International Scholars Journals

International Journal of Management and Business Studies ISSN 2167-0439 Vol. 7 (12), pp. 001-008, December, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

The relationship of price volatility between TSE and TAIFEX stock indices futures with different maturities

Yung-Chang Wang* and Wen-Rong Ho

Department of Banking and Finance, Chinese Culture University, 55 Hwa-Kang Road, Yang-Ming-Shan, Taipei 11114, Taiwan.

Accepted 13 September, 2017

Using the data set from January 2, 2004 to April 28, 2006, this study examined all aspects of the relation between volatility in the cash index and volatility in the nearby-month and nearby-quarter index futures. The GARCH Model was first estimated to examine the impact of the futures volume growth on the conditional variance of the cash price and vice versa. Next, the conditional variances at the 10-day interval were calculated to derive the variance series for performing Granger-Causality Tests. Evidence from the GARCH (1,1) estimation indicated that the cash volume growth lost the power in explaining its own price volatility when the futures volume growth was included in the conditional variance equation of the cash index return, the cash volume growth had no influences on volatility in the futures markets, and the trading volume growth of nearby-month index futures was most influential in explaining volatility in the three markets. The Granger Causality Test was performed for the co-integrated variance series in the context of the error correction model. Evidence indicated that there were one-way volatility spillovers from the index futures to the cash index and there were two-way volatility spillovers between the nearby-month and nearby-quarter index futures markets.

Key words: TSE stock index, TAIFEX stock index futures, GARCH, ECM, Granger causality, volatility.

INTRODUCTION

The Taiwan stock index futures contract is the first futures commodity introduced into the Taiwan futures market by TAIFEX (Taiwan Futures Exchange) on July 21, 1998. Since then the Taiwan futures market has been steadily growing. Seven futures commodities are currently traded on the market. The daily average of the futures contracts traded rose dramatically from 4,512 in 1999 to 40,923 in 2005. The futures contracts traded on TAIFEX include TX, Electronics futures (TE), Financial futures (TF), Small- size Taiwan index futures (MTX), Taiwan 50 futures (T5F), 10-year Government Bond Futures (GBF), 30-day Commercial Paper Futures (CPF), MSCI (Morgan Stanley Capital International) Taiwan index futures (MSF), and Gold futures (GD). The increasing importance of the futures market in the Taiwan financial markets has received considerable attention from academics and financial analysts. The futures contract is extensively used as arbitrage, hedge, and price discovery. The value of the stock index futures is the future value of the cash index. The relation between the futures price and the cash price can be expressed as the cost of carry theory: $F_{t,T} = S_t \exp\{r(T-t)\}$, which states that the futures price ($F_{t,T}$) expected at time t is the compound interest growth of the cash price (S_t) from time t to time T at the cost of capital (r). If instantaneous arbitrage were possible, the index futures would neither lead nor lag the cash index. Price discovery implies that information could be transmitted from the futures market to the spot market because those trading on the futures market are generally informed traders. Arbitrage and information transmission are factors to link the two markets closely.

In the real world, neither instantaneous arbitrage nor efficient information transmission are present; the lead-lag relation between the index futures and the cash index is observed. Some studies suggested that the index futures price is uni-directionally causal with the cash price (Pizzi et al., 1998; Nicto et al., 1998; Frino and West, 1999;

*Corresponding author: E-mail: wyc9@faculty.pccu.edu.tw. Tel: 886-2-28610511. Ext. 36211.

Abbreviations: TAIFEX, Taiwan Futures Exchange; **TSE,** Taiwan Securities Exchange.

Min and Najand, 1999; Hsu and Chien, 2003). Others studies found that the index futures price is bi-directionally causal with the cash price (Turkington and Walsh, 1999; Hsu and Ho, 2000; Huang and Hsu, 1997). Still others reported that the cash index is uni-directionally causal with the index futures (Goo and Chang, 2003; Abhyankar, 1998; Green and Joujon, 2000). According to Darrat and Rahman (1995), two characteristics offer investors easy access to stock index futures, that is, close linkage of the index futures with the spot index and inexpensiveness to trade on the futures market. Both characteristics are considered to be the factor for some observers to attribute stock market volatility to futures trading. Bookstabler and Pomerantz (1989); Ross (1989) showed that the volatility of prices is directly related to the rate of information flow and thus any event that increases the rate of information flow simultaneously increases price volatility. The theory may lead to a conjecture that the futures trading activity causes volatility on the stock market. Some studies found that stock prices have become more volatile since the introduction of stock futures (Lockwood and Linn, 1990; Lee and Ohk, 1992), while others found no more volatility associated with the introduction of stock futures (Yu and Wu, 2000; Schwert, 1990; Ely, 1988). Some studies found mutual volatility spillovers between the two markets (Goo and Chang, 2003; Chuang, 2001; Min and Najand, 1999). Some studies reported evidence for uni- directional volatility spillovers from the index futures to the cash index (Koutmos and Tucker, 1996; Iihara et al., 1996), while others found evidence for uni-directional volatility spillovers from the cash index to the index futures (Chuang, 2001).

The purpose of this study is to examine all aspects of the relation between volatility in the cash index and volatility in the nearby-month and nearby-quarter index futures. We first use the generalized autoregressive conditional heteroscedastic (GARCH) model to examine the impact of futures trading volume growth on the conditional variance of the cash price and vice versa. Next, we calculate the variance series for the cash index, the nearby-month index futures, and the nearby-quarter index futures at the 10- day interval and then conduct the Granger causality test for these co-integrated variance series in the context of the error correction model (ECM). The results from the Granger causality test depict the cross-market volatility spillover effect. The daily data for TSE (Taiwan Securities Exchange) stock index and TAIFEX nearby-month and nearby-quarter stock index futures covers the period from January 2, 2004 to April 28, 2006. The data set is collected from the TEJ (Taiwan Economic Journal) database. This study was organized as follows. A brief introduction is provided, a review of several relevant articles, a comment on them, and a brief introduction to methodology. The empirical results from the GARCH model and the Granger causality test, the summary and conclusions are also presented in this paper.

LITERATURE REVIEW

Gannon (2010) develops simultaneous volatility models that allow for simultaneous and unidirectional volatility and volume of trade effects. Intraday data from the Australian cash index and index futures markets are used to test these effects. Overnight volatility spillover effects are tested with the data from the S and P 500 index using alternative estimates of the United States volatility. It is found that the simultaneous volatility model is robust to alternative specifications of returns equations and to misspecification of the direction of volatility causality. Kanas (2009), using a time-varying regime-switching vector error correction approach, finds that the NIKKEI stock index cash and futures prices are jointly characterized by regime switching, which is time-varying and dependent upon the basis, the interest rate, the volatility of the cash index, and the US futures market.

Goo and Chang (2003), utilizing EC-EGARCH (1,1) and EGARCH(1,1)-X, examined the dynamic relationship between the Taiwan stock index futures and cash prices. The results indicated that co-integration exists between both markets in spite of reducing the transaction tax and the error correction factor exerts significant influences on the conditional mean and variances in both markets. Moreover, it was found from EC-EGARCH (1,1) that, should the error correction factor be assumed to influence the conditional mean only, the cash market would display significant volatility asymmetry, volatility would be transmitted from the cash market to the futures market, and the volatility in the futures market would persist longer than that in the cash market. However, the findings from EGARCH (1,1)-X suggested that both markets display significant volatility asymmetry and volatility spillovers are bi- directional. Chuang (2001) investigated the volatility asymmetry and cross-market volatility spillovers among the spot, nearby-month, and nearby-quarter stock index futures markets traded on TAIFEX. The findings indicated that the nearby-month and nearby-quarter futures markets do not play the price discovery role in the spot market, Moreover, cross-market volatility spillovers exist between the spot and nearby-month futures markets and the unexpected standardized innovation of the spot price shows uni-directional cross-market volatility spillovers to the nearby-quarter futures market.

Yu and Wu (2000), utilizing the modified Levene statistics and GARCH model, examined the impact of the index futures on the spot market volatility for the U.S., U.K., France, Japan, Australia, and Hong Kong. The results derived from the modified Levene statistics were quite different from those from the GARCH model. The former reported that cash market volatility for the period after the introduction of the index futures significantly differs from that for the period before the introduction of the index futures. The latter indicated that no evidence that the futures market increases the cash market volatility and no extensively structural changes after the introduction of the index futures are found.

Darrat and Rahman (1995) presented an empirical examination of the view that futures trading activity has contributed to jump volatility of the stock market. The futures trading activity is represented by the trading volume and the open interest in the S and P 500 index futures. They estimated the underlying cash market volatility by control over the possible impact from other market factors independent of futures trading. It was found that the coefficients on the measures of futures trading (albeit appearing with the correct positive signs) are statistically insignificant at conventional levels and non-rejection of the null hypothesis that futures trading volume does not Granger- cause jump volatility in stock prices. It seems, therefore, that futures trading (however measured) should not be blamed for any increased volatility of stock prices in recent years.

The mixed empirical evidence regarding the cross-market volatility spillover effect for the Taiwanese case, one-way volatility spillovers from the cash index to the index futures or mutual volatility spillovers are found from Goo and Chang (2003); Chuang (2001), depending on what empirical models are constructed or what maturities of futures contracts are in discussion. Darrat and Rahman (1995) found no evidence that the futures trading activity causes stock price volatility. This study purports to examine the impact of the index futures with different maturities on volatility in the cash index. The methods used in this study include the ADF (Augmented Dickey-Fuller) Unit-Root Test, the PP (Phillips-Perron) Unit-Root Test, the Johansen co-Integration Test, the ECM Estimation, the Granger Causality Test, and the GARCH (1,1) Model Estimation. All the methods can be found in the standard econometrics or time-series econometrics textbooks. This study will not be intended to detail any of the methods.

EMPIRICAL RESULTS

Data and variables

The data collected for this study is from the TEJ database at the daily interval, covering the period from January 1, 2004 to April 28, 2006. The arbitrarily chosen period excludes the year 2003 when Severe Acute Respiratory Syndrome (SARS) occurred, which is believed to have had a substantial impact on the Taiwan securities markets. It also excludes the years 2001 and 2002 when the Taiwan economy was in the phase of recession. It could be said that the Taiwanese securities experienced relatively steady growth during the period under investigation.

This data set is comprised of three pairs of time series, namely, the TSE stock index cash price and trading volume in shares, the TAIFEX (Taiwan Futures Exchange) nearby-month stock index futures price and trading volume volume in contracts as well as the TAIFEX nearby-quarter stock index futures price and trading volume in contracts. Each of the six series contains 574 observations and is transformed to the logarithmic form. For convenience, the TSE stock index cash price and trading volume in shares are denoted by P_s and Q_s, the TAIFEX nearby-month stock index futures price and trading volume are denoted by P_{1f} and Q_{1f}, and the TAIFEX nearby-quarter stock index futures price and trading volume are denoted by P_{2f} and Q_{2f}. Their first differences are denoted by DP_i and DQ_i, i = s, 1f, and 2f, where DP_i measures the daily return on Security i and DQ_i measures the daily volume growth in Security i. These series are used to detect the volatility clustering effects associated with each of the markets and to examine how trading volume from each of the markets affect these effects.

The six series from the original data set are grouped as Sample I. The data set is also used to examine cross-market volatility spillovers in the context of the error correction model. In so doing, the variance of each price series is computed by applying the sample variance formula to the series at the 10-day interval. Each of the price variance series has 57 observations. They are denoted by VAR_i, i = s, 1f, and 2f for the cash index, the nearby-month index futures, and the nearby-quarter index futures. Their first differences are denoted by $DVAR_i$, i = s, 1f, and 2f. The three series of price volatility computed on the original data set are grouped as Sample II.

The results from the ADF unit-root test for the series from Sample I are reported in Table 1. The table indicates that the six variables regarding prices and volumes are all I(1) series because their levels are non-stationary and their first differences become stationary. The PP (Phillips-Perron) test and the KPSS (Kwaitkowski-Phillips-Schmidt-Shin) test are also found to have the same results.

Table 2 shows the results from the ADF Unit-Root Test for the series from Sample II. It is found that the three variables regarding price volatility are all I(1) series because their levels are non-stationary and their first differences become stationary.

The GARCH (1,1) model

It has been found in many researches that stock prices display volatility clustering effects, which would reduce when trading volume is introduced in the conditional variance equation of the GARCH model (Bohl and Henke, 2003; Lamoureux and Lastrapes, 1990; Gallo and Pacini, 2000). The GARCH (1,1) model given by Equation (1) is estimated for the time series from Sample I.

$$DP_{i,t} = \beta_0 + \beta_1 DP_{i,t-1} + \varepsilon_{i,t}$$

$$\sigma^2_{i,t} = \alpha_0 + \alpha_1 \varepsilon^2_{i,t-1} + \alpha_2 \sigma^2_{i,t-1} + v_{i,t} \quad (1)$$

Table 1. The ADF unit-root test for the series from Sample I.

Variable	Intercept	Trend and intercept	None
P_s	-1.626(4)	-0.503(4)	0.368(4)
Q_s	-2.658(10)[c]	-2.614(10)	-0.049(10)
P_{1f}	-2.116(1)	-0.521(4)	0.254(4)
Q_{1f}	-4.310(6)[a]	-4.307(6)[a]	0.454(15)
P_{2f}	-1.493(4)	-0.456(4)	0.255(4)
Q_{2f}	-4.709(18)[a]	-4.879(18)[a]	-0.338(18)
DP_s	-17.566(1)[a]	-17.594(1)[a]	-17.567(1)[a]
DQ_s	-9.443(9)[a]	-9.465(9)[a]	-9.451(9)[a]
DP_{1f}	-7.119(16)[a]	-7.227(16)[a]	-7.103(16)[a]
DQ_{1f}	-9.699(18)[a]	-9.725(18)[a]	-9.693(18)[a]
DP_{2f}	-18.029(1)[a]	-18.049(1)[a]	-18.035(1)[a]
DQ_{2f}	-13.154(18)[a]	-13.155(18)[a]	-13.166(18)[a]

The lag length is chosen based on the AIC criterion and reported in the parenthesis. [a, b], and [c] denotes rejection of the null hypothesis at the 1%, 5%, and 10% significance levels.

Table 2. The ADF unit-root test for the series from sample II.

Variable	Intercept	Trend and intercept	None
VAR_s	-3.969(10)[a]	-1.848(10)	-3.200(10)[a]
VAR_{1f}	-2.221(6)	-2.537(10)	-3.462(10)[a]
VAR_{2f}	-2.162(6)	-2.506(10)	-3.569(10)[a]
$DVAR_s$	-4.590(9)[a]	-6.850(9)[a]	-4.325(9)[a]
$DVAR_{1f}$	-2.832(5)[c]	-6.370(9)[a]	-2.853(5)[a]
$DVAR_{2f}$	-4.266(9)[a]	-6.515(9)[a]	-2.872(9)[a]

The lag length is chosen based on the AIC criterion and reported in the parenthesis. [a, b], and [c] denotes rejection of the null hypothesis at the 1, 5, and 10% significance levels.

Where, I = s, 1f, and 2f and v is a white noise. The results from estimating the variance equation in the GARCH (1,1) model are shown in Table 3. The Taiwan stock index cash and futures prices unexceptionally exhibit volatility clustering effects in Panel A. The sum of $_1$ and $_2$ ($_1$+ $_2$) evaluates the degree of persistence in volatility. It is found that the sums for the three cases are all higher than 0.97, which indicates a high degree of volatility persistence for the cash and futures prices. The high degree of volatility persistence implies that shocks to the conditional variance would lead to future forecasts of high variances for a protracted period. Next, the GARCH (1,1) model with the first difference of trading volume (trading volume growth) included in the conditional variance equation is given by Equation (2).

$$DP_{i,t} = \beta_0 + \beta_1 DP_{i,t-1} + \varepsilon_{i,t}$$
$$\sigma^2_{i,t} = \alpha_0 + \alpha_1 \varepsilon^2_{i,t-1} + \alpha_2 \sigma^2_{i,t-1} + \alpha_3 DQ_{i,t} + v_{i,t} \quad (2)$$

Panel B presents the empirical results from estimating the conditional variance equation for the time series from Sample I. The sum of $_1$ and $_2$ shows no substantial reduction in volatility persistence when the trading volume growth is considered. On the contrary, DP_{2f} is observed to have an increase in the sum $_1$+ $_2$ from 0.981 to 0.986. To solve the possible simultaneity bias resulting from weak exogeneity of the contemporaneous trading volume growth, $DO_{i,t}$ is substituted with $DO_{i,t-1}$ in the conditional variance equation. The results, however, are unsatisfactory in the sense that volatility persistence remains the same and $_3$'s are all significant with wrong signs except in the case of Q_{2f}. Finally, the following GARCH (1,1) model is constructed to allow the possible cross -market effect of the trading volume growth in a market on the price volatility in another market.

$$DP_{i,t} = \beta_0 + \beta_1 DP_{i,t-1} + \varepsilon_{i,t}$$
$$\sigma^2_{i,t} = \alpha_0 + \alpha_1 \varepsilon^2_{i,t-1} + \alpha_2 \sigma^2_{i,t-1} + \alpha_3 DQ_{i,t} + \alpha_4 DQ_{j,t} + \alpha_5 DQ_{k,t} + v_{i,t} \quad (3)$$

Where, $DQ_{j,t}$ and $DQ_{k,t}$, j,k i, denote the trading volume growth in other markets. Panel C documents the results from estimating Equation (3). It is found that volatility

Table 3. The estimation of the variance equation of GARCH (1,1).

Panel A: Estimation of Equation (1)				
Variable	$_0$	$_1$	$_2$	$_1+_2$
DP_s	3.16E- 06(2.637)[a]	0.075 (5.712)[a]	0.901(45.019)[a]	0.976
DP_{1f}	3.24E- 06 (3.287)[a]	0.074 (6.582)[a]	0.905 (65.792)[a]	0.976
DP_{2f}	3.09E - 06(3.208)[a]	0.072 (6.567)[a]	0.909 (65.184)[a]	0.981

Panel B: Estimation of Equation (2)					
Variable	$_0$	$_1$	$_2$	$_3$	$_1+_2$
DP_s	5.24E - 06 (2.396)[b]	0.151 (4.911)[a]	0.816(19.536)[a]	7.93E - 05 (4.753)[a]	0.967
DP_{1f}	1.68E - 05(5.610)[a]	0.203 (8.969)[a]	0.676(16.067)[a]	9.87E - 05(32.733)[a]	0.879
DP_{2f}	2.49E - 05(2.479)[b]	0.085(7.216)[a]	0.901(60.656)[a]	1.47E - 05(5.531)[a]	0.986

Panel C: Estimation of Equation (3)								
Variable	$_0$	$_1$	$_2$	$_3$	$_1+_2$	$_4$ **and** $_5$		
						DQ_s	**DQ_{1f}**	**DQ_{2f}**
DP_s	9.97E-06(3.107)[a]	0.225 (5.941)[a]	0.695 (13.510)[a]	1.08E-06 (0.054)	0.920		4.35E-05 (4.330)[a]	9.78E-06 (3886.726)[a]
DP_{1f}	1.41E-05 (4.257)[a]	0.214 (8.250)[a]	0.656 (13.595)[a]	8.68E-05 (8.172)[a]	0.870	8.85E-06(0.462)		
DP_{2f}	1.85E-05 (4.302)[a]	0.197 (5.280)[a]	0.634 (10.797)[a]	1.05E-05 (17.002)[a]	0.831	-6.35E-06(-0.295)	6.57E-05 (6.085)[a]	1.00E-05 (4.458)[a]

[a] and [b] denote significance at the 1 and 5% levels.

persistence measured by $_1+_2$ has somewhat reduced by 0.046 to 0.150 compared with their counterparts in Panel A. Interestingly enough, we observe that $_2$ in the conditional variance equation of DP_S becomes insignificant after the inclusion of the futures trading volume growth. The coefficient of DQ_{1f} in particular is 4.45 (= 43.5/ 9.78) times as much as that of DQ_{2f} , indicating that trading volume of the nearby-month index futures is a better measure for the rate of daily information arrivals to the cash market. It is noted that, in the conditional variance equation of DP_{2f}, $_5$ is 6.26 times (= 6.57/1.05) as much as $_3$, implying that the trading volume growth of nearby-month index futures is far more crucial in influencing volatility in DP_{2f} than its own trading volume growth. Finally, the trading volume growth of cash index plays no role in determining volatility in DP_{1f} and DP_{2f} since the coefficients (8.85E-06 and -6.35E-06) are both statistically insignificant.

In order to capture asymmetry in volatility, the TGARCH (1,1) Model is constructed and estimated. The results from the TGARCH (1,1) are basically the same as those from the GARCH (1,1) Model. The asymmetric effect is observed in the three return series. However, the asymmetric effect disappears when the trading volume growth is included in the TGARCH (1,1) Model. The own trading volume growth becomes insignificant when the volume growth of nearby-month and nearby quarter is furthermore included in the conditional variance equation of DP_S. It is found that the coefficient of DQ_{1f} is 4.57 (= 43.4/ 9.49) times as much as that of DQ_{2f}, which indicates that trading volume of the nearby-month index futures is a better measure for the rate of daily information arrivals to the cash market. It is also found that, in the conditional variance equation of DP_{2f}, the coefficient of DQ_{1f} is 4.58 (= 6.18/1.35) times as much as that of DQ_{2f}. Finally, the trading volume growth of cash index plays no role in determining volatility in DP_{1f} and DP_{2f} since the coefficient (1.25E-05) of DQ_S in the DP_{1f} the conditional variance equation is statistically insignificant and the coefficient (-2.14E-05), though significant at the 5% level, takes the wrong sign.

The volatility spillover effect

The three volatility series from Sample II are used to

Table 4. The Johansen Co-integration Test.

Eigenvalue	Likelihood ratio	5% Critical value	1% Critical value	Hypothesized no. of CE(s)
0.371	43.150[a]	29.68	35.65	r = 0
0.226	19.531[b]	15.41	20.04	r 1
0.119	6.464[b]	3.76	6.65	r 2

[a] and [b] denote significance at the 1 and 5% levels.

examine cross-market volatility spillovers. They are VAR_S, VAR_{1f}, and VAR_{2f} representing volatility in the stock index returns for the three markets, respectively. Since all the series are I(1), the Johansen method is used to detect whether they are co-integrated. The trace test is performed until the likelihood ratio is less than the critical value and thus the null hypothesis of i co-integrating vectors is accepted. The results from the co-integration test are reported in Table 4. The likelihood ratio (6.464) is larger than the 5% critical value (3.76), which leads to rejection of the null hypothesis of at most two co-integration vectors. The trace test is supposed to proceed the null hypothesis of at most three co-integration vectors. We have only three variables and thus the maximum number of co-integrating vectors is two. They are written as:

$$VAR_{s,t} = 0.00252 + 0.774 VAR_{2f,t} + \hat{e}_{1,t}$$
$$(37.087)$$
$$VAR_{1f,t} = -0.000547 + 1.011 VAR_{2f,t} + \hat{e}_{2,t}$$
$$(118.729) \quad (4)$$

Where, t-statistics are in parentheses.

Equation (4) indicates that the volatility series exhibit a long-run equilibrium relationship. The significant positive signs imply that they co-move in the same direction. The cash index volatility will increase by 0.774 units and the nearby-month index futures volatility will increase by 1.011 units with one-unit increase in the nearby-quarter index futures volatility. Next, the error correction terms ($\hat{e}_1, \hat{e}_2$) are incorporated into the vector autoregressive (VAR) model to construct the error correction model which exhibits the long-run equilibrium relationship and the short-run dynamic process. The ECM with 5 lagged terms is estimated as follows:

$$DVAR_{k,t} = \alpha_{k,0} + \gamma_{k,1}\hat{e}_{1,t-1} + \gamma_{k,2}\hat{e}_{2,t-1} + \sum_{j=1}^{5}\sum_{i=s,1f,2f} \alpha_{i,t-j} DVAR_{i,t-j} + w_t$$

(5)

Where, $DVAR_k$ is the first difference of VAR_k, k = s,1f, 2f, $\hat{e}_{i,t-1}$ is the lagged error correction term, w is a white noise.

The maximum likelihood method is employed to estimate the ECM and the results are reported in Table 5. The Granger causality test is conducted in the context of the error correction model. A variable causes another variable through two channels, that is, correction for a deviation from the long-run equilibrium and the short-run dynamic adjustment. The null hypothesis for the Granger causality test is as follows:

$$H_0 : \gamma_{k,1} = \gamma_{k,2} = \alpha_{i,1} = ... = \alpha_{i,5} = 0 \quad (6)$$

Which proposes that the i[th] variable does not Granger cause the k[th] variable, i k = s, 1f, and 2f. The LR test is employed to conduct the Granger causality test and the results are shown in Table 6. It is observed that volatility in the nearby-month and nearby-quarter futures returns uni-directionally Granger-causes volatility in the cash return since the LR statistics are even significant at the 1% level. There is a volatility spillover effect from the futures market to the cash market, but not vice versa. Volatility in the nearby-month index futures return is bi-directionally Granger causal with volatility in the nearby-quarter index futures return. A two-way volatility spillover effect is observed for the two futures markets.

CONCLUSION

The Taiwan Futures Exchange (TAIFEX) was instituted on September 9, 1997 based on the Futures Trade Act enacted on March 26, 1997. The Taiwan stock price index futures was the first contract listed on the exchange on July 21, 1998. Since then the Taiwan futures market has been steadily growing. Seven futures contracts are currently traded on the market. The daily average of the futures contracts traded rose dramatically from 4,512 in 1999 to 40,923 in 2005. The increasing importance of the futures market in the Taiwan financial markets has received considerable attention from academics and financial analysts.

The literature regarding cross-market volatility between the cash index and the index futures for Taiwan is unusual. Chuang (2001) found that bi-directional spillovers between the cash index and the near- by month index futures and uni-directional spillovers from the cash index to the near-quarter index futures. Goo and Chang (2003) found that bi-directional spillovers and uni-directional

Table 5. Estimation of the error correction model (Sample II).

Variable	$DVAR_{s,t}$	$DVAR_{1f,t}$	$DVAR_{2f,t}$
$\hat{e}_{1t-1}$	-3.379 (-1.878)	-3.189(-1.450)	-2.943 (-2.147)
$\hat{e}_{2t-1}$	1.370 (0.372)	0.319(0.071)	1.722 (0.392)
$DVAR_{s,t-1}$	1.482 (1.019)	1.847(1.039)	1.758 (1.013)
$DVAR_{s,t-2}$	2.670 (2.062)	3.410 (2.155)	3.141 (2.032)
$DVAR_{s,t-3}$	1.920 (1.636)	2.065 (1.440)	1.989 (1.420)
$DVAR_{s,t-4}$	1.859 (1.954)	2.202 (1.894)	2.151 (1.895)
$DVAR_{s,t-5}$	0.734 (0.957)	1.059 (1.130)	0.974 (1.065)
$DVAR_{1f,t-1}$	0.282 (0.086)	0.970 (0.242)	0.630 (0.161)
$DVAR_{1f,t-2}$	3.563 (1.289)	4.950 (1.466)	4.403 (1.335)
$DVAR_{1f,t-3}$	3.440 (1.342)	5.233 (1.671)	4.755 (1.555)
$DVAR_{1f,t-4}$	-0.084 (-0.038)	0.570 (0.213)	0.573 (0.219)
$DVAR_{1f,t-5}$	-0.642 (-0.445)	-0.165 (-0.093)	-0.173 (-0.101)
$DVAR_{2f,t-1}$	-2.087 (-0.582)	-3.268 (-0.746)	-2.857 (-0.668)
$DVAR_{2f,t-2}$	-6.020 (-2.029)	-8.230 (-2.269)	-7.449 (-2.104)
$DVAR_{2f,t-3}$	-5.189 (-1.880)	-7.211 (-2.138)	-6.690 (-2.031)
$DVAR_{2f,t-4}$	-1.502 (-0.599)	-2.412 (-0.787)	-2.422 (-0.809)
$DVAR_{2f,t-5}$	-0.028 (-0.016)	-0.733 (-0.351)	-0.700 (-0.343)
	-2.77E-05 (-0.989)	-3.60E-05 (-1.054)	-3.44E-05 (-1.030)
	1.19E-06	1.78E-06	1.70E-06
Log likelihood	375.680	365.454	366.670
R^2	0.772	0.758	0.758
Adj. R^2	0.654	0.633	-0.633
AIC		-49.580	
SC		-47.307	

t-statistics are in parentheses.

Table 6. Chi-squared statistics for the Granger causality test.

Effect cause	$DVAR_s$	$DVAR_{1f}$	$DVAR_{2f}$
$DVAR_s$		11.846 (0.106)	10.837 (0.146)
$DVAR_{1f}$	23.541 (0.001)[a]		22.193 (0.002)[a]
$DVAR_{2f}$	22.958 (0.002)[a]	21.598 (0.003)[a]	

[1]Probabilities are in parentheses. [2]a denotes significance at the 1% level.

directional spillovers from the cash index to the index futures depending on what models (EC-GARCH (1,1) or EGARCH (1,1)-X) are used. However, more studies reported evidence for uni-directional volatility spillovers from the index futures to the cash index (Koutmos and Tucker, 1996; Iihara et al., 1996). It is thus necessary for us to reevaluate the Taiwanese case using different methods and different data sets. Using the data set spanning from January 2, 2004 to April 28, 2006, this study examines all aspects of the relation between volatility in the cash index and volatility in the nearby-month and nearby-quarter index futures. We first use the GARCH Model to investigate the impact of the futures volume growth on the conditional variance of the cash price and vice versa. Next, we calculate the variances at the 10-day interval to derive the variance series and then conduct the Granger causality test for these co-integrated variance series in the context of the error correction model. The results from the Granger causality test documents the cross-market volatility spillovers effect.

The empirical results from the GARCH (1,1) Model suggest that (1) the three markets display a high degree of volatility persistence, (2) the volatility persistence in the three markets does not reduce substantially when the trading volume growth is included in the conditional variance equation, (3) the cash volume growth loses the power to explain its own price volatility when the futures volume growth is included in the conditional variance equation of the cash index return, (4) there is no statistically significant association between the cash volume growth and volatility in the futures markets, and (5) the trading volume growth of nearby-month index futures is the most influential factor for volatility in the three markets. The empirical results from the Granger causality test in the context of the error correction model document that (1) the volatility series are all I(1) and have two co-integrating vectors, which suggests for co-movement in the same direction in the long run, (2) there are uni-directional volatility spillovers from the index futures to the cash index, and (3) there are bi-directional volatility spillovers between the nearby-month and nearby-quarter futures markets. It is crucial for investors to learn from the empirical results that volatility in the cash market increases with the futures volume growth, in particular, the volume growth of the nearby-month index futures, and that there are uni-directional volatility spillovers from the index futures to the cash index. The investors are advised to predict volatility in the cash market by observing the futures volume growth as well as volatility in the index futures since volatility in the cash market is a measure of market risk and, moreover, it serves as one of the inputs in determining the value of cash index options.

REFERENCES

Abhyankar A (1998). Linear and Nonlinear Granger: Evidence from the U. K. Stock Index Futures Market. J. Futures Mark. 18(5): 519-540.

Bohl MT, Henke H (2003). Trading Volume and Stock Market Volatility: The Polish Case. Int. Rev. Financ. Analysis. 12(5): 513-525.

Bookstabler RM, Pomerantz S (1989). An Information-Based Model of Market Volatility. Financ. Anal. J. 45: 37-46.

Chuang CC (2001). The Information Transmission of Price and Price Volatility among Spot, Nearby-Month and Nearby-Quarter Stock Index Futures Markets: The Early Experiences of Taiwan. J. Manage. (Taiwan). 18(2): 311-332.

Darrat AF, Rahman S (1995). Has Futures Trading Activity Causes Stock Price Volatility. J. Futures Mark. 15(5): 537-557.

Ely O (1988). Cost of Rist Shifting and Cash Market Stability. Working Paper. Department of Finance, San Diego State University.

Frino A, West A (1999). The Lead-Lag Relationship between Stock Indices and Stock Index Futures Contracts: Further Australian Evidence. Abacus. 35(4): 333-341.

Gallo GM, Pacini B (2000). The Effects of Trading Activity on Market Volatility. European J. Financ, 6(2): 163-175.

Gannon GL (2010). Simultaneous Volatility Transmission and Spillover Effects. Rev. Pacific Basin Financ. Mark. and Policies. 13(1): 127-56.

Goo YJ, Chang CC (2003). The Information Transmission and Price Volatility between Spot and Stock Index Futures Markets in TAIFEX: Using Bivariate EGARCH-X and Intervention Models. Manage. Rev. (Taiwan). 22(1): 53-74.

Hsu CC, Chien YC (2003). A Study of the Relationship between the Spot Market and Stock Index Futures Using the Intraday Data. Quarterly J. Bank of Taiwan. 54(4): 249-268.

Hsu HN, Ho E (2000). The Dynamic Interrelationship among TAIFEX Taiwan Stock Index Futures, SIMEX MSCI Taiwan Stock Index Futures, and TSE Stock Index. J. National Cheng-Kung University (Taiwan). 35: 187-206.

Huang YC, Shyu D (1997). An Evaluation of the Dynamic Interaction between Spot and Futures Markets for Taiwan Stock Index. Quarterly J. of Securities Mark. Develop. (Taiwan). 9(3): 1-28.

Iihara YK, Kato K, Tokunaga T (1996). Intraday Return Dynamics between the Cash and The Futures Markets in Japan. J. Futures Mark. 16(2): 147-162.

Kanas A (2009). Regime Switching in Stock Index and Futures Markets: A Note on the Nikkei Evidence. Int. J. Financ. Econ. 14(4): 394-99.

Koutmos G, Tucker M (1996). Temporal Relationships and Dynamic Interactions between Spot and Futures Stock Markets. J. Futures Mark. 16(1): 55-69.

Lee SB, Ohk KY (1992). Stock Index Futures Listing and Structural Changes in Time-Varying Volatility. J. Futures Mark. 12(5): 443-509.

Min JH, Najand M (1999). A Further Investigation of the Lead-Lag Relationship between the Spot Market and Stock Index Futures: Early Evidence from Korea. J. Futures Mark. 19(2): 217-232.

Nicto ML, Fernandez A, Jesus MM (1998). Market Efficiency in the Spanish Derivatives Markets: An Empirical Analysis. Int. Adv. in Econ. Res. 4(4): 349-356.

Pizzi MA, Economopoulos AJ, O'Neill HM (1998). An Examination of the Relation between Stock Index Cash and Futures Markets: A Cointegration. J. Futures Mark. 18(3) 297-305.

Ross SA (1989). Information and Volatility: The No-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy. J. Financ. 44: 1-17.

Schwert GW (1990). Stock Market Volatility. Financ. Anal. J. 46: 23-34.

Turkington J, Walsh D (1999). Price Discovery and Causality in the Australian Share Price Index Futures Markets. Aus. J. Manage. 24(2): 97-113.

Yu SW, Wu CC (2000). The Impact of Index Futures on Stock Market Volatility. J. Bus. Admin. (Taiwan). 47: 135-160.