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THE RELATIONSHIP AMONG GOLD, CRUDE OIL, THE US AND TAIWAN'S STOCK MARKET

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This paper tries to explore the relationship between Taiwan stock market and commodity market and American stock market. There are six variables with total 213 observations for each variable by using monthly data from the periods of October 1997 to June 2015. Model 1 examines commodity market including gold price?LLG?, crude oil price?WTI?, USD index ?USDX?and Taiwan stock market. Model 2 adds American stock market, Dow Jones Industrial Average?DJIA?and NASDQA.

The results on Ordinary Least Squares?OLS?showed that USDX has significant negative impact on Taiwan stock market in model 1. However, in Model 2 showed WTI and USDX have significant negative impact but NASDAQ has positive significant impact on Taiwan stock market. The results of Unit Root test demonstrated that all variables are not stationary series in its original numbers, but they become I(1) stationary series after First Difference. In addition, the results of Johansen Cointegration showed that there are no cointegration relationship on both models, but there is on-way leading relationship for Taiwan stock market on WTI, DJIA and NASDAQ from Granger Causality test.

From Impulse Response Analysis, the results showed that Taiwan stock market has negative impulse response on USDX and WTI while it has positive impulse response on LLG, DJIA and NASDAQ, and the impulse lasted for 4 periods. Finally, the results of Forecast Error Variance Decomposition showed there are high self-explanation powers for all variables on both models and NASDAQ has the most influence from DJIA and Taiwan stock market in model 2.

Keywords: *Gold Price, Crude Oil Price, USD Index, Dow Industrial, NASDQ, Taiwan Stock Market*

1. Introduction

Stock market is one of the most important economic and financial indexes for a country's economics development. Taiwan's stock market has been established since the year 1962 and there are total 1496 companies, 838 in list market and 658 in Over the Counter (OTC) market by the end of 2015.

Gold price and crude oil price have been increased sharply since 2002, and these commodities are trading in US dollars. Therefore, this paper is setting up the first model to examine the impact of goods market, gold price (LLG) and crude oil price (WTI) with US dollar index (USDX) on Taiwan's stock market. In addition, Taiwan is a trade-oriented country, most

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products are mainly for export and import and the US market is one of the major trade markets in Taiwan. Thus, in model 2, it added American stock market, Dow Jones Industrial Average (DJIA) and NASDQA into model 1, to explore the relationship between Taiwan and American stock markets.

The main purpose is to explore the relationship between gold price, crude oil price, US dollar index, American stock markets and Taiwan stock market. There are six variables with total 213 observations for each variable in monthly data from October 1997 to June 2015. It tries to find out a long term relationship between Taiwan's stock market and model 1 and model 2 by using cointegration. Further, to observe the causality among variables in Granger causality test. Finally, impulse response analysis and forecast error variance decomposition test the impact of impulse response among variables on other variables and their explanation power.

The results on Ordinary Least Squares?OLS? showed that USDX has significant negative impact on Taiwan stock market in model 1. However, in Model 2 showed WTI and USDX have significant negative impact but NASDAQ has positive significant impact on Taiwan stock market. The results of Unit Root test demonstrated that all variables are not stationary series in its original numbers, but they become I(1) stationary series after First Difference. In addition, the results of Johansen Cointegration showed that there are no cointegration relationship on both models, but there is on-way leading relationship for Taiwan stock market on WTI, DJIA and NASDAQ from Granger Causality test.

From Impulse Response Analysis, the results showed that Taiwan stock market has negative impulse response on USDX and WTI while it has positive impulse response on LLG, DJIA and NASDAQ, and the impulse lasted for 4 periods. Finally, the results of Forecast Error Variance Decomposition showed there are high self-explanation powers for all variables on both models and NASDAQ has the most influence from DJIA and Taiwan stock market in model 2.

2. Literature Review

Hsih (2006) used monthly data between September 1990 to January 2006 to explore the relationship among gold spot and future prices, and crude oil spot and future prices and Taiwan stock market. He found that Taiwan stock market and gold spot price has random walk trend in unit root test. In addition, gold and crude oil prices have long term stable relationship with Taiwan stock market in cointegration test. Gold price has one-way leading relationship in Taiwan stock market in granger causality test. Finally, there has a significant positive relationship between Taiwan stock market and gold price in impulse response analysis test.

Chen S. (2011) used daily data between January 1992 to December 2010 to explore the relationship between gold price and Taiwan stock market. She found that gold price has negative significant impact on Taiwan stock market in OLS regression.

Chang (2006) used monthly data between January 1995 to January 2005 to explore the relationship between high crude oil price and Taiwan stock market. She found out that there are neither leading relationships between WTI and Taiwan stock market in Vector Autoregression (VAR) test, nor causality in grander causality test. Finally, there is a short term impact of WTI on Taiwan stock market in impulse response analysis test.

Huang H. (2008) used monthly data between January 1991 to December 2008 to explore the relationship among WTI, Shanghai stock market DJIA and Taiwan stock market. She found that WTI and Taiwan stock market become stationary series after first difference I(1) in unit root test. In addition, there have a long term stable equilibrium relationship among Shanghai stock market, DJIA, WTI and Taiwan stock market in cointegration test. In addition, there is a feedback relationship between WTI and Taiwan stock market in granger causality test. Finally, there has the same direction movement between Taiwan stock market and WTI in OLS test.

Chen C. (2009) used monthly data between October 1983 to October 2008 to explore the relationship among WTI, new Taiwan Dollar/US Dollar exchange rate and Taiwan stock market. Period 1 includes October 1983 to August 1988, and period 2, August 1988 to September 2001 and period 3, September 2001 to October 2008. She found that WTI and Taiwan stock market has random walk trend and become stationary series after first difference I(1) in unit root test. WTI, Exchange rate and Taiwan stock market have long term stable relationship in cointegration test in period 1 and 3, but not in period 2. WTI has impact on Taiwan stock market in period 3, in granger

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causality test. Finally, there has no impact of WTI and exchange rate on Taiwan stock market in period 1, but WTI has slight impact on Taiwan stock market in period 2 and 3 in impulse response analysis test.

Huang Z. (2009) used daily data between January 2, 2006 to February 27, 2009 to explore the relationship among WTI, LLG, DJIA, German, Japan, Taiwan and Shanghai stock markets. She found that WTI, DJIA and Taiwan stock market has random walk trend and become stationary series after first difference I(1) in ADF unit root test. WTI, LLG, US dollar exchange rate and Taiwan stock market have long term stable equilibrium relationship in Johansen cointegration test. WTI and US dollar exchange rate have feedback effect on Taiwan stock market in VAR test. WTI has also feedback effect on Taiwan stock market, but US dollar exchange rate has one-way leading on Taiwan stock market in granger causality test.

Shi P. (2011) used monthly data between May 1994 to November 2010 to explore the relationship among NASDAQ, Philadelphia semi-conductor index (PSCX) and Taiwan stock market. He found that NASDAQ, PSCX and Taiwan stock market have random walk trend and become stationary series after first difference I(1) in ADF unit root test. NASDAQ, PSCX and Taiwan stock market have no long term stable relationship in cointegration test. NASDAQ has most significant impact on Taiwan stock market in VAR test. NASDAQ has more impact on Taiwan's stock market in granger causality test. Finally, there are positive relationship among NASDAQ, PSCX and Taiwan stock market in correlation teat.

Lee K. (2012) used daily data between January 4, 2000 to December 28, 2011 to explore the NT$/US$ exchange rate (US dollar exchange rate), WTI and LLG. He found that US dollar exchange rate, WTI and LLG have random walk trend and become stationary series after first difference I(1) in ADF unit root test. There is no stable equilibrium relationship among Exchange rate, WTI, and LLG, in Johansen cointegration test. The impact orders are LLG less impact than WTI and US dollar exchange rate. US dollar exchange rate has most sensitive impact in VAR test. WTI and US dollar exchange rate have feedback effect. LLG has one-way leading relationship on US dollar exchange rate in granger causality test.

Tien S. (2013) used monthly data between December 1999 to October 2012 to explore Mining Fund (MF), LLG and US dollar index (USDX). She found that MF, LLG and USDX have stable long term equilibrium relationship in Johansen cointegration test. LLG has one-way leading relationship with USDX in Granger causality test.

3. Research Methodology:

This paper starts from Ordinary Least Square (OLS) and it is important to know that used data series are stationary or not in the empirical studies in time series models. If it is a nonstationary time series data to do regression will cause the estimate model to be biased. Granger & Newbold (1974)[1] called it is a false regression. Therefore, it uses ADF unit root test to test data series stationary, Johansen cointegration, Granger causality, impulse response, and forecast error variance decomposition. In addition, it is also important to decide the fitness of lag period by using Akaike Information Criterion (AIC) before running above tests.

(1). Ordinary Least Squares

In regression analysis, if there is only forecasting variable, it is called simple regression and if there are more than one, it is called multi-regression model. The models in this paper are multi-regression model, formula (3.1).

$$Y_i=\beta_0+\beta_1 X_{1i}+\beta 2 X_{2i}+\beta 3 X_{3i}+\beta 4 X_{4i}+\varepsilon_t \quad (3.1)$$

Y is dependent variable, Xs are independent variables, βs are coefficients, i s are different period of sample data number, and ε_t is error term

(2). Akaike Information Criterion (AIC)

There are two ways of judging the best lag period, Akaike Information Criterion (AIC) and Schwartz Bayesian Information Criterion (SIC). SIC was Schwartz (1978)[2] induced from Bayesian Criterion. AIC was developed by Akaike (1973)[3] from the concept of Maximum Likelihood.

A. AIC

Akaike (1974) uses formula (3.2) to choose the best lag period by using the minimum value of AIC.

1. Granger, CWJ and Newbold, P. (1974). "Spurious regressions in econometrics".

2. Schwarz, Gideon E. (1978). "Estimating The Dimension of A Model".

3. Akaike, Hirotugu (1974). "A New Look at The Statistical Model Identification".

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$$AIC(P) = T\ ln\ \sigma_\varepsilon^2 + 2P \quad (3.2)$$

P: lag period, T: valid sample numbers, σ_ε^2: residuals of variance (maximum likelihood value) B. SBC

Schwarz (1978) used Bayesian Criterion to set up SIC (Schwartz's Bayesian Criterion).

$$SIC(P) = T\ ln(\sigma_\varepsilon^2) + P\ ln(T) \quad (3.3)$$

This paper uses Akaike (1974) AIC rules to choose the best lag period for the models

(3). ADF Unit Root test

Dicker and Fuller (1979)[4] used unit root test to examine the stationary of data series. If the results with unit root, it implies that the data series are nonstationary. There are three different models of ADF unit root as the followings:

Model 1: no intercept, no trend

$$\Delta Y_t = \delta Y_{t-1} + \sum_{t=1}^{p} \alpha_t \Delta Y_{t-1} + \varepsilon_t \quad (3.4)$$

Model 2: with intercept but no trend

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{t=1}^{p} \alpha_t \Delta Y_{t-1} + \varepsilon_t \quad (3.5)$$

Model 3: with intercept and trend

$$\Delta Y_t = \alpha + \gamma t + \delta Y_{t-1} + \sum_{t=1}^{p} \alpha_t \Delta Y_{t-1} + \varepsilon_t \quad (3.6)$$

ΔY_t: first order differentiate, α: intercept, t: time trend, ε_t: error term, γ ` $\alpha_t$ ` δ: coefficient value, and p: lag period

ADF unit root hypothesis?

H_0: δ=0 (with unit root) data series are not stationary?

H_1 $\delta \neq 0$ (without unit root, data series are stationary)

According to the results, if it rejects H_0, without unit root, it implies that original data series are stationary. If the results accept H_0, with unit root, it implies that original data series are nonstationary and it needs to do second order differentiate until it rejects H_0.

(4). Johansen Cointegration

Granger (1981)[5] cointegration concept states that two nonstationary variables will become stationary after linear cointegration and it implies that they will have long-term stable relationship. Engle and Granger (1987)[6] cointegration theory. It implies that if nonstationary data series become stationary after linear programming. The main purpose is to understand if there is a long-term stable relationship among data series.

There are two different cointegration theories including, Engle and Granger (1987) and Johansen (1988)[7], and Johansen and Juselius (1990)[8], maximum likelihood cointegration. In this paper adopts maximum likelihood cointegration test. Johansen cointegration is not only to estimate all cointegration vectors but also it can complete understand long-term or short-term relationship in time series data. In addition, it can use χ^2 normal distribution statistics to examine cointegration vector number (r) improved insufficient of Engle-Granger two stages cointegration. Johansen cointegration sets up under VAR system and assume a lag of k rank and k numbers of vector, its VAR model equation is as (3.7):

$X_t = \pi_1 X_{t-1} + ... + \pi_k X_{t-k} + \mu + \varepsilon_t$ (3.7)

X_t: lag of k rank nonstationary variable, integration I(1), π_i: coefficient matrix, μ: constant vector, ε_t: error term

Johansen and Juselius (1990) used maximum likelihood cointegration test to setup Trace Test and Maximum Eigenvalue Test, two LR (χ^2 distribution statistics to examine cointegration vector number (r))

A. Trace Test

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} ln\ (1 - \hat{\lambda}_i) \quad (3.8)$$

H_0: rank(π) = r (maximum r cointegration)

H_1: rank(π) > r (minimum r+1cointegration)

B. Maximum Eigenvalue Test

$$\lambda_{max} = -T\ ln(1 - \hat{\lambda}_{r+1}) \quad (3.9)$$

4. Dickey, DA; and Fuller, WA (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root".

5.Granger, Clive (1981). "Some Properties of Time Series Data and Their Use in Econometric Model Specification".

6. Engle, Robert F. , Granger, Clive WJ (1987). "Co-integration and error correction: Representation, estimation and testing".

7. S. Johansen (1988). "Statistical Analysis of Cointegration Vectors".

8. S. Johansen, K. Juselius (1990) "Maximum Likelihood Estimation And Inference On Cointegration - With Applications To The Demand For Money".

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H_0: rank(π) = r (with r numbers of cointegration vectors)

H_1:rank(π) = r+1 (with r+1numbers of cointegration vectors)

T: numbers of observatories, n: series numbers, λ_i: i's coefficient value, π: all implies long-term information, and r: cointegration vector numbers

Refers to the critical values of Johansen and Juselius (1990) to decide reject or accept H_0.

(5). Vector Autoregression (VAR)

Sims (1980)[9] used Vector Autoregression (VAR) to solve internal and external problem. VAR uses its own variables with one lag period as an explanation variable and see them as internal variables for all variables. It will be very clear to know how a variable change to affect another variable.

General equation (3.10):

$$Y_t = \alpha + \sum_{i=1}^{n} \beta_i Y_{t-i} + \varepsilon_t \qquad (3.10)$$

$$E(\varepsilon_t \varepsilon_s) = 0 \,, E(\varepsilon_t \varepsilon_t') = \Sigma \neq 0$$

Y_t: internal variable vector, Y_{t-i}: i's one lag period vector of Y_t vector, β_i: coefficient matrix, ε_t: expected error of vector, Σ: covariance matrix

$E(\varepsilon_t \varepsilon_s) = 0$, implies time series independent for each regression

$E(\varepsilon_t \varepsilon_t') = \Sigma$, error term of current period

(6). Granger Causality

Granger (1969)[10] used predictability to measure the causality among variables. If there is a causality relationship, then, adds previous information of an independent variable to increase the explanation ability of dependent variable. If the previous information of variable X helps to predict dependent variable Y. Then, it can state as X variable Granger affect variable Y. In addition, if X and Y variables have mutual Granger effects, they are feedback effect between two variables. Therefore, there are four results for Granger causality to explain the relationship between variables, Granger cause, does not Granger cause, feedback and independent

Granger causality models(3.11) and (3.12)?

$$X_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} X_{t-i} + \sum_{i=1}^{k} \alpha_{2i} Y_{t-i} + \varepsilon_{1t} \qquad (3.11)$$

$$Y_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} X_{t-i} + \sum_{i=1}^{k} \beta_{2i} Y_{t-i} + \varepsilon_{2t} \qquad (3.12)$$

ε_{1t}`ε_{2t}: two irrelevant error terms.

Four coefficients to determine the relationships between variables?

A. If $\alpha_{2i} \neq 0$ and $\alpha_{1i} = 0$ ' implies Y causes X (Y Causes X);

B. If $\beta_{1i} \neq 0$ and $\beta_{2i} = 0$ ' implies X causes Y (X Causes Y);

C. If $\alpha_{2i} \neq 0$ and $\beta_{1i} \neq 0$ ' implies there is feedback between two variables.

D. If $\alpha_{2i} = 0$ and $\beta_{1i} = 0$ ' implies there is independent between two variables.

(7). Impulse Response Analysis

Sims (1980) used impulse response analysis to study an unexpected change of a variable impacted by external shocks in VAR model. It implies a dynamic reaction model when a variable was impacted by external shocks. From impulse response analysis, it can know the positive or negative impact with persistence or volatility impact and periods.

From Wald Decomposition Theorem transfers vector autogression (VAR) model to moving average (MA),

$$Y_t - \sum_{i=1}^{m} \beta_i Y_{t-1} = \alpha + \varepsilon_t$$

$(1 - \beta_1 L - \beta_2 L^2 - \ldots - \beta_m L^m) Y_t = \alpha + \alpha_t$

$Yt = (1 - \beta_1 L - \beta_2 L^2 - \ldots - \beta_m L^m)^{-1} \alpha + (1 - \beta_1 L - \beta_2 L^2 - \ldots - \beta_m L^m)^{-1} \varepsilon_t$

$$Y_t = \alpha' + \sum_{i=0}^{\infty} c_i \varepsilon_{t-i} \qquad (3.13)$$

L: Lag Operator, α': constant vector, c_i: matrix, c_0=I (unit matrix), ε_t: vector forecast error.

If ε_t has no relationship with current period, it can decide the relationship between two variables by calculating forecast error variance percentage.

9. Sims, Christopher (January 1980) "Macroeconomics and reality".

10. Granger, C. W. J. (1969). "Investigating Causal Relations by Econometric Models and Cross-spectral Methods"

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If ε_t has certain relationship with current period, it has to use Cholesky decomposition to choose a lower triangular matrix:

$$Y_t = \alpha' + \sum_{i=0}^{\infty} c_i F F^{-1} \varepsilon_{t-i} \qquad (3.14)$$

F: Non-singular, $D_i = c_i F' \eta_{t-i} = F^{-1} \varepsilon_{t-i}$

To write above equations (3.14) to:

$$Y_t = \alpha' + \sum_{i=0}^{\infty} D_i \eta_{t-i} \qquad (3.15)$$

η_{t-i}: random term with no autocorrelation

(8). Forecast Error Variance Decomposition

In general empirical study, if there are too many variables in VAR model, there may exist collinear, over distribution and parameters problems to affect the results of estimation in regression model.

Y_t t period forecast error equation (3.16):

$Y_t - \hat{E}_{t-k} Y_t = D_0 \eta_t + D_i \eta_{t-1} + ... + D_{k-1} \eta_{t-k+1}$) (3.16)

$\hat{E}_{t-k} Yt = E(Y_t | Y_{t-k}, Y_{t-k-1}, Y_{t-k-2}, ...)$: error term by using previous data of *t-k* period to forecast t period.

Covariance matrix of k rank forecast error:

$E(Y_t - \hat{E}_{t-k} Y_t)(Y_t - \hat{E}_{t-k} Y_t)'$

$= D_0 E(\eta_t \eta_t') D_0' + D_1 E(\eta_t \eta_t') D_1' + ... + D_{k-1} E(\eta_t \eta_t') D_{k-1}'$ (3.17)

4. Empirical Results:

This paper used E-vies software to run regression. The data sample period starts from October 1997 to June 2015. There are total 213 observations for each variable by using monthly data into empirical studies. The data sources are from Taiwan Economic Journal database system (TEJ).

Model 1:

$TAIEX = CONSTAN + \beta_1 LLG + \beta_2 WTI + \beta_3 USDX + \varepsilon$

Model 1 represents the relationship between Taiwan stock market and goods market including WTI, LLG, and USDX.

Model 2:

$TAIEX = CONSTAN + \beta_1 LLG + \beta_2 WTI + \beta_3 USDX + \beta_4 DJIA + \beta_5 NASDAQ + \varepsilon$

Model 2 represents the relationship among Taiwan stock market, goods market including WTI, LLG, and USDX and US stock markets, DJIA and NASDAQ.

Table 1: *Variables Explanation and Symbol*

Variables	Variable Name	Symbols
Taiwan Stock Market	Taiwan Capitalization Weighted Stock Index	TAIEX
Crude Oil Price	West Texas Intermediate	WTI
Gold Price	Loco London Gold Price	LLG
US Dollars Index	US Dollars Index	USDX
Dow Jones Industrial Average	Dow Jones Industrial Average	DJIA
NASDAQ	National Association of Securities Dealers Automated Quotations system	NASDAQ

It can be used coefficient D matrix of moving average (MA) in VAR model applying decomposition on covariance of k rank forecast error in each variable. ?

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4.1 OLS Results

	Model 1		Model 2	
	Coefficient	t-Statistic	Coefficient	t-Statistic
C	10.73138	10.18610	10.99142	12.28049
WTI	-0.034910	-0.798655	-0.239833	**-5.522188*** **
LLG	0.073901	1.415313	0.034399	0.864964
USDX	-0.499887	**-2.648217*** **	-1.241004	**-7.844855*** **
DJIA	-	-	0.013701	0.122880
NASDAQ	-	-	0.518478	**7.825477*** **
R2	0.164048		0.527588	
Adjusted R2	0.152049		0.516177	
D-W Statistic	0.139557		0.233087	
F-Statistic	13.67149		46.23536	

*註：*** ***、represents 1% significant level。*

4.2 ADF Unit Root Test Results:

	Intercept, no trend	Intercept and trend	No intercept and trend
TAIEX	-3.296666（2）	-3.348203（2）	0.219230（7）
WTI	-1.241910（1）	-3.490660（2）	0.821409（1）
LLG	0.148645（0）	-2.322166（0）	1.757081（0）
USDX	-1.222155（2）	-2.465111（2）	-0.165626（2）
DJIA	-2.439977（6）	-2.871435（6）	1.369473（6）
NASDAQ	-2.297691（1）	-2.473811（1）	0.865147（1）

Notes 1. （ ）lag period 2. logarithm statistics 3. ***represents 1% significant level 4.ADF t statistics to choose the best lag period.

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4.2.1 Differentiate:

	Intercept, no trend	Intercept and trend	No intercept and trend
TAIEX	-5.608356 (6) ***	-5.590028 (6) ***	-5.615613 (6) ***
WTI	-11.15097 (0) ***	-11.12423 (0) ***	-11.09896 (0) ***
LLG	-10.99745 (1) ***	-11.11920 (1) ***	-13.88130 (0) ***
USDX	-9.767361 (1) ***	-9.793694 (1) ***	-9.790116 (1) ***
DJIA	-5.791962 (5) ***	-5.807383 (5) ***	-5.599625 (5) ***
NASDAQ	-10.67277 (0) ***	-10.65349 (0) ***	-10.63177 (0) ***

Notes 1. ( ) lag period 2. logarithm statistics 3. ***represents 1% significant level 4.ADF t statistics to choose the best lag period.

4.3 Johansen Cointegration Test Results:

Model 1: Johansen Cointegration

Null Hypothesis	Eigenvalue	Trace Test		
		Trace Test Value	5%	P Value
None	0.093776	44.33554	54.07904	0.2746
1 at most	0.062665	23.65708	35.19275	0.4850
2 at most	0.035770	10.06701	20.26184	0.6333
3 at most	0.011446	2.417589	9.164546	0.6940

Null Hypothesis	Eigenvalue	Maximal Eigenvalue Test		
		Trace Test Value	5%	P Value
None	0.093776	20.67847	28.58808	0.3620
1 at most	0.062665	13.59007	22.29962	0.5001
2 at most	0.035770	7.649418	15.89210	0.5900
3 at most	0.011446	2.417589	9.164546	0.6940

註： represents 5% significant level ，reject null hypothesis.*

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Model 2: Johansen Cointegration

Null Hypothesis	Eigenvalue	Trace Test		
		Trace Test Value	5%	P Value
None	0.109894	85.99390	103.8473	0.4110
1 at most	0.091318	61.54686	76.97277	0.4131
2 at most	0.080432	41.43726	54.07904	0.4001
3 at most	0.047572	23.82852	35.19275	0.4738
4 at most	0.042524	13.59301	20.26184	0.3184
5 at most	0.021049	4.467454	9.164546	0.3469

Null Hypothesis	Eigenvalue	Maximal Eigenvalue Test		
		Trace Test Value	5%	P Value
None	0.109894	24.44704	40.95680	0.8460
1 at most	0.091318	20.10960	34.80587	0.8065
2 at most	0.080432	17.60874	28.58808	0.6091
3 at most	0.047572	10.23551	22.29962	0.8164
4 at most	0.042524	9.125551	15.89210	0.4205
5 at most	0.021049	4.467454	9.164546	0.3469

Notes: * represents 5% significant level ‘ reject null hypothesis.

4.4 AIC Results:

Lag period	Model 1	Model 2
	AIC value	AIC value
0	-0.490260	-3.005872
1	-12.97774	-20.46675
2	-13.08965*	-20.63554*
3	-13.02778	-20.56575
4	-12.95458	-20.47278
5	-12.89462	-20.38183
6	-12.80610	-20.25834
7	-12.73125	-20.24571
8	-12.71282	-20.20535

Notes: * represents AIC minimum value

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4.5 Granger Causality Results

Model 1: Granger Causality

Null Hypothesis H_0			Chi-sq	Prob.
WTI	Granger	TAIEX	1.3675	0.5047
LLG	Granger	TAIEX	0.2243	0.8939
USDX	Granger	TAIEX	0.2312	0.8908
TAIEX	Granger	WTI	14.305	0.0008***
LLG	Granger	WTI	1.4214	0.4913
USDX	Granger	WTI	0.1325	0.9359
TAIEX	Granger	LLG	0.0528	0.9740
WTI	Granger	LLG	2.0893	0.3518
USDX	Granger	LLG	1.2299	0.5407
TAIEX	Granger	USDX	0.2905	0.8648
WTI	Granger	USDX	1.0786	0.5832
LLG	Granger	USDX	4.0788	0.1301

Notes: * 、** 、*** represents 10%, 5% and 1% significant level ，reject null hypothesis.

Model 2: Granger Causality

Null Hypothesis H_0			Chi-sq	Prob.
WTI	Granger	TAIEX	1.4288	0.4895
LLG	Granger	TAIEX	0.2566	0.8796
USDX	Granger	TAIEX	0.1824	0.9128
DJIA	Granger	TAIEX	0.2891	0.8655
NASDAQ	Granger	TAIEX	0.2534	0.8810
TAIEX	Granger	DJIA	11.146	0.0038***
WTI	Granger	DJIA	1.7384	0.4193
LLG	Granger	DJIA	1.9521	0.3768
USDX	Granger	DJIA	0.7568	0.6849
NASDAQ	Granger	DJIA	0.8903	0.6407
TAIEX	Granger	WTI	10.635	0.0049***
LLG	Granger	WTI	1.4887	0.4751
USDX	Granger	WTI	0.3235	0.8506

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DJIA	Granger	WTI	4.7475	0.0931*
NASDAQ	Granger	WTI	0.9634	0.6177
TAIEX	Granger	LLG	0.5261	0.7687
WTI	Granger	LLG	1.5583	0.4588
USDX	Granger	LLG	1.2294	0.5408
DJIA	Granger	LLG	0.9213	0.6309
NASDAQ	Granger	LLG	0.1045	0.9491
TAIEX	Granger	USDX	0.2536	0.8809
WTI	Granger	USDX	1.1077	0.5747
LLG	Granger	USDX	4.5629	0.1021
DJIA	Granger	USDX	1.8307	0.4004
NASDAQ	Granger	USDX	8.8326	0.0121**
TAIEX	Granger	NASDAQ	10.951	0.0042***
WTI	Granger	NASDAQ	0.7253	0.6958
LLG	Granger	NASDAQ	1.0546	0.5902
USDX	Granger	NASDAQ	0.0356	0.9824
DJIA	Granger	NASDAQ	6.0653	0.0482**

Notes: * 、** 、*** represents 10%, 5% and 1% significant level ，reject null hypothesis.

4.6 Impulse Response Analysis

Model 1:

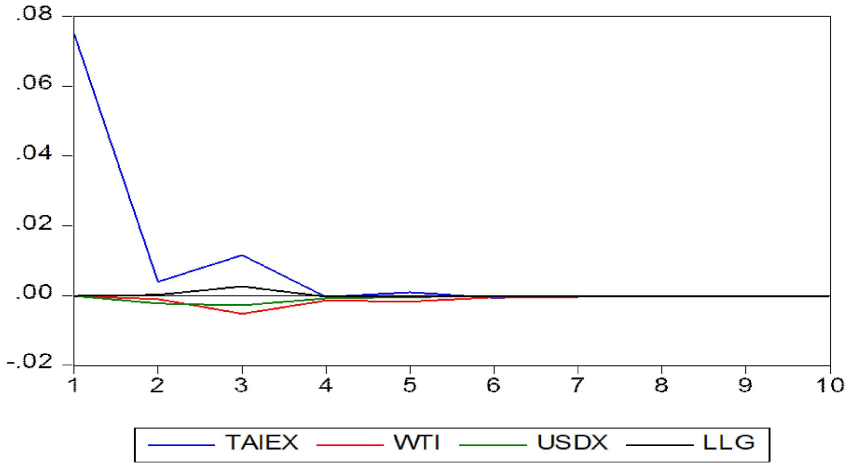

Figure 1: *Model 1 of TAIEX Impulse Response*

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Model 2:

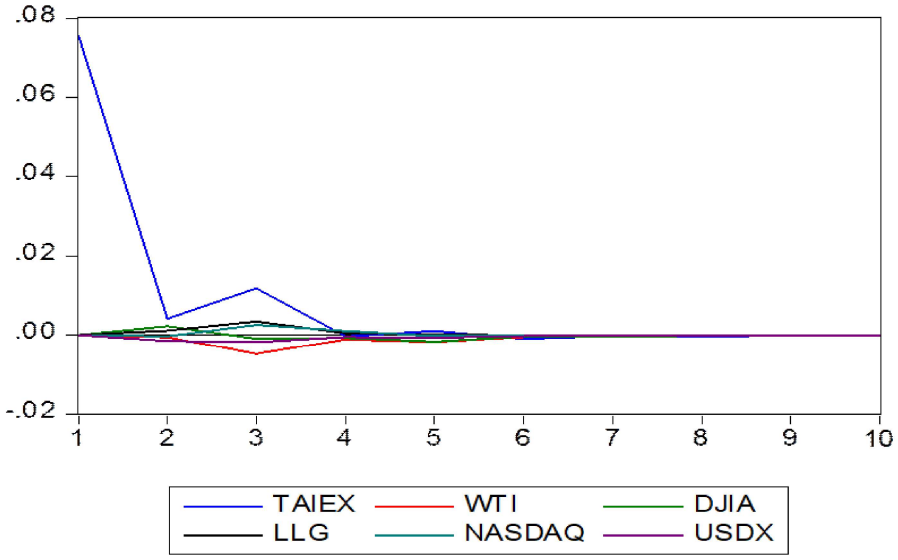

Figure 2: *Model 2 of TAIEX Impulse Response*

4.7 Forecast Error Variance Decomposition Results:

Model 1: TAIEX Forecast Error Variance Decomposition

	Period	TAIEX	WTI	USDX	LLG
TAIEX	1	100.0000	0.000000	0.000000	0.000000
	2	99.89784	0.015453	0.085048	0.001661
	3	99.19198	0.465495	0.210996	0.131530
	4	99.15200	0.496658	0.218988	0.132349
	5	99.10574	0.541581	0.220373	0.132310
	6	99.10345	0.543680	0.220373	0.132499
	7	99.10257	0.544551	0.220377	0.132498
	8	99.10255	0.544551	0.220388	0.132509
	9	99.10255	0.544553	0.220389	0.132509
	10	99.10255	0.544555	0.220389	0.132510

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Model 2: TAIEX Forecast Error Variance Decomposition

	Period	TAIEX	WTI	DJIA	LLG	NASDAQ	USDX
TAIEX	1	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	99.84574	0.005761	0.084915	0.023475	0.001566	0.038541
	3	99.07418	0.402274	0.097901	0.221296	0.110614	0.093735
	4	99.01941	0.422015	0.106522	0.225253	0.129041	0.097763
	5	98.91519	0.471237	0.154777	0.225102	0.129729	0.103963
	6	98.90815	0.474601	0.156564	0.225064	0.130785	0.104839
	7	98.90322	0.476762	0.158725	0.225325	0.130812	0.105155
	8	98.90288	0.476763	0.158998	0.225394	0.130811	0.105155
	9	98.90278	0.476779	0.159063	0.225408	0.130816	0.105156
	10	98.90277	0.476781	0.159066	0.225413	0.130816	0.105157

5. Conclusion

This paper tried to explore the relationship among commodity market (gold price, crude oil price and US dollar index), American stock Market (DJIA and NASDQA) and Taiwan stock market. It also uses two models respectively to examine the relationship between commodity market and American stock market. Model 1 examines commodity market including gold price, crude oil price, USD index and Taiwan stock market. Model 2 adds American stock market, Dow Jones Industrial Average (DJIA) and NASDQA into model 1. There are six variables with total 213 observations for each variable using monthly data from the period of October 19957to June 2015.

The results on Ordinary Least Squares (OLS) showed that USDX has significant negative impact on Taiwan stock market in model 1. However, in Model 2 showed WTI and USDX have significant negative impact but NASDAQ has positive significant impact on Taiwan stock market. The results of Unit Root test demonstrated that all variables are not stationary series in its original numbers, but they become I(1) stationary series after First Difference. In addition, the results of Johansen Cointegration showed that there are no cointegration relationship on both models, but there is on-way leading relationship for Taiwan stock market on WTI, DJIA and NASDAQ from Granger Causality test.

From Impulse Response Analysis, the results showed that Taiwan stock market has negative impulse response on USDX and WTI while it has positive impulse response on LLG, DJIA and NASDAQ, and the impulse lasted for 4 periods. Finally, the results of Forecast Error Variance Decomposition showed there are high self-explanation powers for all variables on both models and NASDAQ has the most influence from DJIA and Taiwan stock market in model 2.

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Summary

Nghiên cứu tìm hiểu mối quan hệ giữa thị trường hàng hoá và thị trường chứng khoán Đài Loan và thị trường chứng khoán Mỹ. Có 6 biến với tổng số 213 quan sát cho mỗi biến được thực hiện bằng cách sử dụng dữ liệu hàng tháng trong giai đoạn từ tháng 10 năm 1997 đến tháng 6 năm 2015. Mô hình 1 xem xét thị trường hàng hoá, gồm giá vàng (LLG), giá dầu thô (WTI), chỉ số đồng đô la Mỹ (USDX) và thị trường chứng khoán Đài Loan. Mô hình 2 có thêm thị trường chứng khoán Mỹ, chỉ số công nghiệp Dow Jones (DJIA) và NASDQA

Kết quả phương pháp bình phương nhỏ nhất (OLS) cho thấy chỉ số USDX có tác động tỉ lệ nghịch đối với thị trường chứng khoán Đài Loan trong mô hình 1. Tuy nhiên, mô hình 2 cho thấy chỉ số WTI và USDX có tác động tỉ lệ nghịch nhưng chỉ số NASDAQ có tác động tỉ lệ thuận tới thị trường chứng khoán Đài Loan. Kết quả kiểm định nghiệm đơn vị cho thấy rằng tất cả các biến đều không phải chuỗi dừng trong giá trị ban đầu, tuy nhiên đã trở thành chuỗi dừng I (1) sau vi phân bậc 1. Bên cạnh đó, kết quả kiểm định đồng liên kết Johansen cũng cho thấy rằng không có quan hệ đồng liên kết trong cả hai mô hình, nhưng có quan hệ định hướng đơn chiều đối với thị trường chứng khoán Đài Loan của chỉ số WTI, DJIA và NASDAQ từ kiểm định nhân quả Granger.

Từ phân tích phản ứng xung, kết quả cho thấy thị trường chứng khoán Đài Loan có phản ứng xung tỉ lệ nghịch với USDX và WTI trong khi có phản ứng xung tỉ lệ thuận với LLG, DJIA và NASDAQ và phản ứng xung kéo dài 4 chu kỳ. Cuối cùng, kết quả phân tách phương sai sai số dự báo cho thấy có tác động tự giải thích đối với tất cả các biến số của cả hai mô hình và chỉ số NASDAQ có tác động lớn nhất từ DJIA và thị trường chứng khoán Đài Loan trong mô hình 2.