CHAPTER 3

Methodology

This paper used series of daily returns from the ICT stock indices of the following ASEAN markets: Singapore, Thailand, Indonesia, Malaysia and the Philippines. There is a total of 6,500 daily observations ranging from April 4th 2011 to March 25th 2016**.**

3.1 Methodology

Step 1 calculating the returns

The daily return has been calculated as the following:

$$R_{j(t)} = \ln\left(\frac{P_{jt}}{P_{j(t-1)}}\right) \quad (3.1)$$

Where $R_{j(t)}$ is the return of ICT stock index of country j on day t

P_{jt} is the price of ICT stock index of country j on day t

$P_{j(t-1)}$ is the price of ICT stock index of country j on day t-1

1. Singapore

$$R_{Singapore(t)} = \ln\left(\frac{P_{Singapore(t)}}{P_{Sinagpore(t-1)}}\right) \quad (3.2)$$

$R_{Singapore(t)}$ is the return of ICT stock index of Singapore on day t

$P_{Singapore(t)}$ is the price of ICT stock index of Singapore on day t

$P_{Sinagpore(t-1)}$ is the price of ICT stock index of Singapore on day t-1

2. Thailand

$$R_{\text{Thailand}(t)} = \ln\left(\frac{P_{\text{Thailand}(t)}}{P_{\text{Thailand}(t-1)}}\right) \quad (3.3)$$

$R_{\text{Thailand}(t)}$ is the return of ICT stock index of Thailand on day t

$P_{\text{Thailand}(t)}$ is the price of ICT stock index of Thailand on day t

$P_{\text{Thailand}(t-1)}$ is the price of ICT stock index of Thailand on day t-1

3. Indonesia

$$R_{\text{Indonesia}(t)} = \ln\left(\frac{P_{\text{Indonesia}(t)}}{P_{\text{Indonesia}(t-1)}}\right) \quad (3.4)$$

$R_{\text{Indonesia}(t)}$ is the return of ICT stock index of Indonesia on day t

$P_{\text{Indonesia}(t)}$ is the price of ICT stock index of Indonesia on day t

$P_{\text{Indonesia}(t-1)}$ is the price of ICT stock index of Indonesia on day t-1

4. Malaysia

$$R_{\text{Malaysia}(t)} = \ln\left(\frac{P_{\text{Malaysia}(t)}}{P_{\text{Malaysia}(t-1)}}\right) \quad (3.5)$$

$R_{\text{Malaysia}(t)}$ is the return of ICT stock index of Malaysia on day t

$P_{\text{Malaysia}(t)}$ is the price of ICT stock index of Malaysia on day t

$P_{\text{Malaysia}(t-1)}$ is the price of ICT stock index of Malaysia on day t-1

5. The Philippines

$$R_{\text{the Philippines}(t)} = \ln\left(\frac{P_{\text{the Philippines}(t)}}{P_{\text{the Philippines}(t-1)}}\right) \quad (3.6)$$

$R_{\text{the Philippines}(t)}$ is the return of ICT stock index of the Philippines on day t

$P_{\text{the Philippines}(t)}$ is the price of ICT stock index of the Philippines on day t

$P_{\text{the Philippines}(t-1)}$ is the price of ICT stock index of the Philippines on day t-1

Step 2 Unit root test by using Augmented Dickey-Fuller Test for test stationary of the data

The data that the study used in this study is the time series data. The study needs to use unit root test method to whether that the time series data is stationary or not.

The equations that used in this test are

Non constant and trend $\Delta R_{jt} = \theta_j R_{j(t-1)} + \sum_{i=1}^{\rho} \emptyset_i \Delta R_{j(t-i)} + \varepsilon_t$ (3.7)

Constant without trend $\Delta R_{jt} = \alpha + \theta_j R_{j(t-1)} + \sum_{i=1}^{\rho} \emptyset_i \Delta R_{j(t-i)} + \varepsilon_t$ (3.8)

Constant and trend $\Delta R_{jt} = \alpha + \beta t + \theta_j R_{j(t-1)} + \sum_{i=1}^{\rho} \emptyset_i \Delta R_{j(t-i)} + \varepsilon_t$ (3.9)

where $R_{j(t)}$ is Returns of ICT stock index of country j at time t

$R_{j(t-i)}$ is Returns of ICT stock index of country j at time t-1

β is The parameters of the securities

p is Lead and Lag

ε_t is The errors term

The assumptions for testing θ_j

$H_0 : \theta_j = 0$ (R_t is non stationary)

$H_1 : \theta_j < 0$ (R_t is stationary)

If the study accepts H_0, $R_{j(t)}$ has Unit Root or $R_{j(t)}$ is non stationary. The study has to use Differencing method until $R_{j(t)}$ can reject H_0.

If accept H_1, $R_{j(t)}$ does not has Unit Root or $R_{j(t)}$ is stationary

Step 3 Analyze data by using OLS estimation

To investigate the day of the week effect in returns, the standard OLS methodology was employed by regressing returns on five daily dummy variables for empirical analysis:

$$R_{j(t)} = \alpha_0 + \alpha_1 R_j (D_{Mt}) + \alpha_2 R_j (D_{Tt}) + \alpha_3 R_j (D_{Ht}) + \alpha_4 R_j (D_{Ft}) \sum_{i=1}^{p} \beta_j R_{j(t-i)} + \varepsilon_t \quad (3.10)$$

When D_{Mt}, D_{Tt}, D_{Ht} and D_{Ft} are the dummy variables of Monday, Tuesday, Thursday and Friday, respectively. The study excludes Wednesday's dummy variable to avoid the dummy variable trap.

D_{Mt}=1 if there is the dummy variable of Monday and 0 if there is other days

D_{Tt}=1 if there is the dummy variable of Tuesday and 0 if there is other days

D_{Ht}=1 if there is the dummy variable of Thursday and 0 if there is other days

D_{Ft}=1 if there is the dummy variable of Friday and 0 if there is other days

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$ and α_5	= Coefficient
β_j	= Coefficient of $R_{j(t-i)}$
R_j	= return on ICT stock index of country j on day t
$R_{j(t-i)}$	= return on ICT stock index of country j on day t
t	= time
p	= Lead and Lag
ε_t	= Error of time given h_t ($\varepsilon_t \sim N(0,h_t)$)

1. Singapore

$$R_{Singapore(t)} = \alpha_0 + \alpha_1 R_{Singapore}(D_{Mt}) + \alpha_2 R_{Singapore}(D_{Tt}) + \alpha_3 R_{Singapore}(D_{Ht}) + \alpha_4 R_{Singapore}(D_{Ft}) + \sum_{i=1}^{p} \beta_j R_{Singapore\,(t-i)} + \varepsilon_t \quad (3.11)$$

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	coefficient
β_j	=	coefficient of $R_{Singapore\,(t-i)}$
$R_{Singapore(t)}$	=	return on ICT stock index of Singapore at time t
$R_{Singapore\,(t-i)}$	=	return on ICT stock index of Singapore at time t-1
t	=	Time
p	=	Lead and Lag
ε_t	=	error of time that h_t ($\varepsilon_t \sim N(0,h_t)$)

2. Thailand

$$R_{Thailand(t)} = \alpha_0 + \alpha_1 R_{Thailand}(D_{Mt}) + \alpha_2 R_{Thailand}(D_{Tt}) + \alpha_3 R_{Thailand}(D_{Ht}) + \alpha_4 R_{Thailand}(D_{Ft}) + \sum_{i=1}^{p} \beta_j R_{Thailand\,(t-i)} + \varepsilon_t \quad (3.12)$$

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	coefficient
β_j	=	coefficient of $R_{Thailand\,(t-i)}$
$R_{Thailand\,(t)}$	=	return on ICT stock index of Thailand at time t
$R_{Thailand\,(t-i)}$	=	return on ICT stock index of Thailand at time t-1
t	=	Time
p	=	Lead and Lag
ε_t	=	error of time that h_t ($\varepsilon_t \sim N(0,h_t)$)

3. Indonesia

$$R_{Indonesia(t)} = \alpha_0 + \alpha_1 R_{\text{Indonesia}}(D_{Mt}) + \alpha_2 R_{\text{Indonesia}}(D_{Tt}) + \alpha_3 R_{\text{Indonesia}}(D_{Ht}) + \alpha_4 R_{\text{Indonesia}}(D_{Ft}) + \sum_{i=1}^{p} \beta_j R_{\text{Indonesia}\,(t-i)} + \varepsilon_t \quad (3.13)$$

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	coefficient
β_j	=	coefficient of $R_{\text{Indonesia}\,(t-i)}$
$R_{\text{Indonesia}\,(t)}$	=	return on ICT stock index of Indonesia at time t
$R_{\text{Indonesia}\,(t-i)}$	=	return on ICT stock index of Indonesia at time t-1
t	=	Time
p	=	Lead and Lag
ε_t	=	error of time that h_t ($\varepsilon_t \sim N(0,h_t)$)

4. Malaysia

$$R_{Malaysia(t)} = \alpha_0 + \alpha_1 R_{\text{Malaysia}}(D_{Mt}) + \alpha_2 R_{\text{Malaysia}}(D_{Tt}) + \alpha_3 R_{\text{Malaysia}}(D_{Ht}) + \alpha_4 R_{\text{Malaysia}}(D_{Ft}) + \sum_{i=1}^{p} \beta_j R_{\text{Malaysia}\,(t-i)} + \varepsilon_t \quad (3.14)$$

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	coefficient
β_j	=	coefficient of $R_{\text{Malaysia}\,(t-i)}$
$R_{\text{Malaysia}\,(t)}$	=	return on ICT stock index of Malaysia at time t
$R_{\text{Malaysia}\,(t-i)}$	=	return on ICT stock index of Malaysia at time t-1
t	=	Time
p	=	Lead and Lag
ε_t	=	error of time that h_t ($\varepsilon_t \sim N(0,h_t)$)

5. The Philippines

$$R_{the\ Philippines(t)} = \alpha_0 + \alpha_1 R_{\text{the Philippines}}(D_{Mt}) + \alpha_2 R_{\text{the Philippines}}(D_{Tt}) + \alpha_3 R_{\text{the Philippines}}(D_{Ht}) + \alpha_4 R_{\text{the Philippines}}(D_{Ft}) + \sum_{i=1}^{p} \beta_j R_{\text{the Philippines}\,(t-i)} + \varepsilon_t \quad (3.15)$$

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	coefficient
β_j	=	coefficient of $R_{\text{the Philippines}\,(t-i)}$
$R_{\text{the Philippines}\,(t)}$	=	return on ICT stock index of the Philippines at time t
$R_{\text{the Philippines}\,(t-i)}$	=	return on ICT stock index of the Philippines at time t-1
t	=	Time

p	=	Lead and Lag
ε_t	=	error of time that h_t ($\varepsilon_t \sim N(0,h_t)$)

Step 4 ARCH effect test

Using ε_t from estimate R_j in the step 2 tests ARCH-EFFECT. That is ARCH(q) of Eagle

$$E_{j(t)}\, \hat{\varepsilon}^2_{j(t-1)} = \alpha_0 + \alpha_1\, \hat{\varepsilon}^2_{j(t-1)} + \ldots + \alpha_n\, \hat{\varepsilon}^2_{j(t-q)} \quad (3.16)$$

Where $\hat{\varepsilon}^2_t$, $\hat{\varepsilon}^2_{t-1}$ = Residuals at time t and t-1

α_0 , α_1 , … , α_n = Coefficient

$H_0 : \alpha_1,\ldots, \alpha_n = 0$

$H_1 : \alpha_1,\ldots, \alpha_n \neq 0$

If accept H_0, the regression has no relationship: No ARCH-EFFECT

If accept H_1, the regression has a relationship : ARCH-EFFECT

Step 5 Estimate the data by using GARCH method

GARCH equation

$$h_{jt} = V_c + \sum_{k=1}^{p} V_{Aj}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bj}\, \varepsilon^2_{Rj(t-k)} \quad (3.17)$$

From the model using GARCH

$$h_{j(t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk}\, \varepsilon^2_{Rj(t-k)} \quad (3.18)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0

Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of country j at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of country j at time t-1

$\varepsilon^2_{Rj(t-k)}$ is the error of ICT stock index of country j at time t-1

k is Lead and Lag

1. Singapore

$$h_{Singapore\ (t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{JAS\ (t-i)} + \sum_{k=1}^{q} V_{Bk}\ \varepsilon^2_{RJAS(t-k)} \quad (3.19)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0
Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of Singapore at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of Singapore at time t-1

$\varepsilon^2_{Rj(t-k)}$ is the error of ICT stock index of Singapore at time t-1

k is Lead and Lag

2. Thailand

$$h_{Thailand\ (t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{JAS\ (t-i)} + \sum_{k=1}^{q} V_{Bk}\ \varepsilon^2_{RJAS(t-k)} \quad (3.20)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0

Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of Thailand at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of Thailand at time t-1

$\varepsilon^2_{Rj(t-k)}$ is the error of ICT stock index of Thailand at time t-1

k is Lead and Lag

3. Indonesia

$$h_{Indonesia\,(t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{JAS\,(t-i)} + \sum_{k=1}^{q} V_{Bk}\ \varepsilon^2_{RJAS(t-k)} \quad (3.21)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0
Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of Indonesia at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of Indonesia at time t-1

$\varepsilon^2_{Rj(t-k)}$ is the error of ICT stock indexof Indonesia at time t-1

k is Lead and Lag

4. Malaysia

$$h_{Malaysia\,(t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{JAS\,(t-i)} + \sum_{k=1}^{q} V_{Bk}\ \varepsilon^2_{RJAS(t-k)} \quad (3.22)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0 Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of Malaysia at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of Malaysia at time t-1

$\varepsilon^2_{Rj(t-k)}$ is the error of ICT stock index of Malaysia at time t-1

k is Lead and Lag

5. The Philippines

$$H_{the\ Philippines\,(t)} = V_M D_M + V_T D_T + V_H D_H + V_F D_F + \sum_{i=1}^{p} V_{Ai}\, h_{JAS\,(t-i)} + \sum_{k=1}^{q} V_{Bk}\ \varepsilon^2_{RJAS(t-k)} \quad (3.23)$$

by $\sum_{i=1}^{p} V_{Aj} > 0$, $\sum_{k=1}^{q} V_{Bk} > 0$ and $\sum_{i=1}^{p} V_{Ai}\, h_{j(t-i)} + \sum_{k=1}^{q} V_{Bk} < 1$

In terms of Heteroscedastic Variance, there is GARCH (0,1) if p=1 and q=0 Where D_M, D_T, D_H and D_F is the dummy variable of Monday, Tuesday, Thursday and Friday

V_M, V_T, V_W, V_H and V_F is the coefficient of Monday, Tuesday, Thursday and Friday

V_{Aj}, V_{Bj} is the parameter

$h_{j(t)}$ is the volatility of ICT stock index of the Philippines at time t of the error term

$h_{j(t-i)}$ is the volatility of ICT stock index of the Philippines at time t-1

$\varepsilon^2_{Rj(t-k)}$	is the error of ICT stock index in of Philippines at time t-1
k	is Lead and Lag

Step 6 Model selection

Finding appropriate lag term of ARCH, GARCH, the study decides from Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC)

Akaike Information Criterion (AIC) = $-2t/\eta + 2k/\eta$ (3.24)
Schwartz Information Criterion (SIC) = $-2t/\eta + k\log\eta/\eta$ (3.25)

Where k is the number of parameter
η is the number of observation
t is the log likelihood function using k parameters

If in this study AIC and SIC are not consistent, 2 use SIC for deciding to choose the best model.

Table 3.1 Shows ICT stock index date of selected countries needs to be tested for the lowest AIC and SIC.

ICT stock index of selected countries	AIC	SIC
1. Singapore	✓	✓
2. Thailand	✓	✓
3. Indonesia	✓	✓
4. Malaysia	✓	✓
5. the Philippines	✓	✓

From table 3.1 shows ICT stock index of selected countries need to be tested for the lowest AIC and SIC. To find the best way for using GARCH (p,q) model, the study selects based on the lowest AIC and SIC. Therefore, the study tests in every country's data.