Volatility and Skewness Spillover between Stock Index and Stock Index Futures Markets during a Crash Period: New Evidence from China

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Abstract

This paper examines volatility and skewness spillover between the Chinese stock index and index futures markets during a market crash in 2015. The volatility spillover from futures to spot is significant and stronger than the other way around. Moreover, the transmission of downside risk is bilateral with the futures market taking the lead. It is revealed that measures announced during the market crash to curb the speculative futures trading enhance the spillover of both volatility and skewness from futures to spot markets. This finding sheds light on validity of such measures to restore market efficiency during a stock market crash.

JEL classifications: G13; G14; G15

Keywords: Volatility Spillover, Skewness Spillover, GARCH Model, Skewed Student's *t* Distribution, Chinese Stock Market Crash, Chinese Stock Index Futures

1. Introduction

In recent years, Chinese stock market has become increasingly more important due to the rising importance of Chinese economy which is now the second largest in the world. Moreover, the role of Chinese stock market in the integration of global financial system has been well recognised (Ng and Wu, 2007). Hence it is important and of great interests to understand Chinese stock market.

In the few years leading up to 2015, China's stock market had been viewed in an increasingly favourable light, less as a "casino," and more as an important new area of financial growth. The stock market, however, burst on June 12, 2015, and sunk again on July 27 and August 24. A third of the value of A-shares on the Shanghai Stock Exchange was lost within one month of the event. Major aftershocks occurred around 27 July and 24 August's "Black Monday". By 8–9 July 2015, the Shanghai stock market had fallen 30 percent over three weeks as 1,400 companies, or more than half listed, filed for a trading halt in an attempt to prevent further losses. The 2015 stock market crash offers a natural experiment for studying how the stock index and index futures market interact with each other and the validity of the measures taken by the government during the crash period. In particular, it provides a unique opportunity to explore the pattern of volatility and skewness spillover under such extreme trading circumstance.

The stock index futures market in China has a short history and did not exist before April 16, 2010. Whether the Chinese stock index futures market functions as expected has been a hot issue for academics, practitioners and regulators[1]. Yang et al. (2012) firstly study the volatility spillover

[1] There are a series of strict trading regulations imposed on the Chinese stock index futures contracts, which result in a small number of market participants, limited types of trading strategies, and limited types of investment funds that involve index futures contracts. Moreover, the Chinese stock and stock index futures markets are different in terms of security supply, trading mechanism and investor structure, leading to some unique features compared to developed countries. More details can found in Yang et al. (2012), Chen et al. (2013), Hou and Li (2013, 2015).

between the Chinese stock index spot and futures markets using high-frequency data during the first three months after futures trading embarked. It is found that the futures market was overshadowed by its counterpart in transmitting volatility risk. As the futures market developed and more data became available, Guo et al. (2013), Hou and Li (2015) and Xu and Wan (2015) find that the price discovery function of the futures prices has improved, as indicated by the enhanced volatility spillover from futures to spot markets. However, all these studies focus on volatility transmission between the Chinese stock index spot and futures markets during normal trading periods. Thus, this study aims fill the gap by investigating both the volatility and skewness spillover between the Chinese stock index spot and futures markets during a stock market crash period started in May 2015.

During the stock market crash in 2015, the index futures trading was heavily restricted by two rounds of announcements by the China Financial Futures Exchange (CFFEX), on which the CSI 300 index futures contracts are traded[2]. After measures in those announcements to restrict the scale of non-hedging open positions were implemented, the daily trading volume of index futures contracts nearly plummeted to zero. This situation is extremely rare for the studies on volatility transmission between stock index spot and futures markets given that trading of the latter comes to a full stop.

In this paper, we examine the volatility and skewness spillover between the CSI 300 index spot and futures markets during the Chinese stock market crash from May 4, 2015 to September 30, 2015. We focus on exploring volatility and skewness spillovers between the two markets across different stages associated with policy changes during the crash. However, investigation of the

[2] In brief, measures in the announcements related to the initial margin for non-hedging trades, single day's total opening position and the clearing fees for intraday trades. For more details, we refer to in Han and Liang (2017, pp.414-415).

exact reasons behind the behaviour of the volatility and skewness spillovers will be left for a future study.

High-frequency data with 1-minute intervals are used for the study. Volatility spillover are analysed by employing a bivariate dynamic–conditional-correlation (DCC) generalised autoregressive conditional heteroscedasticity (GARCH) model. The DCC model is widely applied in the research on volatility spillover (Allen et al., 2017).The DCC GARCH model is used because it not only guarantees the positive definiteness of variance-covariance matrix of returns distribution but also yields better estimation to the dynamic conditional correlations (Engle, 2002; Tse and Tsui, 2002). Furthermore, the skewness spillover is estimated by extending an unconditional bivariate skewed Student's *t* distribution developed by Bauwens and Laurents (2005) to incorporate a conditional autoregressive process for marginal skewness parameters of spot and futures returns. The time-varying feature of skewness parameters follows a univariate model framework, proposed by Hansen (1994), Jondeau and Rockinger (2003) and Bali et al. (2008), which defines the skewness parameter to be conditioned on past shocks and own lagged values. The utilization of the DCC GARCH model under the conditional skewed Student's *t* distribution allows simultaneous estimation of volatility spillover and skewness interdependence.

This paper contributes to the literature in three folds. First, this study investigates the volatility spillover between the Chinese stock index spot and futures markets during the 2015 market crash period. More specifically, the spillover effects are explored by a comparison of results between multiple periods without and with discretionary restrictions imposed on index futures trading. During the periods with the restrictions, trading volume of the index futures contracts dramatically declined toward zero and trading activities were nearly frozen. Information contents of index futures market regarding the transmission of volatility risk under such situation have been rarely investigated by the prior studies. The paper provides some new evidence on this issue which sheds light on informational efficiency of index futures prices under extremely harsh trading circumstance in the turmoil periods.

Second, this paper models skewness spillover that reflects the spillover of downside risk in a bivariate conditional skewed Student's *t* distribution. Unlike the SNP-VSK approach employed in Del Brio et al. (2017), the skewed Student's *t* framework is not based upon the Gaussian density function but straightforwardly extends the symmetric Student's *t* density function by applying a Fernandez and Steel (1998)'s skewed filter. Such extension assures flexibility in modelling time-varying dynamics of conditional skewness for the multivariate case and maintains the number of parameters that control the distributional features in a relatively low level. In addition, compared to the SNP-VSK approach that approximates dynamics of the conditional third moment, the marginal skewness parameters defined in the skewed Student's *t* framework provide a direct link to sample skewness and thus provides more accurate estimation[3]. By using the latter framework, new evidence is revealed regarding the spillover of asymmetry between the Chinese stock index spot and futures markets during the stock market crash. Analogous to volatility spillover, a comparison of skewness spillover in different phases (with or without restrictive trading measures being applied) is conducted. The result provides more insight to the varying patterns of information channels from futures to spot prices in terms of the interaction of higher order moments during the market crash period.

Third, this study provides further evidence for the debate on whether government direct intervention on index futures during a market crash period affects restoration of market efficiency,

[3] According to Bauwens and Laurents (2005), the size of sample skewness of the data series is associated with the square of the marginal skewness parameter. The direction of skewness is indicated by the sign of natural logarithm of the skewness parameter.

in light of dynamic linkages of the second and third moments of returns distribution in the Chinese stock and stock index futures markets. Supportive evidence for the government intervention is obtained. Compared to the phase where there are no constraints on futures trading, both volatility and skewness spillover from futures to spot markets are stronger after those measures are imposed. Even in the period where futures trading activities are extremely suppressed, the spillover effect from futures market remains at a higher level. The quality of information contents of futures prices is enhanced, instead of being exacerbated, by the regulatory intervention. The finding enriches Han and Liang (2017) by focusing on the intertemporal dependence of moments between spot and futures markets.

The remainder of this paper is organised as follows. Section 2 presents the literature review and Section 3 discusses the methodology in details. Section 4 depicts the data and some sample statistics. Empirical results are summarised in Section 5. Conclusions are presented in Section 6.

2. Literature review

Volatility spillover between financial markets has attracted a lot of attention in the last two decades. According to Weber and Strohsal (2012) and Jung and Maderitsch (2014), there are two perspectives in considering volatility spillover. The first one regards volatility spillover as the result of a latent inter-related information flow. The second one perceives volatility spillover as the contagion of uncertainty in asset prices between markets. The existence of volatility spillover has been well documented in the literature, see e.g. Hamao et al. (1990), Lin et al. (1994), Baur and Jung (2006), Savva et al. (2009), Miralles-Marceloa et al. (2010), and Jawadi et al. (2015), among others.

Many studies have examined the volatility spillover between closely correlated financial markets such as the stock index spot and futures markets. Among such studies, a major focus has been on the volatility transmission between stock index spot and futures prices in the developed economies. It has been concluded in the literature that information flows from index futures market to its underlying stock market, implying a leading role of the former in the price discovery process (Chan et al., 1991; Koutmos and Tucker, 1996; Iihara et al., 1996; Tse, 1999; Sim and Zurbreugg, 1999; Bhar, 2001, Kavussanos et al., 2008, and Bohl et al., 2011). The empirical evidence is consistent with the transaction costs theory which states that futures prices always lead spot ones in the information transmission process as the former attracts more informed traders in the market venue due to its lower transaction costs and less market microstructure biases (Silber, 1985; Flemming et al., 1996).

However, the number of studies on volatility spillover between stock index spot and futures markets in the emerging countries is very limited due to the nonexistence or short existence of futures markets in those countries. For example, Zhong et al. (2004) focus on the Mexican markets. They found the local futures market is led by the underlying stock market in the volatility transmission.

There are a few studies on the volatility spillover between Chinese stock index spot and futures markets. These include Yang et al. (2012), Guo et al. (2013), Hou and Li (2015) and Xu and Wan (2015). However, all these studies focus on volatility transmission between the Chinese stock index spot and futures markets during stable periods. There is no study investigating both the volatility spillover and skewness spillover between the Chinese stock index spot and futures markets during a stock market crash in 2015. It is of academic interest to investigate fill this gap in the literature[4].

[4] Before the market crash took place, the Chinese stock market was increasing since the beginning of 2015. During the period between June 12 and August 6, 2015, the maximal drop of the Shanghai stock exchange was close to 34.9% while that of the Shenzhen stock exchange was almost 40%. The two markets were destabilised until August 24, 2015.

There have been quite a few studies exploring volatility spillover between index futures markets during financial crisis periods. Most of them are devoted to international volatility linkages of equity markets during the turmoil periods, across developed and emerging economies. The most recent studies include Jung and Maderitsch (2014), Kim et al. (2015), Allen et al. (2017), Jin and An (2016) and Karunanayake et al. (2010), among others. However, the question whether potential patterns of volatility spillover between index futures markets during a market crash period resemble those in the normal phases remains largely unsolved.

Rubinstein (2006) suggests that skewness is important for investors' decisions since they seek assets that exhibit positive skewness and low kurtosis. Skewness is relevant to asset pricing process as investors require premium for additional risk they bear regarding asymmetry of returns distribution, which has been theoretically rationalised and empirically tested by Harvey and Siddique (2000). That is, information transmission in terms of skewness spillover pertains to how markets are linked in terms of the level of asymmetry of returns distribution that directly pertains to downside (upside) risk. Therefore, informational efficiency in the perspective of capability to absorb cross-border information with respect to downside (upside) risk between financial markets is unveiled by skewness spillover (Do et al., 2016; Del Brio et al., 2017). In particular, skewness spillover in a financial crisis is particularly important since the dependence of extreme negative returns across markets is much more often during a crisis period than a normal trading period (Del Brio et al., 2017).

A time-varying feature of skewness that is conditioned on the past information is modelled for univariate financial time series (Hansen, 1994; Harvey and Siddique, 1999; Jondeau and Rockinger, 2003; Brooks et al., 2005; Bali et al., 2008). However, there have been a few studies

On that date they suffered from another round of hits where the Shanghai and Shenzhen stock markets dropped by 8.49% and 7.83%, respectively. For more details about the market crash, see Han and Liang (2017).

dedicated in skewness spillover between financial markets. Early studies such as Korkie et al. (2006) and Hashmi and Tay (2007) supports skewness spillover within and across equity markets. Hong et al. (2009) explain skewness interdependence using a framework of Granger Causality in risk of extreme downside returns.

In recent years, a lot of attention has been paid to the international skewness linkages of equity returns. Do et al. (2015) use intraday data to construct realised skewness series and explore spillover of these series between equity and foreign exchange (FX) markets at a regional level. By employing a similar method, Do et al. (2016) find significant evidence of realised skewness spillover between equity and FX markets in emerging economies. Meanwhile, Del Brio et al. (2017) examine skewness spillover of the MSCI index prices between regions of North America, Europe, Latin America and Asia Pacific. A model framework of SNP-VSK was applied to estimating spillover effects of weekly data. They find during periods of the sub-prime debt crisis in U.S. and sovereign debt crisis in Europe, North America and Latin America are the main sources of skewness transmission while the rest two are receivers. During the other tranquil periods, North America is the sole information transmitter and the other three are information receivers. To our best knowledge, there is no study in the literature investigating skewness spillover between stock and stock index futures markets during either normal or turmoil periods.

The effects of government's intervention on index futures market during a market crash have attracted a lot of attention. Considering the October 1987 stock market crash in U.S., Kleiden and Whaley (1992) argue that restrictive regulations imposed on derivatives trading during the crash contribute to the delinkage of spot, futures and options markets of the S&P 500 index due to outdated market order processing. Thus the regulatory intervention is not supported. However, contradictive evidence is found by Harris (1987) that the futures market still leads the spot in the short run under the restrictive regulations.

There are also many studies on the 1997 Asian Financial Crisis (AFC). On the one hand, the government's direct intervention on index futures trading as well as the underlying stock market is supported since it is found helpful for stabilising the markets and restoring the arbitrage efficiency. Significant evidence is found mainly for the Hong Kong market (Su et al., 2002; Cheng et al., 2000). On the other hand, Draper and Fung (2003) reveal adverse evidence for the Hong Kong market, suggesting that government's intervention impairs the efficiency of index futures market due to exasperated under-pricing in that market. In the meantime, Hassan et al. (2007) find similar evidence on the Malaysian market.

As to the Chinese stock market crash taking place in the summer of 2015, Han and Liang (2017) find that the announcements made by the CFFEX which almost terminated the trading of index futures contracts during the crash, in fact cause the quality of information in the underlying spot market to deteriorate.

In sum, the debate on the impacts of government intervention on index futures trading during a crisis period is still on-going. Moreover, there have been few studies that unveil the impacts in the perspective of moments' linkages of returns distribution.

3. Methodology

3.1. DCC GARCH Model

Let Y_t be an $n \times 1$ vector of $I(1)$ series and assume that there exist n - 1 cointegrating vectors; that is, Y_t contains a single common stochastic trend (Stock and Watson, 1988)[5]. Then Y_t can be specified in the following vector error correction model (VECM) (Engle and Granger, 1987):

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k} A_i \Delta Y_{t-i} + \varepsilon_t. \quad (1)$$

where $\Pi = \alpha\beta^T$.

It is well acknowledged that the covariance matrix of innovations in Eq. (1) should be conditioned on past information (Bollerslev, 1990; Engle and Kroner, 1995; Engle, 2002). This is in accordance with the phenomenon of volatility clustering observed for unit-root series Y_t where large returns follow large ones while small returns are in tandem with small ones across time. To explore the time-varying nature of the information generation process, this study employs the widely-applied bivariate DCC GARCH model proposed by Engle (2002) to specify the individual heteroscedastic processes as well as the conditional correlation matrix of innovations[6].

Specifically, in the bivariate DCC GARCH model, the error structure of Eq. (1) is specified as

$$\varepsilon_t | \Xi_{t-1} \sim F(0, H_t). \quad (2)$$

where $\varepsilon_t = [\varepsilon_{1,t}, \varepsilon_{2,t}]^T$ is a 2×1 vector. Ξ_{t-1} represents the information set up to t-1. F denotes a bivariate distribution. H_t is a 2×2 positive-definite conditional covariance matrix and it can be decomposed as

$$H_t = D_t R_t D_t, \quad (3)$$

[5] Note that n equals to 2 in this study.
[6] The constancy of correlation between the CSI 300 index spot and futures returns is rejected by Bera and Kim (2002)'s test. Test result is available upon request.

with

$$D_t = diag\{h_{11,t}^{\frac{1}{2}}, h_{22,t}^{\frac{1}{2}}\}, \tag{4}$$

and

$$R_t = diag\{Q_t\}^{-1/2} Q_t diag\{Q_t\}^{-1/2}. \tag{5}$$

where D_t is a 2×2 diagonal matrix containing the square root of individual conditional heteroscedastic processes $h_{ii,t}$ $(i = 1,2)$ on the diagonal; R_t is the conditional correlation matrix of innovations ε_t constituted by the conditional covariance of standardized innovations (Q_t) where standardized innovations $\epsilon_{i,t} = \frac{\varepsilon_{i,t}}{\sqrt{h_{ii,t}}}(i = 1,2)$.

The individual conditional variance is specified in a GARCH (1, 1) process that is shown as

$$h_{ii,t} = \alpha_{1i} + \alpha_{2i}\varepsilon_{i,t-1}^2 + \alpha_{3i}h_{ii,t-1} + \alpha_{4i}\varepsilon_{j,t-1}^2 + \alpha_{5i}h_{jj,t-1}. \tag{6}$$

where *i* =1, when *j* = 2 and *i* =2, when *j* = 1. Parameter α_{2i} measures the effect of arrivals of new information on volatility and theoretically should be positive, as a shock with higher value should have stronger effect on volatility. α_{3i} estimates the effect of persistence of old news. Note that for $h_{ii,t}$ to be stationary, sum of α_{2i} and α_{3i} should be less than 1. In particular, α_{4i} and α_{5i} captures the effects of volatility spillover. α_{4i} estimates the spillover effect of new shocks in market *i* on volatility of market *j* while α_{5i} measures the spillover effect of old news in market *i* on volatility of market *j*. Results of these two coefficients are one of the major focuses of this study.

According to Engle (2002), Q_t in Eq. (11) is specified as

$$Q_t = (1 - \lambda_1 - \lambda_2)\bar{Q} + \lambda_1 \epsilon_{t-1}\epsilon^T{}_{t-1} + \lambda_2 Q_{t-1}. \tag{7}$$

where ϵ_t is a *2×1* vector of $\epsilon_{i,t}$. $\bar{Q} = E[\epsilon_t \epsilon^T{}_t]$ denoting a *2×2* unconditional covariance matrix of ϵ_t. $E[.]$ is the expectation operator. λ_1 and λ_2 are scalar parameters. The positive definiteness of Q_t can be guaranteed if $\lambda_1 > 0, \lambda_2 > 0$ and $\lambda_1 + \lambda_2 < 1$.

3.2. Skewed Student's t Distribution

Parameter estimates in the DCC model are obtained through maximizing the log-likelihood of the probability density function (PDF) of innovations ε_t. ε_t is proposed to follow a bivariate skewed Student's *t* distribution that accounts for both excess kurtosis and skewness. Excess kurtosis, which corresponds with fat tails of distribution, is widely observed in financial time series (Bollerslev, 1987; Baillie and Bollerslev, 2002). In addition, the unconditional distribution of financial returns is often skewed so that capturing the skewness for the conditional distribution is needed (Park and Jei, 2010). Accepting only conditional normality in the estimation of the multivariate GARCH models for non-normal data could result in loss of efficiency (Engle and Gonzalez-Rivera, 1991; Park and Jei, 2010). Thus the utilization of the conditional distribution that captures both excess kurtosis and skewness for the estimation of the multivariate GARCH models could yield more reliable results in cases where the underlying data deviates from normality (Susmel and Engle, 1994; Tse, 1999; Bauwens and Laurents, 2005).

We employ Bauwens and Laurents (2005)'s bivariate skewed Student's *t* density for the standardized innovations ϵ_t, which is based upon Fernandez and Steel (1998)'s skewed filter to bivariate Student's *t*. The contribution of each observation at time *t* to the log-likelihood of a standardized bivariate skewed-*t* can be expressed in general term as

$$l_t(\Theta) = \log(\tfrac{4}{\pi}) + \textstyle\sum_{i=1}^{2} \log(\tfrac{\xi_i s_i}{1+\xi_i^2}) + \log\left\{\Gamma\left(\tfrac{v+2}{2}\right)/(\Gamma\left(\tfrac{v}{2}\right)(v-2))\right\} - (1/2)\,(v+2)\log[1+(\kappa_t^T \kappa_t)/(v-2)] \quad (8)$$

where

$$\kappa_t = (\kappa_{1t}, \kappa_{2t})^T$$

$$\kappa_{it} = (s_i \epsilon_{it}^* + m_i)\xi_i^{-I_i}$$

$$m_i = \frac{\Gamma\left(\frac{v-1}{2}\right)\sqrt{v-2}}{\sqrt{\pi}\Gamma\left(\frac{v}{2}\right)}(\xi_i - \frac{1}{\xi_i})$$

$$s_i^2 = \left(\xi_i^2 + \frac{1}{\xi_i^2} - 1\right) - m_i^2$$

$$I_i = \begin{cases} 1 & \text{if } \epsilon_{it}^* \geq -\frac{m_i}{s_i} \\ -1 & \text{if } \epsilon_{it}^* < -\frac{m_i}{s_i} \end{cases}.$$

Note that Γ is the gamma function and *v* is the degree of freedom for bivariate Student's *t*. *v* is restricted to be more than 2 so that the covariance matrix can exist. *v* governs the thickness of tails of the distribution, that is, the kurtosis. $m_i(\xi_i, v)$ and $s_i(\xi_i, v)$ are the mean and standard deviation of the non-standardized marginal skewed-*t* of Fernandez and Steel (1998). ξ_i is the skewness parameter where the sign of the logarithm of ξ_i indicates the direction of the skewness. When $ln\xi_i > 0$ (< 0), the skewness is positive (negative) and density is skewed to the right (left). The covariance matrix of ϵ_{it}^* is an identity matrix.

Θ is a parameter vector with all of the coefficients of the DCC GARCH model. Estimates for parameter vector Θ can be obtained by maximizing the following equation over the sample period:

$$L(\Theta) = \sum_{t=1}^{T} l_t(\Theta). \tag{9}$$

where T is the sample size.

3.2.1. Modelling skewness spillover

It has been well documented in the literature that investors show risk preference towards the third moment of returns distribution and require relevant risk premium on asymmetry of distribution when trading securities. Thus skewness can significantly contribute to the risk-return trade off (Harvey and Siddique, 2000). Understanding how skewness behaves can shed light on asset pricing and risk management. It is particularly of interest to examine the spillover of skewness between markets when they are highly inter-related as the tail dependence can provide additional insights on informational efficiency as well as inherent informational linkages among markets (Del Brio et al., 2017; Do et al., 2016). The lead-lag relationship of skewness between markets indicates the direction of information flow between them.

Moreover, the skewness parameter of the univariate conditional density for financial returns is found to be time-varying. This feature has been modelled by an autoregressive process and significant empirical results have been reported (see, e.g., Hansen, 1994; Harvey and Siddique, 1999; Jondeau and Rockinger, 2003; Brooks et al., 2005; Bali et al., 2008). Following Hansen (1994), Jondeau and Rockinger (2003), and Bali et al. (2008), we specify the conditional skewness of marginal densities of the standardised bivariate Skew Student's *t* density as follows:

$$\tilde{\xi}_{i,t} = \theta_{0i} + \theta_{1i}\epsilon_{i,t-1} + \theta_{2i}\tilde{\xi}_{i,t-1} + \theta_{3i}\epsilon_{j,t-1} + \theta_{4i}\tilde{\xi}_{j,t-1}. \tag{10}$$

where i =1, when j = 2 and i =2, when j = 1. Recall that $\epsilon_{it} = \frac{\varepsilon_{i,t}}{\sqrt{h_{ii,t}}}$ $(i = 1,2)$ where $\varepsilon_{i,t}$ is the innovations and $h_{ii,t}$ is the individual conditional heteroscedastic process. $\tilde{\xi}_{it}$ is the unrestricted marginal skewness parameter. Since the skewed Student's *t* density function requires the skewness parameter to be positive, we apply the following logistic transformation in the estimation procedure as in Bali et al. (2008):

$$\xi_{it} = exp(\tilde{\xi}_{it}).$$

where *exp(.)* denotes the exponential function. Hence the coefficients in Eq. (10) are estimated without constraints.

In Eq. (10), the coefficient θ_{1i} estimates the effects of lagged standardised shocks on marginal skewness parameters while θ_{2i} measures whether current skewness parameters can be affected by their past. More importantly, Eq.(10) allows testing whether the skewness parameter of one market is affected by the lagged standardised shocks of the other. Meanwhile, it is examined whether the skewness parameter of one market is impacted by the lagged one of the other. These two effects are captured by θ_{3i} and θ_{4i}, respectively. Analogous to volatility spillover, we refer to these parameters as the measures for the skewness spillover. Since Bauwens and Laurents (2005) suggest that marginal skewness parameters in the skewed Student's t distribution highly correlate with sample skewness of the data series.

Estimates of the parameter vector Θ incorporating the coefficients of the bivariate GARCH models along with those of Eq. (10) are obtained by the maximization procedure applied to Eqs. (8) and (9).

4. Data and sample statistics

We collect the minute-by-minute prices of the China Securities Index (CSI) 300 and its futures contracts for this study from Thomson Reuters Tick History (TRTH). Following Han and Liang (2017), the sample period is chosen from May 4, 2015 to September 30, 2015 during which the market crash occurred. The whole sample is split into three sub-periods, based upon two critical dates of announcements made by the China Financial Futures Exchange (CFFEX) on which the CSI 300 index futures contracts are traded. Those dates are August 25 and September 2, respectively. Three measures suggested in the announcements on those dates took effect from August 26 and from September 7, respectively. Briefly speaking, those measures were proposed to substantially constrain the speculative trading in the index futures market, with the purpose of stabilising the underlying stock market[7]. Han and Liang (2017) show that after the second round of measures that started from September 7, the trading of index futures contracts almost ceased. Provided with these facts, it is clear that the index futures market experienced three sub-periods during the market crash. The first period is from May 4 to August 25 during which no

[7] Refer to Han and Liang (2017, pp.414-415) for full details of these measures.

announcements on speculative trading were made (hereafter referred to as Sub-period 1). The second period is from August 26 to September 6 during which the first round of measures applied (hereafter referred to as Sub-period 2). The third period is from September 7 to September 30 where the first and second rounds of measures took effect (hereafter referred to as Sub-period 3). We employ Chow's breakpoint test to check whether there are structural breaks on those selected dates. The null hypothesis of no structural breaks is rejected, validating the division of the original sample[8]. We estimate volatility and skewness spillover of the CSI 300 index spot and futures markets for the three sub-periods to reveal how the effects vary across time.

The data series of CSI 300 index futures are obtained from the most nearby contracts which are defined as the contract that has the nearest maturity date and normally expires within each calendar month. The most nearby contract is the most liquid in each calendar month, and is widely employed for the studies on futures markets in the literature (see, e.g. Chan et al., 1991; Chan, 1992; Koutmos and Tucker, 1996; Kim et al., 1999; Tse, 1999; Kavussanos et al., 2008; Bohl et al., 2011; Yang et al., 2012). To avoid biases caused by irrational trading behaviour when the maturity date approaches, we roll the contract over to the next five working days before the contract expires[9]. Spot and futures prices recorded before either the stock or futures exchange opens or after either of them closes are excluded from the sample. We end up with 19528 observations for Sub-period 1, 1447 observations for Sub-period 2 and 4337 observations for Sub-period 3, respectively. Original prices are taken in the form of natural logarithms and returns are calculated by taking the first difference of the logarithmic prices.

[8] Test results are available upon request.
[9] The biases are referred to as the expiration-day effect in the literature. The effect results from an abnormal volatility of futures prices that occurs in the last weeks of life for futures contracts (Samuelson, 1965). If futures price records of this period are used for analysis, results concluded from statistical inferences could be distorted from the abnormal volatility (Carchano and Pardo, 2009). Ma et al. (1992) suggest that futures prices around the expiration date should be avoided, as they always have excessive volatility. Factors causing such effects are discussed in Stoll and Whaley (1997).

[Insert Figure 1 about here]

Figure 1 depicts the movements of original prices of the CSI 300 stock index spot and futures markets across the Chinese stock market crash in 2015. As can be seen from the figure, the CSI 300 index, representing the overall performance of the broad Chinese A-share market, reached the peak of 5178 points in mid-June. Then it suffered a drastic drop, losing over 34% in 20 days. The loss continued until late August and reached a trough around August 25, 2015, the date on which the first round of measures to curb the speculative futures trading was announced. After that date, the index value was restored back to some certain levels, until the second round of measures started on September 7, 2015. Then the index price kept growing with some reversals until the end of 2015, followed by another round of fall in value in the early 2016. Meanwhile, the index futures prices have a similar pattern to its underlying spot market. During the market crash, almost half of the listed stocks lost over 50% of their pre-crisis market value. On one in every four trading days from mid-June to mid-September, on average, there were more than 1000 stocks losing 10% of their value. The crisis is perceived to be one of the most deteriorating stock market crises in history (Han and Liang, 2017).

[Insert Figure 2 about here]

The movements of prices in the CSI 300 stock index spot and futures markets in Figure 1 motivates the interest in investigating price discovery of futures market and information transmission between spot and futures prices during the market crash, especially for the periods after announcements were made, that is, Sub-periods 2 and 3. From Figure 2, it can be seen that trading volume of the index futures contracts dropped substantially after the first round of measures took effect on August 26, 2015. It almost approached zero after the second round of measures started on September 7, 2015. However, Figure 1 shows that prices of both spot and futures reversed from a trough when the first round of measures were implemented. Such reversal continued when the two rounds of measures were imposed. These facts suggest that those measures are helpful for stabilising both markets. As the measures only apply to the index futures trading, it is natural to ask if these measures impact the futures market first and then the impact is transmitted to the underlying spot market. It thus raises the question whether the index futures market is informationally efficient to lead the underlying spot index market when trading in the former market is seriously intervened by regulators during the market crash. The question is a focus of this paper and will be addressed later.

[Insert Table 1 about here]

Table 1 summarises the descriptive statistics of returns of the CSI 300 index spot and futures. The Sub-period 1 witnesses negative mean returns whereas Sub-period 2 possesses positive mean returns for both markets. This observation is consistent with Figure 1. Regarding the Sub-period 3, the spot market has negative mean return while the futures market has positive one. After two rounds of measures, the futures market continues with the positive trend. For the spot market, the returns are largely similar to those of the Sub-period 1.

Both spot and futures markets have a large standard deviation over the three sub-periods. This is expected as the markets are volatile during the crash. Meanwhile, Table 1 also shows that the index futures market is more volatile than the stock markets during the crash. This might be one of the reasons why regulators focused on the former market. The Ljung-Box test suggests that volatility clustering of return series exists in both Sub-periods 1 and 3. This phenomenon is to be addressed by the DCC-GARCH model.

The values of skewness are large with index returns negatively skewed and futures returns positively skewed. Excess kurtosis is evident in both index and index futures returns. The distributions of both returns are asymmetric and fat-tailed. This is consistent with the Jarque-Bera test which suggests that returns of neither spot nor futures follow a normal distribution. We take into account non-normality in the estimation of the DCC GARCH model via the skewed Student's *t* distribution.

The stationarity of price and return series of spot and futures markets is tested via the Augmented Dickey-Fuller (Dickey & Fuller, 1979) and Phillips-Perron (Phillips & Perron, 1988) tests. The results show that prices of both spot and futures have one unit root and thus the two markets are integrated of the same order. The Johansen (1991) cointegration test suggests that spot and futures prices are cointegrated. Moreover, the likelihood ratio test is performed to examine whether the cointegrating vector is (1,-1). The null hypothesis is rejected, suggesting the restriction on the cointegrating coefficient cannot hold. The three sub-periods hold the similar results[10].

Table 2 shows that the trading volume of CSI 300 index futures contracts is nearly frozen after the two rounds of restrictive measures. Thus it is natural to ask whether the prices of index futures are stale. If so, it may lead to misleading results. Hence, we test the following hypotheses:

(i). for each sub-period, the standard deviation of futures returns equals to that of its sample-estimated standard deviation;

(ii). for each sub-period, the standard deviation of futures returns equals to that of spot returns;

(iii). the standard deviations of futures returns for the three sub-periods are equal.

The test results show that the first hypothesis is not rejected whereas the second and third hypotheses are rejected at the conventional levels. The three sub-periods share the similar results[11].

[10] Details of relevant test results are available upon request. When performing the cointegration tests for Sub-periods 1 and 3, we choose the testing model with no intercept and deterministic trend in the cointegrating vector and no intercept and deterministic trend in the test Vector Autoregressive (VAR). For Sub-period 2, we choose the testing model with an intercept and a deterministic trend in the cointegrating vector and an intercept and a deterministic trend in the underlying Vector Autoregressive (VAR). The optimal lags in the VAR are selected based on the AIC criterion.

[11] Relevant test statistics are available upon request.

This implies that for all the sub-periods during the market crash, the futures prices are more volatile than the spot ones given higher standard deviation of the former. This is even true at the sub-period 3 during which the trading activities of index futures contracts is substantially restrained. The risk level of index futures market during the sub-period 3 behaves differently from the other two sub-periods. Moreover, the cointegration test suggests that the CSI 300 spot and futures prices are cointegrated during the sub-period 3. If the futures prices had been stale, the cointegration would not have existed. Therefore, the staleness of index futures prices is not significant during the sub-period 3 and hence using data for analysis is appropriate.

5. Empirical results

5.1. GARCH model estimates and volatility spillover

Table 2 shows estimation results of the bivariate DCC GARCH model across three sub-periods during the market crash. As can be seen from the table, the residual diagnosis suggests that there is no conditional heteroscedasticity remaining in the standardised innovations for all the sub-periods. Hence, the DCC GARCH model is well specified[12].

[Insert Table 2 about here]

Over the three sub-periods, the conditional heteroscedasticity in returns is well addressed as evidenced by significance of α_{2i} and α_{3i}. Volatility is not only affected by arrival of new information (new shocks) but is also explained by old information (persistence). This is evident for both spot and futures markets. Meanwhile, the correlations between spot and futures returns are found to be significantly affected by lagged shocks during the market crash. But there is no

[12] Estimation results of VECM for conditional mean are not reported but available upon request.

persistence in correlation. The effect of lagged shocks on correlation increases from Sub-period 1 to Sub-period 2 and drops from Sub-period 2 to Sub-period 3.

The results of volatility spillover can be seen from Table 2. Estimates of α_{4i} are significant for both spot and futures markets across all three sub-periods. The lagged shocks in the spot (futures) market affect current volatility of the futures (spot) market. Hence the volatility spillover between the two markets is bidirectional. Furthermore, the spillover from futures to spot are stronger than the other way around during the whole crash period. The effect from futures to spot than the reverse way is augmented in both Sub-periods 2 and 3 provided with enlarged differences in magnitude of α_{4i} between futures and spot, compared to Sub-period 1. The strength of spillover from futures to spot reaches maximum in the Sub-period 3, as indicated by the largest difference in size between α_{41} and α_{42}.

Meanwhile, for all the sub-periods, the lagged volatility in the spot (futures) market affect current volatility of the futures (spot) market, given the significant estimates of α_{5i}. The result confirms bidirectional volatility spillover. In addition, although there is no difference in the strength of between-market spillover of lagged persistence in either Sub-period 1 or 2, the spillover effect from futures to spot is significantly higher than the other way around in Sub-period 3. It suggests enhanced information transmission from futures to spot markets in terms of cross-market effects of old news at that period.

[Insert Figure 3 about here]

The movements of conditional variances over the sub-periods of market crash are depicted in Figure 3. Sub-periods 2 and 3 witness shrinking variation ranges of variances of both spot and futures returns. The magnitudes of value ranges for spot and futures variances are smallest in Sub-period 3. This suggests that measures to restrict index futures trading help to stabilize both markets.

Moreover, spikes of variance in the figure, representing unexpected shocks of variance, in the spot market go in tandem with those in the futures market. This is particularly the case in Sub-periods 2 and 3. Figure 2 is consistent with Table 2 and it visualises the leading role of the futures market in volatility interactions.

[Insert Figure 4 about here]

Figure 4 shows how conditional correlation between spot and futures markets moves during the market crash. One obvious observation is that the conditional correlation becomes less volatile across the sub-periods. This supports the finding that measures to curb futures trading stabilize the market, due to enhanced stabilisation of correlation.

Overall, we find that during the market crash without any strict measure on futures trading undertaken, the CSI 300 index futures market still leads the stock market in light of volatility spillover. This finding complements Chen et al. (2013), Guo et al. (2013), Hou and Li (2013, 2015) and Xu and Wan (2015) who find that the CSI 300 index futures market benefits the Chinese stock markets in normal time. The behaviour of the Chinese index futures market in terms of its functionality towards the underlying stock markets during the market crash is similar to the findings by Harris (1989) on the S&P 500 market and Cheng et al. (2000) on the Hong Kong market.

It is unveiled that after two rounds of restrictive measures to curb the speculative futures trading, information flow from futures to spot is strengthened in terms of volatility spillover, suggesting that the futures market provides better information channels to its counterpart. This implies that those measures might be helpful for improving the quality of information contents of futures prices and the restoration of market efficiency. Such result is consistent with Cheng et al. (2000) and Su et al. (2002) on the Hong Kong stock index futures market.

5.2. Skewness spillover

5.2.1. Impulse response function of sample skewness

Before spillover effects of marginal skewness parameters between the CSI 300 index spot and futures markets in a bivariate conditional Skew Student's t distribution are reported, we examine how the sample skewness of one market responds to its own past shocks as well as shocks of the other. The sample skewness series of the spot and futures returns are respectively obtained via a rolling window procedure with window size of 10 observations and step size of one observation for the three sub-periods. Then the series of sample skewness are modelled by a bivariate vector autoregressive (VAR) model as follows[13]:

$$Skewness_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i Skewness_{t-i} + \eta_t. \quad (11)$$

where $Skewness_t$ is a vector of sample skewness series of spot and futures returns. η_t are innovations, representing shocks of skewness. The optimal lag order p in Eq. (11) is chosen by the Akaike Information Criteria (AIC). The order varies across the three sub-periods. An impulse response function based upon a vector moving average (VMA) transformation of Eq. (11) allows testing the within- and cross-market effects of one-standard-deviation change in lagged η_t on $Skewness_t$ up to j periods. We choose j to be 10 and impulse responses of sample skewness in the three sub-periods are depicted in Figure 5.

[Insert Figure 5 about here]

As can be seen from the figure, the within-market responses of sample skewness to past shocks up to 10 lags are significantly different from zero. The responses are highest at the period of lag order 1 and then they diminish as lag order increases. The evidence stands for both spot and futures markets in all the sub-periods. It implies that skewness might be conditioned on past

[13] Skewness series of both spot and futures returns are stationary for all the sub-periods, as indicated by the stationarity tests. Test results are available upon request.

information, following a time-varying process. On the other hand, for all the sub-periods, the responses of spot skewness to lagged shocks of futures market are significant from a lag of order 1 to 10. These responses firstly rise up to two lags and then slowly decrease as the lag order increases. However, the evidence differs from the responses of futures skewness to lagged spot shocks where none of them are significant whatever the lag order is. This is particularly the case for the sub-periods 1 and 3. In the sub-period 2, although there are weak responses of futures skewness to higher order lags of spot shocks from 6 to 10, the responses of futures skewness are null to the more recent spot shocks. It should be noted that the order of skewness series in $Skewness_t$ might affect the results of impulse responses which are shown in Figure 5. Hence we change the order of spot and futures sample skewness series in $Skewness_t$ of Eq. (11) and re-estimate the impulse responses for the two markets across the sub-periods. The results hold similar to the previous ones without order change, suggesting the robustness of the results to the lag order issue[14].

Overall, the results imply a one-way interaction between skewness of spot and futures returns, where the lead-lag relation is from futures to spot but not vice versa. Such relationship will be explored further by the estimation of Eq. (10) in a joint conditional distribution of spot and futures returns.

5.2.2. Spillover of marginal skewness parameters

The result of conditional marginal skewness parameters is shown in Table 3. Skewness parameters of both spot and futures markets can be significantly driven by their own lagged shocks across the sub-periods. In particular, the effects of past shocks in the spot market are positive. In contrast, before the second round of measures is implemented, the skewness parameter of the

[14] The results are available upon request.

futures market is negatively affected by the past shocks. The effect turns positive when the two rounds of measures take effect.

[Insert Table 3 about here]

The persistence of skewness parameters is found significant after the first round of measures took effect. The evidence is found for the spot market and the effect is positive where the skewness parameter of that market positively links to its past. After the two rounds of measures, the skewness parameter of the futures market is positively affected by its own past, showing a strong persistency (with estimate of θ_{22} equal to around 0.815).

We now turn to looking at the spillover of marginal skewness parameters between spot and futures markets. In Sub-period 1, we find that the lagged shocks of spot market has a significant and negative effect on the skewness parameter of futures market. Meanwhile, although there is no significant effect of the lagged shocks of futures market on the skewness parameter of the spot, we find past skewness parameter of futures returns has a significant and positive effect on that of spot ones. Hence, there are bidirectional spillover of skewness parameters between markets in Sub-period 1. Since persistence reflects the accumulative effect of past information, the spillover from futures to spot markets is stronger than the other way around. The evidence is found under the circumstance where no restrictive measures are undertaken to curb the speculative futures trading.

Both Sub-periods 2 and 3 witness strengthened skewness spillover effects compared to Sub-period 1. After the first round of measures are taken into account, the spillover effects of both futures and spot markets on their counterparts are enhanced, as evidence by the enlarged magnitude of estimates of θ_{3i} and θ_{4i} (i =1, 2). The futures market still leads in the spillover process. Under the two rounds of measures, the lagged shocks of futures market significantly impact the skewness parameter of spot market but not vice versa. Moreover, the two-way cross-market persistence is evidenced where the futures market exhibits a stronger effect on the spot counterpart than the reverse way. It cannot be ruled out that the futures market plays a leading role in the skewness spillover even when the futures trading nearly terminates. We also observe that the cross-market effects of persistence are negative for both Sup-periods 2 and 3. The spillover effects of the lagged shocks do differ in the sign between spot and futures markets in both sub-periods.

[Insert Figure 6 about here]

Figure 6 depicts the movements of estimated conditional marginal skewness parameters of spot and futures markets in all sub-periods. It is worth noting the following two points. First, it is clear to see that volatility of skewness parameters is substantially reduced after the two rounds of measures, given that the value range for movements shrinks across the sub-periods. Such change is particularly evident in the futures market. It implies that those measures on futures trading effectively control the dynamics of downside (upside) risk in the index futures market. The effect might spill into the underlying stock market. Second, consistent with Table 3, Figure 6 shows that the skewness parameter of spot market moves in tandem with that of futures market, indicating a leading role of the latter. This can be visualised via a spike in the futures market followed by another in the spot one.

[Insert Table 4 about here]

To test whether the marginal skewness parameter ξ_{it}, for i = 1,2, is constant, the likelihood ratio test is employed. In particular, let $LogL_{FS}$ and $LogL_{TVS}$ denote the log-likelihood values for the bivariate DCC-GARCH models with the static and time-varying skewness parameters, respectively. Then the likelihood ratio test statistic can be calculated as follows

$$2(LogL_{TVS} - LogL_{FS}) \xrightarrow{d} \chi_p^2,$$

where p is the number of restrictions. The test statistic asymptotically follows a Chi-squared distribution with degree of freedom equal to p. In order to test the constancy of all coefficients, the number of restrictions is 10 (5×2). The result of the likelihood ratio test is shown in Table 4. The critical value of χ^2_{10} at the 1% significance level is 23.2093. Therefore, the test statistics for all sub-periods are significant at the 1% level as reported in Table 4. This result confirms the appropriateness of the model with time-varying marginal skewness parameters.

In a nutshell, the marginal skewness parameters are conditioned on the past information during the market crash. More importantly, we find significant evidence that the CSI 300 index futures prices lead the underlying stock index prices in terms of a two-way skewness spillover during the crash period. The spillover effect from futures to spot is enhanced after the restrictions on futures trading are imposed. It implies that those policies might benefit the quality of information contents of futures prices regarding the tail dependence of returns distribution. In addition, they contribute to controlling the downside (upside) risk given the shrinking volatility of skewness parameters. The evidence complements the result of volatility spillover.

Finally, a caution should be made for the finding regarding the changed information content of the index futures prices during the market crash. Han and Liang (2017) suggest that investors pursuing alpha portfolio strategies suffer great losses due to the restrictive trading policies on index futures contracts during the market crash and this was a contributing factor to the deteriorated market quality of the underlying stock market. Thus the significant enhancement of information content of futures prices after the second round of restrictions might stem from the damaged stock market quality. One might expect that the downgraded market quality of stock market leads to even more inferior information content of the stock market and this might be partially responsible for enhanced informational role of futures prices revealed for sub-period 3. However, the exact reasons for changed information role of futures market relative to spot market still remain unclear, which will be left for a future study.

6. Concluding remarks

Although volatility transmission between stock index spot and futures markets in developed economies has been extensively explored in the literature, evidence on emerging markets remains scarce. Volatility spillover during financial crises has not been well understood with respect to the linkage between stock index spot and futures markets. Furthermore, the spillover of conditional skewness, pertaining to the dependence of downside (upside) risk among financial markets, have drawn little attention in the literature on derivatives markets. These issues have important implications for the stock index spot and futures markets. In addition, it remains inconclusive whether government direct intervention on trading of both stock and stock index futures markets during a market crash benefits the restoration of market efficiency.

This study contributes to the literature by studying the spillover of the second and third moments of returns of the Chinese stock index spot and futures markets during a recent stock market crash in China. Since the Chinese regulatory authority imposed tough restrictions on index futures trading which nearly terminated trading activities in the futures market during the crash period, it is a good opportunity to enrich the literature by revealing how the local futures market transmits information to its underlying stock market in terms of volatility and skewness spillover under an extremely restrictive trading environment.

High frequency prices at 1-minute intervals of the CSI 300 stock index spot and futures during the stock market crash are collected for the study. Specifically, due to two rounds of measures to restrict the futures trading that were implemented within the sample period, the whole sample is split into three sub-periods. A bivariate DCC GARCH model is employed for analysing volatility spillover and estimated together with a conditional skewed Student's t distribution. The latter is extended to incorporate the conditional marginal skewness parameters which are specified in an autoregressive process, enabling the test of spillover of the third moment of returns distribution. Model estimation is respectively conducted for the three sub-periods.

We find that there are bidirectional volatility spillover between spot and futures markets during all three sub-periods. The spillover effect from futures to spot is stronger than the other way around. It is found that information flow from the futures market is even strengthened after two rounds of measures to restrict the index futures trading, suggesting that those policies might be beneficial to restore the informational efficiency of index futures prices.

Furthermore, marginal skewness parameter of each market is conditioned on the past information, which is evidenced across the three sub-periods. More importantly, similar to volatility dynamics, the skewness spillover is found to be bidirectional where spillover from futures to spot market is stronger than the reverse way. Information carrying risk of asymmetry of returns flows from futures to spot markets. Such information flow is even reinforced after the restrictions on futures trading implemented. Evidence of skewness spillover complements that of volatility spillover, suggesting a leading role of the local index futures market in the information transmission process during the market crash. We also find that the intervention helps to stabilise conditional volatility, skewness and correlation of both spot and futures markets.

Our results have two important implications. First, our results suggest that the Chinese stock index futures market still plays a leading role in informational efficiency during the market crash period, compared to conclusions in the normal period (Chen et al., 2013; Hou and Li, 2015).

Second, it seems that supporting evidence is found to show the implementation of measures to curb the speculative futures trading benefits index futures market. Even in the period where index futures trading is nearly frozen, we find information content of futures prices is enhanced. Our finding is in line with supportive evidence for the government intervention on the Hong Kong stock market during the AFC (Cheng et al., 2000; Su et al., 2002).

However, we should be cautious in drawing the supporting evidence for the restrictive trading regulations imposed by CFFEX. This is because there has been no evidence so far to show that the market condition changing in the Chinese stock index futures market is the result of trading restrictions. Although Han and Liang (2017) show that the downgraded information quality of stock market results from the trading constraints, it is not sure that those constraints directly cause the changed informational role of futures market relative to spot market. Some other latent market condition factors may also possibly lead to the changed information content of futures prices. This suggests a future research to investigate whether or not the changed information content of futures market is attributed to the trading restrictions by using e.g. the difference-in-difference approach.

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Table 1. Descriptive statistics of one-minute returns of CSI 300 index spot and futures

	Nobs	*Mean*	*Median*	*Std*	*Skew*	*Kurt*	$LB^2(8)$	$LB^2(12)$	*JB statistics*
Panel A: Sub-period 1									
Spot	19528	-2.29×10^{-5}	7.74×10^{-6}	0.0018	-4.9864	344.7749	88.064***	88.751***	9.51×10^{7}***
Futures	19528	-2.69×10^{-5}	0	0.0025	1.2303	58.4455	127.568***	206.575***	2.51×10^{6}***
Panel B: Sub-period 2									
Spot	1447	6.87×10^{-5}	-1.96×10^{-5}	0.0025	-3.5814	95.3061	11.095	11.124	5.17×10^{5}***
Futures	1447	3.53×10^{-5}	-1.33×10^{-4}	0.0037	2.5667	41.2368	0.887	1.518	8.97×10^{4}***
Panel C: Sub-period 3									
Spot	4337	-1.12×10^{-5}	-9.64×10^{-7}	0.0012	-3.7236	73.6259	175.101***	175.424***	9.11×10^{5}***
Futures	4337	1.15×10^{-5}	-5.94×10^{-5}	0.0021	3.8545	104.1986	167.179***	169.056***	1.86×10^{6}***

Notes: This table reports the descriptive statistics of 1-minute returns of CSI 300 stock index spot and futures prices. *Sub-period 1, 2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively. $LB^2(8)$ and $LB^2(12)$ are the Ljung-Box Q statistics for the squared returns at orders 8 and 12, respectively. *Nobs* denotes the number of observations; *Mean* denotes mean of sample; *Median* denotes median of sample; *Std* denotes standard deviation; *Skew* denotes skewness; *Kurt* denotes kurtosis; *JB statistics* denotes statistics of the Jarque-Bera test for normality. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 2. Estimates of the bivarite DCC GARCH model

	Sub-period 1		*Sub-period 2*		*Sub-period 3*	
Panel A: GARCH model estimates						
Coef.	*Spot* (i = 1)	*Futures* (i = 2)	*Spot* (i = 1)	*Futures* (i = 2)	*Spot* (i = 1)	*Futures* (i = 2)
α_{1i}	$3.76\times10^{-8***}$	$2.75\times10^{-8***}$	$3.13\times10^{-7**}$	$3.39\times10^{-7***}$	$8.68\times10^{-8***}$	$7.38\times10^{-8***}$
	(1.19×10^{-8})	(4.42×10^{-9})	(1.38×10^{-7})	(8.45×10^{-8})	(1.85×10^{-8})	(1.81×10^{-8})
α_{2i}	0.176^{***}	0.059^{***}	0.556^{***}	0.061^{***}	0.479^{***}	0.042^{***}
	(0.0159)	(0.0030)	(0.0940)	(0.0141)	(0.0767)	(0.0103)
α_{3i}	0.791^{***}	0.940^{***}	0.386^{***}	0.916^{***}	0.437^{***}	0.929^{***}
	(0.0268)	(0.0036)	(0.0609)	(0.0076)	(0.0203)	(0.0032)
α_{4i}	0.013^{***}	-0.006^{***}	0.037^{***}	-0.009^{*}	0.022^{***}	$2.85\times10^{-5*}$
	(0.0023)	(0.0004)	(0.0054)	(0.0053)	(0.0051)	(1.66×10^{-5})
α_{5i}	0.050^{***}	0.050^{***}	0.050^{***}	0.050^{***}	0.055^{***}	0.005^{**}
	(0.0108)	(0.0093)	(0.0145)	(0.0116)	(0.0099)	(0.0024)
Panel B: Conditional correlation						
λ_1	0.050^{***}		0.100^{***}		0.010^{*}	
	(0.0034)		(0.0128)		(0.0052)	
λ_2	0.017		-0.014		-0.115	
	(0.0296)		(0.0226)		(0.0971)	
Panel C: Residual diagnosis						
$LB^2(8)$	0.068	0.755	0.142	0.532	0.233	0.309
$LB^2(12)$	0.097	0.872	0.215	0.742	0.313	0.507

Notes: This table reports the estimation results of the bivariate DCC GARCH model in three sub-periods. The coefficients of Eqs. (6) and (7) are estimated via MLE and results are reported. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively. *Spot* denotes the spot equation of Eq. (6) when i =1; *Futures* denotes the futures equation of Eq.(6) when i = 2. $LB^2(8)$ and $LB^2(12)$ are the Ljung-Box Q statistics for the squared standardized residuals at orders 8 and 12, respectively. *Coef.* stands for coefficients. Figures in the parentheses are standard errors. ***, **, and * indicate significance at the 1, 5, and 10%, respectively.

Table 3. Conditional Skewed Student's *t* Distribution and Skewness Parameter Spillover

	Sub-period 1		*Sub-period 2*		*Sub-period 3*	
Coef.	*Spot* (i = 1)	*Futures* (i = 2)	*Spot* (i = 1)	*Futures* (i = 2)	*Spot* (i = 1)	*Futures* (i = 2)
θ_{0i}	0.006 (0.0043)	-0.007 (0.0050)	0.182*** (0.0191)	-0.041* (0.0210)	-0.143 (0.1266)	0.024 (0.0270)
θ_{1i}	0.061*** (0.0097)	-0.247*** (0.0090)	1.063*** (0.0787)	-0.186*** (0.0302)	0.086*** (0.0201)	0.033*** (0.0078)
θ_{2i}	0.114 (0.1001)	-0.028 (0.0185)	0.236*** (0.0790)	-0.164 (0.1037)	0.391*** (0.0957)	0.815*** (0.0416)
θ_{3i}	-0.001 (0.0071)	-0.076*** (0.0077)	0.638*** (0.0703)	-0.633*** (0.0459)	0.062*** (0.0168)	-0.002 (0.0062)
θ_{4i}	0.095*** (0.0233)	0.018 (0.0288)	-0.377* (0.2270)	-0.122*** (0.0441)	-0.678*** (0.1518)	-0.101*** (0.0262)
v	2.490*** (0.0081)		2.921*** (0.0443)		3.070*** (0.0294)	

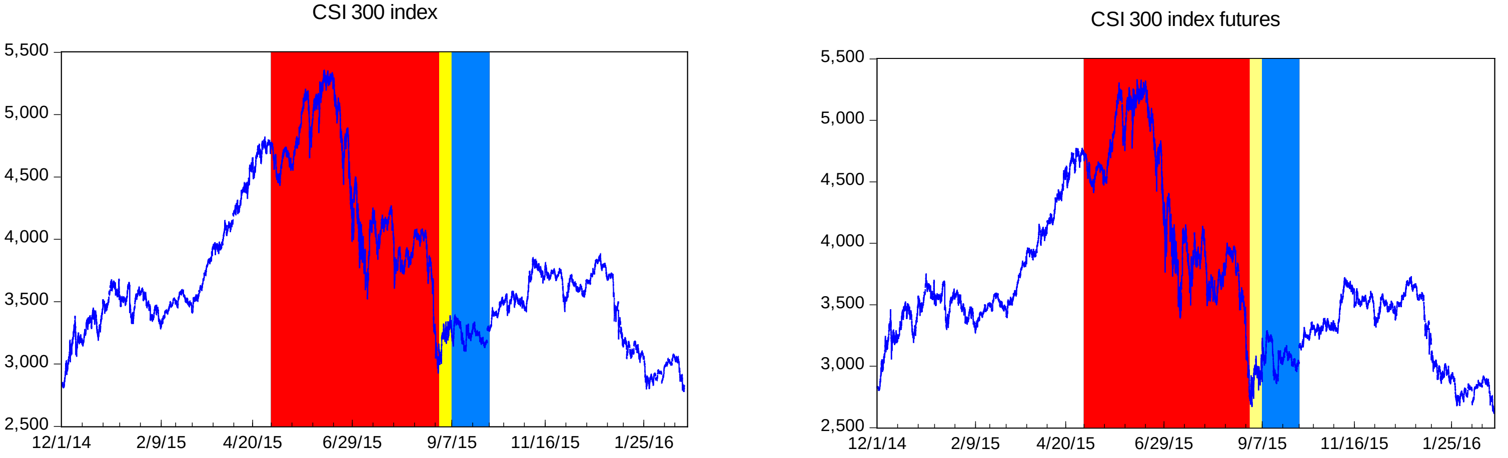
Notes: This table reports the estimation results of Eq. (10) and degree of freedom parameter in Eq. (8). Estimation is conducted via MLE. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively. *Spot* denotes the spot equation of Eq. (10) when i =1; *Futures* denotes the futures equation of Eq.(10) when i = 2. *Coef.* stands for coefficients. Figures in the parentheses are standard errors. ***, **, and * indicate significance at the 1, 5, and 10%, respectively.

Table 4. Likelihood ratio test for the constancy of marginal skewness parameters

	H_0	H_1	LR
Sub-period 1	CS	TVS	6826.06***
Sub-period 2	CS	TVS	367.77***
Sub-period 3	CS	TVS	61.95***

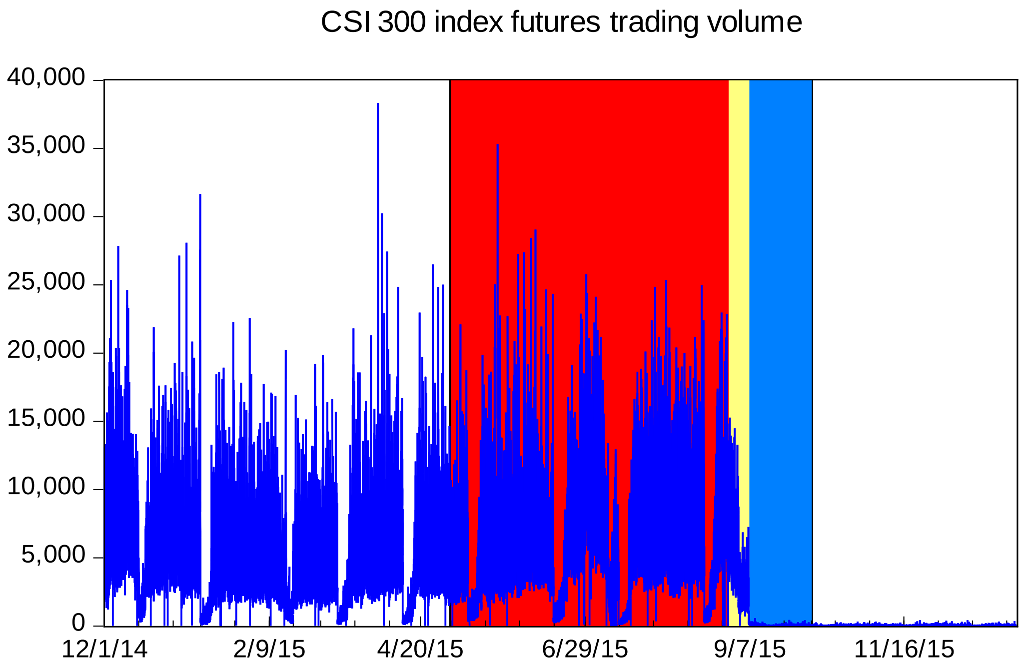
Notes: H_0 denotes the null hypothesis that the skewness parameters are constant. H_1 denotes the alternative that the skewness parameters are the time-varying. *LR* denotes the likelihood ratio test statistic. The critical value at the 1% level of χ^2_{10} is 23.2093. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively. *** denotes statistical significance at the 1% level.

Figure 1. Price movements of CSI 300 index spot and futures[15]



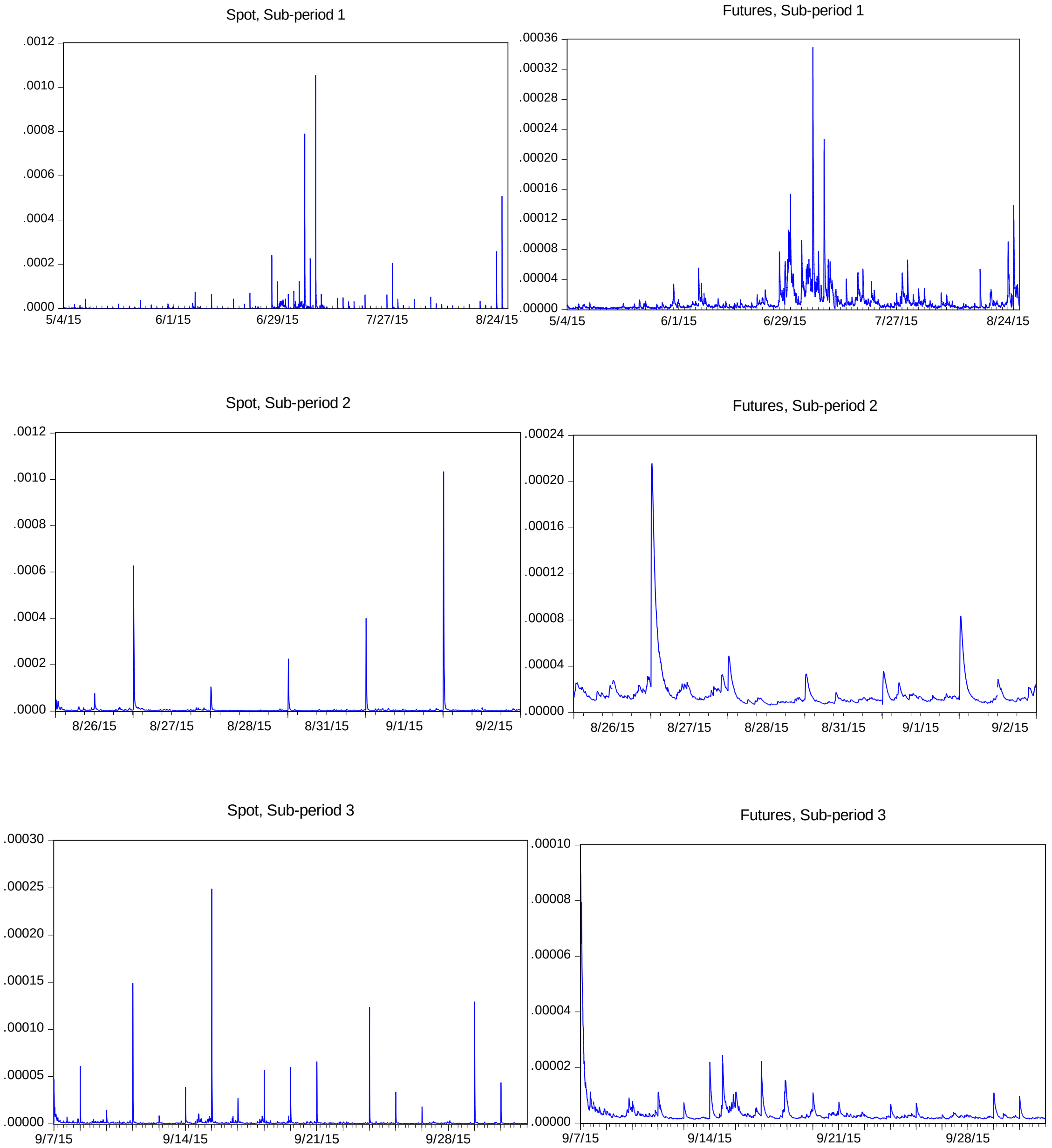
[15] Notes: This figure shows one-minute price series of the CSI 300 stock index spot and futures from December 1, 2014 to February 29, 2016. The three coloured areas from left to right correspond to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015.

Figure 2. Trading volume of the CSI 300 index futures contracts[16]



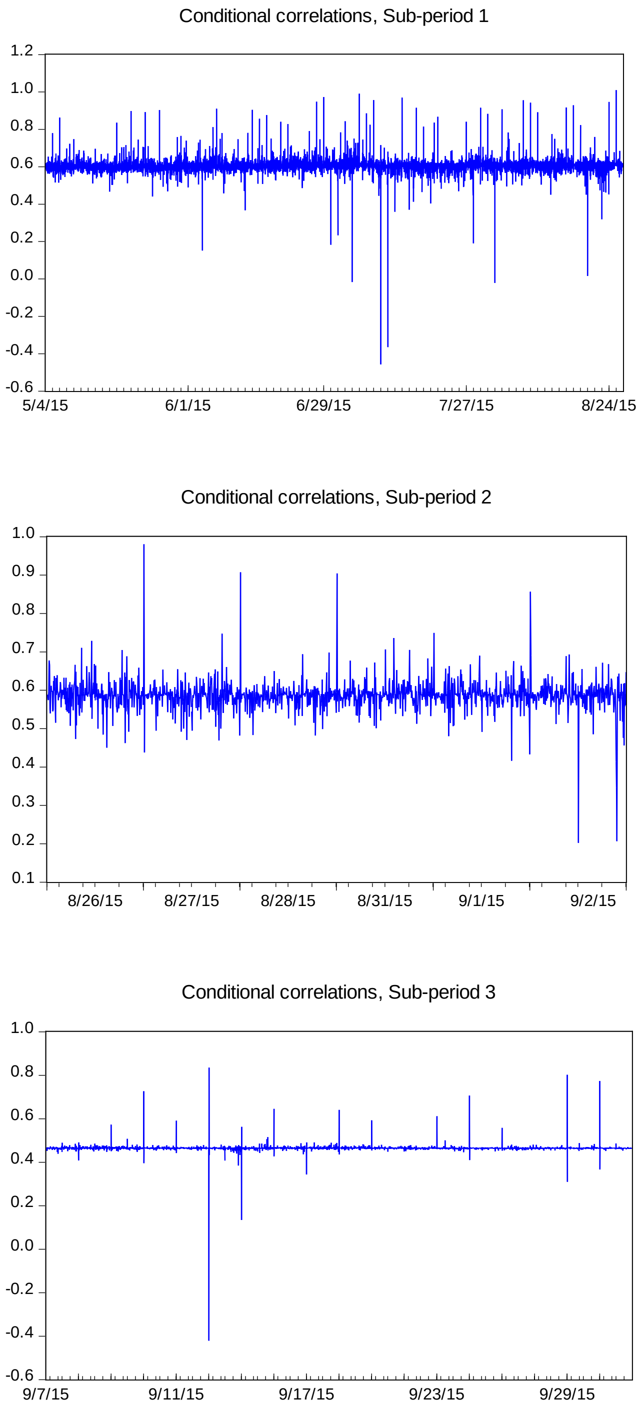
[16] Notes: This figure shows trading volume of the most nearby CSI 300 stock index futures contracts at 1-minute intervals from December 1, 2014 to December 30, 2015. The three coloured regions from left to right correspond to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015.

Figure 3. Conditional variances during the market crash[17]



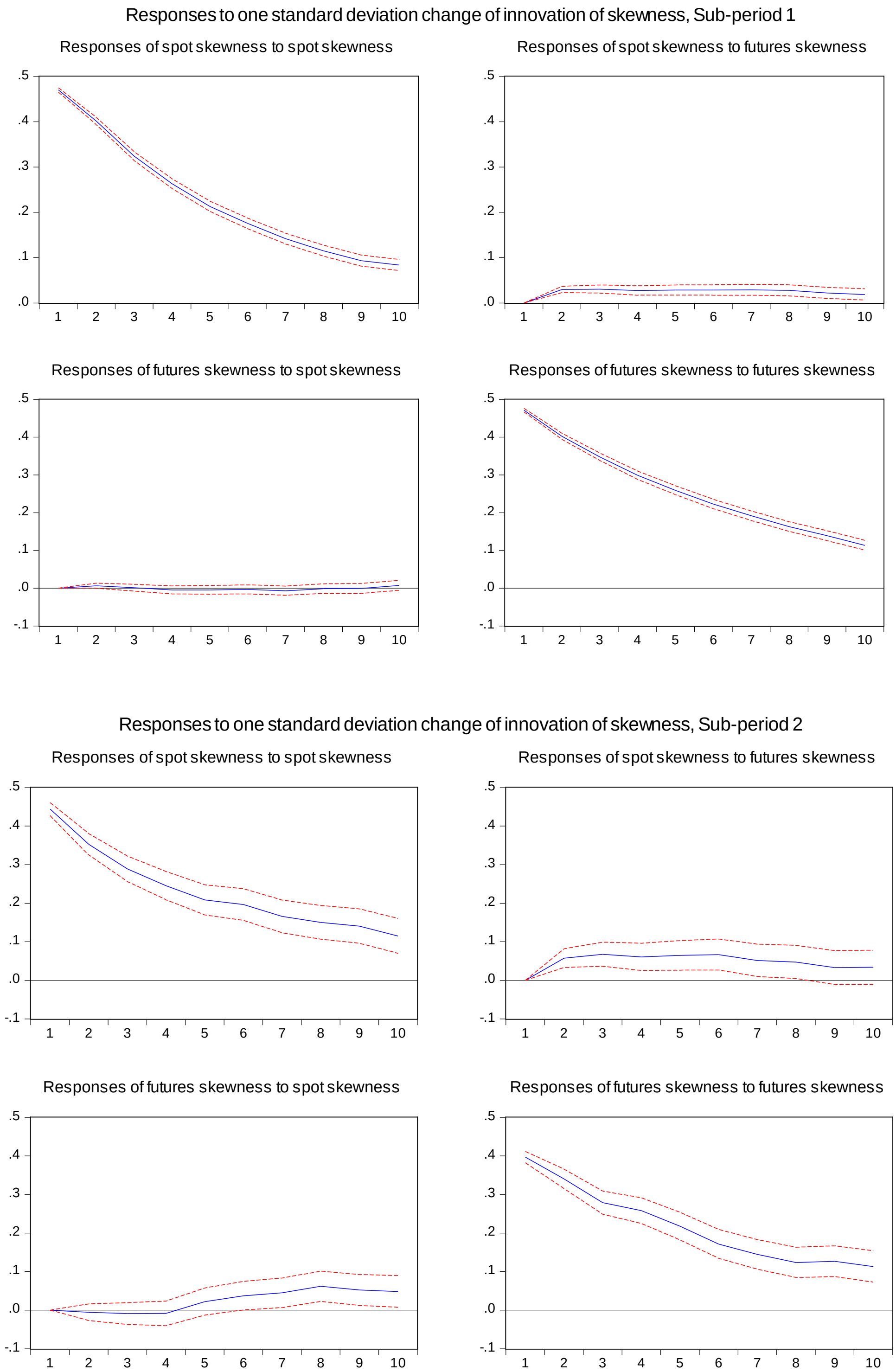
[17] Notes: Spot denotes conditional variance of the CSI 300 spot index; Futures denotes conditional variance of the CSI 300 index futures. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively.

Figure 4. Conditional correlations during the market crash[18]



[18] Notes: Conditional correlations refer to dynamic conditional correlations between the CSI 300 index spot and futures returns estimated by the DCC GARCH model. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively.

Figure 5. Impulse responses of sample skewness[19]



[19] Notes: Impulse responses up to 10 lagged periods are depicted. Confidence intervals between ±2 standard errors of responses are also shown. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively.

Responses to one standard deviation change of innovation of skewness, Sub-period 3

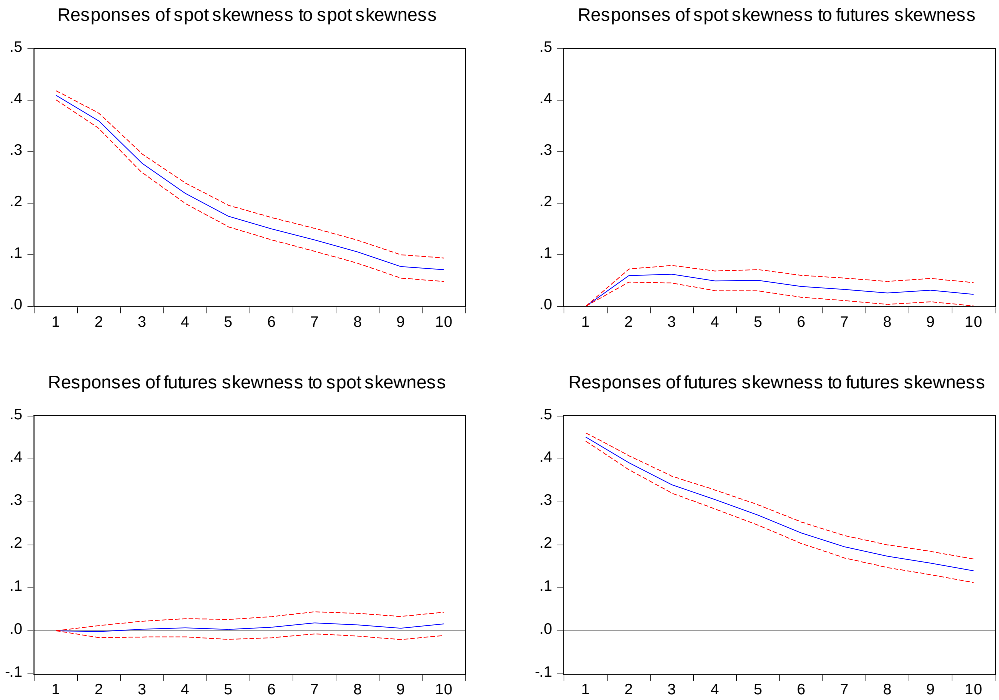
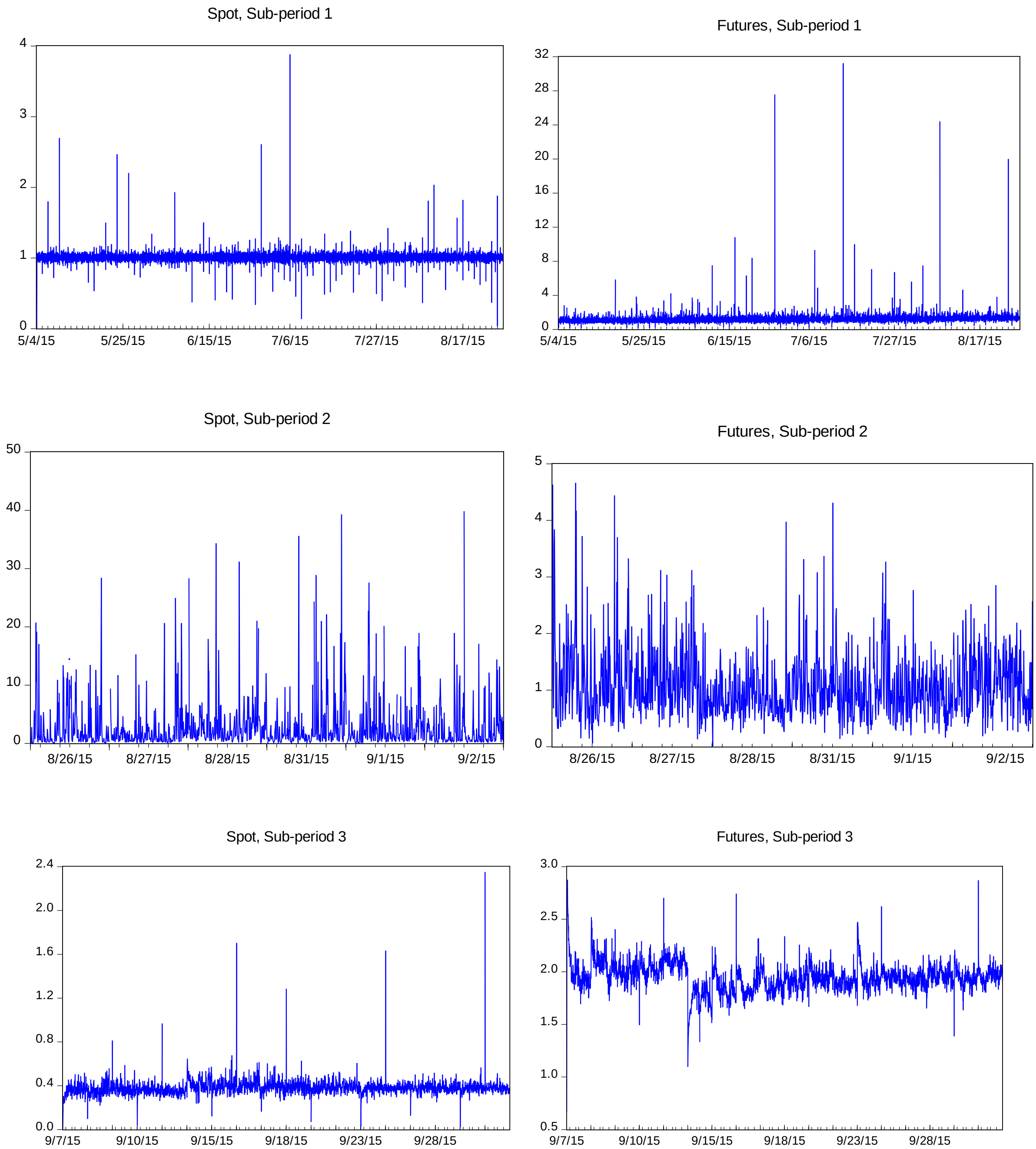


Figure 6. Conditional marginal skewness parameters during the market crash[20]



[20] Notes: Spot denotes conditional marginal skewness parameter of the CSI 300 spot index; Futures denotes conditional marginal skewness parameter of the CSI 300 index futures. *Sub-period 1*, *2* and *3* refer to the three sub-periods: May 4, 2015 – August 25, 2015, August 26, 2015 - September 6, 2015 and September 7, 2015 – September 30, 2015, respectively.

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Friday 19: Dajin Report Hall (大金报告厅), School of Economics, Fudan University

12:30 pm – 1:20 pm	Registration
1:20 pm -- 1:40 pm	
Chair	Qingfu Liu, Executive Dean of Fudan-Stanford Institute for China Financial Technology Risk Analytics
Opening Speech	Shiyi Chen, Secretary of School of Economics and Fanhai International School of Finance, Fudan Univeristy
1:40 pm – 3:40 pm	
Chair	Ke Tang, Tsinghua University
Keynote Speaker	Michael A.H.Dempster, University of Cambridge
Chair	Liyan Han, Beihang University
Keynote Speaker	Robert Webb, University of Virginia
Chair	Renhai Hua, Nanjing University of Economics and Finance
Keynote Speaker	Jianqing Fan, Princeton University
3:40 pm –4:00 pm	Group Shot and Coffee Break
4:00 pm – 6:00 pm	
Chair	Jun Song, Fudan University
Keynote Speaker	Chongfeng Wu, Shanghai Jiaotong University
Chair	Xiaofeng Hui, Harbin Institute of Technology
Keynote Speaker	Huiyan Zhang, Shanghai Futures Exchange
Chair	Xiaoxing Liu, Southeast University
Keynote Speaker	Qingfu Liu, Fudan University
6:30 pm – 8:30 pm	Banquet
Speaker	Jianqing Fan, Princeton University

Saturday 20: Room 510, 514, 614, 710, 805, School of Economics, Fudan University

8:30 am – 10:00 am	Parallel Sessions I
10:00 am – 10:15 am	Coffee Break
10:15 am – 11:45 pm	Parallel Sessions II
12:00 pm – 2:00 pm	Buffet Lunch
2:00 pm – 3:30 pm	Parallel Sessions III

KEYNOTE SPEAKERS:

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Trading and the behavior of speculative prices

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Jianqing FAN, Princeton University

Editor-in-Chief of the Journal of Econometrics, professor of Princeton University. He is a statistician, financial econometrician, and data scientist. He is Frederick L. Moore'18 Professor of Finance, Professor of Statistics, and Professor of Operations Research and Financial Engineering at the Princeton University where he chaired the department from 2012 to 2015. He is the winner of The 2000 COPSS Presidents' Award, Morningside Gold Medal for Applied Mathematics (2007), Guggenheim Fellow (2009), Pao-Lu Hsu Prize (2013) and Guy Medal in Silver (2014). He got elected to Academician from Academia Sinica in 2012.

After receiving his Ph.D. in Statistics from the University of California at Berkeley in 1989, he has been appointed as assistant, associate, and full professor at the University of North Carolina at Chapel Hill (1989-2003), and as professor at the University of California at Los Angeles (1997-2000), Professor of Statistics and Chairman at the Chinese University of Hong Kong (2000-2003), and professor at the Princeton University (2003-), where he directs the Committee of Statistical Studies since 2006 and chaired Department of Operations Research and Financial Engineering from 2012 to 2015. He was named Frederick L. Moore'18 Professor of Finance since 2006

Fan has coauthored two highly-regarded books on Local Polynomial Modeling (1996) and Nonlinear time series: Parametric and Nonparametric Methods (2003) and authored or coauthored over 200 articles on finance, economics, statistical machine learning, computational biology, semiparametric and non-parametric modeling, nonlinear time series, survival analysis, longitudinal data analysis, and other aspects of theoretical and methodological statistics. He has been consistently ranked as a top 10 highly-cited mathematical scientist since the existence of such a ranking. His published work on statistics, financial econometrics, computational biology, and statistical machine learning has been recognized by the 2000 COPSS Presidents' Award, given annually to an outstanding statistician under age 40, invited speaker at The 2006 International Congress for Mathematicians, The Humboldt Research Award for lifetime achievement in 2006, The Morningside Gold Medal of Applied Mathematics in 2007, honoring triennially an outstanding applied mathematician of Chinese descent, Guggenheim Fellow in 2009, Pao-Lu Hsu Prize (2013), presented every three years by the International Chinese Statistical Association to individuals under the age of 50, and Guy Medal in Silver (2014), presented once a year by Royal Statistical Society, and the election to the fellow of American Association for the Advancement of Science, Institute of Mathematical Statistics, and American Statistical Association.

Chongfeng WU, Shanghai Jiaotong University

Editor-in-Chief of the China Finance Review International, professor of Shanghai Jiaotong University. He is Director of Professor Committee of Antai College of Economics and Management, and Director of the Institute of Financial Engineering, Shanghai Jiao Tong University. He achieved his Ph.D. in Systems Engineering from Shanghai Jiao Tong University in 1989. He went to Yale University as a visiting professor from Dec. 2003 to June 2004.

Prof. Wu was Vice Dean of Antai College of Economics and Management, Shanghai Jiao Tong University from 1996 to 2010. In 1993, he won "The government special allowance of the state council". In 1998, Prof. WU was selected into the first and second level of Millions of National Distinguished Scholars Plan and two years later, he won the program sponsored by National Science Fund for Distinguished Yong Scholars. In 2010, he was chosen into the Shanghai Leading Talent Plan.
Prof. Wu is now Member of Teaching Guidance Committee in Finance of MOE, Standing Member of Chinese Research Council of Modern Management, Standing Director of China Association of Finance and Vice Chairman of China Association of Financial Engineering. He is Member of 14th Shanghai Municipal People's Congress, and Standing Member of the 9th, 10th and 11th Standing Committee of Shanghai people's Political Consultative Conference.

Huiyan ZHANG, Shanghai Futures Exchange

Chief representative of Shanghai Futures Exchange in Singapore and Chief financial expert at Shanghai Futures Exchange. He received his Master’s degree and PhD degree in Economics from Fudan University and Johns Hopkins University, respectively. He has been the Chief Financial Engineering Specialist at Shanghai Futures Exchange since 2011.

Conference Chairs:
Qingfu LIU, Fudan University
Liyan HAN, Beihang University
Jianqing FAN, Princeton University
Jinqing ZHANG, Fudan University

Program Committee:
Michael A.H. DEMPSTER, University of Cambridge
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Huiyan ZHANG, Shanghai Futures Exchange
Peng LIU, Cornell University
Jun CAI, City University of Hong Kong
Zhenlong ZHENG, Xiamen University
Jaime CASASSUS, Universidad Catolica de Chile

Journals of Special Issues (学术支持期刊):
1. The Journal of Futures Market (JFM)
2. Quantitative Finance (QF)
3. 《国际金融研究》（Studies of International Finance）
4. 《中国管理科学》（Chinese Journal of Management Science）

PROGRAM PLAN

	Room 510	Room 514	Room 614	Room 710	Room 805
8:30am-10:00am	SAT1-01 Option	SAT1-02 Volatility	SAT1-03 Futures	SAT1-04 Exchange rate	SAT1-05 Bond
10:15am-11:45am	SAT2-01 Commodity Futures	SAT2-02 Volatility and uncertainty	SAT2-03 Stocks	SAT2-04 Options and Futures	SAT2-05 Stock and Futures
2:00pm-3:30pm	SAT3-01 Price Discovery	SAT3-02 Allocation and Risk Premium	SAT3-03 Futures (In Chinese)	SAT3-04 Liquidity Risk	SAT3-05 Futures and Option (In Chinese)

8:30am-10:00am	SAT1-01 Option (Room 510)
Building	Session Chair: **Jianhui Li**
	Which Model for Option Valuation in China? : Empirical Evidence from SSE 50 ETF Options Zhuo Huang, Peking University **Chen Tong**, Peking University Tianyi Wang, University of International Business and Economics Discussant: **Jianhui Li**
	Why (Not) Hedging Housing Price Risks? Liquidity Analysis of US Home Price Index Options **William Cheung**, Waseda University Stephan Unger, University of Toulouse Stephan Unger, Saint Anselm College Discussant: **Chen Tong**
	How do US Option Traders "Smirk" on China: Evidence from FXI Options Market **Jianhui Li**, University of Otago Sebastian Gehricke, University of Otago Jin E. Zhang, University of Otago Discussant: **William Cheung**
8:30am-9:30am	SAT1-02 Volatility (Room 514)
	Session Chair: **Xingguo Luo**
	Volatility Index and the Return-Volatility Relation: Intraday Evidence from China Jupeng Li, Shanghai Stock Exchange

	Xingguo Luo, Zhejiang University Xiaoli Yu, Zhejiang University Discussant: **Yaofei Xu**
	Volatility Information Difference between CDS, Option and the Cross Section of Option Returns Biao Guo, Renmin University of China **Yukun Shi** and **Yaofei Xu**, University of Glasgow Discussant: **Xingguo Luo**
8:30am-10:00am	SAT1-03 Futures (Room 614)
	Session Chair: **Feng He**
	Intraday and Overnight Interaction between Crude Oil Futures and World Equity Markets **Jing Hao**, Tianjin University Xiong Xiong, Tianjin University **Feng He**, Tianjin University of Finance and Economics Wei Zhang, Tianjin University Discussant: **Aysegul Ates**
	Market Quality and the Connectedness of Steel Rebar and Other Industrial Metal Futures in China Ivan Indriawan, Auckland University of Technology **Qingfu Liu**, Fudan University Yiuman Tse, University of Missouri—St.Louis Discussant: Jing Hao
	Information Transmission in Turkish Equity Index Futures Market **Aysegul Ates**, Akdeniz University Hakan Er, Akdeniz University Discussant: **Qingfu Liu**
8:30am-10:00am	SAT1-04 Exchange Rate (Room 710)
	Session Chair: **Jun Song**
	The Term Structure of Sovereign CDS and the Cross-Section of Exchange Rate Predictability **Giovanni Calice**, Loughborough University Ming Zeng, Singapore Management University Discussant: **Yong Mai**
	Oil Price Uncertainty and the Predictability of Exchange Rates Zhi Su, Central University of Finance and Economics Man Lu, Central University of Finance and Economics **Libo Yin**, Central University of Finance and Economics Discussant: **Giovanni Calice**
	Study of Multinational Currency Co-movement and Exchange Rate Stability Relationship Using Network Game Theory

	Yong Mai, East China University of Science and Technology Zhen Yu Li, East China University of Science and Technology Jun Zhong Zou, East China University of Science and Technology Sai-Ping Li, Academia Sinica Discussant: **Libo Yin**
8:30am-10:00am	SAT1-05 Bond (Room 805)
	Session Chair: **Ping Li**
	Valuation Model for Chinese Convertible Bonds with Soft Call/Put under Hybrid Willow Tree Changfu Ma, Tongji University **Wei Xu**, Tongji University George Yuan, Tongji University Discussant: **Xinting Li**
	The Impact of Chinese Write-Down Bonds Issuance on Commercial Bank's Capital Structure Shan LIN, School of Economics and Management **Ping Li**, Beihang University Discussant: **Wei Xu**
	Pricing Corporate Bonds with Credit Risk, Liquidity Risk and Their Correlation Baochen Yang, Tianjin University **Xinting Li**, Tianjin University Yunpeng Su, Tianjin University Yunbi An, University of Windsor Discussant: **Ping Li**
10:15am-11:45am	SAT2-01 Commodity Futures (Room 510)
	Session Chair: **Xiaoquan Liu**
	Demystifying Commodity Futures in China John Hua Fan, Griffith Business School Griffith University **Tingxi Zhang**, Griffith Business School Griffith University Discussant: **Xiaoqian Zhu**
	Impact of US Macroeconomic News Announcements on Chinese Commodity Futures Market **Haidong Cai**, University of Nottingham Ningbo Ying Jiang, University of Nottingham Ningbo Xiaoquan Liu, University of Nottingham Ningbo Discussant: **Tingxi Zhang**

	Identifying the Influence Factors of Commodity Futures Market through a New Text Mining Approach Jianping Li, University of Chinese Academy of Sciences Guowen Li, University of Chinese Academy of Sciences **Yanzhen Yao**, University of Chinese Academy of Sciences Xiaoqian Zhu, University of Chinese Academy of Sciences Discussant: **Haidong Cai**
10:15am-11:45am	SAT2-02 Volatility and Uncertainty (Room 514)
	Session Chair: **Yaofei Xu**
	Subjective Model Uncertainty, Variance Risk Premium, and Speculative Trading **Ming Guo**, Shanghai Tech University Hao Zhou, Tsinghua University Discussant: **Yaofei Xu**
	Digital Economy Era: The Role of Telecommunications Sector in Frequency Department Default Risk Connectedness **Shimeng Shi**, Curtin University Pei Liu, Newcastle University Discussant: **Ming Guo**
	Computing CDS Implied Volatility from Deep Out-of-the-money American Put Options **Yaofei Xu**, University of Glasgow Yukun Shi, University of Glasgow Cheng Yan, Essex University Hao Zhang, Adam Smith Business School Discussant: **Shimeng Shi**
10:15am-11:45am	SAT2-03 Stock (Room 614)
	Session Chair: **Chuanhai Zhang**
	The Impact of Options Introduction on the Underlying Stock: Evidence from Chinese Stock Markets Haiqiang Chen, Ximen University Gideon Bruce Arkorful, Ximen University **Chuanhai Zhang**, Zhongnan University of Economics and Law Discussant: **Hye-Hyun Park**
	Put-call Ratio and the Stock Return: Evidence from China's 50ETF Option **Jianhua Gang**, Renmin University of China Xinchen Ma, Renmin University of China Ke Song, Renmin University of China Ruyi Zhang, Renmin University of China Discussant: **Chuanhai Zhang**

	A Smiling Bear in the Equity Options Market and the Cross-section of Stock Returns **Hye-hyun Park**, Southwestern University of Finance and Economics Baeho Kim, Korea University Business School Hyeongsop Shim, Ulsan National Institute of Science and Technology Discussant: **Jianhua Gang**
10:15am-11:15am	SAT2-04 Futures (Room 710)
	Session Chair: **Libo Yin**
	High-frequency Price Discovery and Price Efficiency on Interest Rate Futures **Jing Nie**, University of International Business and Economics Discussant: **Libo Yin**
	Can Skewness of Futures-Spot Basis Predict Currency Spot Returns Xue Jiang, Beihang University Liyan Han, Beihang University **Libo Yin**, Central University of Finance and Economics Discussant: **Jing Nie**
10:15am-11:15am	SAT2-05 Stock and Futures (Room 805)
	Session Chair: **Steven Li**
	Volatility and Skewness Spillover between Stock Index and Stock Index Futures Markets during a Crash Period: New Evidence from China Yang Hou, University of Waikato **Steven Li**, RMIT University Discussant: **Ze Wang**
	Trading Rules and Spillover Effects: Evidence from China's Stock Index Futures and Spot Markets **Ze Wang**, Shanghai Jiao Tong University Xiao Qin, Shanghai Jiao Tong University Discussant: **Steven Li**
2:00pm-3:30pm	SAT3-01 Price Discovery (Room 510)
	Session Chair: **Mingdong Xu**
	Price Discovery and Spillover Dynamics in Chinese Stock Index Futures Market: A Nature Experiment on Trading Volume Restriction **Feng He**, Tianjin University of Finance and Economics Xiangtong Meng, Tianjin University **Xiong Xiong**, Tianjin University Discussant: **Zhang Maojun**
	The SABR Process for Pricing Interest Rate Derivatives in Negative Rate Market **KunHuang,** HANKEN school of Economics Discussant: **Feng He**

	Long-Term Equilibrium, Short-Term Variations and Capitalization in Commodity Prices in China **Zhang Maojun**, Guilin University of Electronic Technology Wang Wenhua, Dalian University of Technology Qin Xuezhi, Dalian University of Technology Discussant: **KunHuang**
2:00pm-3:30pm	SAT3-02 Allocation and Risk Premium (Room 514)
	Session Chair: **Guangyou Zhou**
	Can the Improved CMBO Strategies Beat CMBO Index and S&P 500 Index **Jow-Ran Chang**, National Tsing Hua University Wei-Han Liu, Southern University of Science and Technology Discussant: **Xiaoxing Liu**
	A Research on Optional Allocation of Internet Financial Assets in China **Guanyou Zhou**, Fudan University Rui Feng, Fudan University Sumei Luo, Shanghai University of Finance and Economics Discussant: **Jow-Ran Chang**
	Comparison of GARCH Models with Application to China's National Bond Futures **Xiaoxing liu,** Southeast University Pan Tang, Southeast University Yutong Wang, Southeast University Discussant: **Guanyou Zhou**
2:00pm-3:30pm	SAT3-03 Futures (in Chinese) (Room 614)
	Session Chair: **Zongxin Zhang** (张宗新)
	引入国债期货合约能否提升债券市场信息效率 **Whether the Introduction of Bond Futures can Improve Bond Market Efficiency?** 张宗新，复旦大学金融研究院 **张秀秀**，复旦大学金融研究院 点评人：**尹亦闻**
	我国商品期货能提高传统投资组合的绩效吗—基于不同投资组合策略的分析 **Can the Commodity Futures Improve the Performance of Portfolio Investment? The Study of Portfolio Strategy** **张琳琳**，复旦大学经济学院 尹亦闻，复旦大学经济学院 点评人：**张秀秀**
2:00pm-3:30pm	SAT3-04 Liquidity Risk (Room 710)
	Session Chair: **Yongmin Zhang**

	Derivatives Pricing with Liquidity Risk: Validation in Futures Markets **Yongmin Zhang**, Ningbo University Shusheng Ding, Ningbo University Meryem Duygum, Ningbo University Discussant: **Liyan Han**
	Forecasting Oil Volatility with Liquidity Effects: A Genetic Programming Based Method **Shusheng Ding**, Ningbo University Tianxiang Cui, University of Nottingham Ningbo Yongmin Zhang, Ningbo University Mohamed Shaban, Sheffield University Discussant: **Jian Sun**
	Bond Yield Curve Convexity Trading **Jian Sun**, Fudan University Peter Carr, New York University Discussant: **Yongmin Zhang**
2:00pm-3:00pm	SAT3-05 Futures and Option (In Chinese) (Room 805)
	Session Chair: **Xianglin Jiang**(蒋祥林)
	基于订单不平衡指标的商品期货交易策略研究 **The Study on the Unbalanced Order of Trade Strategy on Commodity Futures** **蒋祥林**，复旦大学 王子旭，复旦大学 点评人：**郑丹丹**
	期权隐含模糊性及其对标的资产收益率的影响—基于上证50ETF期权的实证研究 **The Implied Ambiguity of Options and its Impact on the Return on Assets：Empirical Study on SH50ETF Option** 张金清，复旦大学金融研究院 **尹亦闻**，复旦大学金融研究院 点评人：**张琳琳**

Registration places:

We set up two days for registration with the initial registration arranged at Howard Johnson Caida Plaza Shanghai on Oct.18 from 6:30 pm to 9:00 pm and the second registration arranged at school of economics in Fudan University on Oct.19 from 12:30 pm to 1:20 pm.

Transportation:

(1) Taxi: You can take a taxi to the conference venue. If taxi drivers do not understand English, please show them the following Chinese address. (上海市杨浦区国权路 600 号，复旦大学经济

学院)

(2) Subway: You can take (or transfer to) line 10 to Guoquan Road Station（国权路）, then walk 8 min to Guoquan Road 600, School of Economics.

Contacts:

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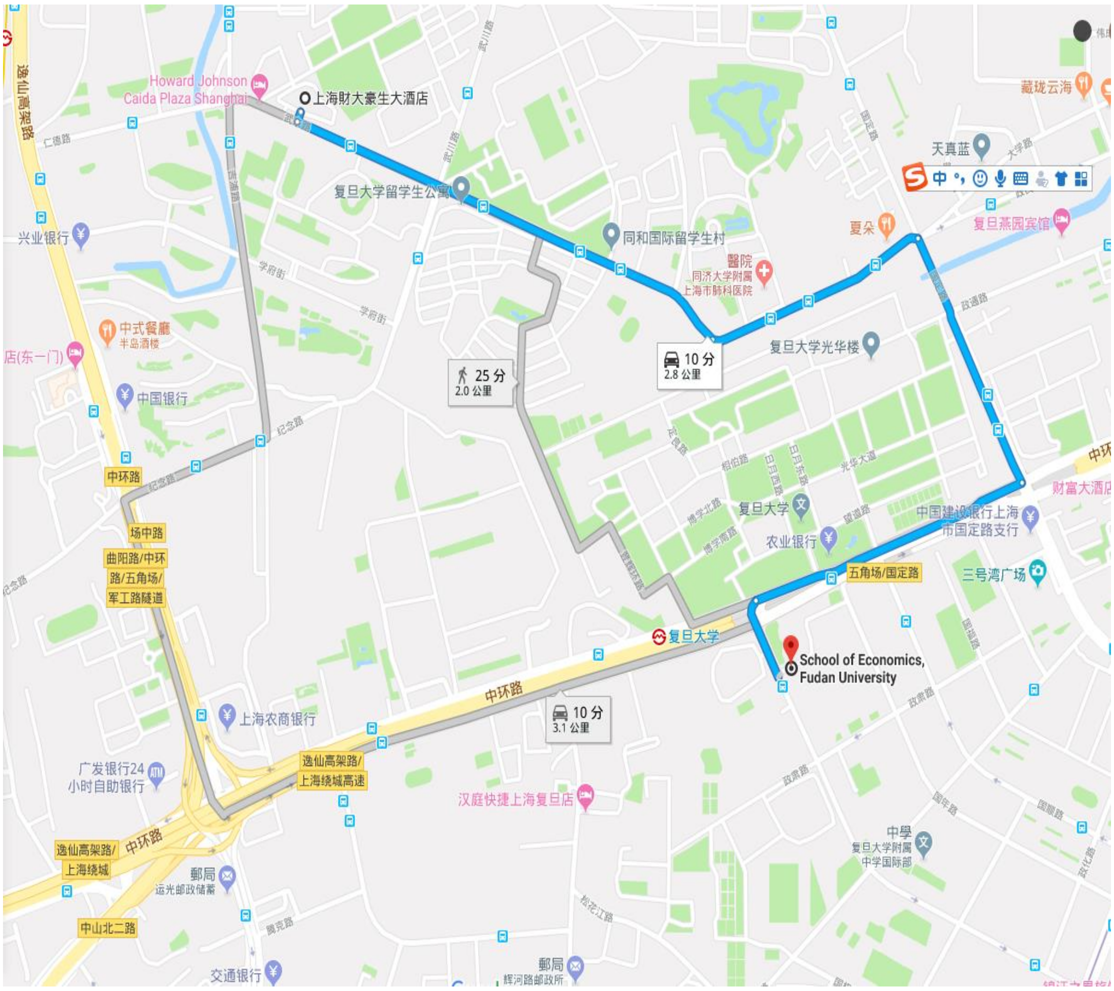
From: Howard Johnson Caida Plaza Shanghai

To: School of Economics, Fudan University



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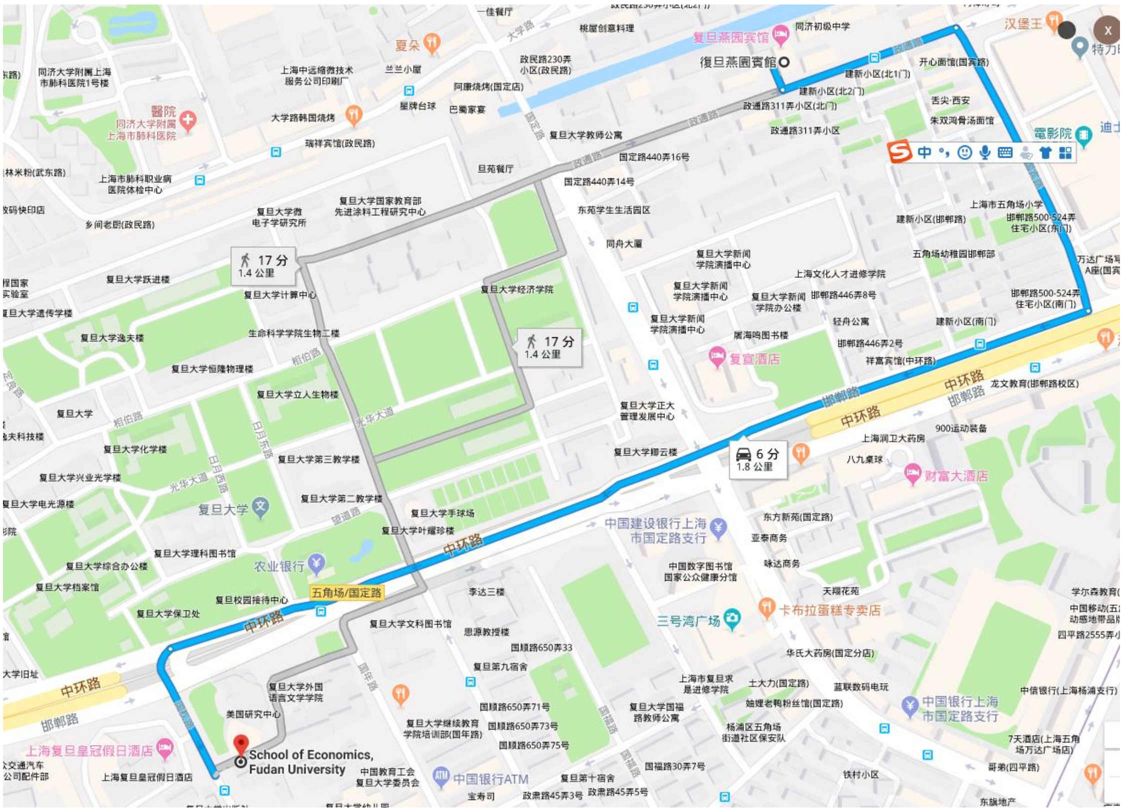
From: Fudan Yanyuan Hotel Shanghai
To: School of Economics, Fudan University



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To: School of Economics, Fudan University