RETURN AND VOLATILITY SPILLOVER BETWEEN SET50 INDEX AND SET50 INDEX FUTURES

BY

MISS PURICHITA SUKHONPITUMART

AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE PROGRAM IN FINANCE (INTERNATIONAL PROGRAM)

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ABSTRACT

This paper investigates the relationship in terms of return and volatility between SET50 index futures and its underlying. The study compares three models of GARCH family including GARCH, EGARCH and GJR-GARCH. The result presents that GJR-GARCH is the best fit model. In addition, this paper also concerns about the structural break in the time series data, by using the Bai and Perron method. The results show that there is unidirectional return spillover from the spot market to the futures market, while there is bidirectional volatility spillover between these two markets but the effect from spot to futures is stronger than the reverse direction. Moreover, in the sub-period analysis, the return spillover shows the consistent result of the unidirectional return spillover of spot to futures markets in every period, while the result of volatility spillover are inconsistence over the time.

Keywords: Spillover, Return, Volatility, SET50 index,GARCH, EGARCH, GJR-GARCH.

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Miss Purichita Sukhonpitumart

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CHAPTER 1
INTRODUCTION

The theories of market efficiency and cost of carry model imply a futures price should move along with a spot price, so investors do not have an arbitrage opportunity. However, it does not hold in the real world, the lead-lag relationship always exist in the markets. Tse (1995) found the unidirectional of the futures index price spillover to the stock market when they examine the data of Nikkei stock exchange. Liu (2008) examines the relationship of the copper futures and spot markets in China, the empirical results indicate the same outcomes for both return and volatility that there exist the bidirectional spillovers between the copper futures and spot market but the spillover effect from the futures market to the spot market is stronger. Chatrath and Song (1998) investigate the relationship between the Japanese yen futures and spot markets. The result suggests that the futures market causes spot market to be volatile.

As above examples, the lead-lag relationship occurs in every market. However, this paper focuses on the equity market. The existing evidences show the inconsistent results whether futures markets lead their underlying equity markets, or vice versa. For example, Kavussanos (2008), Frino (2000) find the bidirectional relationship but the result is more obvious that the futures returns lead the spot returns. While the futures volatility only spillover to spot market. Tse (1999) finds the bidirectional information flow, but the futures market volatility spillover to the spot market more than vice versa. Nevertheless, some previous papers show the contradictory result, Streche (2009) found that the price of the cash market lead the futures market on Romanian stock exchange. Başdaş (2009) examines the lead-lag relationship between the Istanbul Stock Exchange 30 (ISE 30) Index and its index futures, the result indicate that the spot index return lead the futures index.

This study examines the return and volatility spillover on the spot index and the futures index on Thailand’s stock market. As Thailand’s stock and futures market are relatively young and small when compared with other financial markets, 10 years old for the futures market, it’s the suitable period for examine the whole daily data in order to studying on the progress of the market. Furthermore, there are a few papers study on related topic of return and volatility spillover on Thailand's market such as Judge and Reancharoen (2014) examine the lead-lag relationship on spot and futures price, the results show that lagged changes in spot prices lead changes in futures prices.

This research expands the examination of the lead-lag relationship on both return and volatility by separating the research into two parts. First, the paper tests the spillover effect by using different types of GARCH's family models which cover both symmetric and asymmetric effect including GARCH , EGARCH and GJR-GARCH , then the study identifies the best fit model by using RMSE. Second, as the entire data is a time series data that may contain the structural break such as the sub-prime crisis, and the break can lead the error estimating in the model. The paper employs the Bai and Perron (1998, 2003) to detect the structural break and then using the best fit model, which obtains from the first part to examine the return and volatility spillover on SET50 index and SET50 index futures over each sub-periods.

To achieve the study's objectives, the research questions should be set as, first, whether they are spillover effect on return and volatility between these two markets. Second, which method is the best fit model to estimate the spillover effect? Finally, how the spillover effect changes after the structural break period. With the study of spillover effect, it will improve the understanding for any participants about the dynamic between the spot and futures markets. Especially, for investor, they are able to cope with any circumstances or shocks which could effect to them. The policymaker, they should realize on how these two markets react to new information for controlling the stability of market.

The remainder of the research is organized as follows, section 2, several related literatures are reviewed. Section 3, it contains the data description and the methodology employed. Section 4 shows the analysis and interpretation for both the comparison of different model and the changing dynamic over the studied period. Section 5 provides the conclusion of the research.

CHAPTER 2
REVIEW OF LITERATURE

In order to study on a relationship between the index futures and its underlying asset, most existence papers about return spillover and volatility spillover could be separated into two main groups which are the case of developed and developing country according to World bank database[1].

For the return spillover, the examples of research on developed country, Abhyankar (1995) splits the entire data of FTSE-100 into three sub-periods and investigate each period to find the lead-lag relationship. The evidence shows the futures index return seems to lead the spot but the spot market tends to reacting to the futures index movement faster over time. Lafuente (2002) finds the unidirectional of return spillover from the futures index to the spot index on Spain's market. For the developing country, Patia and Rajib(2011) examine the relationship between the National Stock Exchange(NSE) S&P CNX Nifty futures and its underlying index, India's market, by using GARCH-BEKK which provides the result of the bidirectional spillover between these two markets, but more obvious for the futures index return lead the spot index. Başdaş (2009) finds the result that the spot index return lead the futures index on examining the lead-lag relationship between the Istanbul Stock Exchange 30 (ISE 30) Index and its index futures. These existence studies show the consistent result of developed country that the return spillover from the futures market to the spot market, while the developing country has unclear pattern as some evidences show the return spillover from the spot market to the futures market but some provide the against result.

Many papers have been studied on the volatility spillover, The example of developed country, Bhar(1999) try to capture the dynamic behavior of the joint spot equity and index futures return-generating process on Australia market, the result shows the unidirectional of volatility spillover effect from futures market to spot market, and the effect decreased after the structural break (the intervention date). This study also examines on the persistence of volatility which increasing over time on

[1] Source : http://data.worldbank.org/about/country-classifications.

both markets. Iihara (1996) examines the dynamic of intraday data of Japan's market which shows the new information disseminates in the futures market volatility first and then effect to the cash market with a diminishing trend over time. On the other hands, the example of developing country, Feng and Yang (2013) examine the volatility spillover on CSI300 index futures and its underlying with GARCH-BEKK model, they find a unidirectional volatility spillover effect from the CSI spot market to the index futures market. Lin (2002) states the conclusion of Taiwan's market that the volatility spillover is bidirectional and it would more efficient from the spot to the futures market. These papers are examples which represent the consistence result of the developed country that the volatility spillover from the futures market to the cash market. While most of previous researches of the developing country show the volatility spillover from the spot market to the futures market which different from the developed country.

To investigate the spillover effect on any assets, most researches employ vary types in the GARCH family such as Karolyi (1995) studies short-run dynamics of stock traded on two markets by using GARCH model in order to capture the magnitude and the persistence of return innovations across the markets. Booth, Martikainen and Tse (1995), they study the spillover effect among Scandinavian markets and concern on the impact of good and bad information by employing the EGARCH model to examine the asymmetric effect. The research is concluded that the spillover effect being more pronounced for bad news than good news. Kang and Yoon (2013) investigate the return and volatility linkage between the foreign exchange and stock market in Korea's market by using bivariate GJR-GARCH which the model allow to capture the asymmetric volatility spillover but they do not find any asymmetric effect on this research. Bracker and Smith (1999) compare the ability of five models for the study of the changing volatility on copper futures market by RMSE. The result shows that GARCH is the best fit model and follow by EGARCH , GJR-GARCH , AGARCH and the random walk respectively.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Theoretical Framework

3.1.1 Cost of carry

This study purposes to examine the dynamics for the return and volatility of the index (spot price) and its futures index which their relationship can be identified by the cost of carry model.

Let S_t be the spot price of an index at time t

F_t be the futures price of an index at time t

In order to find the no-arbitrage equilibrium between spot and futures index prices, the following conditions must be set as assumptions:

A1. No transaction costs , taxes and any kind of risk.

A2. Borrowing and lending are at the same risk free rate.

A3. There are only the financing cost of a futures position and dividend yield.

A4. No limitations on short sale of the asset in the spot market.

As r_t is the continuously compounded of non-stochastic interest rates, d_t is dividend yield and T is stand for the maturity date. If r_t and d_t appropriate to the period from t to T . With above assumption A1. - A4., the no-arbitrage equilibrium can be written as :

$$F_t = S_t e^{(r_t - d_t)(T-t)} \tag{1}$$

In efficient financial market, the prices of financial assets will quickly adjust to any shock in order to reflect the incidence of new information. Importantly, there should exist of the relationship between spot price and futures price, otherwise an arbitrage will occur.

Hence, if spot and futures markets are perfectly efficient then all available information should be immediately and totally utilized to determine the price of related assets. As the index (spot) which is the underlying asset of the futures index, both prices of spot and futures should reflect the same information simultaneously.

Equation (1) can be written as

$$r_{s.t} = (r_t - d_t) + r_{f,t} \quad (2)$$

Where $r_{f,t} = \ln(\frac{F_t}{F_{t-1}})$, $r_{s,t} = \ln(\frac{S_t}{S_{t-1}})$ and $r_t - d_t$ is net cost of carrying the underlying stocks in the index. As the equation (2) and assumption of perfect market and non-stochastic interest rates and dividend yield, Stoll and Whaley (1990) state that it can be implied following

(a) The expected rate of price on the spot index portfolio E($r_{s,t}$) equals the net cost of carry $(r_t - d_t)$ plus the expected rate of return on the futures contract E($r_{f,t}$)

(b) The standard deviation of the rate of return on the spot contract equals the standard deviation of the rate of return of the futures index.

However, there are many market factors in the real world such as trading cost, short sale restriction that let several empirical studies find that there is lead-lag relationships exist between spot and futures markets. Also the same with our objective of the study, as we try to examine the relationship of return and volatility between SET50 index and SET50 index futures.

3.1.2 Sameulson effect

The Samuelson effect (1965) ,or maturity effect, is a well-known theory which states that the volatility of the futures prices will increase when the contract approaches maturity date. The theory is based on the premise that more information on futures prices are released when the contract approaches its maturity. Several papers examine on the Samuelson effect, for example, Khoury and Yourougou (1993) examine the six Canadian-agricultural commodities and found the strong support for the Samuelson effect. However, there are some researches which show the result against the theory. Chen, Duan and Hung (1999) find the volatility of the futures price decreases when the contract is closer to its maturity for the examining on Japan's market. This example support the argument of Bessembinder et al. (1996) that the Samuelson hypothesis is more appropriate to the markets which hold a negative covariance between changes in spot prices and changes in net carry cost.

According to Dolsutham (2011) examines the Samuelson hypothesis on Thailand's market by using regression and GARCH model, the both results support the hypothesis as the volatility of SET50 index futures price increases when it approaches the maturity date. Hence, the Samuelson effect should be taken into account for creating a time series data as the higher volatility in last period which is caused by the information released. It means the price will reflect all information that makes it more accurate. However, the studied period of previous research is between 2006-2010 which there was only quarterly contact available in the market. Therefore, in order to conform to that research, the study chooses the data from the nearest quarterly contract to represent the daily futures price and then shift the data to next nearby quarterly contract when it reaches the maturity date.

3.1.3 Spillover effect

Generally, when information arrives the market, investors react immediately for their own profit cause the price fluctuations. The spillover effect occurs when the financial markets have a transmission of price fluctuations from one market to others, for example, Kanas (1998) shows the result of volatility spillover across three largest European stock markets; London, Frankfurt and Paris, the bidirectional spillover are found between London and Paris, Paris and Frankfurt but the unidirectional spillover is found between London to Frankfurt. Theodossiou and Lee (1993) find the statistical significant of mean and volatility spillover from US market to UK, Canada and Germany markets but they find only the volatility spillover from US to Japan market.

Moreover, the spillover effect can occur among assets in the same market. Lafuente (2002) examines the relationship of return and volatility in the IBEX35 spot and futures markets, they find the unidirectional return spillover from futures to spot market and they also find the bidirectional volatility spillover between these two markets.

However, whether the spillover effect occur across markets or among assets in the same market, it is important to understand the mechanism of how the information spillovers in order to get the effective financial risk management.

3.2 Methodology

To examine these time series data in the research, the existence of unit root must be firstly tested and this study generally applies the augment Dickey-Fuller (ADF) following:

3.2.1 Cointegration

To test for stationarity, this research is chosen for the most common methods as Augment Dickey-Fuller (ADF) ,(Dickey and Fuller, 1979) unit roots test following :

$$\Delta P_t = \alpha + \beta t + (\rho - 1)P_{t-1} + \sum_{i=1}^{k-1} \theta_i \, \Delta P_{t-i} + \omega_t \tag{3}$$

Where ΔP =($P_t - P_{t-1}$) , for example , to test stationarity of futures series then ΔP is the first difference of the futures price, on the other hand, to test stationarity of spot series then ΔP is the first difference of the spot price. Next, t is a time trend variable, ω_t is a white noise, k is a lagged number which is chosen by the Akaike information criterion (AIC), β is a coefficient on a time trend. The hypothesis is

$$H_0 : \rho = 1$$
$$H_a : \rho \neq 1$$

if accept the null, that means there is a unit root or non-stationary series which can create spurious problem. For example, when testing correlation between return of stock and weather, they may have a high r-square value even if they are uncorrelated. However, if reject the null that means the data is stationary.

Next step, the study employs Johansen's (1988) cointegration to test the existence of long-run equilibrium relationship between these two assets which are spot and futures price, this method can be conducted in the vector autoregression (VAR) of order p given by

$$P_t = \mu + A_1 P_{t-1} + \cdots + A_p P_{t-p} + \varepsilon_t \tag{4}$$

Where P_t is an (2x1) vector of variables ; for spot and futures, and ε_t is an (2x1) vector of innovations. This VAR can be re-written as

$$\Delta P_t = \mu + \prod P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \varepsilon_i \quad (5)$$

Where $\Delta P_t = P_t - P_{t-1}$, $\prod = \sum_{i=1}^{p} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$

The cointegration relationship can be detected by examining the rank of $\prod$ because the number of cointegration vectors equals to the rank of $\prod$. Then using the trace statistic as follow to test the null hypothesis that the number of cointegration vectors is equal to r (the alternative hypothesis should be the number of cointegration vectors is not equal to r).

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (6)$$

Where T is the number of observations and $\hat{\lambda}_i$ is the estimated value for the *i* th largest accepted correlation.

3.2.2 Conditional mean

The study purposes to examine the return spillover between the spot index and the futures index which the bivariate mean equations can be conducted as

$$R_{n,t} = \gamma_{n0} + \sum_{i=1}^{k} \gamma_{i,n1} R_{1,t-i} + \sum_{i=1}^{k} \gamma_{i,n2} R_{2,t-i} + \varepsilon_{n,t} \quad (7)$$

Where $R_{n,t}$ is the return of asset n at time t. The variables n equals to 1,2 for spot and futures market respectively. *k* is a lagged number which is chosen by the Akaike information criterion (AIC).

The parameter γ_{12}, γ_{21} imply the return spillover effect across market with the null hypothesis of there is no return spillover. For example, γ_{12} measures the return spillover from the futures market to the spot market, with rejection the null hypothesis that means there is return spillover effect from futures to spot market. On the other hand, γ_{21} measures the return spillover from the spot market to the futures market. The rejection of the null hypothesis express that there is the impact of past spot market on the futures market return.

3.2.3 Conditional Variance

In order to model the dynamic of the second moment of the return of index, the study employs 3 models of GARCH, EGARCH and GJR-GARCH to cover both of symmetric and asymmetric effect of the shock. Moreover, the study also compares their results to find the best fit model.

(1) GARCH model

The generalized autoregressive conditional heteroscedastic (GARCH) is a model of Bollerslev (1986) which assumes a symmetrical distribution of innovations. This model extends the Engle's ARCH model, which focus on the changing variance with the autoregressive conditional heteroscedasticity, a GARCH (p,q) model ; p is the number of lagged conditional variances and q is the number of lagged squared innovations , both of p and q are chosen by the Akaike information criterion (AIC), can be conducted as

$$\sigma_t^2 = \omega_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{8}$$

Where the usual restrictions on the parameter are $\omega > 0$,α and $\beta \geq 0$. These restrictions are set in order to ensure the positive variance.

However, this study focus on the spillover effect of two assets, the bivariate GARCH is employed as

$$\sigma_{n,t}^2 = \omega_n + \sum_{i=1}^{q} \alpha_{i,n1} \varepsilon_{1,t-i}^2 + \sum_{i=1}^{q} \alpha_{i,n2} \varepsilon_{2,t-i}^2 + \sum_{j=1}^{p} \beta_{j,n} \sigma_{n,t-j}^2 \tag{9}$$

Where n = 1, 2 for spot and futures respectively, as following

$$\sigma_{1,t}^2 = \omega_1 + \sum_{i=1}^{q} \alpha_{i,11} \varepsilon_{1,t-i}^2 + \sum_{i=1}^{q} \alpha_{i,12} \varepsilon_{2,t-i}^2 + \sum_{j=1}^{p} \beta_{j1} \sigma_{1,t-j}^2 \tag{9.1}$$

$$\sigma_{2,t}^2 = \omega_2 + \sum_{i=1}^{q} \alpha_{i,21} \varepsilon_{1,t-i}^2 + \sum_{i=1}^{q} \alpha_{i,22} \varepsilon_{2,t-i}^2 + \sum_{j=1}^{p} \beta_{j,2} \sigma_{2,t-j}^2 \tag{9.2}$$

Where $\sigma_{n,t}^2$ is the conditional variance, β_j is the parameter which measures the persistence in volatility. $\varepsilon_{n,t-i}^2$ is a lagged white noise. the parameter α_{in} detect the impact of the white noise which can be split as, α_{11}, α_{22} capture the impact of our own market lagged standardized innovations, while α_{12} , α_{21} are parameter which capture the impact of crossmarket standardized innovations for the spot and futures market. To test the volatility spillover from the futures to the spot market, α_{12}, the null hypothesis can be conducted as there is no volatility spillover from the futures to the spot market. On the other hand, to test the volatility spillover from the spot to the futures market , α_{21}, the null hypothesis can be conducted as there is no volatility spillover from the spot to the futures market.

However, GARCH model generally has two limitations. First, it equally treats the effect of positive and negative information which is not reasonable in some cases. Second, there is the assumption on the non-negative parameters which is difficult to achieve them all. Hence, Nelson (1991) constructed the EGARCH model and Glosten, Jagannathan and Runkel (1993) proposed GJR-GARCH model to solve the asymmetric effect.

(2) EGARCH model

The exponential GARCH model was created by Nelson(1991) in order to extend the restriction of nonnegative parameters on the GARCH model since the equation in on log variance instead of variance itself then the positivity of variance is automatically satisfied. This main advantage of EGARCH model can be apply to stock market in term of the asymmetry distribution between good news and bad news, a EGARCH (p,q) model ; p is the number of lagged conditional variances and q is the number of lagged squared innovations, both of p and q are chosen by the Akaike information criterion (AIC), can be conducted as

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^{q} \alpha_i G(z_{t-i}) + \sum_{j=1}^{p} \beta_j \ln(\sigma_{t-j}^2) \tag{10}$$

Where $G(z_{t-i}) = [|z_{t-i}| - E(|z_{t-i}|)] + \theta_i z_{t-i}$ (10a)

As the study examine on the spillover effect, the bivariate EGARCH is employed to investigate on these two asset following

$$\ln(\sigma_{n,t}^2) = \omega_{n0} + \sum_{i=1}^{q} \alpha_{i,n1} G_1(z_{1,t-i}) + \sum_{i=1}^{q} \alpha_{i,n2} G_2(z_{2,t-i}) + \sum_{j=1}^{p} \beta_{j,n} \ln(\sigma_{n,t-j}^2) \tag{11}$$

Where $G_1(z_{1,t-i}) = [|z_{1,t-i}| - E(|z_{1,t-i}|)] + \theta_{i,n} z_{1,t-i}$ (11a)

$$G_2(z_{2,t-i}) = [|z_{2,t-i}| - E(|z_{2,t-i}|)] + \theta_{i,n} z_{2,t-i} \tag{11b}$$

The term $G_1(z_{1,t-i})$, $G_2(z_{2,t-i})$ allow past standardized innovations to have an asymmetric effect, the first two term which are $|z_{1,t-i}| - E(|z_{1,t-i}|)$ and $|z_{2,t-i}| - E(|z_{2,t-i}|)$ measure the size effect. The last term, $\theta_{i,n} z_{1,t-i}$ and $\theta_{i,n} z_{2,t-i}$, measure the sign effect.

For construct the conditional variance for spot index and futures index, let substitute n = 1, 2 for spot and futures respectively, as following

$$\ln\left(\sigma_{1,t}^2\right) = \omega_{10} + \sum_{i=1}^{q} \alpha_{i,n1} G_1\left(z_{1,t-i}\right) + \sum_{i=1}^{q} \alpha_{i,n2} G_2\left(z_{2,t-i}\right) + \sum_{j=1}^{p} \beta_{j,1} \ln(\sigma_{1,t-j}^2) \quad (11.1)$$

$$\ln\left(\sigma_{2,t}^2\right) = \omega_{20} + \sum_{i=1}^{q} \alpha_{i,n1} G_1\left(z_{1,t-i}\right) + \sum_{i=1}^{q} \alpha_{i,n2} G_2\left(z_{2,t-i}\right) + \sum_{j=1}^{p} \beta_{j,2} \ln(\sigma_{2,t-j}^2) \quad (11.2)$$

In equation (10) ,$\sigma_{n,t}^2$ is the conditional variance , $z_{n,t-i}$ is the standardized innovation, β_j is the parameter which measures the persistence in volatility. In equation (11.1) and (11.2), the parameter α_{11}, α_{22} employ to capture the impact of our own market lagged standardized innovations, while α_{12} , α_{21} are parameter which capture the impact of crossmarket standardized innovations for the spot and futures market returns. To test the volatility spillover from the futures to the spot market , α_{12}, the null hypothesis can be conducted as there is no volatility spillover from the futures to the spot market. For example, the significant of α_{12} means there is the impact of past futures index innovations on the spot index volatility.

On the other hand, to test the volatility spillover from the spot to the futures market, α_{21}, the null hypothesis can be conducted as there is no volatility spillover from the spot to the futures market. For example, the significant of α_{21} also represent the impact of past spot index innovations on the futures index volatility.

Nevertheless, not only the EGARCH model that can solve the asymmetry information,but GJR-GARCH model also provides a solution for this problem.

(3) GJR-GARCH

The Glosten-Jagannathan-Runkle GARCH model is an alternative model which is designed to capture the increased volatility from asymmetric shocks. The model also have a restriction on nonnegative parameters which mean all these parameters are $\omega, \alpha, \tau, \beta > 0$ then a GJR-GARCH (p,q) model ; p is the number of lagged conditional variances and q is the number of lagged squared innovations, both of p and q are chosen by the Akaike information criterion (AIC), can be conducted as

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i + \tau_i \, D_{t-i}) \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \quad (12)$$

Where the dummy variable, D_{t-i} , is unity when $\varepsilon_{t-i} < 0$ otherwise equal to zero. Hence, with $\tau_i > 0$, a negative shock will have a greater impact on the conditional variance.

In order to measure the spillover effect, the bivariate GJR-GARCH can be constructed as

$$\sigma_{n,t}^2 = \omega_n + \sum_{i=1}^{q}(\alpha_{i,n1} + \tau_{i,n}\,D_{t-i})\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q}(\alpha_{i,n2} + \tau_{i,n}\,D_{t-i})\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p}\beta_{j,n}\sigma_{n,t-j}^2 \quad (13)$$

Where n = 1, 2 for spot and futures respectively, as following

$$\sigma_{1,t}^2 = \omega_1 + \sum_{i=1}^{q}(\alpha_{i,11} + \tau_{i,1}\,D_{t-i})\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q}(\alpha_{i,12} + \tau_{i,1}D_{t-i})\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p}\beta_{j,1}\sigma_{1,t-j}^2 \quad (13.1)$$

$$\sigma_{2,t}^2 = \omega_2 + \sum_{i=1}^{q}(\alpha_{i,21} + \tau_{i,2}\,D_{t-i})\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q}(\alpha_{i,22} + \tau_{i,2}\,D_{t-i})\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p}\beta_{j,2}\sigma_{2,t-j}^2 \quad (13.2)$$

Where $\sigma_{n,t}^2$ is the conditional variance, the parameter β_j measure the persistence in volatility. $\varepsilon_{n,t-i}^2$ is a lagged white noise. The impact of the white noise could be measured by the parameter $\alpha_{ij} + \tau_{ij}$ if $\varepsilon_{t-i} < 0$, otherwise it could be measured by the only parameter α_{ij}.

However ,from equation (13.1) and (13.2) the impact of our own market lagged standardized innovations could be checked by the parameters $\alpha_{11} + \tau_1$, $\alpha_{22} + \tau_2$ while the impact of cross market standardized innovations for the spot and futures market returns are shown at $\alpha_{12} + \tau_1$, $\alpha_{21} + \tau_2$. To test the volatility spillover from the futures to the spot market, $\alpha_{12} + \tau_1$, the null hypothesis can be conducted as there is no volatility spillover from the futures to the spot market. If the result shows the significant of $\alpha_{12} + \tau_1$ means the impact of past futures index innovations on the spot index volatility.

On the other hand, to test the volatility spillover from the spot to the futures market, $\alpha_{21} + \tau_2$, the null hypothesis can be conducted as there is no volatility spillover from the spot to the futures market. For example, the reject of the null hypothesis means there is the impact of past spot index innovations on the futures index volatility.

However, all parameters in every model can be estimated by the maximum likelihood estimation method that the condition log likelihood function $L(\theta)$ is expressed as

$$L(\theta) = -\frac{N}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{N} log\sigma_t^2 - \frac{1}{2}\sum_{t=1}^{N}\frac{\varepsilon_t^2}{\sigma_t^2} \quad (14)$$

Where N is the number of observations and θ denotes the vector of all unknown parameters.

Next, the study uses the Root Mean Square Error (RMSE) to measure the residuals and compare all 3 models to find out the best performance model which has the lowest RMSE.

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(\sigma_t^2 - \hat{\sigma}_t^2)^2}{N}} \quad (15)$$

Where $\hat{\sigma}_t$ is the estimated of the volatility which get from measurement by GARCH, EGARCH and GJR-GARCH. σ_t is the realized volatility at time t, the realized volatility can be represented by the absolute of return.

As the most previous studies of the developing country that mentioned in first section, the study may provide the result of the spillover effect from stock market to the futures market in both cases of return and volatility, for all employed method. Moreover, when compared these three models, the best fit model should be GJR-GARCH model as Engle (1993) ,Liu and Hung (2010) find that GJR-GARCH model generates smallest loss function values among the various competitors.

3.2.4 Structural Break

Generally for analysis the time series, some circumstances which effect to the overall such as the crisis, the changing of the role on financial market, these situations may impact to an unexpected significant shift in parameters of an entity, it is called as structural break or structural change. For the time series, the structural break can occurs one or more points depend on the frequency of severe incident. However, the ignoring of structural break in financial time series can lead error estimation. Several method have been created to detect any change points in the data set such as the classical approach of Chow test (1960) which tests for the known single break in mean. The Gregory and Hansen test (1996) which is used to examine the one unknown structural break. However, this paper employs the Bai and Perron (1998,2003) method to detect the multiple structural breaks.

The method of Bai and Perron is an outstanding tool which can easily detect the multiple unknown structural breaks. The concept of model is consecutively starting by first testing for single structural break with the null hypothesis of there is no structural break. If the result shows the rejection that means there is structural break. Then, the entire data is spilt into two sub-samples, after that the test is re-examined to each sub-sample. This process continues until each sub-sample show the evidence of failed to reject the null hypothesis.

This outstanding method can be employed to both the pure structural change and the partial structural change which both types are differ in case of all or partial of model's coefficient are subject to change, respectively. Consider the multiple linear regressions with m breaks ($m + 1$ regimes)

$$y_t = x'_t\beta + z'_t\delta_j + u_t \tag{16}$$

Where y_t is the observed independent variable , x_t , z_t are vector of variables at time t which its effects are constant and vary over time respectively. β and δ_j are the analogous vectors of coefficients which could be obtained by minimizing the sum of squared residuals. u_t is the innovations. Importantly, all break points are treated as unknown. This model intent to estimate the unknown regression coefficients with the break points when T observations on existence variables are available. The method of estimation is based on the least-squares approach.

For each m-partition $(T_1, \dots, T_m)$, denoted $\{T_j\}$, and Let $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ denote the calculated estimates then substituting them into the objective function and showing the resulting sum of squared residuals as $S_T(T_1, \dots, T_m)$, the estimated break points $(\hat{T}_1, \dots, \hat{T}_m)$ are such that

$$(\hat{T}_1, \dots, \hat{T}_m) = argmin_{T_1, \dots, T_m} S_T(T_1, \dots, T_m) \tag{17}$$

Hence, the break-point estimators are global minimizers of the objective function. After detecting the break-point, we expect the paper hold at least one structural break because the study’s period cover the sub-prime crisis which intensively impact to the global financial market. Then, this paper will employ the best fit model on the first part to test structural break effect as how do the dynamic of the futures index and its underlying change over time.

3.3 Data

The sample used in the research consists of daily data of SET50 index futures and cash markets. The SET50 index is calculated from the stock prices of the top 50 listed companies on Stock Exchange of Thailand by choosing large market capitalization, high liquidity and compliance with requirements regarding the distribution of shares to minor shareholders.

The SET50 index futures, the futures contract of SET50 index, are very liquid with average daily volume of 300,000 contracts for the period examined. With the higher value of the underlying asset, the multiplier of SET50 index futures has been reduced from THB 1,000 to THB 200 on May 6th, 2014 to provide more liquidity to the investor, it also be a benefit to a retail investor who can easier access the investment. The maturity of the contract is the business day immediately preceding the last business day of the contract month and the time at which trading ceases on last trading day is 16.30 p.m. As there are six contracts with different maturity available on the trading system (3 consecutive months and next 3 quarterly months), we create a time series data by choosing the nearest quarterly maturity to represent the futures price according to the samuelson hypothesis (1965). The data is shifted to the next quarterly maturity when it reaches the maturity date. Moreover, both data are available on Datastreams.

Although the SET50 index futures was launched on April 2006, there was less volume and liquidity on the first period which could lead the inconsistent of data and we also terminate the data at end of April to avoid the contract size effect hence this study employ the data from January 3, 2007 – April 29, 2014. However, the study also employ the Bai and Perron(1998,2003) to detect the structural break and then examine on the changing dynamic of the time series data.

CHAPTER 4
RESULTS AND DISCUSSION

Table 4.1 reports some basic statistics for daily return series of both spot and futures contracts over the sample period from January 3, 2007 to April 29, 2014. There are 1791 observations. The mean of spot is 0.00041172 and the variance is 0.000253 , while the mean of futures is 0.00041172 and the variance is 0.000341. The normality test that both of spot and futures return are not normal distribution as the result from Jarque Bera test for normality provide the p-value of 0.0001, then we reject the null hypothesis of skewness=0 and excess kurtosis=0.

Table 4.1 Preliminary statistics of the return of spot and futures contracts on the Thailand markets

	N	MEAN	VARIANCE	SKEWNESS	KURTOSIS	Jarque Bera	ADF
SPOT	1791	4.12^{a}	2.53^{a}	-0.48525	6.163894	62.9826***	-1721.48***
FUTURES	1791	4.11^{a}	3.41^{a}	-0.26858	5.607364	60.4895***	-1890.78***

***Statistically significant at the 1% significant level. ^{a} represent that the number has to multiply by 10^{-4}. The sample period covers January 2007 to April 2014, and the number of observations is 1791. The normality is tested by Jarque Bera.

Before starting the analysis, the time series should be checked for stationarity and cointegration. This table also shows the Augmented Dickey Fuller test, the result shows that both of the spot and futures contracts are stationary at 1% significant level. Table 4.2 reports the cointegration test, the result shows the spot and futures series are co-integrated with rank 1.

Table 4.2 Cointegration Test for the spot and futures contracts.

H0: Rank=r	**H1: Rank>r**	**Trace**	**Critical Value**
0	**0**	127.0333	12.21
1	**1**	0.9363	4.14

Note. The cointergration is tested by Johansen , type of trace value, with the null hypothesis of the number of the cointegration is equal to r.

4.1 Conditional Mean

Table 4.3 Estimation results for Return spillovers

SPOT		***FUTURES***	
Parameter	**Estimate**	**Parameter**	**Estimate**
γ_{10}	0.043	γ_{20}	0.0418
	(1.14)		*(0.97)*
$\gamma_{1,11}$	0.2484	$\gamma_{1,21}$	0.4619*
	(1.20)		*(1.93)*
$\gamma_{1,12}$	-0.1665	$\gamma_{1,22}$	-0.4159**
	(-0.95)		*(-2.05)*
$\gamma_{2,11}$	0.1002	$\gamma_{2,21}$	0.3054**
	(0.9)		*(2.38)*
$\gamma_{2,12}$	-0.0602	$\gamma_{2,22}$	-0.2634**
	(-0.57)		*(-2.18)*
$\gamma_{3,11}$	-0.1326	$\gamma_{3,21}$	0.0442
	(-1.43)		*(0.41)*
$\gamma_{3,12}$	0.1046	$\gamma_{3,22}$	-0.0877
	(1.25)		*(-0.91)*
$\gamma_{4,11}$	0.0829	$\gamma_{4,21}$	0.1533
	(0.99)		*(1.59)*
$\gamma_{4,12}$	-0.0931	$\gamma_{4,22}$	-0.1532
	(-1.25)		*(-1.77)*
δ_1	0.01938	δ_2	0.03104
	(0.6)		*(0.72)*

*,**,*** indicated the significant level of 10% ,5%and 1% respectively, the numbers in parentheses indicate t statistics. The table shows the coefficient from the mean equation of $R_{n,t} = \gamma_{n0} + \sum_{i=1}^{k} \gamma_{i,n1} R_{1,t-i} + \sum_{i=1}^{k} \gamma_{i,n2} R_{2,t-i} + \delta_n \varphi_{n,t-1} + \varepsilon_{n,t}$ Where $R_{n,t}$ is the return of asset at time t. n = 1,2 which stand for spot and futures market respectively. *k* is a lagged number which is chosen by the Akaike information criterion (AIC).

As the result shows the cointegration, the study should be included an error correction term, which is important for predictive power, into the conditional means equations as following

$$R_{n,t} = \gamma_{n0} + \sum_{i=1}^{k} \gamma_{i,n1} R_{1,t-i} + \sum_{i=1}^{k} \gamma_{i,n2} R_{2,t-i} + \delta_n \varphi_{n,t-1} + \varepsilon_{n,t} \quad (18)$$

where $\varphi_{n,t-1}$ is the error correction term which obtains from equation (5). For example, $\varphi_{1,t-1}$ are the lagged residuals from the co-integrating of log-spot prices on log-futures prices. On the other hand, $\varphi_{2,t-1}$ are the lagged residuals from the co-integrating of log-futures prices on log-spot prices.

Table 4.3 displays the estimates of conditional means which obtained from VAR model with the optimal lags of 4 which chosen by the Akaike and Schwarz information criterion or AIC which provide the lowest of -0.47771. The significant of $\boldsymbol{\gamma_{1,21}}$, $\boldsymbol{\gamma_{2,21}}$ represent the unidirectional return spillover from the lagged term of spot market to the futures market. $\boldsymbol{\gamma_{1,22}}$ and $\boldsymbol{\gamma_{2,22}}$ show the return spillover from the lagged term itself of $t-1$ and $t-2$. This outcome is consistent with previous researches of the developing market such as Basdas (2009) that the return spillover from spot market to futures market. The result can state that investors in the developing country prefer to invest in stock market than futures market, as the futures market is still nascent so they may not yet be a deeper understanding and familiar with the futures market.

4.2 Conditional Variance

In order to compute the GARCH ,EGARCH and GJR-GARCH model, The study first identify the optimal lag of the model by using the lowest of AIC, which provide the result as GARCH (1,1) , EGARCH(2,2) and GJR-GARCH(3,3) with the AIC value of 7.192 ,7.124 and 7.149 respectively.

Table 4.4 Estimation results for Volatility Spillovers by The generalized autoregressive conditional heteroscedastic (GARCH)

SPOT		*FUTURES*	
Parameter	**Estimate**	**Parameter**	**Estimate**
ω_1	0.0288***	ω_2	0.0266***
	(2.89)		*(2.64)*
$\alpha_{1,11}$	0.1677***	$\alpha_{1,21}$	0.0404
	(3.04)		*(0.87)*
$\alpha_{1,12}$	-0.0417	$\alpha_{1,22}$	0.0705*
	(-0.87)		*(1.75)*
$\beta_{1,1}$	0.8721***	$\beta_{1,2}$	0.8927**
	(58.37)		*(75.34)*

*,**,*** indicated the significant level of 10% ,5%and 1% respectively, the numbers in parentheses indicate t statistics. The table shows the coefficient from the variance equation of $\sigma_{n,t}^2 = \omega_n + \sum_{i=1}^{q} \alpha_{i,n1}\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q} \alpha_{i,n2}\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p} \beta_{j,n}\sigma_{n,t-j}^2$ Where $\sigma_{n,t}^2$ is the conditional variance at time t. n = 1,2 which stand for spot and futures market respectively. *p,q* are lagged numbers which are chosen by the Akaike information criterion (AIC).

The result in Table 4.4 , the parameters β_1 and β_2 show the persistent in volatility as both of them are significant that means the variance on time t got the effect from their past variance. The significant of $\alpha_{1,11}$ and $\alpha_{1,22}$ show the impact of its own market lagged standardized innovations of spot market and futures market respectively. However, in the part of spillover effect, the parameters $\alpha_{1,12}$, $\alpha_{1,21}$ are not significant which provide the results of there are no impact from the cross market standardized innovations for the spot and futures markets. This result is inconsistent with the existing studies of the developing country as most of them , such as Feng and Yang (2013) and Lin (2002) , provide the unidirectional and bidirectional of volatility spillover from spot market to futures market respectively.

Table 4.5 Estimation results for Volatility Spillovers by The exponential GARCH

SPOT		***FUTURES***	
Parameter	**Estimate**	**Parameter**	**Estimate**
ω_1	-0.1267***	ω_2	-0.0973***
	(-5.01)		*(-3.94)*
$\alpha_{1,11}$	0.0275**	$\alpha_{1,21}$	-0.0426***
	(2.28)		*(-4.54)*
$\alpha_{1,12}$	0.058***	$\alpha_{1,22}$	-0.0475***
	(4.75)		*(-5.78)*
$\alpha_{2,11}$	0.1312***	$\alpha_{2,21}$	0.0535**
	(3.00)		*(2.53)*
$\alpha_{2,12}$	0.079**	$\alpha_{2,22}$	0.046***
	(2.50)		*(2.58)*
$\beta_{1,1}$	0.7934***	$\beta_{1,2}$	0.5921***
	(5.53)		*(4.15)*
$\beta_{2,1}$	0.1805	$\beta_{2,2}$	0.3871***
	(1.28)		*(2.74)*
$\theta_{1,1}$	6.1334***	$\theta_{1,2}$	8.7813***
	(7.62)		*(9.66)*
$\theta_{2,1}$	3.1026***	$\theta_{2,2}$	-7.4025**
	(2.77)		*(-2.31)*

*,**,*** indicated the significant level of 10% ,5%and 1% respectively, the numbers in parentheses indicate t statistics. The table shows the coefficient from the variance equation of $\ln(\sigma^2_{n,t}) = \omega_n + \sum_{i=1}^{q} \alpha_{i,n1} G_1(z_{1,t-i}) + \sum_{i=1}^{q} \alpha_{i,n2} G_2(z_{2,t-i}) + \sum_{j=1}^{p} \beta_{j,n} \ln(\sigma^2_{n,t-j})$ Where $\sigma^2_{n,t}$ is the conditional variance at time t. n = 1,2 which stand for spot and futures market respectively. *p,q* are lagged number which are chosen by the Akaike information criterion (AIC).Moreover, $G_1(z_{1,t-i}) = [|z_{1,t-i}| - E(|z_{1,t-i}|)] + \theta_{i,n} z_{1,t-i}$ and $G_2(z_{2,t-i}) = [|z_{2,t-i}| - E(|z_{2,t-i}|)] + \theta_{i,n} z_{2,t-i}$.

Table 4.5 shows the bidirectional volatility spillover between the spot and futures markets, the parameters $\alpha_{1,12}$, $\alpha_{2,12}$, $\alpha_{1,21}$ and $\alpha_{2,21}$ are all significant which $\alpha_{1,12}$, $\alpha_{2,12}$ can capture impact of past futures index innovations , both of 1 and 2 lags, on the spot index volatility. Moreover, $\alpha_{1,21}$, $\alpha_{2,21}$can represent the impact of past spot index innovations ,both of 1 and 2 lags, on the futures index volatility. The persistent of volatility which represent by the parameter $\beta_{j,n}$. Most of them are significant, including $\beta_{1,1}$, $\beta_{1,2}$ and $\beta_{2,2}$, which mean the lagged term variance itself effect to its conditional variance.

The outstanding parameter of EGARCH model which capture the asymmetric effect, $\theta_{i,n}$, the significant of $\theta_{1,1}$, $\theta_{1,2}$ and $\theta_{2,2}$ show that there are the sign effect in the model. These parameters show the positive significant that means , with the negative of residual term or bad news will decrease the impact on volatility.

However, these positive results are different to several existing researches, for example Bhar (1999) and Doğanay (2013) find the negative significant of asymmetric term from testing volatility spillover of Australia's market and Turkish's market respectively. With the negative of $\theta_{i,n}$, the negative of residual term will increase volatility more than the positive residual term with the equal magnitude.

Table 4.6 shows the result of another asymmetry model , GJR-GARCH , which can capture the sign effect from the parameter $\tau_{i,n}$, all of them are significant. For the spillover, the model states the bidirectional volatility spillover between two markets as the results show significant of $\alpha_{1,12}$, $\alpha_{2,12}$, $\alpha_{3,12}$ and $\alpha_{1,21}$. For expansion, $\alpha_{1,12}$, $\alpha_{2,12}$, $\alpha_{3,12}$, these parameters can capture the volatility spillover from futures market to spot market. And $\alpha_{1,21}$ also can capture the volatility spillover from spot market to futures market even if this parameter shows a negative value as -0.2226 which means the volatility spillover from lagged residual can reduce the volatility in the futures market. However, because of absolute value of $\alpha_{1,21}$ is greater than $\alpha_{1,12}$, $\alpha_{2,12}$, $\alpha_{3,12}$, the volatility spillover from spot to futures is stronger than the reverse direction.

All of lagged innovations itself also effect to the conditional variance of spot market, according to the significant of $\alpha_{1,11}$, $\alpha_{2,11}$ and $\alpha_{3,11}$, while there is only significant of $\alpha_{1,22}$ which represent the lagged innovations of futures market effect to its conditional variance. Moreover, most of its lagged variance which represent by $\beta_{j,n}$ are significant , except $\beta_{2,2}$, that mean there are persistent in volatility.

Table 4.6 Estimation results for Volatility Spillovers by The Glosten-Jagannathan-Runkle GARCH

SPOT		FUTURES	
Parameter	**Estimate**	**Parameter**	**Estimate**
ω_1	0.0011***	ω_2	0.0845***
	(6.12)		*(3.55)*
$\alpha_{1,11}$	0.0053***	$\alpha_{1,21}$	-0.2226***
	(40.66)		*(-7.17)*
$\alpha_{1,12}$	0.0332***	$\alpha_{1,22}$	0.1476***
	(26.35)		*(5.95)*
$\alpha_{2,11}$	0.0735***	$\alpha_{2,21}$	0.1057
	(55.95)		*(1.19)*
$\alpha_{2,12}$	-0.0697***	$\alpha_{2,22}$	-0.0046
	(-67.6)		*(-0.06)*
$\alpha_{3,11}$	-0.0910***	$\alpha_{3,21}$	0.0181
	(-141.21)		*(0.43)*
$\alpha_{3,12}$	0.0467***	$\alpha_{3,22}$	0.0624
	(41.77)		*(1.56)*
$\beta_{1,1}$	0.9380***	$\beta_{1,2}$	0.2996***
	(588.78)		*(5.90)*
$\beta_{2,1}$	0.8255***	$\beta_{2,2}$	0.0492
	(328.88)		*(1.08)*
$\beta_{3,1}$	-0.7641***	$\beta_{3,2}$	0.4067***
	(-446.87)		*(9.36)*
$\tau_{1,1}$	0.1556***	$\tau_{1,2}$	0.1690***
	(66.56)		*(4.61)*
$\tau_{2,1}$	-0.0344***	$\tau_{2,2}$	0.1397***
	(-92.09)		*(2.68)*
$\tau_{3,1}$	-0.1194***	$\tau_{3,2}$	-0.1019***
	(-50.65)		*(-3.74)*

*,**,*** indicated the significant level of 10% ,5%and 1% respectively, the numbers in parentheses indicate t statistics. The table shows the coefficient from the variance equation of $\sigma_{n,t}^2 = \omega_n + \sum_{i=1}^{q}(\alpha_{i,n1} + \tau_{i,1} D_{t-i})\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q}(\alpha_{i,n2} + \tau_{i,2} D_{t-i})\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p}\beta_{j,n}\sigma_{n,t-j}^2$ Where $\sigma_{n,t}^2$ is the conditional variance at time t. n = 1,2 which stand for spot and futures market respectively. *p,q* are lagged numbers which are chosen by the Akaike information criterion (AIC).

For summary, the above three models provide the different result of volatility spillover as the symmetric model, GARCH cannot capture any cross market volatility spillover effect but it only finds the impact of its own market lagged innovations of spot market. On the other hand , the asymmetric model including EGARCH and GJR-GARCH, both of them show there are the evidence of bidirectional volatility spillover between the spot and futures markets. Despite the results from GJR-GARCH show the volatility spillover effect from the spot market to the futures market is stronger.

After we got the result from three differences GARCH models, the study then measures and compares the RMSE of each model. Table 4.7 shows the lowest RMSE of GJR-GARCH model (7.4440), so we decide to employ the GJR-GARCH, which can explain the volatility movement the best, to measure return and volatility spillover of each sub-period which detected multi structural break by Bai and Perron model.

Table 4.7 The comparison of RMSE of three models

	GARCH	EGARCH	GJR-GARCH
RMSE	7.6662	7.5510	7.4440

A root mean square error is measured from a square root of the difference between realized volatility and estimated volatility from each model. The minimum RMSE presents the best model among these three that can describe volatility behavior.

4.3 Structural Breaks

Since the structural change may lead error estimation, the study employs the Bai and Perron method to detect the break. The result is shown in Table 4.8 as there are 3 structural breaks 14/7/2008, 30/7/2010 and 8/8/2012 which spilt the data into 4 sub-periods.

First sub-period contain data since 3/1/2007 until 14/7/2008 which is commonly known as the sub-prime crisis. Second period contain data between 15/7/2008 – 30/7/2010. This period might be occurred from the first economic adjustment programed of Greece or usually referred to the bailout package which was signed on mid of 2010. Moreover, the QE2 also was released in the close time of end of 2010. Next, the third period is the data between 31/7/2010 – 8/8/2012 which might take the effect of the beginning of QE3 at the end of 2012. Therefore, the last period hold the data since 9/8/2012 – 29/4/2014.

Table 4.8 Estimation results for Bai and Perron multiple structural changes

Bai and Perron's Multiple Structural Change Tests

Number of Breaks	Break
3	14/7/2008
	30/7/2010
	8/8/2012

This paper does not only study the return spillover on the entire data, but it also examines whether the return spillover between the spot market and the futures market have changed over time. As the result in Table 4.9 shows there is no any return spillover from the futures market to the spot market in both of full and sub-period analysis except the last period with 4 lags. On the other hand, the study finds the return spillover from the spot market to the futures market for both of the entire and sub-period data which make the result of spillover effect consist over time.

These results can be stated that investors in Thai markets prefer to invest in the stock market, the proper reason are investment in the stock market can get capital gain and dividend, the stock market has limited loss, and investor can hold the stock longer as required. Another explanation is that the investors may not yet have a profound understanding and be familiar with the futures market.

Table 4.9 Estimation results for return spillover (full and sub-periods)

Equation	Parameter	Full		Period 1		Period 2		Period 3		Period 4	
		Estimate	t Value	Estimate	t Value	Estimate	t Value	Estimate	t Value	Estimate	t Value
SPOT	γ_{10}	0.0431	1.14	0.0404	0.55	0.0320	0.34	0.0726	1.22	0.0276	0.48
	$\gamma_{1,11}$	0.2485	1.20	-0.0012	-0.01	0.2010	1.21	0.2059	1.12	-0.2090	-0.87
	$\gamma_{1,12}$	-0.1665	-0.95	0.0692	0.52	-0.1573	-1.10	-0.1533	-0.94	0.2120	0.99
	$\gamma_{2,11}$	0.1002	0.90	-0.1748	-1.06	0.3209*	1.84	-0.1456	-0.73	-0.2355	-0.85
	$\gamma_{2,12}$	-0.0602	-0.57	0.1585	1.11	-0.2154	-1.40	0.1730	0.95	0.1675	0.66
	$\gamma_{3,11}$	-0.1326	-1.43	-0.0746	-0.46	-0.1551	-0.91	-0.1402	-0.71	-0.0027	-0.01
	$\gamma_{3,12}$	0.1046	1.25	0.1424	1.00	0.1211	0.79	0.0776	0.42	-0.0144	-0.06
	$\gamma_{4,11}$	0.0829	0.99	-0.2777	-1.90	0.0980	0.62	0.0698	0.39	0.7703***	3.32
	$\gamma_{4,12}$	-0.0936	-1.25	0.2000	1.57	-0.1011	-0.73	-0.1399	-0.85	-0.6827***	-3.20
	δ_1	0.0193	0.60	-0.0012	-0.64	0.0365	0.28	-0.0489	-0.61	-0.1041	-1.36
FUTURES	γ_{20}	0.0419	0.97	0.0377	0.43	0.0313	0.29	0.0708	1.07	0.0274	0.43
	$\gamma_{1,21}$	0.4619	1.93	0.4380**	2.31	0.6914***	3.59	0.7349***	3.60	0.3831	1.41
	$\gamma_{1,22}$	-0.4159**	-2.05	-0.3968**	-2.50	-0.6472***	-3.90	-0.6850***	-3.75	-0.3671	-1.52
	$\gamma_{2,21}$	0.3054**	2.38	0.0393	0.20	0.6127***	3.04	0.3125	1.41	0.0888	0.29
	$\gamma_{2,22}$	-0.2634**	-2.18	-0.0738	-0.43	-0.5192***	-2.91	-0.2538	-1.25	-0.1435	-0.51
	$\gamma_{3,21}$	0.0442	0.41	0.1466	0.75	0.0133	0.07	0.0578	0.26	0.2562	0.82
	$\gamma_{3,22}$	-0.0877	-0.91	-0.0694	-0.41	-0.0782	-0.44	-0.1359	-0.67	-0.2694	-0.94
	$\gamma_{4,21}$	0.1533	1.59	-0.2658	-1.52	0.1759	0.97	0.2466	1.23	0.9386***	3.61
	$\gamma_{4,22}$	-0.1532*	-1.77	0.1866	1.22	-0.1730	-1.08	-0.2935	-1.61	-0.8343***	-3.49
	δ_2	0.0310	0.72	0.0037	0.94	0.0918	0.53	0.1488	1.26	0.1357	1.11

*,**,*** indicated the significant level of 10% ,5%and 1% respectively. The table shows the coefficient from the mean equation of $R_{n,t} = \gamma_{n0} + \sum_{i=1}^{k} \gamma_{i,n1} R_{1,t-i} + \sum_{i=1}^{k} \gamma_{i,n2} R_{2,t-i} + \delta_n \varphi_{n,t-1} + \varepsilon_{n,t}$ Where $R_{n,t}$ is the return of asset at time t. n = 1,2 which stand for spot and futures market respectively. k is a lagged number which is chosen by the Akaike information criterion (AIC).

Table 4.10 Estimation results for Volatility Spillover using the GJR- GARCH (full and sub-periods)

Equation	Parameter	Full		Period 1		Period 2		Period 3		Period 4	
		Estimate	t Value	Estimate	t Value	Estimate	t Value	Estimate	t Value	Estimate	t Value
SPOT	$\boldsymbol{\omega_1}$	0.0011***	6.12	0.2859**	2.26	5.4218***	101.08	0.5579***	8.49	0.0729***	3.86
	$\boldsymbol{\alpha_{1,11}}$	0.0053***	40.66	0.3464***	2.60	0.0661***	3.66	-0.1951***	-34.71	-0.0503***	-6.53
	$\boldsymbol{\alpha_{1,12}}$	0.0332***	26.35	-0.1756*	-1.90	-0.0358***	-7.90	0.1291***	15.72	-0.0544***	-11.60
	$\boldsymbol{\alpha_{2,11}}$	0.0735***	55.95	-0.3415***	-3.22	0.0492***	28.88	0.2361***	92.82	0.9654***	65.79
	$\boldsymbol{\alpha_{2,12}}$	-0.0697***	-67.60	0.3385***	3.86	-0.1029***	-222.46	-0.2129***	-54.45	-0.5675***	-40.49
	$\boldsymbol{\alpha_{3,11}}$	-0.0910***	-141.21	0.0247	0.14	0.0664***	5.97	0.2842***	2.91	-0.9702***	-68.90
	$\boldsymbol{\alpha_{3,12}}$	0.0467***	41.77	-0.0187	-0.12	-0.0714	-1.60	-0.1536*	-1.85	0.8176***	38.40
	$\boldsymbol{\beta_{1,1}}$	0.9380***	588.78	-0.0067	-0.04	0.0316	0.93	-0.3999***	-13.96	0.3685***	24.83
	$\boldsymbol{\beta_{2,1}}$	0.8255***	328.88	0.1069	1.06	0.0336	0.85	0.1989***	10.00	-0.1095***	-39.59
	$\boldsymbol{\beta_{3,1}}$	-0.7641***	-446.87	0.3715***	3.14	0.0359***	12.80	0.4334***	19.52	0.4520***	58.26
	$\boldsymbol{\tau_{1,1}}$	0.1556***	66.56	-0.1206	-1.42	0.0999	0.59	0.1887***	14.94	0.1292***	16.58
	$\boldsymbol{\tau_{2,1}}$	-0.0344***	-92.09	0.3789***	3.59	0.1025	1.63	0.4573***	15.23	-0.0930**	-2.38
	$\boldsymbol{\tau_{3,1}}$	-0.1194***	-50.65	0.1914	1.49	0.1064*	1.67	0.1445***	6.46	0.1405***	9.38
FUTURES	$\boldsymbol{\omega_2}$	0.0845***	3.55	0.3181**	2.55	7.4108***	4.37	0.4039***	5.59	0.0352**	2.44
	$\boldsymbol{\alpha_{1,21}}$	-0.2226***	-7.17	-0.2917**	-2.43	-0.0992	-0.49	-0.1328***	-34.15	-0.3611***	-3.70
	$\boldsymbol{\alpha_{1,22}}$	0.1476***	5.95	0.2964***	3.30	0.0382	0.23	0.0478***	14.02	0.1959**	2.08
	$\boldsymbol{\alpha_{2,21}}$	0.1057	1.19	-0.4500***	-3.88	-0.0069	-0.04	0.3041***	143.35	0.5123***	4.66
	$\boldsymbol{\alpha_{2,22}}$	-0.0046	-0.06	0.3862***	2.88	0.0590	0.37	-0.3009***	-98.72	-0.3837***	-4.54
	$\boldsymbol{\alpha_{3,21}}$	0.0181	0.43	0.5773***	4.13	-0.0652	-0.30	0.2268***	27.70	-0.4454***	-3.64
	$\boldsymbol{\alpha_{3,22}}$	0.0624	1.56	-0.3957***	-3.47	0.0315	0.18	-0.0850***	-8.60	0.5061***	5.13
	$\boldsymbol{\beta_{1,2}}$	0.2996***	5.90	-0.0131	-0.08	0.0343	0.67	-0.3292***	-46.00	0.3184***	6.31
	$\boldsymbol{\beta_{2,2}}$	0.0492	1.08	0.3391***	4.82	0.0335	0.65	0.3515***	19.80	-0.0275	-0.35
	$\boldsymbol{\beta_{3,2}}$	0.4067***	9.36	0.1910**	2.22	0.0362	0.71	0.5622***	22.37	0.4836***	10.22
	$\boldsymbol{\tau_{1,2}}$	0.1690***	4.61	-0.1494**	-2.55	0.3030	1.45	0.1327***	2.70	0.4294***	12.76
	$\boldsymbol{\tau_{2,2}}$	0.1397***	2.68	0.5788***	4.71	0.0734	0.33	0.3264***	10.07	0.0214	-0.38
	$\boldsymbol{\tau_{3,2}}$	-0.1019***	-3.74	0.0924	0.68	0.2097	0.77	0.0370	1.23	-0.0910**	-2.00

*,**,*** indicated the significant level of 10% ,5%and 1% respectively, the numbers in parentheses indicate t statistics. The table shows the coefficient from the variance equation of $\sigma_{n,t}^2 = \omega_n + \sum_{i=1}^{q}(\alpha_{i,n1} + \tau_{i,1} D_{t-i})\varepsilon_{1,t-i}^2 + \sum_{i=1}^{q}(\alpha_{i,n2} + \tau_{i,2} D_{t-i})\varepsilon_{2,t-i}^2 + \sum_{j=1}^{p}\beta_{j,n}\sigma_{n,t-j}^2$ Where $\sigma_{n,t}^2$ is the conditional variance at time t. n = 1,2 which stand for spot and futures market respectively. *p*,*q* are lagged numbers which are chosen by the Akaike information criterion (AIC).

This study also investigates on how the volatility spillover changes during the time. After we split the data into 4 sub-periods and re-estimate parameters by employing the bivariate GJR-GARCH model, the result is shown in Table 4.10. For spillover effect, the whole observations show the bidirectional volatility spillover; the split data analysis also displays the consistent result of the spillover effect from the futures market to the spot market in every sub-period. However, for the volatility spillover from the spot market to the futures market, the second period is the only time that does not represent the spillover effect. It might be resulted from the extreme financial crisis, sub-prime, most investors lost their fund and some were waiting for the rebound signal of the stock market, making the capital market was so stagnated at that time. On the other hand, in the futures market, investor can easily take the short position for several reasons such as hedging their portfolios or making a profit during bear market, explaining why the volatility spillover from futures market to spot market are represented in the second period.

In the spot market, the lagged variance are effect their conditional variance in every sub-period, but their impact do not consistence over time. In the futures market, the persistent of volatility exists in every sub-period except the second period. Moreover, the study finds the evidence of the asymmetry effect on most of period of both the spot and futures markets except the second period of futures market.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This study examines the daily return and volatility spillover transmission between SET50 index futures and its underlying by using three different bivariate models including GARCH, EGARCH, GJR-GARCH then comparing them, which the asymmetric model of GJR-GARCH provides the lowest RMSE. Moreover, the study operates the Bai and Perron model to test the structural change of whole observations. Then, the study finally employs GJR-GARCH, the best fit model, to test how the return and volatility spillover have changed in each sub-period.

As Thailand is a developing country. Most of the investment is geared to the stock market because investing in the stock market can get both of capital gain and dividend, while having positions in futures may end up with a huge loss and a futures contract also has the maturity date which hinder long-term investment. Moreover, most investors, especially individuals, are not well understood the new instruments that make them less attractive to invest in the futures market. Conform to the results which show that there is return spillover from a lagged residual of spot market to the futures market. On the other hand, most of the whole and sub-period observations do not have return spillover from the futures market to the spot market except the only significant of return spillover at the last sub-period with 4 lags.

The results from three models of GARCH family do not provide the exact outcome. Nevertheless, the result from the best fit model, GJR-GARCH, shows bidirectional spillover but the volatility spillover from spot to futures market is stronger. This result consists with Lin (2002) , who finds the bidirectional volatility spillover in Taiwan’s market and he also finds the stronger spillover effect from spot to futures market. For sub-period analysis, the split data also displays the spillover effect from the futures market to the spot market in every sub-period. However, for the volatility spillover from the spot market to the futures market, the second period is the only time that does not represent the spillover effect. Another outstanding for using GJR-GARCH model is the asymmetry effect, most of the results for both of the entire and sub-period data show the significant of the sign effect term which means there is the asymmetry effect, excepting the result from the second period of observation.

The contributions of the study of the relationship between these two markets are that traders can apply hedging and arbitrage trading strategies, fund managers can cope with risk management in any particular level, and policymakers are able to control market stability.

Notwithstanding, the examination of return and volatility spillover may be more efficient with the intraday data. This issue can be improved in future research. With the higher frequent data, the measurement would be more instantaneous, which benefits to investors.

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