A Model of the Oil Prices' Return Rate Threshold for the Two Stock Market Returns: An Evidence Study of the U.S. and the Canada's Stock Markets

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Abstract

The empirical results show that the dynamic conditional correlation (DCC) and the bivariate asymmetric-IGARCH (1, 1) model is appropriate in evaluating the relationship of the U.S. and the Canada's stock markets. The empirical result also indicates that the U.S. and the Canada's stock markets is a positive relation. The average estimation value of correlation coefficient equals to 0.686, which implies that the two stock markets is synchronized influence. Besides, the empirical result also shows that the U.S. and the Canada's stock markets have an asymmetrical effect, and the variation risks of the U.S. and the Canada's stock market returns also receives the influence of the positive and negative of the oil prices' volatility rate.

JEL classification: C32, C51, G15
Keywords: Stock market returns, oil price, asymmetric effect,GJR-GARCH model, bivariate asymmetric-GARCH model.

1. Introduction

We know that Canada is a good country based on the politics stability and social welfare, and it is also the world main petroleum exporting country. Canada is one of big eight industrial countries (G8) in the global economical financial system and also has been very influential in the global economy. When the investor has an investment in the international stock market, he/she will usually care about the international capital the motion situation, the international politics and the economical situation change, in particular, in the U.S. stock market change. There is a close relationship for Canada based on the trade and the circulation of capital with the U.S., but the U.S. is also powerful global economical nations. Therefore, the relation between Canada's of stock market and the U.S. stock market is worth further discussion.

Petroleum (oil) is an important energy which in one's daily life is the crucial essential factor of economical development, and its price also affects economic growth and the stock markets. We know that the oil price is still rising as evidenced by a barrel of oil rising to US$96.63 by December 27, 2007. The oil prices impacts the stock markets whether or not which is also worth further discussion. For related oil prices research on the influence of the stock markets, we can also refer to, for example, the papers of Hammoudeh, Dibooglu and Aleisa (2004), Hammoudeh, and Li and Jeon (2003). Therefore, the influence factor of the oil prices volatility is considered on the markets of U.S. and Canada.

The purpose of the present paper is to examine the relations of the Canada's and the U.S. stock markets. This paper also further discusses the affect of the oil prices' volatility for the U.S. and the Canada's stock market returns. And the positive and negative values of oil prices' return volatility are used as the threshold. The organization of this paper is as follows: Section 2 descibes the data characteristics; Section 3 introduces the asymmetric test of the DCC and the bivariate IGARCH(1, 1); Section 4 presents the proposed model and the empirical results, and finally Section 5 summarizes the conclusions of this study.

2. Data characteristics

2.1 Data sources

The data of this research included the oil price, the U.S. and the Japanese stock price collected between January 2, 1998 and December 31, 2007. The source of the stock data was the Taiwan economic Journal (TEJ), a database in Taiwan. The source of the oil price data was the Energy Information Administration (EIA), a database in USA. The U.S. stock price refers to the S&P500 index, the Canada's stock price refers to Toronto 300 index. During the process of data analysis, in case that there was no stock market price available on the side of the Canada's stock market or on the side of the U.S. stock market due to holidays, the identical time stock price data from one side was deleted. After this, the three variables samples are 2,454.

2.2 Returns calculation and basic statistics

To compute the return of the U.S. stock market adopts the natural logarithm difference, rides 100 again. The return of the Canada stock market also adopts the natural logarithm difference, rides 100 again. The return volatility of the oil price also adopts the natural logarithm difference, rides 100 again.

Table 1 presents the three sequences kurtosis coefficients are all bigger than 3, which this result implies that the normal distribution test of Jarque-Bera is not normal distribution. Therefore, the heavy tails distribution is used in this paper.

Table 1. Data statistics

Statistics	RCANA	RUSA	ROP
Mean	0.029	0.017	0.070
S-D	1.043	1.150	2.552
Skewed	-0.605	-0.063	-0.304
Kurtosis	7.874	5.690	7.523
J-B N (p-value)	2577.69*** (0.0000)	740.97*** (0.0000)	2128.74*** (0.0000)
sample	2453	2453	2453

Notes: (1) J-B N is the normal distribution test of Jarque-Bera. (2) S-D is denoted the standard deviation (3) *** denote significance at the level 1%.

2.3 Unit root and co-integration tests

This paper further uses the unit root tests of ADF (Dickey and Fuller, 1979) and KSS (Kapetanios et al., 2003) to determine the stability of the time series data. The ADF and KSS examination results is listed in Table 2. It shows that the Canada's stock returns, the US stock returns, and the oil price volatility rate do not have the unit root characteristic- namely, the three markets are stationary time series data, under $\alpha = 1\%$ significance level.

Table 2. Unit root test of ADF and KSS for the return data

ADF	RCANA	RUSA	ROP
Statistic	-25.616***	-20.718***	-12.125***
Critical value	-3.962	-3.412	-3.128
(Significant level)	(α=1%)	(α=5%)	(α=10%)
KSS	RCANA	RUSA	ROP
Statistic	-19.392***	-27.898***	-23.936***
Critical value	-2.820	-2.220	-1.920
(Significant level)	(α=1%)	(α=5%)	(α=10%)

Notes: *** denote significance at the level 1%.

Using Johansen's (1991) co-integration test as illustrated in Table 3 at the significance level of 0.05 (α=5%) does not reveal of $\lambda_{\max}$ and Trace statistics. This indicated that the oil price market, the U.S. stock market and the Canada's stock market do not have a co-integration relation. Therefore, we do not need to consider the model of error correction.

Table 3. Co-integration test (VAR lag=5)

H_0	$\lambda_{\max}$	Critical value
None	18.1955	24.2520
At most 1	8.6762	17.1477
At most 2	1.4346	3.8415
H_0	Trace	Critical value
None	28.3063	35.0109
At most 1	10.1108	18.3977
At most 2	1.4346	3.8415

Notes: The lag of VAR is selected by the AIC rule (Akaike, 1973).The critical value is given under the level 5%.

2.4 ARCH effect test

Based on the formula (1) and (2) as below, we uses the methods of LM test (Engle, 1982) and F test (Tsay, 2004) to test the conditionally heteroskedasticity phenomenon. In Table 4, the results of the ARCH effect test show that the two markets have the conditionally heteroskedasticity phenomenon exists. This result suggests that we can use the GARCH model to match and analyze it.

Table 4. ARCH effect test

Canada	Engle LM test	Tsay F test
Statistic	490.796***	8.116***
(p-value)	(0.0000)	(0.0000)
U.S.	Engle LM test	Tsay F test
Statistic	641.619***	10.957***
(p-value)	(0.0000)	(0.0000)

Notes： *** denote significance at the level 1%.

3. Asymmetric test of the Bivariate-IGARCH(1, 1) Model

The bivariate-IGARCH(1, 1) model with a DCC can be constructed in this paper, the details are omitted. The asymmetric test methods (Engle and Ng, 1993) are used the following two methods as: positive size bias test and joint test.

By the positive size bias test and the joint test shows that the U.S. and the Canada's stock price markets does have the asymmetry effects in Table 5.

Table 5. Asymmetric test of the DCC and the bivariate-IGARCH(1, 1)

Canada	Positive size bias test	Joint test
F statistic	5.2722	2.5131
(p-value)	(0.0218)	(0.0568)
U.S.	Positive size bias test	Joint test
F statistic	13.2318	12.7068
(p-value)	(0.0003)	(0.0000)

Notes: p-value < α denote significance. (α =1%, α =5%).

4. Proposed model and empirical results

Based on the results of the asymmetric test, we follows the idea of GJR-GARCH model (Glosten, Jaganathan and Runkle, 1993), and the ideas of Engle (2002) and Tse and Tusi (2002), and uses the positive and negative value of oil price volatility is as a threshold. This idea of threshold can also refer the paper of Horng (2007). After model process selection, in this paper, we may use the bivariate asymmetric-IGARCH (1, 1) model to construct the relationships of the Canada and the U.S. stock market returns, the model is illustrated as follows:

$$RUSA_t = u_{t-1} \times (\phi_{10} + \sum_{i=1}^{2} \phi_{1i} RUSA_{t-i} + \sum_{i=1}^{2} \phi_{2i} RCANA_{t-i} + a_{1,t}) + (1-u_{t-1}) \times (\phi'_{10} + \sum_{i=1}^{2} \phi'_{1i} RUSA_{t-i} + \sum_{i=1}^{2} \phi'_{2i} RCANA_{t-i} + a_{1,t}) \quad (1)$$

$$RCANA_t = w_{t-1} \times (\varphi_{10} + \sum_{j=1}^{2} \varphi_{1j} RCANA_{t-i} + \sum_{j=1}^{2} \varphi_{2i} RUSA_{t-j} + a_{2,t}) + (1-w_{t-1}) \times (\varphi'_{10} + \sum_{j=1}^{2} \varphi'_{1j} RCANA_{t-i} + \sum_{j=1}^{2} \varphi'_{2i} RUSA_{t-j} + a_{2,t}) \quad (2)$$

$$h_{11,t} = u_{t-1}(\alpha_{10} + \alpha_{11} a_{1,t-1}^2 + \beta_{11} h_{11,t-1}) + (1-u_{t-1})(\alpha'_{10} + \alpha'_{11} a_{1,t-1}^2 + \beta'_{11} h_{11,t-1}) \quad (3)$$

$$h_{22,t} = w_{t-1}(\alpha_{20} + \alpha_{21} a_{2,t-1}^2 + \beta_{21} h_{22,t-1}) + (1-w_{t-1})(\alpha'_{20} + \alpha'_{21} a_{2,t-1}^2 + \beta'_{21} h_{22,t-1}), \quad (4)$$

$$h_{12,t} = \rho_t \sqrt{h_{11,t}} \sqrt{h_{22,t}}, \quad (5)$$

$$\rho_t = \exp(q_t) / (\exp(q_t) + 1), \quad (6)$$

$$q_t = \gamma_0 + \gamma_1 \rho_{t-1} + \gamma_2 a_{1,t-1} a_{2,t-1} / \sqrt{h_{11,t-1} h_{22,t-1}}, \quad (7)$$

$$u_t = \begin{cases} 1, & if \ ROP_{t-1} > 0 \\ 0, & if \ ROP_{t-1} \le 0 \end{cases}, \quad w_t = \begin{cases} 1, & if \ ROP_{t-1} > 0 \\ 0, & if \ ROP_{t-1} \le 0 \end{cases},$$

with $ROP_t > 0$ denote bad news, $ROP_t \le 0$ denote good news. The white noise of $\vec{a}'_t = (a_{1,t}, a_{2,t})$ is obey the bivariate Student's t distribution, this is, $\vec{a}_t \sim T_v(\vec{0}, (v-2)H_t / v)$, among $\vec{0}' = (0,0)$ and H_t is the covariance matrix of $\vec{a}'_t = (a_{1,t}, a_{2,t})$, and ρ_t is the dynamic conditional correlation coefficient of $a_{1,t}$ and $a_{2,t}$. The maximum likelihood algorithm method of BHHH (Berndt et. al., 1974) is used to estimate the model's unknown parameters. The programs of RATS and EVIEWS are used in this paper.

From the empirical results, we know that the U.S. and the Canada's stock return volatility may be constructed on the DCC and the bivariate asymmetric-IGARCH (1, 1) model. Its estimate result is stated in Table 6.

Under the bad news, the U.S. stock return receives before 2 period's impact of the Canada's stock return (ϕ_{22} =-0.101). And the U.S. stock return receives before 1 period's impact of the U.S. stock return (ϕ_{11} =-0.064). Under the good news, the U.S. stock return does not receive the impact of the Canada's stock return. And the U.S. stock return receives before 2 period's impact of the U.S. stock return (ϕ'_{12}=-0.070). Under the bad news, the Canada's stock return receives before 2 period's impact of the Canada's stock return (φ_{12}=-0.088). And the Canada stock return receives before 2 period's impact of the U.S. stock return (respectively φ_{21} =0.096 and φ_{22}=0.051). Under the good news, the Canada's stock return receives before 1 period's impact of the Canada's stock return (φ'_{11}=-0.076). And the Canada stock return receives before 1 period's impact of the U.S. stock return (φ'_{21}=0.133). The volatility rate of oil price is truly influent the return of the U.S. and Canada's stock markets.

On the other hand, the correlation coefficient average estimation value ($\hat{\bar{\rho}}_t$=0.686) of the U.S. and the Canada's stock return volatility is significant. This result also shows the U.S. stock price return's volatility is mutually synchronized influence. In additional, estimated value of the degree of freedom for the Student's t distribution is 8.998, and is significant under the significance level of 0.01(α =1%). This also demonstrates that this research data has the heavy tailed distribution.

From the Table 6, the estimated coefficients of the conditional variance equation will produce the different variation risks under the bad news and good news. In Table 6, we have also the results of $\alpha_{11}+\beta_{11}=1$, $\alpha'_{11}+\beta'_{11}=0.958$, $\alpha_{21}+\beta_{21}=1$ and $\alpha'_{21}+\beta'_{21}=0.903$. This results conforms the condition supposition of the IGARCH and GARCH models, respectively. This result also demonstrates the DCC and the bivariate asymmetric-IGARCH (1, 1) model may catch the U.S. and the Canada's stock return volatilities' process. Under the good news, the U.S. stock market has a fixed variation risk, and the Canada's stock market has also the fixed variation risk. Besides, under the good news as a sample, the U.S. and the Canada stock market returns have the different conditional variation risks (respectively $\beta'_{11}=0.861$ and $\beta'_{21}=0.777$). This result demonstrates that the good news and bad news of the oil prices' volatility will produce the different variation risks on the U.S. and the Canada's stock markets. Therefore, the explanatory ability of the DCC and the bivariate asymmetric-IGARCH(1, 1) model is better than the model of the DCC and the bivariate IGARCH (1, 1).

Table 6. Parameter estimation of the DCC and the bivariate asymmetric-IGARCH(1, 1) model

Parameters	ϕ_{10}	ϕ_{11}	ϕ_{12}	ϕ_{21}	ϕ_{22}
Coefficient	0.0397	-0.0639	0.0065	0.0450	-0.1010
(p-value)	(0.1084)	(0.0798)	(0.8533)	(0.1811)	(0.0020)
Parameters	ϕ'_{10}	ϕ'_{11}	ϕ'_{12}	ϕ'_{21}	ϕ'_{22}
Coefficient	0.0673	-0.0454	-0.0704	-0.0269	0.0456
(p-value)	(0.0118)	(0.2397)	(0.0610)	(0.4586)	(0.1962)
Parameters	φ_{10}	φ_{11}	φ_{12}	φ_{21}	φ_{22}
Coefficient	0.0751	-0.0226	-0.0875	0.0958	0.0511
(p-value)	(0.0010)	(0.5624)	(0.0105)	(0.0017)	(0.0826)
Parameters	φ'_{10}	φ'_{11}	φ'_{12}	φ'_{21}	φ'_{22}
Coefficient	0.0735	-0.0761	0.0336	0.1331	-0.0128
(p-value)	(0.0022)	(0.0518)	(0.3929)	(0.0000)	(0.6943)
Parameters	α_{10}	α_{11}	β_{11}	α'_{10}	α'_{11}
Coefficient	0.0110	0.0712	0.9288	0.0400	0.0971
(p-value)	(0.3342)	(0.0000)	(0.0000)	(0.0067)	(0.0000)
Parameters	β'_{11}	α_{20}	α_{21}	β_{21}	α'_{20}
Coefficient	0.8605	0.0062	0.0752	0.9248	0.0775
(p-value)	(0.0094)	(0.5393)	(0.0000)	(0.0000)	(0.0000)
Parameters	α'_{21}	β'_{21}	v	$\bar{\rho}_t$	
Coefficient	0.1261	0.7769	8.9982	0.6857	
(p-value)	(0.0094)	(0.0000)	(0.0000)	(0.0000)	
Parameters	γ_0	γ_1	γ_2		
Coefficient	-1.8417	3.7509	0.0840		
(p-value)	(0.0000)	(0.0000)	(0.0000)		

Notes：p-value< α denote significance. (α =1%, α =5%).

To test the inappropriateness of the DCC and the bivariate asymmetric-IGARCH(1, 1) model, the test method of Ljung & Box (1978) is used to examine autocorrelation of the standard residual error. This model does not show an autocorrelation of the standard residual error. Therefore, the DCC and the bivariate asymmetric-IGARCH(1, 1) model are more appropriate.

5. Conclusions

The empirical results show that the U.S. and the Canada's stock price market return's volatility have an asymmetric effects, and the U.S. and the Canada's

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stock price return volatility may construct in the DCC and the bivariate asymmetric-IGARCH (1, 1) model with a positive and negative threshold of oil price volatility. From the empirical result also obtains that the dynamic conditional correlation coefficient average estimation value ($\hat{\rho}_t$ =0.686) of the U.S. and the Canada's stock price return volatility is positive. The positive and negative values of the oil price volatilities affects the variation risks of the U.S. and the Canada's stock markets. The U.S. and the Canada's stock market returns is truly received the impact of the oil prices' volatility. Therefore, the explanation ability of the bivariate asymmetric-IGARCH(1, 1) is better than the bivariate-IGARCH (1, 1) model.

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