 2.2 about here]

Table 2.3 provides the estimates of the Open Interest regressions for the Put Option contracts. The results differ for these contracts relative to the futures contracts and the call options contracts. In contrast with the call options, volatility has a negative effect on open interest, but similar to the call options regressions it is insignificant in the full model (Model 3) when lagged open interest is added as a regressor. Similar to the call options and futures contracts, the Dodd-Frank structural break points are associated with significantly declining open interest levels for the S&P futures and T-Bond futures contracts. However, the Dodd Frank dummy variables are not significant for any of the other market traded derivatives contracts.

[Please insert Table 2.3 about here]

To summarize, based on these results, measured liquidity does appear to fall for many US financial futures and options. Interestingly, the relationship is not significant for US T-bond futures or call options. This result may be due to expectations that T-bonds would be exempted from Dodd-Frank and the Volker rule. Such expectations have been justified by subsequent regulatory rulings. The significantly negative association of Dodd-Frank with the liquidity of the other financial derivative products is consistent with Duffie (2012). Increased liquidity of foreign currency derivatives, however, is not consistent with the fear expressed by Greenspan (2011), that "a significant proportion of the foreign exchange derivatives market would leave the US." However, this result need not rule out increased participation in the US foreign exchange derivative markets due to planned migration of asset holders and investors to foreign venues in order to escape the regulatory tax (Houston, Lin, and Ma (2012)).

In the next section, we will examine the effects of Dodd Frank on the efficiency of exchange traded futures contracts.

2.3 THE IMPACT OF DODD FRANK ON MISPRICING OF S&P FUTURES CONTRACTS

In this section, we test the hypothesis that Dodd Frank derivative provisions may improve the efficiency of the exchange traded markets due to an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. The alternative hypothesis is that Dodd-Frank adversely affects the OTC markets relative to the exchange traded markets, as trading in both the former and the latter may be confounded due to additional "noise" (see e.g. Verma (2012)).

The approach we take is to test for changes in mispricing of derivative contracts as a result of the introduction of Dodd-Frank regulations pertinent to derivatives markets.

2.3.1 Empirical Modeling

As in Switzer, Varson and Zghidi (2000) the theoretical futures price used to test for market efficiency is the Cost of Carry relationship. As noted therein, the relationship is obtained from an arbitrage strategy that consists of a long position in the index portfolio, with a price P_0 and a short position in an equal amount of index futures, priced at F_0. Over time, the hedged strategy will yield a fixed capital gain of F_0 - P_0, as well as a flow of dividends. In the absence of dividend risk, the position is riskless and hence should earn the riskless rate of interest. To prevent profitable arbitrage, the theoretical equilibrium futures price at time t F_t^e can be written as:

$$F_t^e = P_t e^{r(T-t)} - D_{(t,T)} \tag{2.2}$$

where T is the maturity date and $D(t,T)$ is the cumulative value of dividends paid assuming reinvestment at the riskless rate of interest r up to date T is held until the futures contract expires.

We adopt a commonly used formula for mispricing for index futures (e.g., MacKinlay and Ramaswamy (1988), Bhatt and Cakici (1990), Switzer, Varson and Zghidi (2000), Andane, Lafuente and Novales (2009); and others). Assuming a constant dividend yield d mispricing is measured as the difference between the actual futures price and its theoretical equilibrium price, deflated by the underlying index

$$x_t = (F(t,T) - F_t^e) / P_t \tag{2.3}$$

where $F(t,T)$ is the actual index futures price, and $F_t^e = P_t e^{(r-d)(T-t)}$.

2.3.2 Data Description

The futures data used in this study are for the nearby Chicago Mercantile Exchange (CMER) S&P 500 Index futures contracts for the period February 1, 2004 through July 31, 2012. We perform the analyses using daily data (2161 observations). We use the actual daily dividend series for the S&P 500 obtained from Standard and Poor's. Daily three-month Treasury bill rates from Bloomberg are used for the riskless rate of interest.

2.3.3 Empirical Results

[Please insert Figure 2.1 about here.]

Figure 2.1 shows the path of mispricing over the sample period. As is noted therein, during the most severe periods of the financial crisis in 2008 were associated with extremely large levels of mispricing. The structural break point that we use is the onset of the Dodd-Frank regulatory period, which we define as the date of the Treasury submission of specific legislative proposals regarding derivatives to Congress, August 11, 2009. Our hypothesis is that arbitrage activities in the exchange traded markets would increase in anticipation of the final mandated restrictions on using OTC markets for this purpose. There is evidence of market participants reacting to anticipated changes in the regulatory environment. Indeed, an internal report from Deutsche Bank's head of government affairs for the Americas states, than was leaked to the media on July 7, 2010 states that "opportunities for global regulatory arbitrage could be significant.[3]" We noted in the previous section that this date appeared most significant as a watershed for open interest variations associated with Dodd Frank across a wide variety of exchange traded contracts. Some evidence of a reduction of mispricing can be observed, in the shaded area to the right of the August 11, 2009 vertical line. This is confirmed in the statistical analyses. Table 2.4 shows that average mispricing has declined in the period subsequent to Dodd Frank. Indeed the t statistics for a reduction in mispricing and a reduction in absolute mispricing are both significant at the 1% level.

[Please insert Table 2.4 about here]

Table 2.5 shows regression results for the signed mispricing series and for the absolute mispricing on a dummy variable that is equal to 1 on the day of and subsequent to the Treasury OTC report release date dummy variable. Panel A shows the results for the signed mispricing regression, while Panel B uses the absolute mispricing series as the dependent variable. In both cases, the dummy variable coefficients are significant at the 1% level. These results provide further confirmation of the improved efficiency hypothesis, as opposed to the induced noise hypothesis. It is observed that there was a very significant increase in mispricing prior to the Dodd-Frank related events that can be linked to the global financial crisis. Our basic point is that this mispricing has come down coincidental to the new legislative efforts to regulate the markets. We might conjecture that given the high degree of volatility lingering in the markets, which may in part be associated with the continued regulative uncertainty that it may be a long while before markets return to pre-crisis mispricing levels.

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[3] See http://www.foxbusiness.com/markets/2010/07/07/deutsche-bank-rips-financial-reform/#ixzz2HmqZt0pX

[Please insert Table 2.5 about here]

2.4 DODD FRANK AND THE DEVIATIONS OF EURODOLLAR FUTURES VS. FORWARD CONTRACTS

2.4.1 Data Description

As a final test, we explore the impact of Dodd-Frank on pricing efficiency using the metric of the deviation of Eurodollar futures yields from implied forward contract rates. We use Eurodollar futures prices and 1, 3, 6, 9, and 12 month LIBOR quotations in the analysis. Daily Eurodollar futures prices and daily spot LIBOR quotations are obtained from the Bloomberg. Our sample period is from January 2007 through June 2012.

2.4.2 Empirical Modeling for Forward and Futures Rates

Three-month implied forward rates are computed from LIBOR spot quotations based on the Grinblatt and Jegadeesh (1996) formula (with time measured in years)

$$f(s, s+.25) = d(s, s+.25)*[P(0,s)/P(0,s+.25)-1] \tag{2.4}$$

where f(s, y) is the annualized Eurodollar forward rate at time 0 over the period s to y;

d(s,y) is the LIBOR conversion factor, computed as 360/number of days between s and y and P(s,y) = $1/[1+L_s(y\text{-}s)/d(s,y)]$ is the time s price of $1 paid out at y in the Eurodollar market, and $L_s(y\text{-}s)$ is the (y-s) year LIBOR rate prevailing at time s.

We compute the 3-month forward rates f(.25, .5), f(.5, .75), and f(.75, 1) using the 3-, 6-, 9-, and 12-month spot quotations of LIBOR rates.

The futures rate is computed with the daily closing price of the futures contract (Futures Price_t) that matures on date s from the expression:

$$F(s, s+.25; t) = 1 - Futures\_\Pr ice_t / 100 \tag{2.5}$$

where F(s,y,t) is the annualized Eurodollar futures rate at time t for the interval s to y.

We focus on futures contracts maturing in March, June, September, and December in our sample period. Since futures contracts mature in a quarterly cycle, the futures rate intervals do not in general coincide with the forward rate intervals. For comparisons of futures rates with forward rates, we replicate the two interpolation methods used by Grinblatt and Jegadeesh (1996) to align the intervals.

With the futures interpolation method, we fit a cubic spline to the futures rates of the four nearest maturing contracts to construct an interpolated term structure of futures rates. For each sampling date, we use the futures prices of the four nearest maturing contracts on that date to fit a curve, and pick interpolated futures rates for intervals that coincide with the forward rate intervals to get F(0.25, 0.5), F(0.5, 0.75), and F(0.75, 1). We interpolated the four nearest maturity futures contracts starting from 01/02/2007 to 03/19/2012 to obtain F(.25, .5), F(.5, .75), and F(.75, 1). We interpolated the three nearest maturity futures contracts starting from 03/20/2012 to 06/19/2012 to obtain F (.25, .5) and F(.5, .75).We then compare these interpolated rates with the implied forward rates, f(0.25, 0.5), f(0.5, 0.75), and f(0.75, 1).

With the spot LIBOR interpolation method, we use the 1-, 3-, 6-, 9-, and 12-month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (2.4). Futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts is directly computed from closing prices with equation (2.5).

2.4.3 Empirical Results

The analysis is performed using two breakpoints. Table 2.6 below uses the Treasury Date (08/11/2009) as the breakpoint, while Table 2.7 shows the results using the Conference Date (06/25/2010) as the breakpoint. These tables present the differences between the futures and forward Eurodollar yields expressed in basis points employing weekly (Thursday) data from January 2007 through June 2012. We also include the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods.

In Panel A of Tables 2.6 and 2.7, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5; DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively; N is the number of observations.

Panel B of Tables 2.6 and 2.7 report the results using the spot LIBOR interpolation method to compute the implied forward rates. DIFF1 is the difference between the annualized 3-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized 3-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized 3-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts.

[Please insert Tables 2.6 and Table 2.7 about here]

As is shown in these tables, aggregate trading volume and open interest in the Eurodollar contracts decline in the period of the study. Again, this is in part likely a consequence of the low Fed funds rate since January 2009. In general, we find that futures rates are below forward rates throughout the sample. This phenomenon is also observed in the latter part of the Grinblatt and Jegadeesh (1996) sample, which covers the period 1987-92. The downward bias appears to be exacerbated in our sample, amounting to over 30 basis points for nearby contracts, and considerably more for the more distant contracts.

Some evidence of improved price efficiency is shown for the Dodd Frank breakpoints for nearby contracts – ranging between 13 and 15 basis points, depending on whether we use the Treasury or Conference dates as breakpoints. The differential between futures and forward rates widens, however, for more distant contracts. The latter may be due to a shift to shorter maturity preferences for futures traders, with the increase in market uncertainty.

2.5 SUMMARY AND CONCLUSIONS

This report provides new evidence on the impact of key Dodd Frank events on market activity for financial derivatives (futures and option contracts on US T bonds, Eurodollar futures and options, and S&P 500 Futures contracts) and on foreign exchange derivatives (futures and options contracts on EURO, British Pounds, and Canadian dollars). First, we look at how liquidity on the markets has been affected. Next, we test for mispricing of derivatives contracts. We find that measured liquidity does fall for US financial futures and options but rises for foreign exchange futures and options subsequent to the introduction of the treasury guidelines for OTC trading. Specifically, the Dodd Frank structural breakpoints appear to be negatively associated with open interest, but only for certain financial futures. However, this relationship is not significant for the Eurodollar contracts and the T-bond contracts. The lack of significance for the Eurodollar contracts may be due to the overwhelming effects of a decline in interest rates over the sample period – with the Fed maintaining the Fed funds rate at close to zero since January 2009. The lack of significance for T-bonds could be due to the expectation (which has been subsequently justified) of an exemption of T-bonds from Dodd-Frank and the Volker Rule.

The significantly negative association of Dodd-Frank with the other financial derivative products is consistent with Duffie's (2012) hypothesis of a withdrawal of participants in markets for US assets (OTC and exchange traded) due to a reduction of quality of fundamentals. The increased liquidity of foreign currency derivatives, however is not consistent with Greenspan's (2011) warning of an exodus of foreign exchange derivatives from the US. However, our result may not preclude increased participation in the US foreign exchange derivative markets due to planned migration of asset holders and investors to foreign venues in order to escape the regulatory tax (Houston, Lin, and Ma (2012)).

Finally, our study shows mixed results on how Dodd Frank derivative provisions affect the efficiency of the exchange traded markets. An increase in efficiency reflected by lower deviations of futures prices from their cost of carry is observed for the S&P futures contracts. This may reflect an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. Increased pricing efficiency based on lower spreads between futures and implied forwards for nearby Eurodollar contracts is also observed. This is not the case, however, for more distant futures.

At this juncture in time, the implementation of the individual provisions of Dodd-Frank has been piecemeal and heavily delayed. The implications of such delays are certainly worth investigating as topics for future research, along with additional comparative impact studies of Dodd-Frank on US vs. foreign derivatives markets and financial institutions.

CHAPTER THREE

POSITION GROWTH RATE INTERACTIONS BETWEEN EXCHANGE-TRADED DERIVATIVES AND OTC DERIVATIVES

3.1. INTRODUCTION

Starting from April 1989, every three years the Bank for International Settlements coordinates a global central bank survey of foreign exchange and derivatives market activity on behalf of the Markets Committee and the Committee on the Global Financial System. The objective of the survey is to provide the most comprehensive and internationally consistent information on the size and structure of global foreign exchange markets and other derivatives markets, allowing policymakers and market participants to better monitor patterns of activity in the global financial system. Coordinated by the BIS, each participating institution collects data in April from the reporting dealers in its jurisdiction and calculates aggregate national data. In addition, participating institutions around the world report data on notional amounts outstanding at end-June of each survey year. The triennial survey has been conducted every three years since April 1989, covering data on amounts outstanding since 1995. In this paper, we provide the analysis of OTC derivatives market activity across different risk categories for different years. We also grouped the data into different district segments and made comparisons of the derivatives market activity in those regions across different years. We also checked the OTC derivatives market activity by global non-financial reporters since researchers also pay attention to surveys of derivatives utilization by non-financial firms.

Trades in the OTC market are typically much larger than trades in the exchange-traded market. In OTC market the terms of a contract do not need to be specified as in an exchange. Market participants are free to negotiate any mutually attractive deal. But there is some credit risk in an OTC trade as the contract might not be honored. Due to the lack of data, it is not easy to assess the interaction between OTC and exchange-traded derivative products. Some work has been done on the relationships between exchange-traded futures vs. spot markets. Chan et al. (1991) examined the relationship between returns and returns volatility in the stock index and stock index futures markets. They found that price innovations that originate in either the stock or futures markets can predict the future volatility in the other market. Chan (1992) checked the lead-lag relation between returns of market index and returns of the market index futures and found strong evidence that the futures leads the index and weak evidence that the index leads the futures. Ng and Pirrong (1996) found that spreads between spot and futures prices explain all spot return volatility innovations for gasoline and heating oil, and spot returns are more volatile when spot prices exceed futures prices. Koutmos and Tucker (1996) found that innovations originating in the futures markets increase volatility in the stock market in an asymmetric fashion: bad news increases volatility more than good news. And innovations in the stock market have no impact in the volatility of the futures market. Min and Najand (1999) found a bi-directional causality between volatilities between cash and futures markets in Korea. They also found that the trading volume has significant explanatory power for volatility changes in both spot and futures markets. Scholars also used trading volume to study the effects of competition between exchanges and trading venues. Silber (1981) studied the competition between competitive contract modifications and an existing high-volume contract on different exchange. Holder et al. (2002) used the volumes of corn and soybean futures contracts traded in different exchanges to examine the interactions between those contracts, and found that they exhibit a complementary relationship rather than substitutes. Some scholars also studied the relationship between trading volume and volatility. Switzer and Fan (2008) found that trading activity in exchange-traded futures market leads the OTC markets. Compared with OTC market, the exchange-traded market shows greater responsiveness to changes in market-wide risk. And these two markets behave as substitutes rather than complements.

In this paper, our objective is to examine the interaction between the growth rates of positions between exchange-traded market and OTC market. Here, we use the data of the statistics on positions in the global OTC derivatives market and exchange-traded derivatives market obtained from the Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity and the regular semiannual survey of positions in the global OTC derivatives market by Bank for International Settlements starting from June 1998 to December 2012. Those surveys cover the notional amounts outstanding and gross market values of foreign exchange, interest rate, equity, commodity and credit derivatives traded in OTC markets. They refer to the worldwide consolidated positions of reporting dealers. The triennial survey is more comprehensive, covering more than 400 market participants in a total of 47 jurisdictions. The semiannual survey is based on data from 59 major dealers in the G10 countries and Switzerland.

The remainder of the paper is organized as follows: A generalization of the global OTC derivatives markets activity is given in section 3.2. Section 3.3 provides a description of the research methodology and the empirical results. Section 3.4 provides the analysis of the

OTC derivatives had non-financial customers as counterparties. The paper concludes with a summary in section 3.5.

3.2. GENERALIZATION OF OTC DERIVATIVES MARKET ACTIVITY

We provide the analysis and comparison of notional amounts outstanding, gross market values, and turnover in global OTC derivatives across different risk categories in different survey year. Data of the statistics on positions in OTC derivatives market are obtained from triennial surveys of positions in the global OTC derivatives market by Bank for International Settlements from 1998 to 2010. It covers the notional amounts outstanding and gross market values of foreign exchange, interest rate, equity, commodity and credit derivatives traded in OTC markets. They refer to the worldwide consolidated positions of reporting dealers. The triennial survey covers more than 400 market participants in a total of 47 jurisdictions.

3.2.1 OTC Derivatives: Notional Amounts Outstanding

Nominal or notional amounts outstanding provide a measure of market size. Table 3.1 provides the notional amounts outstanding of OTC derivatives net of inter-dealer double-counting. The 1998 survey data confirmed the predominance of OTC over exchange-traded positions, and within the OTC market, the overwhelming importance of interest rate instruments over foreign exchange contracts (67% and 31% of notional amounts respectively).

At the end of June 2001, global OTC positions in all categories of market risk increased by 38% to nearly $100 trillion, with interest rate product growing sharply (58%) and foreign exchange instruments contracting (7%).

At end-June 2004, the notional amounts of outstanding OTC contracts rose by 121% to $221 trillion. It was a much faster rate of expansion than the 38% recorded in the three years between 1998 and 2001. Reflecting the developments in turnover, expansion was stronger for interest rate products (134%) than for exchange rate products (54%). Positions in OTC derivatives grew at an even more rapid pace than turnover.

Notional amounts outstanding went up by 135% to $516 trillion at the end of June 2007. Positions in the credit segment of the OTC derivatives market expanded from $5 trillion to $51 trillion. Notional amounts outstanding of commodity derivatives rose more than sixfold to $8 trillion. Open positions in interest rate contracts increased by 119% to $389 trillion, and those in equity contracts by 111% to $11 trillion. Growth in foreign exchange derivatives was less brisk at 83%. Positions in OTC derivatives are dominated by interest rate contracts, which accounted for 75% of total notional amounts.

The 2010 survey shows that the growth in the positions of OTC foreign exchange instruments was moderate at 9%, compared with an increase of 83% in notional amounts outstanding of currency instruments in the 2004-2007 period. The 2007 and 2010 BIS triennial surveys bracket a period of strong growth in amounts outstanding. Notional amounts outstanding in all instruments peaked in June 2008, declined thereafter (due in part to trade compression) and recovered somewhat by June 2010. Currency swaps increased to almost $19 trillion outstanding, growing by a third relative to 2007. Currency options outstanding fell by 12 % to $12 trillion.

From the triennial survey data in Table 3.1, we can see that compared with other risk categories, interest rate contracts dominated the positions in OTC derivatives. The same phenomenon was observed in exchange-traded derivatives. Interest rate contracts dominated the positions in exchange-traded derivatives.

[Please insert Table 3.1 about here.]

3.2.2 OTC Derivatives: Gross Market Values

Notional amounts outstanding provide useful information on the structure of the OTC derivatives market but should not be interpreted as a measure of the riskiness of these positions. Gross market value provides useful information, which is the cost of replacing all open contracts at the prevailing market prices.

Table 3.2 provides gross market values of OTC derivatives markets. Gross market values rose from $2.6 trillion to $3 trillion at the end of June 2001, but declined relative to notional amounts outstanding. The reduction in the aggregate ratio mainly resulted from interest rate products and equity-related instruments, although short-term interest rates began a steep descent and the volatility of equity markets increased substantially from the beginning of 2001.

Gross market values are more than doubled, increasing from $3 trillion at end-June 2001 to $6.4 trillion at end-June 2004. The growth rate was lower than the corresponding increasing rate in notional amounts outstanding. The growth in gross market values was mainly due to interest rate products, which was largely derived from higher interest rate volatility in mid-2004. Drop in the volatility of equity markets and the stability of the main stock indices contributed to the decline in the market to notional ratio of equity-linked contracts.

Gross market value increased at a considerably lower rate (74%) than notional amounts to $11 trillion at the end of June 2007. The reasons why the replacement values of derivatives positions increased at a lower rate than face values might be due to the stable long-term interest rates and implied volatility. Long-term interest rates are the main driver of the market value of interest rate swaps. And implied volatilities are an important input for the market value of options.

Gross market value increased from $11 trillion to $24.7 trillion at the end of June 2010. The ratio of market value to notional amounts rose to 4.2%, from 2.2% in 2007. The ratio grew across almost all the risk categories except equity-linked contracts. The decline in stock prices during the crisis resulted in much smaller positions in the equity segment of the OTC derivatives market. Interest rate risk remains by far the largest type of risk traded on the OTC derivatives market in terms of both notional amounts and gross market values.

[Please insert Table 3.2 about here.]

3.2.3 OTC Derivatives: Turnover

Turnover data provide a measure of market activity as well as an indication of market liquidity. Table 3.3 provides the turnover data of the two main segments of the OTC derivatives market: interest rate and currency products, had all the counterparties and non-financial customers as the counterparty. The reported OTC turnover data show adjustments for double-counting in local and cross-border transactions. For 1998 survey, notional amounts outstanding have been higher for interest rate contracts than for foreign exchange contracts, the turnover has been greater for the latter. It maybe because foreign exchange contracts have tended to have considerably shorter terms than interest rate contracts. Swaps dominate turnover in both foreign exchange and interest rate segments of the OTC market.

In 2001, the global daily turnover in foreign exchange and interest rate derivatives contracts increased by 10% to nearly $1.4 trillion. Business in foreign exchange products declined by 12% and in interest rate instruments rose by 86%. The slowdown reflected a number of structural influences affecting the foreign exchange segment. Higher volume of business in interest rate products resulted largely from changes in hedging and trading practices in the interest rate swap market.

Global daily turnover in foreign exchange and interest rate derivatives contracts rose by 74% to $2.4 trillion in April 2004. Growth in interest rate segment (110%) continued to exceed growth in foreign exchange segment (51%). Daily activity in exchange-traded derivatives expanded by 114% to $4.5 trillion.

Average daily turnover in OTC foreign exchange and interest rate contracts went up by 73% to $4.2 trillion in April 2007. Activity in foreign exchange derivatives rose by 78%. More moderate growth was recorded in the interest rate segment, where turnover went up by 64%. For the first time since 1995, growth in turnover in the OTC market outstripped that in exchange-traded interest rate and currency derivatives (36%). Growth in the FX segment accelerated since 2004 and, for the first time outstripped growth in interest rate segment.

The 2010 survey only reports turnover data in the global foreign exchange markets. Turnover of outright forwards, foreign exchange swaps, currency swaps, currency options and other OTC foreign exchange products continues to be many times larger than the volumes traded on organized exchanges. Daily turnover for currency instruments on organized exchanges was $168 billion, less than 7% of the $2.5 trillion average daily turnover in those instruments.

[Please insert Table 3.3 about here.]

BIS also provides geographical distribution of OTC average daily turnover for more than 50 countries. We grouped those countries into three regions: the Americas, Europe, and Asia and Pacific. Table 3.4 provides the geographical distribution of daily average net turnover of total reported OTC derivatives market of the three regions for triennial surveys conducted in 2004, 2007, and 2010, respectively. For those three regions, turnovers on both foreign exchange contracts and interest rate contracts keep rising these years. It can be seen from the 2004 and 2007 surveys that in Americas, the turnover has been slightly greater for interest rate derivatives than for foreign exchange derivatives. While in Europe and Asia and Pacific region, it has been greater for foreign exchange instruments than for interest rate instruments. Especially in Asia and Pacific region, the turnover in OTC derivatives has been dominated by foreign exchange contracts, which accounted for more than 75% of the total turnover. It is quite similar in the three regions that swaps outstripped other instruments with the largest turnover in both OTC foreign exchange contracts and OTC interest rate contracts. Sharp increase can be seen in the turnover of swaps in OTC derivatives market in both Europe and Asia and Pacific region from 2004 to 2007.

[Please insert Table 3.4 about here.]

3.3. INTERACTION BETWEEN OTC AND EXCHANGE TRADED DERIVATIVES

3.3.1 Data Description

Data of the statistics on positions in OTC and exchange-traded derivatives market are obtained from the semiannual survey of positions in the global OTC derivatives market by Bank for International Settlements starting from June 1998 to December 2012. The semiannual survey covers the notional amounts outstanding and gross market values of derivatives across different risk categories traded in OTC markets and exchange-traded markets. They refer to the worldwide consolidated positions of reporting dealers. The survey is based on data from 59 major dealers in the G10 countries and Switzerland.

To obtain the growth rate of the positions in OTC derivatives and exchange-traded derivatives, we divided notional amounts outstanding of current period by notional amounts outstanding of previous period. A total of 30 semi-annual notional amounts outstanding of the total derivatives market and derivatives market of different risk categories including foreign exchange, interest rate, equity-linked derivatives from June 1998 to December 2012 are used. Therefore, we obtain 29 semi-annual growth rates of the positions for the total derivatives and derivatives of each risk category. Our objective is to examine the positions growth rate interactions between OTC derivatives and exchange-traded derivatives both in total and in different risk categories. First, we use the original sample of 29 observations to test for whether the growth rate in positions of exchange-traded derivatives tend to lead the growth rate in positions of the OTC derivatives, or vice versa.

The basic variables that we use in our analyses are defined as follows:

OTC_rate: semi-annual growth rate of total notional amounts outstanding in global OTC derivatives market.

Futures_rate: semi-annual growth rate of total notional amounts outstanding in exchange-traded market.

OTC_fx: semi-annual growth rate of notional amounts outstanding of the risk category of foreign exchange derivatives in global OTC market.

Futures_fx: semi-annual growth rate of notional amounts outstanding of the risk category of foreign exchange derivatives in global exchange-traded market.

OTC_ir: semi-annual growth rate of notional amounts outstanding of the risk category of interest rate derivatives in global OTC market.

Futures_ir: semi-annual growth rate of notional amounts outstanding of the risk category of interest rate derivatives in global exchange-traded market.

OTC_eq: semi-annual growth rate of notional amounts outstanding of the risk category of equity-linked derivatives in global OTC market.

Futures_eq: semi-annual growth rate of notional amounts outstanding of the risk category of equity-linked derivatives in global exchange-traded market.

[Please insert Table 3.5 about here.]

Table 3.5 shows the descriptive statistics for the variables used in the tests. We also examined ARCH/GARCH effects for all the series, based on standard chi-squared tests using one and four lags. As is shown in the table, all those series do not show ARCH/GARCH effects. So we can check Granger Causality tests based on OLS.

3.3.2 Methodology and Empirical Results

[Please insert Table 3.6 about here.]

Table 3.6 shows the contemporaneous correlations for these variables. It reports the bi-variate correlations between those growth rates based on the original sample of 29 observations. Growth rate of positions in OTC derivatives is significantly positive related to growth rate in exchange-traded derivatives and growth rate of the risk category of interest rate derivatives in that market. Growth rate of positions in OTC derivatives is also significantly positive related to the growth rates of the three risk categories in OTC derivatives (foreign exchange, interest rate, and equity-linked derivatives). On the other hand, growth rate of positions in exchange-traded derivatives is significantly positive related to not only growth rate in OTC derivatives but also the three risk categories in OTC market. It is not significantly related to that of foreign exchange derivatives in exchange-traded market. For the specific risk category, we can see that the growth rates of different risk categories of OTC market are significantly positive related to each other. It seems that growth rate of positions of the risk category of foreign exchange derivatives in exchange-traded market is not significantly related to any variables. Growth rate of positions of the risk category of interest rate derivatives in exchange-traded market is significantly related to that of the three risk categories in OTC market and that of the equity-linked derivatives in exchange-traded market. Growth rate of positions of the risk category of equity-linked derivatives in exchange-traded market is not significantly related to that of three risk categories of OTC market. However, we should interpret those correlations with caution, since they do not reflect causality. Now we try to establish the causality relationships between those variables.

The statistically insignificant ARCH/GARCH test results reported in Table 3.5 indicate that most of the variables we examined do not exhibit any form of conditional heteroscedasticity. So we do not consider GARCH terms for the residual series for the Granger Causality tests. For two different time series x, and y with autoregressive lags of length p and k, we estimate:

$$y_t = \alpha_0 + \sum_{i}^{p} \beta_i x_{t-i} + \sum_{i}^{k} \alpha_i y_{t-i} + \varepsilon_{1t} \tag{3.1}$$

$$x_t = \alpha_1 + \sum_{i}^{p} \beta_i x_{t-i} + \sum_{i}^{k} \alpha_i y_{t-i} + \varepsilon_{2t} \tag{3.2}$$

where ε_{1t} and ε_{2t} are the error terms. The subscripts stand for the date with appropriate lags. The sixteen x, y combinations that we test are comprised of pair-wise groupings of the OTC growth rate series and exchange-traded growth rate series. Significance of the causality results are based on Wald-tests of the null hypotheses:

$$H_0 : \beta_1 = \beta_2 = ... = \beta_p = 0 \qquad \text{for eq.3.1} \tag{3.3}$$

$$H_0 : \alpha_1 = \alpha_2 = ... = \alpha_k = 0 \qquad \text{for eq. 3.2} \tag{3.4}$$

Before conducting Granger Causality tests, we test the variables for unit roots using Augmented Dickey-Fuller and Phillips and Perron tests. If those series are nonstationary, the significance tests of the causality tests could incorrectly identify significant relationships between those variables. Table 3.7 reports the results of unit roots tests for two models, either with an intercept, or with an intercept and trend. The null hypothesis is that the series has a unit root. We can see from the table that the null hypothesis is rejected at 1% level for all the series. Therefore, all the variables can be treated as stationary in the causality tests. Before conducting causality tests, we use the Akaike Information Criterion or Schwarz Information Criterion benchmark to select the optimum autoregressive lags of length p and k for each variable in equations (3.1) and (3.2). The Akaike Information Criterion and Schwarz

Information Criterion indicate lags between 1 and 2 with different model tested on the serials, respectively. We performed the estimation using 2 lags. Two lags were determined as optimal for these variables.

[Please insert Table 3.7 about here.]

Table 3.8 reports the results for the causality tests based on pair-wise regressions. Test 1 shows that the growth rate of exchange-traded derivatives leads the growth rate of OTC derivatives. Test 3 shows that the growth rate of exchange-traded interest rate derivatives leads the growth rate of OTC derivatives. Test 5 shows that growth rate of exchange-traded derivatives leads growth rate of OTC foreign exchange derivatives. Test 6 shows that growth rate of exchange-traded derivatives leads growth rate of OTC interest rate derivatives. Test 7 shows that growth rate of exchange-traded derivatives leads growth rate of OTC equity-linked derivatives. Test 8 shows that growth rate of OTC foreign exchange derivatives leads growth rate of exchange-traded foreign exchange derivatives. Test 9 shows that the growth rate of exchange-traded interest rate derivatives leads growth rate of OTC interest rate derivatives. Test 9 shows the bi-directional feedback between the growth rates in OTC interest rate derivatives and exchange traded interest rate derivatives. Test 11 shows that the growth rate of exchange-traded interest rate derivatives leads growth rate of OTC foreign exchange derivatives. Test 16 shows that growth rate of exchange-traded interest rate derivatives leads growth rate of OTC equity-linked derivatives.

[Please insert Table 3.8 about here.]

Finally, to assess the potential problem of unreliable inferences of the Granger Causality tests when the significance tests are conducted with the original 29 samples, we also perform bootstrap simulations to test the robustness of the critical value of the Wald statistics for our model. Konya (2006), Dufour and Jouini (2006), and Godfrey (2007) employ reduced (null hypothesis) models to generate the boot series. We first use OLS estimates of the equations of (3.1) and (3.2) under the null hypothesis that there is no causality from X to Y and from Y to X to obtain the residuals. Then we subtract the sample mean of the OLS residuals from each residual to generate i.i.d. error vectors. Then, we use the OLS estimators of the coefficients on the reduced model with the bootstrap errors being obtained by simple random sampling with replacement from the empirical distribution function to generate a bootstrap sample, by assuming again that Y is not caused by X in (3.1), and X is not caused by Y in (3.2). Then, we use the resampled Y in (3.1) without imposing any parameter restrictions and perform the Wald test implied by the no-causality null hypothesis. And by repeating the previous two steps 10,000 times, we get the empirical distributions of the Wald tests.

Table 3.9 provides Wald test statistic distributions generated by the bootstrap. Our conclusions do not change when we compare the original test statistics with those based on critical values generated by bootstrapping.

[Please insert Table 3.9 about here.]

3.4 ANALYSES OF OTC DERIVATIVES BY USING NON-FINANCIAL CUSTOMERS AS THE COUNTERPARTIES

3.4.1 Notional Amounts Outstanding: Non-financial Reporters

Table 3.10 provides notional amounts outstanding of OTC derivatives with non-financial customers. Use of financial derivative contracts by non-financial customers has grown rapidly during 2001-2004 and 2004-2007 survey periods. Notional amounts outstanding of foreign exchange derivatives increased by 59% to $7.1 trillion in 2004 survey and by 75% to $12.4 trillion in 2007 survey. Notional amounts outstanding of interest rate derivatives rose more than thrice to $23.9 trillion and more than twice to $50.6 trillion according to the surveys in 2004 and 2007, respectively.

For OTC foreign exchange contracts, forwards and swaps are used much more frequently than options by non-financial customers. Whereas for OTC interest rate contracts, swaps are the most popular risk management instrument by non-financial customers.

[Please insert Table 3.10 about here.]

3.4.2 Gross Market Values: Non-financial Reporters

Table 3.11 provides gross market values of OTC derivatives with non-financial customers. At the end of June 2001, the gross market value of forwards and swaps of interest rate products declined from $4.8 billion to $3.1 billion, and from $187 billion to $172 billion respectively, while notional amounts outstanding of both instruments increased. At end-June 2004, gross market values are more than doubled across most instruments of risk categories of both foreign exchange and interest rate. But the growth rate was lower than the corresponding growth rate in notional amounts outstanding. Gross market value increased at a much lower rate than notional amounts across all the instruments of both foreign exchange and interest rate risk categories at the end of June 2007. It might be due to the stable long-term interest rates and implied volatility. Gross market values increased across all the foreign exchange products at the end of June 2010, although notional amounts outstanding of those products declined. It resulted from another bout of turbulence going through the foreign exchange markets in the first half of 2010.

[Please insert Table 3.11 about here.]

3.4.3 Turnover: Non-financial Reporters

Table 3.12 provides the geographical distribution of daily average net turnover of non-financial customers reported OTC derivatives market of the three regions for triennial surveys conducted in 2004, 2007, and 2010. Turnover on foreign exchange contracts reported by non-financial customers in the three regions was more than doubled from 2004 to 2007, with a smaller increasing rate in interest rate derivatives market in the three regions for the same period. However, turnover on foreign exchange contracts reported by non-financial customers dropped in the three regions from 2007 to 2010. Turnover by non-financial customers has been uniformly greater in foreign exchange derivatives than in interest rate derivatives in the three regions in 2004, 2007, and 2010. Similarly in Asia and Pacific region, the turnover by non-financial customers in OTC derivatives has been dominated by foreign exchange contracts, which accounted for more than 75% of the total turnover in both 2004 and 2007. In the three regions, swaps reported by non-financial customers again outstripped other instruments with the largest turnover in both foreign exchange derivatives market and interest rate derivatives market. Sharp increase can be seen in the turnover of swaps in foreign exchange derivatives market in all three regions from 2004 to 2007. And it uniformly dropped for all three regions from 2007 to 2010.

[Please insert Table 3.12 about here.]

3.5. SUMMARY

In this paper we made a general description and comparison of OTC derivatives market and exchange-traded derivatives market activity across different risk categories in different years by using data of triennial surveys by BIS. We grouped the turnover data of the global OTC derivatives markets into three regions: the Americas, Europe, and Asia/Pacific, and compared the activities in those regions. Similar analysis is also applied for non-financial reporters.

We focused on the interaction between the growth rates of positions between OTC derivatives market and exchange-traded derivatives market. The empirical results show that the growth rate of exchange-traded derivatives leads growth rate of OTC derivatives. The conclusion still holds for derivatives of different risk categories. Only for foreign exchange derivatives, OTC market leads exchange-traded market and it is significant at 10% level. Our conclusions do not change when we compare the original test statistics with those based on critical values generated by bootstrapping.

CHAPTER FOUR

VOLATILITY, THE SIZE PREMIUM, AND THE INFORMATION QUALITY OF THE VIX: NEW EVIDENCE

4.1 INTRODUCTION

It is now more than 30 years since the small firm (small cap) anomaly appeared in the finance literature as a challenge to the efficient markets paradigm (see e.g. Banz (1981), Reinganum (1981a, 1981b). While this anomaly has been questioned over the years (Bhardwaj and Brooks (1993), Horowitz et al (2000) and Schwert (2003)) recent work suggests that since 2000, economically and statistically significant abnormal performance is observed for small cap stocks in the US and Canada (Switzer (2010)), and that differential performance for size based asset portfolios is found to be associated with risk factors that are distinct from business cycle turning points per se. The purpose of this paper is to further explore the argument that the riskiness of the market can explain the nature of the small-cap premium through time, using a popular measure of market volatility, the CBOE Volatility Index (VIX). This index is often referred to as the *fear index* or the *fear gauge*, since high levels of VIX coincide with high degrees of market turmoil. The VIX is meant to capture the market's expectation of stock market volatility over the next 30 calendar days, and has been disseminated by the CBOE on a real-time basis since 1993, as a weighted blend of prices for a range of options on the S&P 500 index. The VIX is quoted in percentage points and translates, roughly, to the annualized expected movement in the S&P 500 index over the upcoming 30-day period.

Banerjee et al. (2007) and Kanas (2013) find that the VIX predicts returns on large cap stock market indices, suggesting implied volatilities measured by VIX are a risk factor affecting security returns or an indicator of market inefficiency. If implied volatility is a risk factor in the time series of returns, then it should have predictive ability for the future returns of all portfolios, even after appropriate adjustment for other risk factors. If markets are inefficient, then alternative portfolios could have sporadic or random patterns of return responses to implied volatilities. Our objective is to test whether the implied volatility of the market has predictive power for the small-cap premium, which is measured by the difference of returns on small-caps and large caps. We find that the current VIX is significantly negative related to S&P 500 index excess returns and Russell 2000 index excess returns. The VIX and VIX modeled by an ARIMA process are not significantly related to future values of the small-cap premium. In contrast, VIX futures show forecasting prowess for the S&P 500 excess return, the Russell 2000 excess return and the small-cap premium. VIX futures are significantly negatively related to these series. The results for the speculative efficiency of the VIX futures contracts are mixed, however. Overall, the analyses support the hypothesis of informational advantages of the futures markets relative to the spot market in the price discovery process (see e.g. Grossman (1986, 1989)).

The remainder of the paper is organized as follows: Section 4.2 presents the methodology. Section 4.3 provides the description of the data. Section 4.4 tests the forecast performance of the VIX for large-cap and small-cap returns and the small cap premium. Section 4.5 provides tests of the efficiency of VIX futures contracts. The paper concludes with a summary in section 4.6.

4.2 METHODOLOGY

Britten-Jones and Neuberger (2000) derive the “model-free” implied volatility from current option prices. Jiang and Tian (2005) extend the model-free implied volatility to asset price processes with jumps. They investigate the forecasting ability and information content of the model-free implied volatility. They find that the model-free implied volatility subsumes all information contained in Black-Scholes implied volatility and past relized volatility and is a more efficient forecast for future relized volatility. Carr and Wu (2009) develop a direct and robust method for quantifying the return variance risk premium on financial assets. They use the notion of a variance swap, which is an OTC contract that pays the difference between a standard estimate of the realized variance and the fixed variance swap rate. No arbitrage dictates that the variance swap equals the risk-neutral expected value of the realized variance

$$SW_{t,T} = E_t^Q[RV_{t,T}] \tag{4.1}$$

where $RV_{t,T}$ denotes the realized annualized return variance between time t and T, $SW_{t,T}$ denotes the fixed variance swap rate that is determined at time t and paid at time T, $E_t^Q[.]$ denotes the time-t conditional expectation operator under some risk-neutral measure Q.

Using P to denote the statistical probability measure, they link the variance swap rate to the realized variance through the following valuation equation:

$$SW_{t,T} = \frac{E_t^P[M_{t,T} RV_{t,T}]}{E_t^P[M_{t,T}]} = E_t^P[m_{t,T} RV_{t,T}] \tag{4.2}$$

where $M_{t,T}$ denotes a pricing kernel and $m_{t,T} = M_{t,T} / E_t^P[M_{t,T}]$. Equation (4.2) can also be written as

$$SW_{t,T} = E_t^P[m_{t,T} RV_{t,T}] = E_t^P[RV_{t,T}] + Cov_t^P(m_{t,T}, RV_{t,T}) \qquad (4.3)$$

The negative of this covariance defines the return variance risk premium. If $SW_{t,T}$ is regarded as the forward cost of a variance swap investment, $RV_{t,T} / SW_{t,T} - 1$ captures the excess return from the investment, which can be measured by a CAPM model.

$$\ln(RV_{t,T}) - \ln(SW_{t,T}) = \alpha + \beta \bar{r}^m_{t,T} + \varepsilon \qquad (4.4)$$

where $\bar{r}^m$ denotes the excess return on the market portfolio.

Since literature shows that implied volatility is the most efficient, but upward-biased predictor of future realized volatility, we can express realized volatility as,

$$\sigma^2_{RV,T} = \alpha' + \psi \sigma^2_{IV,t} \qquad (4.5)$$

where $\sigma^2_{IV,t}$ is the implied volatility at time t prior to time T. Combining equation (4.4) and (4.5), the relation between excess return and implied variances can be written as:

$$\bar{r}^m_{t,T} = (\alpha' - \alpha) / \beta + (\psi - 1) / \beta \sigma^2_{IV,t} - \varepsilon / \beta \qquad (4.6)$$

which can be rewritten as

$$\bar{r}^m_{t,T} = \alpha^* + \beta^* \sigma^2_{IV,t} + \varepsilon^* \qquad (4.7)$$

Kanas (2013) specifies the benchmark equation for the conditional excess total market returns as

$$r_t = c + \sum_{i=1}^{l} a_i r_{t-i} + \lambda h_t + h_t \varepsilon_t \qquad (4.8)$$

with the conditional variance equation following GARCH (1, 1) by including the squared implied volatility as an exogenous variable.

$$GARCH(1,1): h_t = \omega + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + gVIX^2_{t-1} \qquad (4.9)$$

Rt is the excess total market return, ht is the conditional variance and λ is the risk-return parameter. Kanas find that the squared implied volatility helps improve the precise measurement of the conditional variance and helps detect a positive risk-return relation.

To examine the predictive ability of current VIX on future small cap premium, we extend Kanas's methodology and set the benchmark equation for the conditional small cap premium as

$$R_t^{Russell2000} - R_t^{sp500} = c + \sum_{i=1}^{l} a_i (R_{t-i}^{Rusell2000} - R_{t-i}^{sp500}) + \lambda h_t + h_t \varepsilon_t \qquad (4.10)$$

For the conditional variance equation, we allow the squared VIX as an exogenous variable, and consider the standard GARCH (1, 1) specification:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} + gVIX_{t-1}^2$$

The sum (α + β) measures volatility persistence and g captures the effect of VIX upon the conditional variance.

The Russell 2000 appears to be the first constantly available small cap stock series. Reilly, F. and Wright, D. (2002) compared the alternative small-cap stock benchmarks, and concluded that there are strong similarities among the small-cap stock indexes. We use the data for Russell 2000 returns and data for S&P 500 returns to construct the small cap premium and examine the predictive power of VIX by equation (4.9) and (4.10). We also use the benchmark equation (4.8) to discover the risk-return relations for S&P 500 and Russell 2000 from 1990 through July 2013.

4.3 DATA DESCRIPTION

Substantial work has been done to test the relationship between volatility and returns. Most studies focus on the relationship between realized or implied volatility and the risk premium, testing the theoretical implication of the CAPM that there is a positive relationship between the level of volatility and the size of the risk premium. We hypothesize that the VIX possesses information content that is useful in forecasting future market returns. We extend the extant literature by testing whether the VIX and VIX futures contracts have predictive power for capturing the differential performance between a portfolio of large capitalization stocks and portfolio of small capitalization stocks, i.e. the small cap premium.

To test the forecasting ability of the VIX for the small cap premium, we consider the return series for the S&P 500 and Russell 2000 as proxies for the large cap and small cap portfolios, respectively. We obtain data for S&P 500, Russell 2000, and VIX index from Bloomberg. The sample period is from January 1990 to July 2013. Dividend yields for the S&P 500 and Russell 2000 are also obtained from Bloomberg for the same sample period. We measured the S&P 500 total returns and Russell 2000 total returns, and use the GARCH-M model to test the significance of the coefficient λ. We measured daily, weekly, and 30 day returns of both indices respectively to estimate the small cap premium to see if there is any difference in the risk-return relation for data of different frequencies. To construct the excess returns series of both S&P 500 and Russell 2000, we obtained the data of 3 month Treasury bill of the total sample period from Federal Reserve Bank Reports.

A summary of the statistical distribution of the series is provided in Table 4.1. All variables exhibit departures from normality based on the Jarque-Bera (JB) normality test. We tested for the presence of stationarity of S&P 500 returns, Russell 2000 returns, small-cap premium, VIX level, and squared VIX levels by using augmented Dickey-Fuller unit root tests. The test statistics for daily, weekly, and 30 day observations are large, consistent with stationarity of the variables. A graphical representation of the small cap premium and VIX over the period January 1990- July 2013 is provided in Fig. 4.1(weekly data) and Fig. 4.2 (daily data).

[Please insert Table 4.1 about here]

[Please insert Figure 4.1 and Figure 4.2 about here]

4.4 FORECAST PERFORMANCE OF THE VIX FOR LATGE-CAP AND SMALL-CAP RETURNS AND THE SMALL CAP PREMIUM

In this section, we examine the ability of the current VIX to forecast large and small cap returns as well as the future small cap size premium. Table 4.2 provides the result of the estimation of future small cap size premium with the squared current VIX in the conditional variance equation for the total sample period from 1990 to July 2013.

To eliminate the effect of a momentum factor in the VIX on the estimation result, we also model VIX as an ARMA(p, q) process:

$$VIX_t = c + u_t$$

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \ldots + \rho_p u_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \ldots + \theta_q \varepsilon_{t-q}$$

We try different ARIMA models and choose the one that have insignificant Ljung-Box Q-statistics for the residual diagnosis. We choose AR(5) and MA(3), which have insignificant Ljung-Box Q-statistics until lag 8 in the residual diagnosis, and guarantee no autocorrelation in the residuals until lag 8. Table 4.3 provides the result of the forecast ability of the VIX programmed by ARIMA process for future small cap size premium. Table 4.4

provides the result of the estimation of small cap premium without VIX in the conditional variance equation from January 1990 to July 2013.

[Please insert Table 4.2, Table 4.3, and Table 4.4 about here]

The conditional variance equation parameters reveal evidence of volatility persistence (i.e. the sum of α and β is close to 1). As we can see in Table 4.2, including squared current VIX in the conditional variance equation does not help predict the future small cap size premium (insignificant λ), although the coefficients g of VIX in the conditional variance equation are significant at 1% level for both daily returns and weekly returns. In Table 4.3, we show that when the VIX is modeled by ARMA (5, 3) process in the conditional variance equation we also do not obtain improved forecasts of the future small cap size premium. As is shown therein, the VIX is insignificant in the conditional variance equation for all daily returns, weekly returns, as well as monthly returns.

Table 4.5 provides the results of the estimation of excess return of the S&P 500 index using the squared current VIX in the conditional variance equation for the total sample period. Table 4.6 examines the forecast prowess of the VIX modeled by ARIMA process for future excess S&P 500 index return. Table 4.7 provides the result of the estimation of excess S&P 500 index return without VIX in the conditional variance equation for the total sample period.

[Please insert Table 4.5, Table 4.6, and Table 4.7 about here.]

As is shown in Table 4.5, including squared current VIX in the conditional variance equation does not provide improved forecasts of future S&P 500 index excess returns. On the other hand we find that the current VIX is significantly negatively related (at the 1% level) to future excess returns for both daily returns and weekly returns. The coefficient g of current

VIX in the conditional variance equation is significantly positive at 1% level for daily returns, weekly returns, and monthly returns. In Table 4.6, we note that while the inclusion of an ARMA (5, 3) model for the VIX leads to positive estimates of λ, the coefficients are not significant for the different investment horizons, while the VIX is only significantly negative in the conditional variance equation for daily returns.

Table 4.8 shows the results of the estimation of the excess Russell 2000 index return using the squared current VIX in the conditional variance equation for the total sample period. Table 4.9 tests the forecasting ability of an ARIMA model for the VIX for future excess Russell 2000 index return. Table 4.10 provides the result of the estimation of excess Russell 2000 index return without VIX in the conditional variance equation for the total sample period.

[Please insert Table 4.8, Table 4.9, and Table 4.10 about here.]

We note that from Table 4.8, including squared current VIX in the conditional variance equation provides improved forecasts of future Russell 2000 index excess returns. The current VIX is significantly negatively related to future excess returns for weekly returns (at the 1% level). The coefficient g on the current VIX in the conditional variance equation is significantly positive at the 1% level for daily returns, weekly returns, and monthly returns. In Table 4.9, including VIX modeled as an ARMA (5, 3) process in the conditional variance equation generates positive estimates of λ to positive numbers, although the result is only significant (at the 5% level) for daily returns. Finally, the coefficient for VIX is significantly positive at 1% level in the conditional variance equation for daily returns only.

4.5 TESTING EFFICIENCY OF VIX FUTURES

Trading in VIX volatility index futures was introduced at the CBOE Futures Exchange in 2004. VIX futures are settled in cash on the Wednesday that is 30 days prior to the next month's S&P 500 index options expiration date, which is the third Friday of the next month. In this section, we look at the ability of VIX futures to forecast the small cap size premium, S&P 500 excess returns, and Russell 2000 excess returns. Before we examine the efficiency of VIX futures, we test the futures market speculative efficiency hypothesis. This hypothesis requires that the futures prices are unbiased predictors of future spot prices. If it is violated, risk-neutral speculators could make consistent profits on long or short futures positions through time.

4.5.1 Testing Speculative Market Efficiency

To test the speculative market efficiency hypothesis, we obtain the data of VIX futures starting from April 2004 to July 2013 from Bloomberg. First, we test the unbiasedness of VIX futures prices based on monthly series. We look at how well futures and the spot prices on the day immediately after the expiration of the contract are used as the best available forecast for the coming month. It avoids problems associated with autocorrelation of overlapping series. We implement Fama's (1984) regression approach to test whether the basis at any period contains information about future spot prices or contains information about the risk premium at the expiration of the contract. We estimate two equations:

$$S_{t+1} - S_t = \alpha_1 + \beta_1 (F_t - S_t) + \varepsilon_{1,t+1} \tag{4.11}$$

$$F_t - S_{t+1} = \alpha_2 + \beta_2(F_t - S_t) + \varepsilon_{2,t+1} \quad (4.12)$$

where $F_t - S_t$ is the basis at time t, S_{t+1} is the observed spot price at time t+1 and F_t is the futures contract price at time t, and $\varepsilon_{1,t+1}$ and $\varepsilon_{2,t+1}$ are residual terms.

[Please insert Table 4.11, Table 4.12, and Table 4.13 about here]

Estimation of Equations (4.11) and (4.12) requires the data series to be stationary. Table 4.11 reports the unit root tests with Dickey and Fuller (1979), augmented Dickey-Fuller (1981), and Phillips-Perron (1988) tests. The tests indicate that the futures, the spot, the basis, the premium, and the change in the future spot prices are indeed stationary. Table 4.12 reports the regression results for equations (4.11) and (4.12). Based on the insignificant coefficient of β_1 in equation (4.11), we conclude that the basis at time t does not contain information about future changes in the spot market. The unbiasedness of the futures as predictors of spot prices is not supported because the slope coefficient is not significantly from zero. For regression (4.12), the results are consistent with a time-varying risk premium. We conclude that the risk premium has variations that show up in the basis. Table 4.13 reports the Wald test results for both models in which we examine the expectation hypothesis by testing the joint restrictions $\alpha_1 = 0, \beta_1 = 1$ in equation (4.11) and $\alpha_2 = 0, \beta_2 = 1$ in equation (4.12).The results show that for model (4.11) the expectation hypothesis is rejected.

Second, we test market efficiency by examining the prowess of futures prices relative to random walk predictors using daily data. As per Park and Switzer (1997) we examine

$$S_T^i = \alpha_0 + \alpha_1 F_{t,T}^i + \alpha_2 MAT_t^i + \varepsilon_t^i \quad (4.13)$$

where S_T^i is the prevailing spot price for contract i at time T (when contract i matures); $F_{t,T}^i$ is the futures price of contract i at time t; MAT is the number of days for contract i to mature as of time t, and ε_t^i is the error term. If α_1 is found to be significantly different from 0, then the current contract prices are good predictors of future spot prices.

[Please insert Table 4.14 about here.]

In the analyses, we examine the period from April 2004 to July 2013, totally 107 VIX futures contracts used. Table 4.14 reports the estimation results. Since α_1 is found to be significantly different from zero in equation (4.13), we can conclude that current future contracts are significant predictors of future spot prices.

4.5.2 Testing Efficiency of VIX Futures

The empirical results show that current VIX futures prices are significant predictors of future VIX spot prices, although the hypothesis of the unbiasedness of the VIX futures as predictors of VIX spot prices is not supported.

[Please insert Table 4.15 and Table 4.16 about here.]

Analogously, we also estimate daily excess returns, weekly excess returns, and monthly excess returns for S&P 500 index and Russell 2000 index to estimate the small cap size premium. We replace the lagged VIX by lagged VIX futures price in equations (4.9) and (4.10). The estimation sample period is from April 2004 to July 2013. Table 4.15 provides the result of the estimation of future small-cap size premium with the squared current VIX futures price in the conditional variance equation. Including squared current VIX futures in the conditional variance equation does improve the prediction of future small cap size premium. The coefficient of λ is significant at 1% level for weekly returns. Current VIX futures are indeed significantly negatively related to future small-cap premium.

Table 4.16 provides the result of the estimation of future S&P 500 index excess returns using squared current VIX futures price in the conditional variance equation. We can see that VIX futures prices contain useful information in predicting future S&P 500 index excess returns. The coefficient of λ is significant at 1% level for daily returns and weekly returns, and at 5% level for monthly returns. The current VIX futures price is negatively related to future S&P 500 index excess returns for all the series.

In Table 4.17 we show relate future Russell 2000 index excess returns to the squared VIX futures price in the conditional variance equation. The results are quite similar to those obtained in the estimation of future S&P 500 index excess returns. The coefficient of λ is significant at 1% level for daily, weekly, and monthly returns. The current VIX futures price is negatively related to future Russell 2000 index excess returns for all the series.

[Please insert Table 4.17 about here]

Finally, we examine how well the VIX futures price on the day immediately after the expiration of the previous futures contract can be used to forecast the small-cap size premium, S&P 500 index excess returns, and Russell 2000 index excess returns for the subsequent month. All of the series are calculated based on a monthly horizon. The estimation sample period is April 2004 to July 2013. The estimation results are shown in Table 4.18.

[Please insert Table 4.18 about here]

We can see that VIX futures price on the day immediately after the expiration of the previous contract does not provide improved predictions of either small cap size premium, S&P 500 index excess returns, or Russell 2000 index excess returns (insignificant λ) for the coming month, although the coefficient g of VIX futures in the conditional variance equation is significant for all the series.

4.6 SUMMARY

Based on our estimation results for the sample period from 1990 to July 2013, current VIX and VIX modeled by ARMA (5, 3) process do not demonstrate forecast prowess for the future small cap size premium. However, the current VIX is significantly negatively related to future S&P 500 index excess returns for both daily and weekly returns. VIX modeled by an ARMA (5, 3) process does not provide information useful for forecasting S&P 500 index excess returns. However, the current VIX is significantly negative related to future Russell 2000 index excess returns for weekly observations. In addition, VIX modeled by ARMA (5, 3) process is significantly positively related to the Russell 2000 index excess returns for daily observations. These results suggest that the actual (ARIMA filtered) VIX predicts asset returns based on size based portfolios symmetrically (asymmetrically).

We also find that VIX futures prices are significant predictors of future VIX spot prices, although the hypothesis of the unbiasedness of the VIX futures as predictors of VIX spot prices is not supported. Including squared current VIX futures price in the conditional variance equation does improve the prediction of future small cap size premium, S&P 500 index excess returns, and Russell 2000 index excess returns. These analyses support the hypothesis of informational advantages of the futures markets relative to the spot market in the price discovery process not just for sized based asset returns, but on the size premium as well.

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Table 2.1

This table shows the results of the regressions for open interest for Exchange Traded Futures Contracts three models:

Model 1:

$$OpenInterest_r = \alpha_0 + \alpha_1 DoddFrank_t + \epsilon_t \quad (1a)$$

Model 2:

$$OpenInterest_r = \alpha_0 + \alpha_1 HistoricalVar_t + \alpha_2 DoddFrank_t + \epsilon_t \quad (1b)$$

Model 3:

$$\text{OpenInterest}_r = \alpha_0 + \alpha_1 \text{HistoricalVar}_t + \alpha_2 \text{Lag(OI)} + \alpha_3 \text{DoddFrank}_t + \varepsilon_t \quad (1c)$$

The panels: Treasury Date, Conference Date, and Volker Date show the results for the three Dodd-Frank structural break points: Aug.11, 2009, Jun.25, 2010, and Oct. 6, 2011, respectively. The numbers in the table give the coefficient estimate of the explainable variables and t-statistics in the parenthesis, with * significant at .05 level and ** significant at .01 level.

Table 2.1: Open Interest Regressions for Futures Contracts

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Treasury Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9251274	-1065095			.01	.118
		(163.6)**	(-13.88)**				
	Model2	9830834	-1599466	-331296.7		.01	.163
		(114.5)**	(-16.6)**	(-8.8)**			
	Model3	44314.62	-10497.8	-5957	.996	2.104	.99
		(1.76)	(-1.24)	(-4.2)**	(378.8)**		
10 yr Treasury Bond	Model1	1943392	-336060.8			.005	.107
		(103.2)**	(-13.144)**				
	Model2	2807549	-694123	-11779.5		.042	.81
		(190.96)**	(-54.37)**	(-72.81)**			
	Model3	11180	-1240.9	-46.88	.995	2.03	.996
		(2.28)*	(-.5953)	(-2.9)**	(484.9)**		
S&P 500	Model1	583236.5	-263534.9			.18	.768
		(207.1)**	(-68.89)**				
	Model2	591289	-268520.7	-7.99		.18	.77
		(166.2)**	(-66.37)**	(-3.68)**			
	Model3	48535.6	-21778	.72	.915	2.37	.962
		(7.62)**	(-6.745)**	(1.28)	(84.6)**		
EURO	Model1	181030.9	53776.24			.082	.21
		(88.98)**	(19.45)**				
	Model2	212982	49879.5	-235.37		.097	.33
		(77.16)**	(19.45)**	(-15.79)**			
	Model3	9322.5	2494.2	-9.11	.955	2.324	.937
		(5.57)**	(2.84)**	(-2.52)*	(124.97)**		
British pound	Model1	113906.8	13799.4			.085	.04
		(88.16)**	(7.86)**				
	Model2	130831.8	7317.9	-111.27		.097	.16
		(77.43)**	(4.3)**	(-14.33)**			
	Model3	5492.44	541.96	-2.85	.96	2.247	.92
		(5.16)**	(1.024)	(-1.53)	(122.35)**		
Canadian dollar	Model1	111022	7549.5			.084	.017
		(100.7)**	(5.04)**				
	Model2	141505.8	-2678.46	-169.02		.147	.434
		(112.58)**	(-2.27)*	(-32.5)**			
	Model3	6033.59	262.38	-3.61	.95	2.124	.92
		(5.63)**	(.59)	(-2.55)*	(117.3)**		

Table 2.1: Open Interest Regressions for Futures Contracts (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Conference Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8753293 (168.46)**	-206776.1 (-2.48)*			.0088	.0036
	Model2	8708810 (122.1)**	-166234.9 (-1.76)	32889.16 (.91)		.0089	.0035
	Model3	31502.5 (1.42)	-5360.91 (-0.67)	-5663.5 (-4.066)**	.997 (402.9)**	2.106	.99
10 yr Treasury Bond	Model1	1806861 (105.5)**	-117851.4 (-4.285)**			.004	.012
	Model2	2492980 (122.8)**	-402082.2 (-20.27)**	-10124.98 (-41.17)**		.0145	.55
	Model3	10707 (2.67)**	-1659.6 (-.88)	-46.48 (-3.08)**	.996 (538.8)**	2.035	.996
S&P 500	Model1	530416.6 (159.7)**	-231922.6 (-43.5)**			.096	.57
	Model2	518902 (127.98)**	-226227.7 (-41.77)**	14.12 (4.97)**		.098	.577
	Model3	23971.96 (5.49)**	-10292 (-4.2)**	.887 (1.57)	.95 (116.9)**	2.41	.96
EURO	Model1	184746.7 (111.37)**	65595.9 (24.61)**			.093	.297
	Model2	217938.6 (96.247)**	65304.77 (27.51)**	-260.92 (-19.34)**		.118	.44
	Model3	10787.87 (6.11)**	3331.4 (3.485)**	-10.29 (-2.84)**	.95 (116.1)**	2.3165	.937
British pound	Model1	113494.2 (104)**	20359.54 (11.61)**			.089	.085
	Model2	128487.6 (83.59)**	13379.33 (7.69)**	-101.94 (-13.15)**		.0998	.184
	Model3	5648.17 (5.4)**	804.2 (1.45)	-2.68 (-1.44)	.95 (119.9)**	2.245	.92
Canadian dollar	Model1	110797.8 (117.3)**	11135.5 (7.34)**			.086	.0356
	Model2	140981.8 (117.88)**	-2300.15 (-1.86)	-169.26 (-31.71)**		.147	.433
	Model3	6034.4 (5.71)**	445.7 (.97)	-3.45 (-2.41)*	.95 (116.89)**	2.124	.92

Table 2.1: Open Interest Regressions for Futures Contracts (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Volker Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8747749 (197.86)**	-461355.5 (-4.2)**			.012	.0089
	Model2	8718387 (156.5)**	-434382 (-3.8)**	28606.4 (.867)		.011	.009
	Model3	31516 (1.43)	-7810.8 (-.75)	-5582.9 (-4.078)**	.997 (401.3)**	2.106	.99
10 yr Treasury Bond	Model1	1771717 (120.44)**	-65440.87 (-1.79)			.004	.0015
	Model2	2335538 (121.7)**	-322681.5 (-11.66)**	-9182.8 (-35.45)**		.011	.469
	Model3	9545.3 (2.53)*	-785.55 (-.32)	-43.55 (-2.95)**	.996 (546.99)**	2.03	.996
S&P 500	Model1	475707 (130.2)**	-217245.9 (-23.95)**			.0576	.285
	Model2	452209.1 (104.8)**	-210602.6 (-23.87)**	33.65 (9.6)**		.061	.328
	Model3	13382.7 (4.33)**	-6170.3 (-2.45)*	.834 (1.468)	.97 (151.6)**	2.437	.96
EURO	Model1	192693.3 (155.3)**	108303.7 (35.05)**			.124	.461
	Model2	223700 (120.8)**	105547.4 (38.88)**	-241.1 (-20.7)**		.162	.585
	Model3	14633.4 (7.3)**	7525.6 (5.22)**	-11.27 (-3.11)**	.93 (100.43)**	2.3	.938
British pound	Model1	112739 (142.24)**	53600.8 (27.15)**			.124	.34
	Model2	123867 (110)**	48111.02 (25.19)**	-84.96 (-13.2)**		.139	.41
	Model3	7451.7 (6.5)**	3005.98 (3.56)**	-2.95 (-1.63)	.94 (100.54)**	2.23	.92
Canadian dollar	Model1	112293.8 (140.15)**	17473.83 (8.76)**			.087	.05
	Model2	137568.4 (136.78)**	7977.5 (5.12)**	-160.88 (-31.73)**		.149	.44
	Model3	6242.1 (5.96)**	931.03 (1.55)	-3.56 (-2.55)*	.95 (115.5)**	2.123	.92

Table 2.2: Open Interest Regressions for Call Options

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Treasury Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	11110293	-6015890			.0454	.606
		(116.3)**	(-46.63)**				
	Model2	10759291	-5692162	199953.7		.045	.608
		(72.32)**	(-34.23)**	(3.07)**			
	Model3	236525.7	-147278	-2604.47	.98	1.37	.98
		(3.7)**	(-3.47)**	(-.52)	(179.8)**		
10 yr Treasury Bond	Model1	1044361	-295457.5			.11	.19
		(88.2)**	(-18.4)**				
	Model2	1316545	-408107.6	-3713.78		.14	.352
		(73.3)**	(-26.2)**	(-18.78)**			
	Model3	62063.6	-17932.94	-37.22	.94	2.004	.91
		(5.55)**	(-2.85)**	(-.85)	(105.94)**		
S&P 500	Model1	280235.3	-98541.67			.18	.402
		(119.7)**	(-31.02)**				
	Model2	292412	-106068.5	-12.01		.187	.42
		(99.82)**	(-31.9)**	(-6.74)**			
	Model3	25197.6	-8884.03	.36	.91	2.022	.898
		(7.81)**	(-5.2)**	(.755)	(81.65)**		
EURO	Model1	57010.93	40980.92			.132	.357
		(53.25)**	(28.2)**				
	Model2	61767.56	40386.56	-34.92		.134	.364
		(39.42)**	(27.8)**	(-4.14)**			
	Model3	3851.2	2786.324	-.945	.93	2.078	.92
		(5.27)**	(4.29)**	(-.403)	(99.1)**		
British pound	Model1	14434	5351.49			.069	.095
		(45)**	(12.3)**				
	Model2	13760.5	5610.7	4.41		.069	.0975
		(30.7)**	(12.44)**	(2.15)*			
	Model3	480.4	204.13	.166	.96	2.097	.938
		(3.37)**	(1.65)	(.41)	(139.7)**		
Canadian dollar	Model1	17127.6	3574.84			.145	.085
		(75.26)**	(11.58)**				
	Model2	18252.39	3195.3	-6.22		.147	.097
		(53.7)**	(10.03)**	(-4.43)**			
	Model3	1301.78	247.2	-.378	.93	2.007	.87
		(6.5)**	(1.99)*	(-1.06)	(93.25)**		

Table 2.2: Open Interest Regressions for Call Options (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Conference Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9846937 (99.765)**	-5189630 (-32.95)**			.03	.434
	Model2	8682386 (68)**	-4128451 (-24.5)**	862583.6 (13.32)**		.034	.497
	Model3	122577.7 (2.57)*	-78891.6 (-2.21)*	-561.69 (-.11)	.99 (215.6)**	1.37	.98
10 yr Treasury Bond	Model1	954910.7 (86.96)**	-182905.5 (-10.4)**			.096	.07
	Model2	1148330 (63.11)**	-262925.9 (-14.8)**	-2856.9 (-12.95)**		.108	.167
	Model3	48142.63 (5.18)**	-10401.12 (-1.79)	-13.86 (-.33)	.95 (115.75)**	2.012	.912
S&P 500	Model1	252705.4 (106.4)**	-66912.3 (-17.58)**			.13	.177
	Model2	253385.6 (86.53)**	-67318.75 (-17.24)**	-.664 (-.324)		.131	.177
	Model3	16474.3 (6.51)**	-4314.2 (-2.89)**	.4896 (1.02)	.933 (96.39)**	2.045	.896
EURO	Model1	70475.94 (64.5)**	22605.8 (12.88)**			.094	.104
	Model2	77757.68 (46.88)**	22523.93 (12.98)**	-57.1 (-5.79)**		.096	.12
	Model3	3554.784 (4.85)**	879.3 (1.56)	-1.88 (-.8)	.95 (118.7)**	2.096	.92
British pound	Model1	15762.41 (55.59)**	4059.68 (8.92)**			.0658	.052
	Model2	15254.19 (36.1)**	4296.9 (8.99)**	3.45 (1.62)		.0659	.053
	Model3	536.5 (3.82)**	52.03 (.42)	0.033 (0.08)	.97 (143.25)**	2.099	.939
Canadian dollar	Model1	18241.72 (89.99)**	2129.7 (6.55)**			.137	.0285
	Model2	19629.34 (59.13)**	1510.4 (4.4)**	-7.76 (-5.25)**		.139	.046
	Model3	1325.2 (6.565)**	92.56 (.74)	-.462 (-1.27)	.93 (96.5)**	2.012	.87

Table 2.2: Open Interest Regressions for Call Options (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Volker Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9846937	-5189630			.03	.434
		(99.765)**	(-32.95)**				
	Model2	8682386	-4128451	862583.6		.034	.497
		(68)**	(-24.5)**	(13.32)**			
	Model3	122577.7	-78891.6	-561.69	.99	1.37	.98
		(2.57)*	(-2.21)*	(-.11)	(215.6)**		
10 yr Treasury Bond	Model1	954910.7	-182905.5			.096	.07
		(86.96)**	(-10.4)**				
	Model2	1148330	-262925.9	-2856.9		.108	.167
		(63.11)**	(-14.8)**	(-12.95)**			
	Model3	48142.63	-10401.12	-13.86	.95	2.012	.912
		(5.18)**	(-1.79)	(-.33)	(115.75)**		
S&P 500	Model1	252705.4	-66912.3			.13	.177
		(106.4)**	(-17.58)**				
	Model2	253385.6	-67318.75	-.664		.131	.177
		(86.53)**	(-17.24)**	(-.324)			
	Model3	16474.3	-4314.2	.4896	.933	2.045	.896
		(6.51)**	(-2.89)**	(1.02)	(96.39)**		
EURO	Model1	70475.94	22605.8			.094	.104
		(64.5)**	(12.88)**				
	Model2	77757.68	22523.93	-57.1		.096	.12
		(46.88)**	(12.98)**	(-5.79)**			
	Model3	3554.784	879.3	-1.88	.95	2.096	.92
		(4.85)**	(1.56)	(-.8)	(118.7)**		
British pound	Model1	15762.41	4059.68			.0658	.052
		(55.59)**	(8.92)**				
	Model2	15254.19	4296.9	3.45		.0659	.053
		(36.1)**	(8.99)**	(1.62)			
	Model3	536.5	52.03	0.033	.97	2.099	.939
		(3.82)**	(.42)	(0.08)	(143.25)**		
Canadian dollar	Model1	18241.72	2129.7			.137	.0285
		(89.99)**	(6.55)**				
	Model2	19629.34	1510.4	-7.76		.139	.046
		(59.13)**	(4.4)**	(-5.25)**			
	Model3	1325.2	92.56	-.462	.93	2.012	.87
		(6.565)**	(.74)	(-1.27)	(96.5)**		

Table 2.3: Open Interest Regressions for Put Options

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
		Intercept	DoddFrank	HistVar	Lag(OI)		
Treasury Date Eurodollar	Model1	9913346	-2859060			1.964	.0017
		(8.645)**	(-1.85)				
	Model2	8733923	-1771163	671011		1.965	.0015
		(4.87)**	(-.88)	(.86)			
	Model3	10114784	-3204726	-245737	.025	2.017	.0014
		(7.8)**	(-1.96)*	(-.81)	(.93)		
10 yr Treasury Bond	Model1	1113088	-244650			.123	.0994
		(77.59)**	(-12.58)**				
	Model2	1509601	-408757	-5410.2		.176	.358
		(73.59)**	(-22.97)**	(-23.95)**			
	Model3	79340.91	-18492.6	-84.34	.93	2.0145	.89
		(5.9)**	(-2.42)*	(-1.49)	(98.04)**		
S&P 500	Model1	597100.8	-282730			.112	.474
		(102.8)**	(-35.89)**				
	Model2	675232.7	-331318.2	-77.08		.143	.582
		(102.7)**	(-44.4)**	(-19.28)**			
	Model3	34925.35	-16810.2	-1.289	.944	2.051	.944
		(6.06)**	(-4.565)**	(-1.389)	(107.9)**		
EURO	Model1	889901.9	-754256			2.008	-.000004
		(1.597)	(-.997)				
	Model2	1500167	-830512	-4480		2.01	.000015
		(1.829)	(-1.09)	(-1.014)			
	Model3	1167628	-809494.7	-1922.1	-.0017	2.006	-.0012
		(1.575)	(-1.058)	(-.56)	(-.0625)		
British pound	Model1	2979498	-2955388			2.009	.00013
		(1.49)	(-1.087)				
	Model2	4540749	-3556383	-10230.8		2.009	-.00013
		(1.62)	(-1.26)	(-.8)			
	Model3	3314802	-3122135	-1927.6	-.0016	2.006	-.00125
		(1.29)	(-1.104)	(-.197)	(-.06)		
Canadian dollar	Model1	839297.2	-817494.9			2.0085	.00012
		(1.5)	(-1.08)				
	Model2	1012879	-876036.7	-959.92		2.009	-.00053
		(1.21)	(-1.115)	(-.277)			
	Model3	868780.9	-833018	-122.58	-.0015	2.006	-.0013
		(1.21)	(-1.067)	(-.052)	(-.055)		

Table 2.3: Open Interest Regressions for Put Options (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Conference Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9162239 (9.26)**	-2081242 (-1.32)			1.962	.00052
	Model2	7886180 (5.8)**	-918272.8 (-.51)	943672.6 (1.37)		1.965	.0011
	Model3	9155846 (8.31)**	-2247551 (-1.38)	-166877 (-.56)	0.03 (.98)	2.017	.000028
10 yr Treasury Bond	Model1	1027769 (79.59)**	-122566 (-5.92)**			.113	.0234
	Model2	1331522 (65.3)**	-248233 (-12.48)**	-4486.6 (-18.15)**		.14	.207
	Model3	64898.8 (5.66)**	-9391.67 (-1.29)	-53.88 (-.98)	.94 (104.3)**	2.02	.891
S&P 500	Model1	523333 (86.7)**	-205390 (-21.23)**			.0766	.239
	Model2	559737.2 (77.06)**	-223977.8 (-23.13)**	-43.23 (-8.51)**		.081	.276
	Model3	19887.7 (4.71)**	-7674.96 (-2.5)*	-.531 (-.583)	.963 (132.7)**	2.068	.943
EURO	Model1	694985.3 (1.44)	-552382 (-.71)			2.008	-.00034
	Model2	1208766 (1.635)	-558159 (-.72)	-4028.7 (-.92)		2.009	- .000456
	Model3	917542.6 (1.38)	-577733 (-.74)	-1652.9 (-.483)	-.0012 (-0.05)	2.006	-.0016
British pound	Model1	2233283 (1.29)	-2209540 (-.795)			2.008	-.00026
	Model2	3684264 (1.425)	-2886892 (-.99)	-9841.3 (-.76)		2.009	-.00056
	Model3	2444251 (1.06)	-2327163 (-.802)	-1295.9 (-.13)	-.001 (-.044)	2.006	-.00165
Canadian dollar	Model1	632770.4 (1.31)	-610887.9 (-.79)			2.008	-.00026
	Model2	800416.8 (1.004)	-685691 (-.83)	-938.3 (-.264)		2.008	- .000916
	Model3	650308.1 (.99)	-621690 (-.767)	-75.5 (-.03)	-.001 (-.04)	2.006	-.0017

Table 2.3: Open Interest Regressions for Put Options (Cont.)

Underlying Asset	Model	Independent Variables				Durbin Watson Statistic	Adj. R squared
Volker Date		Intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8717814 (10.34)**	-2273364 (-1.09)			1.961	.000134
	Model2	7690599 (7.25)**	-1330059 (-.61)	1004727 (1.595)		1.965	.0012
	Model3	8605641 (9.28)**	-2327582 (-1.101)	-116573 (-.4)	.027 (1.002)	2.017	-.00046
10 yr Treasury Bond	Model1	998020.3 (89.95)**	-110962 (-4.03)**			.112	.0106
	Model2	1240796 (67.95)**	-221560 (-8.43)**	-3959 (-16.04)**		.134	.1615
	Model3	60580.97 (5.68)**	-7454.3 (-.79)	-43.7 (-.81)	.94 (105.4)**	2.022	.891
S&P 500	Model1	474348.5 (85.41)**	-190152 (-13.82)**			.066	.117
	Model2	490943.4 (72.99)**	-195047 (-14.21)**	-23.36 (-4.28)**		.067	.128
	Model3	15606.6 (4.42)**	-6391.75 (-1.71)	-.312 (-.345)	.968 (143.5)**	2.074	.943
EURO	Model1	545736.8 (1.33)	-403232.8 (-.39)			2.007	-.00059
	Model2	1074041 (1.53)	-451076.3 (-.44)	-4099.85 (-.93)		2.009	-.0007
	Model3	761500.4 (1.25)	-445672.4 (-.43)	-1627.4 (-.475)	-.001 (-.038)	2.006	-.0018
British pound	Model1	1637637 (1.1)	-1621303 (-.44)			2.007	-.00056
	Model2	2614011 (1.17)	-2103776 (-.56)	-7442 (-.586)		2.008	-.001
	Model3	1631748 (.83)	-1621132 (-.43)	95.41 (.01)	-.0008 (-.03)	2.0056	-.002
Canadian dollar	Model1	467626.5 (1.135)	-445398 (-.435)			2.007	-.00057
	Model2	500648.7 (.74)	-457831.5 (-.44)	-209.93 (-.06)		2.007	-.0013
	Model3	424198.3 (.762)	-425316.4 (-.41)	282 (.12)	-.0008 (-.03)	2.006	-.002

Table 2.4
Mispricing Series for S&P 500 Futures February 2004 – August 2012
Pre vs. Post-OTC Guidelines[a]

Panel A. Daily Data	02/04 – 08/09	08/09 – 08/2012	02/04 – 08/12
1. Average Mispricing			
N	1411	750	2161
Mean (%)	.000713	-.000130	.000420
Standard Deviation (%)	.002251	.001486	.002058
Minimum (%)	-.012880	-.007074	-.012880
Maximum (%)	.018113	.007743	.018113
t-statistic	11.89*	-2.39*	9.49*
t-statistic of difference between periods[b]			9.24*
2. Average Absolute Mispricing			
N	1411	750	2161
Mean (%)	.001487	.001085	.001348
Standard Deviation (%)	.001833	.001023	.001611
Minimum (%)	$1.89*10^{-7}$	$5.89*10^{-7}$	.000000189
Maximum (%)	.018113	.007743	.018113
t-statistic	30.47011*	29.04008*	38.90*
t-statistic of difference between periods[b]			5.56*

[a]the mispricing series are as defined in the equation $x_t = (F(t,T) - F^e(t,T))/P_t$ where, $F_{(t,T)}$ is the actual index futures price, and $F^e_{(t,T)} = P_t e^{(r-d)(t-T)}$
[b] the *t*-statistic measures the difference between the average mispricing between the Pre- and Post-OTC guideline periods
(*)indicates significant at .01 level

Table 2.5 Estimates of Daily Futures Mispricing

Panel A

Dependent Variable is the signed mispricing series:

$$x_t = \alpha_0 + \alpha_1 dum_t + e_t$$

where dum is equal to 1 after August 11, 2009 (Treasury OTC Report Release Date) and 0 otherwise.

	Parameter	*t-statistic*	
a_0	.000713	13.260*	
a_1	-.000843	-9.238*	$R^2 = .0380$

Panel B

Dependent Variable is the absolute mispricing series

$$|x_t| = \beta_0 + \beta_1 dum_t + e_t$$

where dum is equal to 1 after August 11, 2009 (Treasury OTC Report Release Date) and 0 otherwise.

	Parameter	*t-statistic*	
a_0	.001487	34.927*	
a_1	-.000402	-45.568*	R^2=.0142

(*)indicates significance at .01 level

Table 2.6 Futures-Forward Yield Differences – with Treasury Date Breakpoint

This table shows the difference in basis points between the futures and forward Eurodollar yields using weekly (Thursday) data from January 2007 through June 2012, using the Treasury Date 08/11/2009 as the Breakpoint. The table also reports the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods. In Panel A, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5. DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively. Panel B reports the results using the spot LIBOR interpolation method to compute the implied forward rates. We use the 1, 3, 6, 9, and 12 month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (2.4), and is compared with futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts. DIFF1 is the difference between the annualized 3-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized 3-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized 3-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts. N is the number of observations. The t-statistics are presented in parentheses; ** denotes significance at the 1% level; *denotes significant at the 5% level.

Panel A

Year	DIFF0.25_0.5			DIFF0.5_0.75			DIFF0.75_1			T	
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Avg. Volume	Avg. O.I.
01/07-06/12	-38.70 (-20.42)**	-27.08	285	-49.27 (-25.20)**	-48.74	285	-62.43 (-26.17)**	-73.62	272	273,669	1,168,244
01/07-08/09	-46.76 (-13.00)**	-31.25	136	-39.87 (-10.96)**	-18.89	136	-42.48 (-10.90)**	-21.77	136	327,113	1,309,352
08/09-06/12	-31.29 (-25.02)**	-25.86	149	-57.84 (-41.37)**	-52.69	149	-82.39 (-62.25)**	-78.22	136	223,799	1,036,576

Panel B

Year	DIFF1		DIFF2		DIFF3	
	Mean	Median	Mean	Median	Mean	Median
01/07-06/12	-39.02 (-6.04)**	-26.24	-50.39 (-7.71)**	-46.10	-64.53 (-7.57)**	-76.53
01/07-08/09	-46.65 (-3.45)**	-27.52	-43.20 (-3.28)**	-25.41	-47.57 (-3.20)*	-26.51
08/09-06/12	-33.15 (-6.86)**	-25.70	-56.38 (-11.51)**	-52.74	-81.49 (-17.51)**	-81.45

Table 2.7 Futures-Forward Yield Differences – with Conference Date Breakpoint

This table shows the difference in basis points between the futures and forward Eurodollar yields using weekly (Thursday) data from January 2007 through June 2012, using the Conference Date 06/25/2010 as the Breakpoint. The table also reports the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods. In Panel A, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5. DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively. Panel B reports the results using the spot LIBOR interpolation method to compute the implied forward rates. We use the 1, 3, 6, 9, and 12 month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (2.4), and is compared with futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts. DIFF1 is the difference between the annualized 3-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized 3-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized 3-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts. N is the number of observations. The t-statistics are presented in parentheses; ** denotes significance at the 1% level; *denotes significant at the 5% level.

Panel A

Year	DIFF0.25_0.5			DIFF0.5_0.75			DIFF0.75_1			T	
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Avg. Volume	Avg. O.I.
01/07-06/12	-38.70 (-20.42)**	-27.08	285	-49.27 (-25.20)**	-48.74	285	-62.43 (-26.17)**	-73.62	272	273,669	1,168,244
01/07-06/10	-43.19 (-15.35)**	-28.59	182	-47.47 (-15.89)**	-47.21	182	-54.25 (-16.31)**	-59.64	182	303,299	1,221,864
06/10-06/12	-30.68 (-23.34)**	-26.26	103	-52.44 (-45.82)**	-49.51	103	-78.98 (-52.78)**	-76.38	90	219,607	1,070,411

Panel B

Year	DIFF1		DIFF2		DIFF3	
	Mean	Median	Mean	Median	Mean	Median
01/07-06/12	-39.02 (-6.04)**	-26.24	-50.39 (-7.71)**	-46.10	-64.53 (-7.57)**	-76.53
01/07-06/10	-42.48 (-4.25)**	-26.79	-50.17 (-5.00)**	-46.61	-59.69 (-5.05)**	-63.41
06/10-06/12	-33.63 (-5.73)**	-26.05	-50.77 (-10.13)**	-46.10	-75.82 (-12.39)**	-76.53

Table 3.1: Global positions in (notional amounts outstanding) OTC derivatives markets by type of instrument
In billions of US dollars

	Notional amounts at end-June 1998	Notional amounts at end-June 2001	Notional amounts at end-June 2004	Notional amounts at end-June 2007	Notional amounts at end-June 2010
Foreign exchange contracts	**22,055**	**20,435**	**31,500**	**57,597**	**62,933**
Outright forwards and FX swaps	14,658	13,275	16,764	29,771	31,935
Currency swaps	2,324	4,302	7,939	14,127	18,890
Options	5,040	2,824	6,789	13,662	12,107
other	33	33	8	37	1
Memo: Exchange-traded currency contracts	103	66	98	303	386
Interest rate contracts	**48,124**	**75,813**	**177,457**	**388,627**	**478,093**
FRAs	6,602	7,678	14,399	25,607	60,028
Swaps	32,942	57,220	137,277	306,438	367,541
Options	8,528	10,913	25,757	56,575	50,519
Other	52	2	25	7	5
Memo: Exchange-traded interest rate contracts	13,107	17,515	49,385	86,135	69,551
Equity-linked contracts	**1,341**	**2,039**	**5,094**	**10,760**	**6,868**
Forwards and swaps	180	373	773	3,426	1,854
Options	1,161	1,666	4,321	7,333	5,013
Memo: Exchange-traded equity index contracts	1,047	1,912	3,318	10,246	5,524
Commodity contracts	**506**	**674**	**1,354**	**8,255**	**3,273**
Gold	228	278	359	1,051	669
Other	278	396	995	7,204	2,604
Forwards and swaps	165	235	541	3,481	1,686
Options	113	162	453	3,724	918
Credit-linked and other contracts	**118**	**698**	**4,664**	**51,173**	**31,416**
Total contracts	72,143	99,659	220,070	516,411	582,583

Table 3.2: Global positions in (gross market values) OTC derivatives markets by type of instrument

In billions of US dollars

	Gross market values at end-June 1998	Gross market values at end-June 2001	Gross market values at end-June 2004	Gross market values at end-June 2007	Gross market values at end-June 2010
Foreign exchange contracts	**982**	**967**	**1,113.7**	**1,610.5**	**3,158**
Outright forwards and FX swaps	583.8	548	459.6	667.5	1,330
Currency swaps	254.8	339.2	505.4	664.7	1,372
Options	141	79.8	148.7	278.3	456
Other	2.1	--	--	--	--
Interest rate contracts	**1,353**	**1,748**	**4,582**	**6,724**	**18,508**
FRAs	38.7	32.4	210.8	145.1	204
Swaps	1,186	1530.6	3,978	5,812.6	16,703
Options	126	184.9	393.2	766.5	1,600
Other	2.3	--	--	--	--
Equity-linked contracts	**201.3**	**218.1**	**320.8**	**1,213**	**796**
Forwards and swaps	21.5	53.8	71.9	266	202
Options	179.8	164.3	249	947	595
Commodity contracts	**39**	**88**	**176**	**690**	**492**
Gold	9	25	46	56	52
Other	30	63	130	634	439
Forwards and swaps	--	--	--	--	--
Options	--	--	--	--	--
Credit-linked and other contracts	**4**	**22**	**196**	**907**	**1,720**
Total contracts	2,580	3,042	6,391	11,145	24,673

Table 3.3: Global OTC derivatives market turnover (Daily averages in billions of US dollars)
Total reported transactions in all currencies

	April 1998		April 2001		April 2004		April 2007		April 2010	
	Total	Non-financial	Total	Non-financial	Total	Non-financial	Total	Non-financial	Total	Non-financial
Foreign exchange turnover	959		853		1,303		2,319		2,491	
Outright forwards	128	46	130	37	209	56	362	107	475	108
FX swaps	734	98	656	60	954	89	1,714	236	1,765	170
Currency swaps	10	2	7	2	21	3	32	6	43	4
Options sold	68	10	43	8	81	10	135	28	137	16
Options bought	68	11	44	8	85	11	138	31	131	18
Total options	87		60		117		212		207	
Other	0		0		2		0		0	
Interest rate turnover	265		489		1,025		1,686			
Forward rate agreements	74	7	129	5	233	8	258	27		
Swaps	155	11	331	14	621	55	1,210	85		
Options sold	26	3	24	3	115	8	146	13		
Options bought	28	4	21	2	114	8	175	12		
Total options	36		29		171		215			
Other	0		0		0		1			
Estimated gap in reporting	39		43		92		193		144	
Total	1,265		1,385		2,420		4,198			
Memo: Exchange-traded derivatives	1,382		2,198		4,547		6,173			
Currency instruments	11		10		22		72		168	
Interest rate instruments	1,371		2,188		4,524		6,101			

Table 3.4: Geographical distribution of reported OTC derivatives market activity
Daily average net turnover in April, in millions of US dollars (net of local inter-dealer double-counting)

	The Americas			Europe			Asia/ Pacific		
	2004	2007	2010	2004	2007	2010	2004	2007	2010
Foreign exchange derivatives total*	**329,284**	**498,486**	**496,783**	**1,011,552**	**1,812,249**	**1,913,265**	**428,047**	**665,326**	**813,718**
Outright forwards	67,445	120,902	130,660	141,693	215,187	300,038	51,526	97,512	128,181
FX swaps	217,861	291,296	312,245	763,104	1,435,722	1,418,785	347,739	522,524	630,019
Currency swaps	3,252	8,405	11,122	18,231	23,581	29,608	4,316	7,676	16,251
Options	40,726	77,881	42,756	86,508	137,761	164,834	24,416	37,617	39,267
Single currency interest rate derivatives total **	**331,859**	**548,665**		**927,632**	**1,430,503**		**71,237**	**192,132**	
Forward rate agreements	44,312	98,628		246,938	231,948		11,454	12,745	
Swaps	205,207	331,111		570,587	1,074,711		47,655	150,203	
Options	82,340	118,928		110,105	123,845		12,126	29,186	

* Outright forwards, FX swaps, currency swaps and options. Does not include other products.
**Forward rate agreements, swaps and options.
Regional aggregates are adjusted for local inter-dealer double-counting, ie trades between reporting dealers located in the same countries were halved. Regional aggregates are not adjusted for intraregional double-counting, ie trades between reporting dealers located in different countries of the same region were not halved.

Table 3.5. Descriptive Statistics

	OTC_rate	OTC_fx	OTC_ir	OTC_eq	Futures_rate	Futures_fx	Futures_ir	Futures_eq
Mean	1.0822	1.0509	1.0920	1.0678	1.0701	1.0848	1.0697	1.1039
Median	1.1107	1.0792	1.1113	1.0553	1.0293	1.0554	1.0373	1.0861
Maximum	1.2465	1.2145	1.2358	1.3530	1.6044	1.8858	1.6337	2.8399
Minimum	0.8005	0.7018	0.8420	0.6052	0.6845	0.5536	0.7028	0.4609
Std. Dev.	0.0972	0.1057	0.0920	0.1496	0.2333	0.3123	0.2332	0.4105
				Test for ARCH(1)				
Chi-squared	0.5072	0.1447	0.0596	0.2048	2.5406	0.1471	1.5465	0.0236
p-value	0.4764	0.7037	0.8072	0.6509	0.1110	0.7013	0.2136	0.8778
				Test for ARCH(4)				
Chi-squared	3.0100	0.7352	1.0529	1.1428	2.5334	0.9040	1.9987	0.4549
p-value	0.5562	0.9469	0.9017	0.8874	0.6387	0.9240	0.7360	0.9777

Table 3.5 shows the summary measures of the variables used in the tests and tests for ARCH/GARCH effects with one and four lags. OTC_rate is the semi-annual growth rate of total notional amounts outstanding in global OTC derivatives market in billions of US dollars. Futures_rate is the semi-annual growth rate of total notional amounts outstanding in exchange traded market in billions of US dollars. OTC_fx is the semi-annual growth rate of notional amounts outstanding in global OTC foreign exchange derivatives market in billions of US dollars. Futures_fx is the semi-annual growth rate of notional amounts outstanding in exchange traded foreign exchange derivatives market in billions of US dollars. OTC_ir is the semi-annual growth rate of notional amounts outstanding in global OTC interest rate derivatives market in billions of US dollars. Futures_ir is the semi-annual growth rate of notional amounts outstanding in exchange traded interest rate derivatives market in billions of US dollars. OTC_eq is the semi-annual growth rate of notional amounts outstanding in global OTC equity-linked derivatives market in billions of US dollars. Futures_eq is the semi-annual growth rate of notional amounts outstanding in exchange traded equity-linked derivatives market in billions of US dollars. A total sample of 29 semiannual growth rates from June 1998 to December 2012 is used.

Table 3.6. Contemporaneous Correlation between Series.

	OTC_rate	Futures_rate	OTC_fx	OTC_ir	OTC_eq	Futures_fx	Futures_ir	Futures_eq
OTC_rate	1							
Futures_rate	0.5326**	1						
OTC_fx	0.7749**	0.4763**	1					
OTC_ir	0.9577**	0.5409**	0.6564**	1				
OTC_eq	0.7038**	0.3802*	0.5452**	0.7051**	1			
Futures_fx	0.2307	0.2594	0.2146	0.2071	0.1935	1		
Futures_ir	0.5384**	0.9892**	0.5125**	0.5360**	0.3758*	0.2197	1	
Futures_eq	0.2506	0.5825**	0.0116	0.3236	0.2385	0.3150	0.4593*	1

This table reports the contemporaneous Pearson correlation coefficients between position growth rate measures for the OTC and exchange traded market. OTC_rate is the semi-annual growth rate of total notional amounts outstanding in global OTC derivatives market in billions of US dollars. Futures_rate is the semi-annual growth rate of total notional amounts outstanding in exchange traded market in billions of US dollars. OTC_fx is the semi-annual growth rate of notional amounts outstanding in global OTC foreign exchange derivatives market in billions of US dollars. Futures_fx is the semi-annual growth rate of notional amounts outstanding in exchange traded foreign exchange derivatives market in billions of US dollars. OTC_ir is the semi-annual growth rate of notional amounts outstanding in global OTC interest rate derivatives market in billions of US dollars. Futures_ir is the semi-annual growth rate of notional amounts outstanding in exchange traded interest rate derivatives market in billions of US dollars. OTC_eq is the semi-annual growth rate of notional amounts outstanding in global OTC equity-linked derivatives market in billions of US dollars. Futures_eq is the semi-annual growth rate of notional amounts outstanding in exchange traded equity-linked derivatives market in billions of US dollars. A total sample of 29 semiannual growth rates from June 1998 to December 2012 is used.

* significant at 5% level; ** significant at 1% level. Significance tests are based on the computed t-statistic.

Table 3.7: Unit Root Tests

	OTC_rate		OTC_fx		OTC_ir		OTC_eq	
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	Intercept	Trend & Intercept	Intercept	Trend & Intercept
t-Stat ADF	-4.2766	-4.4895	-4.9744	-4.9059	-0.1398	-5.1264	-5.9449	-6.3194
p-Value ADF	0.0024	0.0068	0.0004	0.0026	0.9335	0.0015	0.0000	0.0001
t-Stat PP	-4.3452	-4.5361	-4.9678	-4.8975	-4.7011	-5.1475	-5.8999	-6.2859
p-Value PP	0.0020	0.0061	0.0004	0.0026	0.0008	0.0015	0.0000	0.0001
	Futures_rate		Futures_fx		Futures_ir		Futures_eq	
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	Intercept	Trend & Intercept	Intercept	Trend & Intercept
t-Stat ADF	-2.7507	-8.8079	-9.3753	-5.8769	-2.6513	-8.4837	-6.6462	-7.3212
p-Value ADF	0.0789	0.0000	0.0000	0.0003	0.0956	0.0000	0.0000	0.0000
t-Stat PP	-7.6194	-8.5191	-11.5083	-12.8731	-7.4704	-8.1169	-6.7697	-8.6624
p-Value PP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

t-statistics and MacKinnon (1996) one-sided p-values of Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) with automatic selection of lags on semiannual measures of growth rates in the OTC and exchange traded derivatives markets are presented. The maximum lag is set at 37 in 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. OTC_rate is the semi-annual growth rate of total notional amounts outstanding in global OTC derivatives market in billions of US dollars. Futures_rate is the semi-annual growth rate of total notional amounts outstanding in exchange traded market in billions of US dollars. OTC_fx is the semi-annual growth rate of notional amounts outstanding in global OTC foreign exchange derivatives market in billions of US dollars. Futures_fx is the semi-annual growth rate of notional amounts outstanding in exchange traded foreign exchange derivatives market in billions of US dollars. OTC_ir is the semi-annual growth rate of notional amounts outstanding in global OTC interest rate derivatives market in billions of US dollars. Futures_ir is the semi-annual growth rate of notional amounts outstanding in exchange traded interest rate derivatives market in billions of US dollars. OTC_eq is the semi-annual growth rate of notional amounts outstanding in global OTC equity-linked derivatives market in billions of US dollars. Futures_eq is the semi-annual growth rate of notional amounts outstanding in exchange traded equity-linked derivatives market in billions of US dollars. A total of 29 semiannual growth rates from June 1998 to December 2012 are used.

Table 3.8: Pair-wise Causality Regressions

Test	Pair	Null Hypothesis	F-Stat	p-Value	Chi-square	p-Value	Conclusion
1	OTC_rate &Futures_rate	Futures growth rate does not explain OTC growth rate	3.0405	0.0683*	6.0809	0.0478**	Futures leads OTC market
		OTC growth rate does not explain Futures growth rate	0.1187	0.8887	0.2374	0.8881	
2	OTC_rate & Futures_fx	Futures FX growth rate does not explain OTC growth rate	0.1860	0.8316	0.3719	0.8303	No causality between OTC growth rate and Futures FX growth rate
		OTC growth rate does not explain Futures FX growth rate	0.7797	0.4708	1.5593	0.4586	
3	OTC_rate & Futures_ir	Futures IR growth rate does not explain OTC growth rate	2.7934	0.0830*	5.5869	0.0612*	Futures IR leads OTC market
		OTC growth rate does not explain Futures IR growth rate	0.2054	0.8159	0.4108	0.8143	
4	OTC_rate & Futures_eq	Futures EQ growth rate does not explain OTC growth rate	0.6483	0.5326	1.2966	0.5229	No causality between OTC growth rate and Futures EQ growth rate
		OTC growth rate does not explain Futures EQ growth rate	0.7754	0.4727	1.5507	0.4605	
5	Futures_rate & OTC_fx	OTC FX growth rate does not explain Futures growth rate	0.0661	0.9362	0.1322	0.9360	Futures market leads OTC FX
		Futures growth rate does not explain OTC FX growth rate	2.4283	0.1115*	4.8566	0.0882*	
6	Futures_rate & OTC_ir	OTC IR growth rate does not explain Futures growth rate	0.3545	0.7055	0.7090	0.7015	Futures market leads OTC IR
		Futures growth rate does not explain OTC IR growth rate	4.0251	0.0324**	8.0502	0.0179*	

7	Futures_rate & OTC_eq	OTC EQ growth rate does not explain Futures growth rate	0.0316	0.9689	0.0632	0.9689	Futures market leads OTC EQ
		Futures growth rate does not explain OTC EQ growth rate	2.3781	0.1161*	4.7563	0.0927*	
8	OTC_fx & Futures_fx	Futures FX growth rate does not explain OTC FX growth rate	0.0802	0.9232	0.1604	0.9229	OTC FX leads Futures FX
		OTC FX growth rate does not explain Futures FX growth rate	2.3865	0.1153*	4.7730	0.0920*	
9	OTC_ir & Futures_ir	Futures IR growth rate does not explain OTC IR growth rate	3.5961	0.0445**	7.1923	0.0274**	Futures IR leads OTC IR
		OTC IR growth rate does not explain Futures IR growth rate	0.3846	0.6852	0.7692	0.6807	
10	OTC_eq & Futures_eq	Futures EQ growth rate does not explain OTC EQ growth rate	0.2718	0.7645	0.5437	0.7620	No causality between OTC EQ growth rate and Futures EQ growth rate
		OTC EQ growth rate does not explain Futures EQ growth rate	0.8516	0.4403	1.7032	0.4267	
11	OTC_fx & Futures_ir	Futures IR growth rate does not explain OTC FX growth rate	2.3453	0.1193*	4.6906	0.0958*	Futures IR leads OTC FX
		OTC FX growth rate does not explain Futures IR growth rate	0.2263	0.7993	0.4526	0.7975	
12	OTC_fx & Futures_eq	Futures EQ growth rate does not explain OTC FX growth rate	1.6557	0.2139	3.3114	0.1910	No causality between OTC FX growth rate and Futures EQ growth rate
		OTC FX growth rate does not explain Futures EQ growth rate	0.6122	0.5511	1.2244	0.5421	
13	OTC_ir & Futures_fx	Futures FX growth rate does not explain OTC IR growth rate	0.4186	0.6631	0.8372	0.6580	No causality between OTC IR growth rate
		OTC IR growth rate					

		does not explain Futures FX growth rate	0.4587	0.6380	0.9173	0.6321	and Futures FX growth rate
14	OTC_ir & Futures_eq	Futures EQ growth rate does not explain OTC IR growth rate	0.5506	0.5843	1.1013	0.5766	No causality between OTC IR growth rate and Futures EQ growth rate
		OTC IR growth rate does not explain Futures EQ growth rate	0.6616	0.5260	1.3232	0.5160	
15	OTC_eq & Futures_fx	Futures FX growth rate does not explain OTC EQ growth rate	0.1202	0.8873	0.2404	0.8867	No causality between OTC EQ growth rate and Futures FX growth rate
		OTC EQ growth rate does not explain Futures FX growth rate	1.4692	0.2518	2.9384	0.2301	
16	OTC_eq & Futures_ir	Futures IR growth rate does not explain OTC EQ growth rate	2.3155	0.1223*	4.6309	0.0987*	Futures IR leads OTC EQ
		OTC EQ growth rate does not explain Futures IR growth rate	0.0500	0.9513	0.1000	0.9512	

Table 3.8 reported wald tests on coefficients of pair-wise OTC growth rate and Futures growth rate causality models. The test models and hypotheses are from equation 3.1 to equation 3.4 in the text. OTC_rate is the semi-annual growth rate of total notional amounts outstanding in global OTC derivatives market in billions of US dollars. Futures_rate is the semi-annual growth rate of total notional amounts outstanding in exchange traded market in billions of US dollars. OTC_fx is the semi-annual growth rate of notional amounts outstanding in global OTC foreign exchange derivatives market in billions of US dollars. Futures_fx is the semi-annual growth rate of notional amounts outstanding in exchange traded foreign exchange derivatives market in billions of US dollars. OTC_ir is the semi-annual growth rate of notional amounts outstanding in global OTC interest rate derivatives market in billions of US dollars. Futures_ir is the semi-annual growth rate of notional amounts outstanding in exchange traded interest rate derivatives market in billions of US dollars. OTC_eq is the semi-annual growth rate of notional amounts outstanding in global OTC equity-linked derivatives market in billions of US dollars. Futures_eq is the semi-annual growth rate of notional amounts outstanding in exchange traded equity-linked derivatives market in billions of US dollars. A total of 29 semiannual growth rates from June 1998 to December 2012 are used

* significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table 3.9: Bootstrapped Wald Statistics for the Pair-Wise Causality Regressions.

Test	Pair	Null Hypothesis	Initial Model	95%	90%	75%	50%	25%	10%
			OLS	Quantiles of Bootstrap Samples F(29, 2)					
1	OTC & Futures	OTC does not explain Futures	0.1187	3.7695	2.8143	1.5961	0.7802	0.3179	0.1168
		Futures does not explain OTC	**3.0405**	3.6627	2.7552	1.6071	0.7691	0.3140	0.1129
2	OTC & Futures_ir	OTC does not explain Futures_ir	0.2054	4.9139	3.6950	2.2283	1.1208	0.4893	0.1839
		Futures_ir does not explain OTC	**2.7934**	3.6503	2.7603	1.5873	0.7765	0.3255	0.1200
3	OTC & Futures_fx	OTC does not explain Futures_fx	0.7797	3.7334	2.7454	1.5681	0.7589	0.3030	0.1138
		Futures_fx does not explain OTC	0.1860	3.6356	2.7454	1.6022	0.7786	0.3202	0.1134
4	OTC & Futures_eq	OTC does not explain Futures_eq	0.7754	3.7351	2.7634	1.5994	0.7653	0.3119	0.1083
		Futures_eq does not explain OTC	0.6483	3.8085	2.7844	1.6179	0.8100	0.3329	0.1195
5	OTC_fx & Futures	OTC_fx does not explain Futures	0.0661	3.6901	2.7311	1.5879	0.7685	0.3093	0.1186
		Futures does not explain OTC_fx	**2.4283**	3.8493	2.8417	1.6395	0.8065	0.3225	0.1207
6	OTC_fx & Futures_ir	OTC_fx does not explain Futures_ir	0.2263	4.8919	3.6610	2.2054	1.0986	0.4713	0.1635
		Futures_ir does not explain OTC_fx	**2.3453**	3.8489	2.7968	1.6017	0.7888	0.3187	0.1200
7	OTC_fx & Futures_fx	OTC_fx does not explain Futures_fx	**2.3865**	3.5971	2.7046	1.5752	0.7726	0.3099	0.1146
		Futures_fx does not explain OTC_fx	0.0802	3.6769	2.7434	1.5850	0.7795	0.3290	0.1206
8	OTC_fx & Futures_eq	OTC_fx does not explain Futures_eq	0.6122	3.4842	2.5864	1.5274	0.7392	0.3013	0.1075
		Futures_eq does not explain OTC_fx	1.6557	3.8625	2.8291	1.5612	0.7406	0.2962	0.1087
9	OTC_ir & Futures	OTC_ir does not explain Futures	0.3545	3.7254	2.7370	1.5718	0.7922	0.3276	0.1212
		Futures does not explain OTC_ir	**4.0251**	3.7140	2.7806	1.5864	0.7799	0.3141	0.1090
10	OTC_ir & Futures_ir	OTC_ir does not explain Futures_ir	0.3846	4.8264	3.6463	2.1703	1.0813	0.4563	0.1688
		Futures_ir does not explain OTC_ir	**3.5961**	3.6699	2.7526	1.6022	0.7727	0.3136	0.1185

11	OTC_ir & Futures_fx	OTC_ir does not explain Futures_fx	0.4587	3.7561	2.7758	1.6059	0.7695	0.3105	0.1134
		Futures_fx does not explain OTC_ir	0.4186	3.5200	2.6620	1.5465	0.7548	0.3102	0.1200
12	OTC_ir & Futures_eq	OTC_ir does not explain Futures_eq	0.6616	3.6644	2.7038	1.5569	0.7570	0.3093	0.1157
		Futures_eq does not explain OTC_ir	0.5506	3.8443	2.8553	1.6584	0.8109	0.3388	0.1189
13	OTC_eq & Futures	OTC_eq does not explain Futures	0.0316	3.6374	2.7025	1.5594	0.7652	0.3234	0.1159
		Futures does not explain OTC_eq	**2.3781**	3.5957	2.6849	1.5720	0.7698	0.3189	0.1169
14	OTC_eq & Futures_ir	OTC_eq does not explain Futures_ir	0.0500	4.8578	3.7004	2.2113	1.1160	0.4713	0.1758
		Futures_ir does not explain OTC_eq	**2.3155**	3.6306	2.6630	1.5509	0.7395	0.3031	0.1130
15	OTC_eq & Futures_fx	OTC_eq does not explain Futures_fx	1.4692	3.7216	2.7975	1.5897	0.7733	0.3158	0.1186
		Futures_fx does not explain OTC_eq	0.1202	3.5451	2.6833	1.5637	0.7572	0.3021	0.1079
16	OTC_eq & Futures_eq	OTC_eq does not explain Futures_eq	0.8516	3.6725	2.7537	1.5834	0.7696	0.3110	0.1136
		Futures_eq does not explain OTC_eq	0.2718	3.6647	2.7032	1.5754	0.7665	0.3107	0.1123

Quantiles of Wald test statistics based on bootstrapped samples are presented. Table 3.9 reports the Wald tests of the OLS regressions.

Table 3.10: Amounts outstanding of OTC foreign exchange and interest rate derivatives with non-financial customers

In billions of US dollars (* Includes FX swaps for FX derivatives)

	Foreign Exchange					Interest Rate			
	1998	2001	2004	2007	2010	1998	2001	2004	2007
Forwards*	2,673	2,524	3,350	6,914	6,691	564	843	1,045	1,227
Swaps	688	1,215	1,747	2,466	2,372	4,113	5,059	17,685	41,331
Option Sold	892	340	993	1,506	1,331	862	1,052	2,918	4,658
Options Bought	720	378	990	1,526	1,288	628	576	2,213	3,431
Total: Non-financial Firms	4,973	4,457	7,080	12,412	11,682	6,167	7,530	23,861	50,647
Total-All Types, All Firms	22,055	20,435	31,500	57,597	62,933	48,124	75,813	177,458	388,627
Non-financial Percent of Total	22.5%	21.8%	22.5%	21.5%	18.6%	12.8%	9.9%	13.4%	13%

Note: The 2010 triennial survey only supplies the instruments breakdown for foreign exchange derivatives transactions. It does not report the instrument breakdown for interest rate derivatives. So we only include the information of interest rate derivatives up to 2007.

Table 3.11: Gross market values of OTC foreign exchange and interest rate derivatives with non-financial customers

In billions of US dollars (* Includes FX swaps for FX derivatives)

	Foreign Exchange					Interest Rate			
	1998	2001	2004	2007	2010	1998	2001	2004	2007
Forwards*	102	104	103	157	290.7	4.8	3.1	20	12
Swaps	88	120	162	183	266.5	186.6	172	603	760.4
Option Sold	20.5	12.4	26	31	41	7.2	18.6	44	38.6
Options Bought	18	14.6	27	27.9	58.8	13.3	13.8	39.9	34.8

Table 3.12: Geographical distribution of reported OTC derivatives market activity with non-financial customers
Daily average net turnover in April, in millions of US dollars (net of local inter-dealer double-counting)

	The Americas			Europe			Asia/ Pacific		
	2004	2007	2010	2004	2007	2010	2004	2007	2010
Foreign exchange derivatives total*	**34,465**	**89,680**	**60,999**	**98,783**	**245,258**	**186,163**	**35,347**	**73,733**	**68,549**
Outright forwards	13,050	33,454	18,765	28,524	49,384	57,357	14,028	24,152	32,208
FX swaps	15,610	37,952	31,733	57,375	161,094	111,314	15,662	36,938	27,392
Currency swaps	421	2,470	1,586	2,094	2,860	1,410	492	1,083	560
Options	5,383	15,804	8,915	10,787	31,911	16,082	5,168	11,559	8,389
Single currency interest rate derivatives total**	**24,245**	**48,299**		**50,783**	**80,079**		**3,873**	**7,681**	
Forward rate agreements	1,014	522		6,907	25,732		224	426	
Swaps	16,946	35,502		35,311	44,859		2,635	4,666	
Options	6,284	12,275		8,567	9,494		1,010	2,588	

* Outright forwards, FX swaps, currency swaps and options with non-financial customers.
**Forward rate agreements, swaps and options with non-financial customers.
Regional aggregates are adjusted for local inter-dealer double-counting, ie trades between reporting dealers located in the same countries were halved. Regional aggregates are not adjusted for intraregional double-counting, ie trades between reporting dealers located in different countries of the same region were not halved.

Table 4.1: descriptive statistics (*Reject Jarque-Bera normality test at the 5% level. The DF_GLS unit root tests show that all the series are stationary.)

		Return-SP500	Return-Russell 2000	Small cap premium	VIX	VIX^2
Mean	Daily	0.0004	0.0005	0.00008	0.20	0.047
	Weekly	0.0020	0.0021	0.00016	0.20	0.048
	30 day	0.0083	0.0092	0.00083	0.20	0.047
Standard deviation	Daily	0.0117	0.0137	0.0068	0.082	0.05
	Weekly	0.023	0.029	0.015	0.08	0.05
	30 day	0.043	0.056	0.033	0.078	0.043
JB test	Daily	18574*	8886*	3868*	16496*	304856*
	Weekly	1529*	1050*	485*	3519*	64615*
	30 day	32.7*	26.8*	250*	310*	3499*
Augmented DF unit root test	Daily	-57.89	-77.82	-77.10	-4.77	-5.54
	Weekly	-38.21	-35.58	-35.86	-4.86	-6.31
	30 day	-15.6	-14.78	-18.06	-4.87	-5.52

Table 4.2: Estimation results for the small cap size premium with squared current VIX in the conditional variance equation for the sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day return
Conditional mean equation parameters			
c	0.0001(0.63)	0.0009(1.20)	-0.0023(-0.34)
a1	-0.02(-1.28)	-0.06*(-1.92)	-0.087(-1.37)
a2	0.005(0.35)	0.03(0.86)	0.064(0.88)
a3	-0.002(-0.17)	0.05*(1.80)	-0.007(-0.11)
a4	0.01(0.60)	0.01(0.35)	-0.073(-1.08)
a5	-0.002(-0.12)	-0.04(-1.37)	-0.05(-0.64)
a6	-0.02(-1.51)	-0.05(-1.51)	-0.10(-1.53)
a7	-0.02(-1.35)	-0.003(-0.104)	0.005(0.07)
a8	0.003(0.22)	-0.003(-0.09)	0.09(1.39)
λ	1.29(0.39)	-3.38(-0.92)	0.13(0.50)
Conditional variance equation parameters			
ω(*10,000)	0.006***(4.10)	0.138**(2.54)	0.131(0.53)
α	0.071***(9.64)	0.113***(3.58)	0.106**(2.45)
β	0.878***(73.34)	0.692***(9.25)	0.868***(17.17)
g (*10,000)	0.36***(6.65)	6.16***(3.42)	2.97(0.59)
Log likelihood	21016	3506	569
Durbin-Watson stat	2.00	1.93	2.01

Table 4.3: Estimation results for the small cap size premium with squared VIX modeled by ARMA (5, 3) process in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day return
Conditional mean equation parameters			
c	0.0000(0.07)	0.0006(0.77)	-0.003(-0.46)
a1	-0.02(-1.56)	-0.06*(-1.85)	-0.09(-1.30)
a2	0.004(0.27)	0.03(1.10)	0.05(0.73)
a3	-0.003(-0.23)	0.04(1.37)	-0.01(-0.22)
a4	0.009(0.67)	0.01(0.32)	-0.08(-1.18)
a5	-0.0001(-0.01)	-0.06*(-1.88)	-0.06(-0.85)
a6	-0.02(-1.58)	-0.05*(-1.67)	-0.11*(-1.70)
a7	-0.02(-1.29)	0.02(0.64)	0.003(0.04)
a8	0.005(0.37)	0.006(0.20)	0.09(1.42)
λ	3.45(1.09)	-0.90(-0.25)	0.167(0.67)
Conditional variance equation parameters			
ω(*10,000)	-0.051(-0.51)	0.867(0.43)	-36.70(-1.10)
α	0.069***(12.95)	0.102***(5.50)	0.119**(2.32)
β	0.919***(142.36)	0.857***(36.17)	0.863***(14.34)
g (*10,000)	1.40(0.56)	-19.30(-0.39)	915.22(1.10)
Log likelihood	20987	3386	564
Durbin-Watson stat	1.99	1.94	2.01

Table 4.4: Estimation results for the small cap size premium without VIX in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.00001(0.088)	0.0003(0.44)	0.001(0.27)
a1	-0.02(-1.55)	-0.05(-1.63)	-0.09(-1.32)
a2	0.004(0.28)	0.03(1.07)	0.06(0.89)
a3	-0.003(-0.24)	0.05(1.53)	-0.001(-0.01)
a4	0.009(0.66)	0.02(0.54)	-0.07(-1.05)
a5	-0.000007(-0.0005)	-0.05(-1.55)	-0.05(-0.65)
a6	-0.02(-1.56)	-0.04(-1.40)	-0.1(-1.54)
a7	-0.02(-1.29)	0.01(0.40)	0.002(0.03)
a8	0.005(0.38)	0.008(0.28)	0.097(1.46)
λ	3.37(1.07)	-0.42(-0.12)	0.28(0.08)
Conditional variance equation parameters			
ω(*10,000)	0.0056***(5.37)	0.0928***(3.79)	0.235(0.93)
α	0.069***(12.99)	0.101***(5.48)	0.122***(2.63)
β(*10,000)	0.918***(142.4)	0.857***(36.08)	0.857***(15.28)
Log likelihood	20987	3495	568.5
Durbin-Watson stat	1.996	1.95	2.01

Table 4.5: Estimation results for the excess S&P 500 index return with squared current VIX in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day return
Conditional mean equation parameters			
c	0.0016***(11.71)	0.0053***(6.60)	0.01***(2.76)
a1	-0.05***(-3.52)	-0.13***(-4.51)	-0.03(-0.45)
a2	-0.05***(-3.91)	-0.00004(-0.001)	0.04(0.57)
a3	-0.04***(-3.39)	-0.02(-0.85)	0.04(0.7)
a4	-0.03**(-2.34)	-0.05*(-1.76)	-0.06(-1.06)
a5	-0.05***(-4.13)	-0.07***(-2.65)	0.04(0.63)
a6	-0.04***(-3.04)	0.02(0.79)	-0.07(-1.35)
a7	-0.03**(-2.57)	-0.02(-0.88)	0.07(1.24)
a8	-0.02*(-1.73)	-0.02(-0.71)	-0.02(-0.3)
λ	-10.34***(-6.53)	-7.06***(-3.48)	-2.47(-0.999)
ω(*10,000)	-0.158***(-9.05)	-0.469**(-2.50)	-1.87(-1.03)
α	-0.024***(-3.80)	-0.009(-0.30)	-0.118(-1.57)
β	0.150**(2.02)	-0.054(-0.43)	-0.192(-1.14)
g	0.002***(11.48)	0.012***(7.72)	0.053***(5.11)
Log likelihood	18203.25	3093	524
Durbin-Watson stat	2.07	1.92	1.90

Table 4.6: Estimation results for the excess S&P 500 index return with squared VIX modeled by ARMA (5, 3) process in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day return
Conditional mean equation parameters			
c	0.0005***(3.29)	0.002**(2.06)	0.004(0.84)
a1	-0.02(-1.15)	-0.12***(-3.54)	-0.01(-0.15)
a2	-0.01(-0.94)	0.01(0.41)	0.02(0.36)
a3	-0.03**(-2.32)	-0.01(-0.42)	0.03(0.44)
a4	-0.02(-1.54)	-0.04(-1.33)	-0.006(-0.08)
a5	-0.05***(-3.61)	-0.05(-1.43)	0.03(0.45)
a6	-0.03**(-2.35)	0.04(1.18)	-0.06(-0.87)
a7	-0.01(-0.997)	-0.001(-0.02)	0.04(0.61)
a8	-0.01(-0.70)	-0.007(-0.26)	0.02(0.30)
λ	2.10(1.36)	2.72(1.35)	1.98(0.68)
ω(*10,000)	1.2***(260.25)	-0.087(-0.02)	-20.10(-0.29)
α	0.091***(17.41)	0.161***(9.25)	0.189***(3.19)
β	0.905***(169.95)	0.822***(40.97)	0.787***(13.36)
g	-0.0029***(-219.15)	0.0006(0.04)	0.051(0.30)
Log likelihood	18370	2921	494
Durbin-Watson stat	2.09	1.89	1.84

Table 4.7: Estimation results for the excess S&P 500 index return without VIX in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.0004***(2.77)	0.0017*(1.94)	0.005(1.002)
a1	-0.02(-1.50)	-0.11***(-3.5)	-0.02(-0.23)
a2	-0.02(-1.31)	0.02(0.57)	0.01(0.22)
a3	-0.03**(-2.38)	-0.02(-0.53)	0.01(0.16)
a4	-0.02(-1.50)	-0.03(-0.95)	-0.01(-0.18)
a5	-0.05***(-3.63)	-0.04(-1.31)	0.03(0.38)
a6	-0.03**(-2.35)	0.03(1.04)	-0.05(-0.76)
a7	-0.02(-1.20)	-0.0008(-0.03)	0.04(0.56)
a8	-0.02(-1.21)	-0.005(-0.16)	0.02(0.28)
λ	2.997*(1.90)	2.74(1.36)	1.74(0.59)
Conditional variance equation parameters			
ω (*10,000)	0.01***(7.88)	0.153***(3.57)	0.615(1.3)
α	0.075***(16.06)	0.166***(9.27)	0.187***(3.2)
β	0.917***(179.43)	0.814***(39.21)	0.79***(13.68)
Log likelihood	17959.41	3013	499
Durbin-Watson stat	2.08	1.90	1.83

Table 4.8: Estimation results for the excess Russell 2000 index return with squared current VIX in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.0005***(2.75)	0.0066***(6.16)	0.02***(3.27)
a1	0.08***(5.37)	-0.06**(-2.02)	-0.03(-0.47)
a2	-0.02(-1.44)	0.012(0.45)	-0.008(-0.12)
a3	0.02(1.51)	-0.006(-0.20)	-0.11*(-1.81)
a4	-0.01(-0.70)	-0.02(-0.82)	-0.11*(-1.79)
a5	-0.02(-1.39)	-0.02(-0.81)	-0.1(-1.63)
a6	-0.03**(-2.02)	0.004(0.13)	-0.06(-0.98)
a7	-0.01(-0.75)	-0.057**(-2.34)	-0.009(-0.15)
a8	0.004(0.27)	-0.003(-0.10)	0.01(0.18)
λ	2.28*(1.82)	-6.04***(-3.50)	-3.36(-1.44)
Conditional variance equation parameters			
ω(*10,000)	0.0026(1.15)	0.0014(0.004)	-0.332(-0.096)
α	0.110***(14.72)	0.046(1.59)	-0.04(-0.68)
β	0.869***(108.93)	-0.149(-1.26)	-0.074(-0.35)
g (*10,000)	0.806***(7.28)	180.03***(7.49)	724***(3.85)
Log likelihood	17710	2797	441
Durbin-Watson stat	2.21	1.93	1.898

Table 4.9: Estimation results for the excess Russell 2000 index return with squared VIX modeled by ARMA (5, 3) process in the conditional variance equation for the total sample period from 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.0004**(2.57)	0.002(1.54)	0.01(1.02)
a1	0.08***(5.48)	0.004(0.13)	0.07(0.94)
a2	-0.02(-1.30)	0.06*(1.72)	0.02(0.22)
a3	0.02(1.53)	0.003(0.09)	-0.07(-1.15)
a4	-0.01(-0.70)	-0.01(-0.41)	-0.05(-0.73)
a5	-0.02(-1.42)	-0.03(-0.90)	-0.06(-0.90)
a6	-0.03*(-1.85)	0.03(0.97)	-0.06(-0.95)
a7	-0.01(-0.71)	-0.04(-1.44)	0.03(0.40)
a8	0.003(0.23)	0.008(0.26)	0.01(0.13)
λ	2.61**(2.08)	2.24(1.46)	1.12(0.42)
Conditional variance equation parameters			
ω(*10,000)	-0.341**(-2.49)	-2.78(-0.47)	64.53(0.28)
α	0.105***(17.87)	0.183***(7.97)	0.212***(3.04)
β	0.890***(150.13)	0.800***(31.89)	0.709***(6.46)
g (*10,000)	8.76***(2.59)	74.58(0.515)	-1532.5(-0.27)
Log likelihood	17696	2684	416
Durbin-Watson stat	2.21	2.01	1.94

Table 4.10: Estimation results for the excess Russell 2000 index return without VIX in the conditional variance equation for the total sample period form 1990 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.0004**(2.54)	0.0013(1.37)	0.0078(1.02)
a1	0.08***(5.47)	0.02(0.52)	0.08(1.04)
a2	-0.02(-1.28)	0.07**(2.10)	0.02(0.35)
a3	0.02(1.55)	0.005(0.14)	-0.08(-1.22)
a4	-0.01(-0.69)	-0.009(-0.30)	-0.05(-0.79)
a5	-0.02(-1.41)	-0.02(-0.79)	-0.07(-1.05)
a6	-0.03*(-1.84)	0.02(0.87)	-0.06(-0.89)
a7	-0.01(-0.70)	-0.05(-1.53)	0.02(0.30)
a8	0.003(0.22)	0.02(0.54)	0.009(0.14)
λ	2.64**(2.10)	2.17(1.45)	1.18(0.44)
Conditional variance equation parameters			
ω(*10,000)	0.013***(8.69)	0.244***(3.48)	2.65(1.37)
α	0.104***(17.80)	0.187***(8.26)	0.207***(3.06)
β	0.890***(148.12)	0.795***(32.69)	0.714***(6.68)
Log likelihood	17695	2777	420
Durbin-Watson stat	2.21	2.02	1.96

Table 4.11. Unit Root Test Statistics for Series

Series: April 2004-July 2013	ADF	DF-GLS	PP
Futures	-2.902361**	-2.891745***	-2.826658*
Spot	-3.035169**	-2.725211***	-3.732812***
Change in spot	-8.733933***	-8.774688***	-9.385980***
Basis	-8.330195***	-6.954144***	-8.352570***
Risk premium	-7.877872***	-6.637666***	-7.155431***

Note: ADF, DF-GLS, and PP denote augmented Dickey-Fuller (1981), Dickey-Fuller (1979), and Phillips-Perron (1988), respectively. The values reported in the table represent the t-statistics for the ADF and DF test and the adjusted t-statistic for the PP test. The *** denotes significance at a 1% level. Critical values at 1% level are -3.432942, -2.565951 and -3.432932 for ADF, DF, and PP, respectively, from Mackinnon (1996). The** denotes significance at a 5% level. Critical value at 5% level is -2.862568 for ADF. The * denotes significance at a 10% level. Critical values at 10% level are -2.567362 and -2.567362 for ADF and PP, respectively.

Table 4.12. Results of Fama (1984) Model

Estimated period: April 2004-July 2013	α_1	β_1	F-Stat
Regression (4.11)	0.148349	-0.264397	2.131705
$S_{t+1} - S_t = \alpha_1 + \beta_1(F_t - S_t) + \varepsilon_{1,t+1}$	[0.574634]	[0.181089]	
	α_2	β_2	F-Stat
Regression (4.12)	-0.148349	1.264397*	48.75081*
$F_t - S_{t+1} = \alpha_2 + \beta_2(F_t - S_t) + \varepsilon_{2,t+1}$	[0.574634]	[0.181089]	

Note: Robust standard errors are reported inside parentheses. The * denotes significance at a 1% level.

Table 4.13. Wald Test Results of the Fama (1984) Model

Estimated period: April 2004-July 2013	$\alpha_1 = 0, \beta_1 = 1$	$\beta_1 = 1$	$\alpha_1 = 0$
Regression (4.11) $S_{t+1} - S_t = \alpha_1 + \beta_1(F_t - S_t) + \varepsilon_{1,t+1}$	27.18831* [0.0000]	48.75081* [0.0000]	0.066648 [0.7968]
	$\alpha_2 = 0, \beta_2 = 1$	$\beta_2 = 1$	$\alpha_2 = 0$
Regression (4.12) $F_t - S_{t+1} = \alpha_2 + \beta_2(F_t - S_t) + \varepsilon_{2,t+1}$	1.104387 [0.3352]	2.131705 [0.1473]	0.066648 [0.7968]

Note: F values reported. p-values reported in parentheses.

Table 4.14. VIX Futures Contracts as Predictors of Futures Spot VIX: Daily Data

Independent variable	Coefficient	t-Statistics
OLS estimates of $S_T^i = \alpha_0 + \alpha_1 F_{t,T}^i + \alpha_2 MAT_t^i + \varepsilon_t^i$		
Estimation period: April 2004-December 2012		
$F_{t,T}^i$	0.999243** [0.013601]	73.47
MAT	-0.019037* [0.011416]	-1.67
α_0	0.115214 [0.377704]	0.31
F-statistic	2714.689	
Prob(F-statistic)	0.0000	

Note: ** denotes significance at a 1% level. * denotes significance at 10%. Robust standard errors are reported in parentheses. S_T^i is the prevailing spot price for contract i that matures at time T; $F_{t,T}^i$ is the futures price of contract i at time; MAT is the number of days for contract i to mature as of time t, and ε_t^i is the error term.

Table 4.15: Estimation results for the future small cap premium with squared current VIX futures price in the conditional variance equation for the sample period from April 2004 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day
Conditional mean equation parameters			
c	0.0001(0.45)	0.006***(4.62)	0.029(0.44)
a1	-0.03(-1.56)	-0.13***(-3.53)	-0.02(-0.02)
a2	-0.03(-1.30)	-0.05(-0.97)	-0.09(-0.07)
a3	-0.001(-0.04)	-0.06(-1.54)	-0.14(-0.09)
a4	-0.04*(-1.74)	-0.05(-1.12)	-0.08(-0.07)
a5	-0.04*(-1.68)	0.005(0.13)	0.01(0.01)
a6	-0.06***(-2.72)	-0.08*(-1.75)	0.05(0.04)
a7	-0.02(-0.87)	-0.05(-1.16)	0.21(0.19)
a8	0.01(0.58)	0.02(0.51)	0.39(0.33)
λ	4.12(0.79)	-30.11***(-3.60)	-0.15(-0.24)
Conditional variance equation parameters			
ω(*10,000)	0.009**(2.54)	1.47***(5.37)	5.7(0.25)
α	0.079***(5.83)	-0.071***(-6.99)	-1.36(-0.45)
β	0.864***(35.93)	-0.784***(-12.46)	0.73***(3.39)
g (*10,000)	0.329***(3.21)	34.07***(4.92)	1311.87(1.14)
Log likelihood	8552.85	1411.81	111.86
Durbin-Watson stat	2.11	1.95	1.79

Table 4.16: Estimation results for the future excess S&P 500 index return with squared current VIX futures price in the conditional variance equation for the total sample period from April 2004 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	Weekly return	30 day return
Conditional mean equation parameters			
c	0.002***(9.46)	0.007***(6.65)	0.02***(4.85)
a1	-0.113***(-5.10)	-0.13***(-4.18)	0.03(0.38)
a2	-0.076***(-3.98)	-0.06(-1.33)	-0.03(-0.37)
a3	-0.035*(-1.84)	-0.09*(-1.94)	-0.03(-0.37)
a4	-0.057***(-2.91)	-0.06(-1.29)	0.02(0.23)
a5	-0.053***(-2.84)	-0.08*(-1.84)	-0.13*(-1.89)
a6	-0.053***(-2.83)	-0.02(-0.40)	-0.005(-0.06)
a7	-0.034*(-1.73)	-0.02(-0.57)	-0.015(-0.20)
a8	-0.026(-1.32)	0.01(0.17)	0.06(0.81)
λ	-11.75***(-5.45)	-10.96***(-2)	-8.61**(-2.40)
ω(*10,000)	-0.305***(-8.71)	-0.674**(-2.37)	-3.96*(-1.67)
α	-0.001(-0.09)	-0.068**(-2.21)	-0.16(-1.64)
β	-0.470***(-7.48)	-0.042(-0.29)	-0.11(-0.32)
g	0.005***(19.20)	0.013***(6.61)	0.05***(2.89)
Log likelihood	7498.62	1201.16	214.84
Durbin-Watson stat	1.99	1.86	1.76

Table 4.17: Estimation results for the future excess Russell 2000 index return with squared current VIX futures price in the conditional variance equation for the total sample period from April 2004 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	daily return	weekly return	30 day return
Conditional mean equation parameters			
c	0.003***(7.98)	0.013***(6.43)	0.04***(4.57)
a1	-0.08***(-3.85)	-0.14***(-3.22)	-0.12(-1.36)
a2	-0.06***(-3.17)	-0.06(-1.25)	-0.04(-0.49)
a3	-0.04**(-2.13)	-0.09**(-2.01)	-0.10(-1.31)
a4	-0.06***(-2.98)	-0.06(-1.36)	-0.13*(-1.89)
a5	-0.05***(-2.62)	-0.06(-1.30)	-0.16**(-2.48)
a6	-0.05***(-2.74)	-0.05(-0.98)	-0.14**(-1.97)
a7	-0.02(-1.17)	-0.07(-1.59)	0.02(0.29)
a8	-0.02(-1.19)	0.003(0.06)	0.096(1.34)
λ	-9.35***(-5.13)	-10.85***(-4.30)	-13.72***(-3.20)
Conditional variance equation parameters			
ω(*10,000)	-0.090(-0.98)	0.686(0.70)	3.82(0.90)
α	0.006(0.76)	-0.039(-1.06)	-0.15***(-3.63)
β	-0.537***(-5.94)	-0.397***(-3.13)	-0.26(-0.79)
g	0.008***(13.65)	0.03***(6.90)	0.05***(2.72)
Log likelihood	6693.74	1038.45	182.35
Durbin-Watson stat	2.01	1.80	1.82

Table 4.18: Estimation results of the small cap premium, S&P 500 index excess return, and Russell 2000 index excess return with lagged squared VIX futures prices in the conditional variance equation for the total sample period from April 2004 to July 2013. (***, **, * denote significant at 1%, 5%, and 10% level, respectively. t statistics in parentheses)

	Small cap premium	S&P 500 excess return	Russell 2000 excess return
Conditional mean equation parameters			
c	-0.003(-0.37)	0.017(1.10)	-0.009(-0.58)
a1	-0.09(-0.92)	-0.05(-0.25)	-0.08(-0.56)
a2	-0.06(-0.56)	0.03(0.25)	0.07(0.69)
a3	-0.11(-0.98)	0.18(1.27)	0.08(0.56)
a4	-0.17*(-1.68)	0.15(1.24)	-0.18(-1.46)
a5	-0.11(-1.14)	-0.07(-0.70)	0.05(0.51)
a6	-0.18*(-1.73)	-0.18*(-1.81)	-0.12(-0.89)
a7	0.15(1.49)	-0.07(-0.91)	0.03(0.29)
a8	0.07(0.69)	-0.15**(-2.18)	0.05(0.43)
λ	0.18(0.42)	-2.09(-0.36)	3.87(1.15)
Conditional variance equation parameters			
ω(*10,000)	7.58***(5.34)	10.10***(2.85)	18.54(1.64)
α	0.116*(1.73)	0.259*(1.78)	-0.042(-0.32)
β	-1.064***(-14.39)	0.556***(2.69)	-0.778***(-5.73)
g	0.004**(2.08)	-0.01***(-3.83)	0.106***(3.61)
Log likelihood	233.38	164.86	141.63
Durbin-Watson stat	2.06	1.899	1.75

Figure 2.1

This figure graphs mispricing of S&P futures contracts for the period 02/01/2004 to 07/31/2012

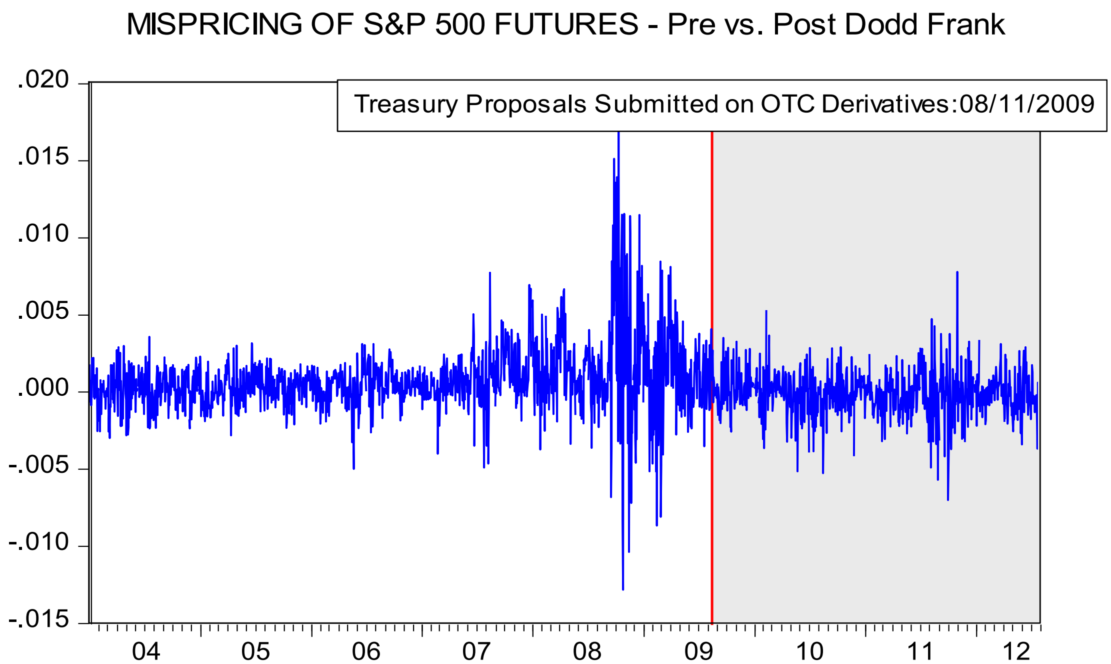
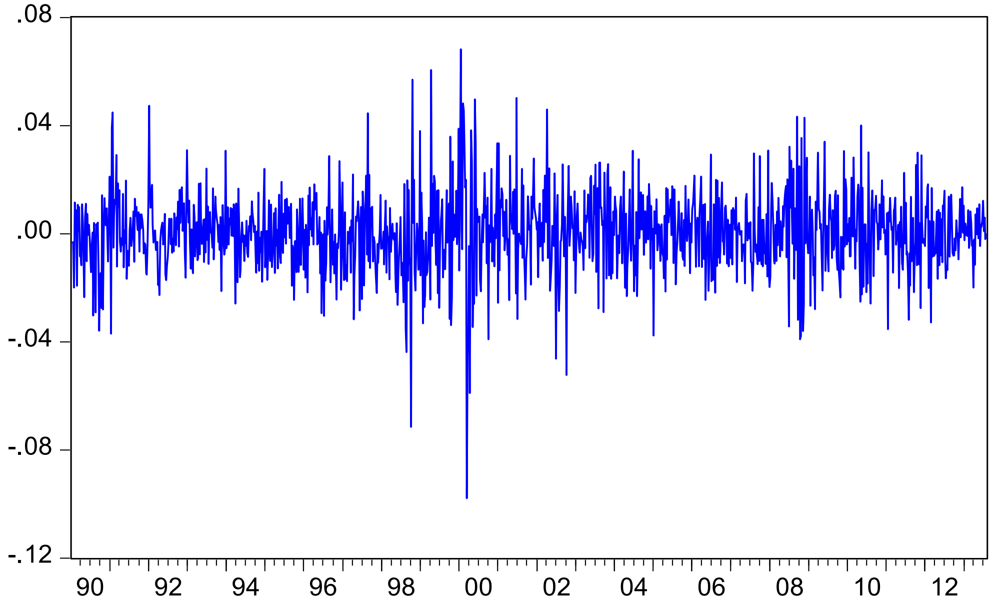


Figure 4.1
Weekly data

small cap premium: 1990-Jul. 2013



VIX: 1990 - July 2013

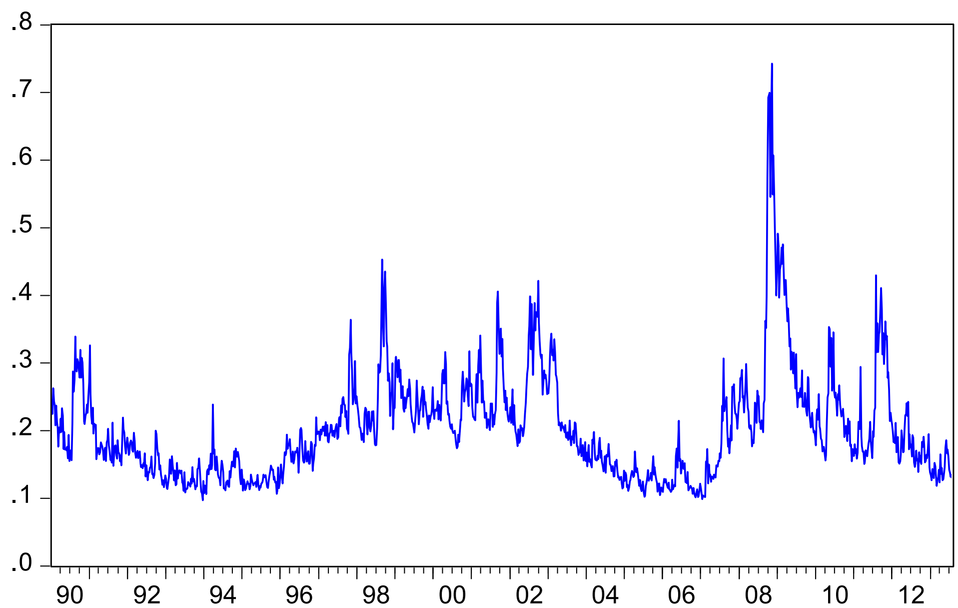
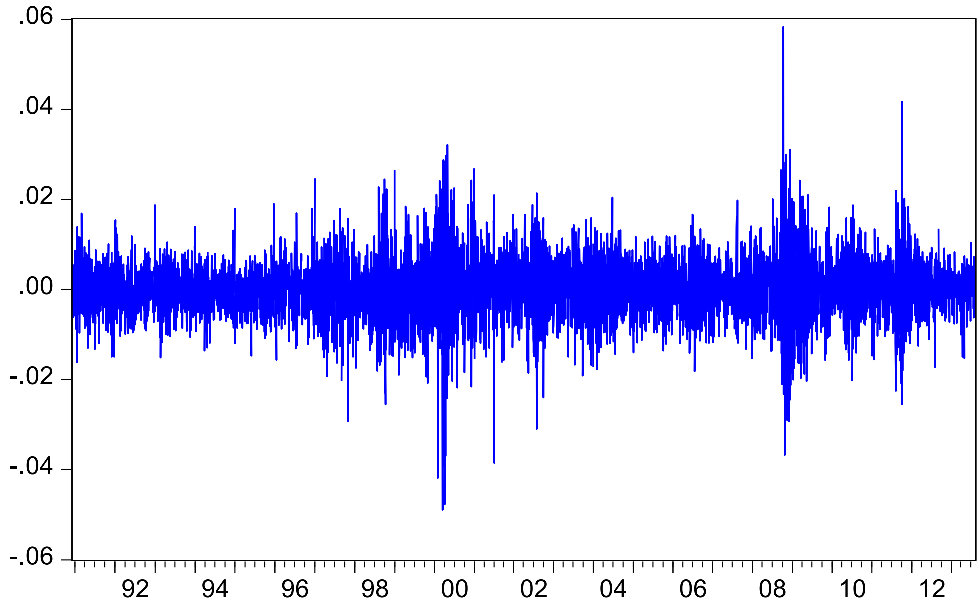


Figure 4.2
Daily data

small cap premium: 1990-July 2013



VIX: 1990-July 2013