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DETERMINANTS OF SILVER FUTURES PRICE VOLATILITY: EVIDENCE FROM THE THAILAND FUTURES EXCHANGE

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ABSTRACT

This research studies determinants of silver futures price volatility in Thailand Futures Exchange using generalized autoregressive conditional heteroskedasticity model. The sample data consist of daily closing price, volume, and open interest of silver futures from the period June 21, 2011 to December 26, 2012 for the nearby month contract with 376 sample data points. I construct data sample by switching or rolling over to the next maturing contract one day before the expiration date. The empirical results reveal there is no significant relationship between volatility and time to expiration. There are a negative role for trading volume and a positive role for open interest in determining silver futures price volatility. The analysis of silver futures price volatility insists the Clearing House that margin requirements for silver futures should not be affected as the time to maturity of the contract decreases. The findings are also helpful to risk managers dealing with silver futures and predicting silver futures price volatility.

JEL: C32, G13, G32

KEYWORDS: Futures Price Volatility, Silver Futures, Samuelson Hypothesis

INTRODUCTION

Derivatives products such as forwards, futures, and options are great tools, which investors can use to predict future spot prices and minimize their risk. Derivatives in Thailand have started long before Thailand Futures Exchange (TFEX) came into existence. Usually they are in the form of an over-the-counter between each counterparties. On May 17, 2004, TFEX, a subsidiary of the Stock Exchange of Thailand (SET), was established as a derivatives exchange. TFEX has traded SET50 index futures, SET50 index options, gold futures, silver futures, interest rate futures, single stock futures, crude oil futures, USD futures, and sector futures since then. In 2013, TFEX's average daily volume was 68,017 contracts, 55.21% more than the 43,823 in the previous year. About 99.61% of the 2013 derivatives trading were futures. Before trading futures in TFEX, investors are required to deposit initial margin with their respective brokers to ensure that they fulfill their futures contract obligations. Initial margin requirements for futures contracts are set by Thailand Clearing House Co., Ltd. (TCH). Their required rates are the same on the same underlying across different maturities and typically only 10 to 15 percent of the full value of the futures contracts. At the end of day, brokers will calculate the profit and loss and add or subtract funds via a Mark-to-Market process. If the balance in the margin account falls below the maintenance margin level, investor will receive a margin call to top up his or her margin account to meet the initial margin requirement. One of the important factors affecting margin rate is futures price volatility. Therefore, understanding and characterizing futures price volatility has been a key issue in futures market research. Previous research has explained futures price volatility by variables such as time to maturity, volume, and open interest.

Samuelson (1965) states that volatility of futures prices should increase as the contract approaches expiration. It is widely referred to as the "Samuelson hypothesis". The logic behind this conclusion is that the market is more sensitive to news regarding near-maturity contracts than more-distant contracts, which is indicated by greater volatility for the near-maturity contract (Ripple and Moosa, 2009). Numerous studies have investigated the Samuelson hypothesis empirically, and the hypothesis has been supported in commodity futures markets (Daal and Farhat, 2004; Duong and Kalev, 2008; Karali, Dorfman and Thurman, 2009; Karali and Thurman, 2010) and currency futures markets (Madarassy Akin, 2003). Samuelson hypothesis also holds in TFEX where SET50 futures price volatility (Dolsutham et al., 2011) and gold futures price volatility (Jongadsayakul, 2014b) increase as expiry approaches. However, using GARCH(1,1), Jongadsayakul (2014a) find the evidence of inverse maturity effect in case of crude oil futures traded in TFEX. In addition, Chen, Duan and Hung (1999) find that the volatility of the Nikkei-225 index futures price decreases when the contract is closer to its maturity.

Futures trading activity proxied by volume and open interest is another important determinant of futures price volatility. Numerous works have examined the relationship between trading volume and futures price volatility. Considerable evidence exists a positive correlation between futures price volatility and trading volume (Madarassy Akin, 2003; Xin, Chen and Firth, 2005; Kuo, Hsu and Chiang, 2005; Pati, 2006; Ripple and Moosa, 2009; Jongadsayakul, 2014a, 2014b); however, Bessembinder and Seguin (1993) suggest that the volatility-volume relationship might depend on the type of trader. Daigler and Wiley (1999) find that the public drives the positive volatility-volume relationship whereas trades by clearing members and floor traders often exhibit an inverse relationship between volatility and volume. Moreover, Avramov et al. (2006) show that informed trades lead to a reduction in volatility while non-informational trades lead to an increase in volatility. The introduction of open interest as an additional explanatory variable is motivated by the fact that open interest and its change differ significantly from trading volume. The expectation is that open interest is negatively related to volatility (Xin, Chen and Firth, 2005; Feng and Chuan-zhe, 2008; Ripple and Moosa, 2009; Jongadsayakul, 2014b), as the availability of more contracts represents increased market depth, implying greater liquidity. However, Madarassy Akin (2003) and Pati (2006) find the positive relationship between open interest and financial futures price volatility. Higher open interest means that there are more future trade expected and more opportunity for the prices to move into higher or lower levels. This implies an increase in current futures price volatility.

This paper therefore examines the relationships between silver futures price volatility, time to expiration, trading volume, and open interest in TFEX using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. The results from the MA(1,7,15)-GARCH(1,1) model reveal there is no significant relationship between volatility and time to expiration. Silver futures price volatility is negatively related to trading volume and positively related to open interest. The analysis of silver futures price volatility insists TCH that margin requirements for silver futures should not be affected as the time to maturity of the contract decreases. The findings are also helpful to risk managers dealing with silver futures and predicting silver futures price volatility. Moreover, it adds to literature as another evidence of a negative role for trading volume and a positive role for open interest in determining silver futures price volatility, which are not as expected. The rest of the paper is organized as follows. In section 2, I discuss earlier work related to determinants of futures price volatility. Then I describe the data and outline the methodology in section 3. In section 4, I present empirical results from the MA(1,7,15)-GARCH(1,1) model. Finally, I conclude the paper and summarize the findings in section 5.

LITERATURE REVIEW

The literature contains numerous studies attempting to identify the important variables that influence futures price volatility. Samuelson (1965) states that volatility of futures prices should increase as the contract approaches expiration. It is widely known as the "Samuelson hypothesis". His study is based on two assumptions, namely that: (1) futures price equals expected future spot price, and (2) the spot price is stationary following an AR(1): $P_t = aP_{t-1} + u_t$, where $E(u_t) = 0$ and $E(u_t^2) = \sigma^2$. Bessembinder et al. (1996) presents a new analysis of the economic issues underlying the prediction of greater volatility for the near-maturity futures contract. They show the Samuelson hypothesis is successful without the two assumptions. In their study, the change in the log futures price (Δf_t) is the summation of the ex-ante spot market risk premium (π), the unexpected rate of spot market price appreciation (u_t), and the change in the futures term slope weighted by the remaining time to expiration ($\Delta s_t \tau$). Therefore, the variance of futures price changes is

$$\mathrm{VAR}(\Delta f_t) = \mathrm{VAR}(u_t) + \tau^2 \mathrm{VAR}(\Delta s_t) + 2\tau \mathrm{COV}(u_t, \Delta s_t). \tag{1}$$

where VAR and COV denote variance and covariance, respectively. If $\mathrm{VAR}(\Delta s_t)$ is a positive constant, then the variance of futures price increases with the square of the remaining time to contract expiration. Higher variance for more distant delivery date is inconsistent with the Samuelson hypothesis. Unlike $\mathrm{VAR}(\Delta s_t)$, the sign of $\mathrm{COV}(u_t, \Delta s_t)$ can be negative or positive. If $\mathrm{COV}(u_t, \Delta s_t) < 0$, then the third term on the right side of (1) increases (toward zero) as the trading date approaches the contract expiration date. Therefore, their analysis implies that the Samuelson hypothesis requires negative covariance between spot returns and the slope of the futures term structure, which occurs in markets where prices are mean reverting.

The Samuelson hypothesis has been empirically supported in commodity futures markets (Daal and Farhat, 2004; Duong and Kalev, 2008; Karali, Dorfman and Thurman, 2009; Karali and Thurman, 2010) and currency futures markets (Madarassy Akin, 2003). Samuelson hypothesis also holds in cases of SET50 futures price volatility (Dolsutham et al., 2011) and gold futures price volatility (Jongadsayakul, 2014b). However, Chen, Duan and Hung (1999) find the inverse maturity effect in the Nikkei-225 index futures price volatility. Other studies also show that their results depend on the data and the methodology. Floros and Vougas (2006) find that the Samuelson hypothesis seems to be correct in simple linear regressions for both FTSE/ASE-20 and FTSE/ASE Mid 40 index. On the other hand, using GARCH models, there is no evidence to support Samuelson's hypothesis in FTSE/ASE-20 index over the whole period. However, using monthly series, GARCH models show a stronger support to the Samuelson hypothesis rather than linear regressions. Moreover, Jongadsayakul (2014a) shows that there is no significant relationship between crude oil futures price volatility and time to expiration in linear regression model while there is an evidence of inverse maturity effect in GARCH(1,1) model.

Futures trading activity proxied by volume and open interest is another important determinant of futures price volatility. When trading volume increases, it increases the probability that prices will move into higher or lower regions, and that their volatility will be greater than before (Xin, Chen and Firth, 2005). On the other hand, trading volume can be used as a measure of the information flow. Therefore, when new and unexpected information arrives, both volatility and volume change contemporaneously and positively to new information. Numerous works identify a strong positive relation between price volatility and trading volumes (Madarassy Akin, 2003; Xin, Chen and Firth, 2005; Kuo, Hsu and Chiang, 2005; Pati, 2006; Ripple and Moosa, 2009; Jongadsayakul, 2014a, 2014b). However, Bessembinder and Seguin (1993) suggest that the volatility-volume relationship might depend on the type of trader.

Daigler and Wiley (1999) find that the public drives the positive volatility-volume relationship whereas trades by clearing members and floor traders often exhibit an inverse relationship between volatility and volume. Moreover, Avramov et al. (2006) show that informed trades lead to a reduction in volatility while non-informational trades lead to an increase in volatility. Besides trading volume, open interest is important indicator of trading activity. It reflects the current willingness of futures traders to risk their capital in the futures position, which indicates the level of market depth (Bessembinder and Seguin, 1993). A high level of open interest could help to create market conditions that would reduce pressure from prices when trading provides new information (Xin, Chen and Firth, 2005). Several studies find that open interest is negatively related to volatility (Xin, Chen and Firth, 2005; Feng and Chuan-zhe, 2008; Ripple and Moosa, 2009; Jongadsayakul, 2014b). However, Madarassy Akin (2003) and Pati (2006) find the positive relationship between open interest and financial futures price volatility. Higher open interest means that there are more future trade expected and more opportunity for the prices to move into higher or lower levels. This implies an increase in current futures price volatility.

DATA AND METHODOLOGY

This study examines determinants of silver futures price volatility by using daily data downloaded from the websites of SETSMART and TFEX. The sample data consist of daily closing price, time to maturity, trading volume, and open interest of silver futures from the period June 21, 2011 to December 26, 2012 for the nearby month contract with 376 sample data points. I construct data sample by switching or rolling over to the next maturing contract one day before the expiration date. To analyze the volatility of silver futures price, I employ Generalized Autoregressive Conditional Heteroskedasticity (GARCH) methodology. Based on Akaike Information Criterion (AIC) and Schwarz-Bayes Criterion (SBC), a MA(1,7,15)-GARCH(1,1) model is chosen. Moreover, the basic GARCH specification is augmented by time to maturity variable and two trading activity variables, open interest and trading volume, in order to determine their relative contribution to the conditional variance. The following model is then estimated to investigate silver futures price volatility in TFEX.

$$R_t = \lambda_0 + \varepsilon_t + \mu_1\varepsilon_{t-1} + \mu_7\varepsilon_{t-7} + \mu_{15}\varepsilon_{t-15};\ \varepsilon_t|\Omega_{t-1} \sim N(0, h_t) \quad (2)$$

$$h_t = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} + b_1 m_t + b_2 q_t + b_3 o_t \quad (3)$$

where R_t is the futures return, which are obtained by taking the difference of log of futures prices, h_t is the conditional variance, m_t is the time to maturity, q_t is the trading volume, o_t is the open interest, $\boldsymbol{\lambda}_0$, α_0, μ_i, and b_i are parameters, α_1 is the ARCH coefficient, β_1 is the GARCH coefficient. The sum of ARCH and GARCH coefficients indicates the degree of persistent in volatility.

RESULTS

To study determinants of silver futures price volatility, the MA(1,7,15)-GARCH(1,1) model is augmented by including time to maturity (m), trading volume (q), and open interest (o) as explanatory variables in the conditional variance equation. Then Bellerslev-Woodbridge's Quasi-Maximum Likelihood (QML) is used to estimate the MA(1,7,15)-GARCH(1,1) model. Table 1 presents the estimated results of MA(1,7,15)-GARCH(1,1) model, displaying the estimated coefficients and their P-values, as well as diagnostics tests and Wald test. The validity of the estimated model is assessed first by testing the standardized residuals for the presence of serial correlation and heteroskedasticity. Ljung-Box Q-test statistics up to lags 36 for serial correlation in the standardized residuals and standardized squared residuals are 18.224 (Prob. = 0.9824) and 38.456 (Prob. = 0.2361), respectively. Then a Lagrange Multiplier test is employed to examine whether the standardized squared residuals exhibit additional ARCH. LM ARCH (5) test is 8.272 (Prob. = 0.1419), which implies that the null hypothesis of no ARCH effects cannot be rejected and reveals that no further ARCH effects left in the standardized residuals.

The insignificant Ljung-Box Q statistics and LM ARCH statistics implies that the residuals of the estimated MA(1,7,15)-GARCH(1,1) model are reasonably well behaved and adequately capture the persistence in the variance of returns. Moreover, the estimation results of MA(1,7,15)-GARCH(1,1) model show that the coefficient for the previous shock (the ARCH coefficient: α_1) is 0.1787 and that for its lagged conditional variance (the GARCH coefficient: β_1) is 0.5080. The GARCH coefficient (β_1) is highly statistically significant at the level of 1%. The sum of the two coefficients is 0.6867, which implies that the persistent in volatility is not so high. Since the Wald test shows the sum of the two coefficients statistically less than 1 at the 1% significance level, the volatility process is co-variance stationary, stable and evidences of mean reverting. Maturity is shown to be insignificant. The estimated coefficients of volume and open interest are -0.0003 and 0.0003, respectively, which are statistically significant at the level of 10% and 5%, respectively.

However, the signs of trading volume and open interest coefficients are not as expected. The results indicate a negative relationship between trading volume and volatility due to higher informed trades in TFEX. An increase in open interest means that there are more future trade expected and more opportunity for the prices to move into higher or lower levels. This leads to an increase in current futures price volatility.

$$R_t = \lambda_0 + \varepsilon_t + \mu_1 \varepsilon_{t-1} + \mu_7 \varepsilon_{t-7} + \mu_{15} \varepsilon_{t-15};\ \varepsilon_t | \Omega_{t-1} \sim N(0, h_t)$$
$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + b_1 m_t + b_2 q_t + b_3 o_t$$

Table 1: Estimation Results of MA(1,7,15)-GARCH(1,1) Model

Conditional Mean Equation Coefficient/Statistic	Estimated Value	P-Value
λ_0	-0.0005	0.4871
μ_1	-0.0759	0.1998
μ_7	0.0592	0.2481
μ_{15}	-0.1051^{**}	0.0459
Conditional Variance Equation		
α_0	0.0001	0.1630
α_1	0.1787	0.2225
β_1	0.5080^{***}	0.0092
b_1	0.0000	0.7573
b_2	-0.0003^{*}	0.0651
b_3	0.0003^{**}	0.0378
Standardized Residual Diagnostics		
Ljung-Box Q (36)	18.224	0.9824
Ljung-Box Q^2 (36)	38.456	0.2361
LM ARCH (5)	8.272	0.1419
Wald Test		
H_0: $\alpha_1 + \beta_1 \geq 1$	-2.490^{***}	0.0064

*This table shows the estimation results of MA(1,7,15)-GARCH(1,1) Model. Diagnostics tests based on LM ARCH (5), Ljung-Box Q (36), and Ljung-Box Q^2 (36) of residual and squared residual indicate that the estimated model is well fit. The sum of ARCH and GARCH coefficients is 0.6867, indicating that the persistent in volatility is not so high. Wald test shows its value statistically less than one, indicating that volatility process is co-variance stationary, stable and evidences of mean reverting. Maturity is insignificant, whereas trading volume and open interest tend to be significant. ***, **, and * indicate statistically significant at the 1%, 5%, and 10% level, respectively.*

CONCLUDING COMMENTS

This research studies determinants of silver futures price volatility in Thailand Futures Exchange using the MA(1,7,15)-GARCH(1,1) model. The sample data consist of daily closing price, volume, and open interest of silver futures from the period June 21, 2011 to December 26, 2012 for the nearby month contract with 376 sample data points. I construct data sample by switching or rolling over to the next maturing contract one day before the expiration date. The results from the MA(1,7,15)-GARCH(1,1) model reveal there is no significant relationship between silver futures price volatility and time to expiration, whereas trading volume and open interest tend to be significant. However, the signs of trading volume and open interest coefficients are not as expected. The results indicate a negative relationship between silver futures price volatility and trading volume, and a positive relationship between silver futures price volatility and open interest. Therefore, trading volume and open interest are the two important variables, explaining the price volatility of silver futures traded in TFEX. Since margin requirement is affected by futures price volatility, the results of this study will assist TCH in setting margin requirements. No consistent relationship between silver futures price volatility and time-to-maturity indicates that the margin requirement should not be affected as the time-to-maturity of the silver futures contract decreases. The findings are also helpful to risk managers dealing with silver futures and predicting silver futures price volatility. It is noted that the role of trading volume on silver futures price volatility is negative. The inverse relationship between volume and volatility is possible due to trading by clearing members and floor traders. However, this study uses total volume. Therefore, further analysis of this issue should include both informed trades and non-informational trades to confirm the results.

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