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THE ASYMMETRIC DEPENDENCE STRUCTURE BETWEEN OIL AND STOCK PRICES

Abstract. *This study applied the copula method to analyze the asymmetric dependence structure between international prices of crude oil and major stocks in 20 countries during the period from January 1, 1988 to August 1, 2008. In other words, this study aimed to determine whether the relationship between oil and stock prices is differs when oil price go up sharply and stock prices go down sharply and when oil prices go down sharply and stock prices go up sharply. The tail dependence coefficient shows an asymmetric dependence exists between crude oil prices and major international stock markets. Additionally, the dependence is different in different periods (stable period and rise period), and has different changes in different types of countries, e.g. developing or developed countries, European countries or Asian countries, oil-producing net exporters or net importers.*

Keywords: Copula methods, asymmetric dependence, crude oil price, stock prices
JEL Classification: C01, C51, G10, Q43

1. Introduction

Crude oil is the lifeline of the modern economy. It is also a key factor that influences global economic development. In the past, increases in oil prices were mostly related to war or supply factors. For example, in August 1990, the invasion of Kuwait by Iraq caused the first Gulf Crisis and almost doubled the price from the original US$16/barrel. At the end of 1998, the United Nations' Oil-for-Food Program encouraged many members of the Organization of Petroleum Exporting Countries (OPEC) to aggressively export oil. The increase in oil supply combined with two consecutive warm winters in the US led to a drop to US$10/barrel. In order to boost oil price, OPEC acted to reduce oil output, which raised the oil price to US$34/barrel in 2000. The conflict between Israel and Palestine in September 2000 and the US invasion of Iraq in March 2003 pushed the oil price to US$37/barrel.

Figure 1 shows the spot market trend of international crude oil prices from Q1 of 1988 to Q2 of 2008. As seen in Figure 1, the oil price has been soaring since 2000. This is because of the instability in supply, and more importantly, the expansion in demand due to the economic recovery of the US and the emergencies of Asian economies. Both supply and demand factors have resulted in an under-supply. The lack of supply combined with speculation from hedge funds and others boosted the price of international crude oil to above US$100/barrel at the end of February 2008. The price of crude oil hit a historical high of US$145/barrel in early July 2008.

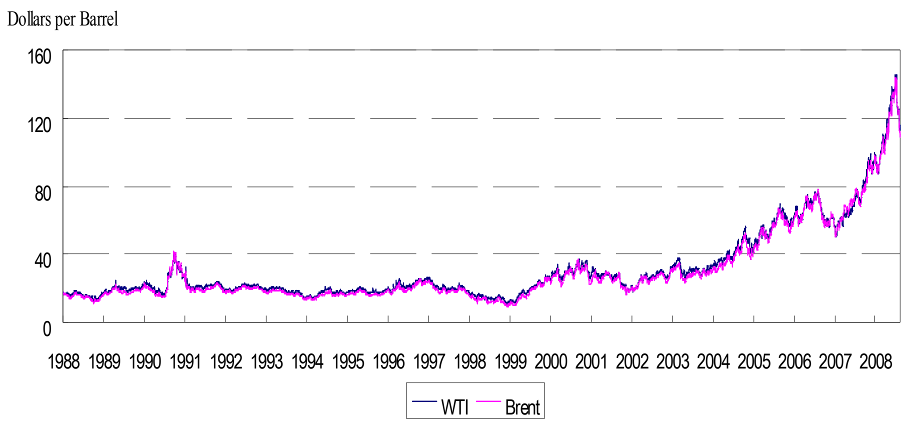

Figure 1. ***The trend of international crude oil price of WTI (West Texas Intermediate) and Brent from Q1 of 1988 to Q2 of 2008 (Data source: Energy Information Administration)***

Oil price changes also impact operations and profitability for many companies. Hammoudeh et al. (2004) indicated that high oil price affects company profitability by eroding dividends, retained earnings, and stock prices. Ciner (2001) argued that if oil prices influence real outputs, any rise in oil price will cause a reduction in earnings or expected income. As a result, stock prices will generally decline. Additionally, a rise in oil price can be considered an increase in the price of an important commodity. This will boost supply costs and exert pressures on companies to increase the quantity of products. An increase in cost implies adverse impacts on profitability. Increased product prices may also lead to a reduction in sales and profits, which can cause stock prices to drop. Therefore, the influence of the price of international crude oil on stock markets cannot be overlooked. It is worth noting that the effect of this influence varies due to the components of different stock indices. If oil related industries account for a high percentage of the index, the correlation between the stock market in question and the price of international crude oil is high.

Crude oil prices have a negative relationship with stock prices. Jones and Kaul (1996), Sadorsky (1999), Ciner (2001), Papapetru (2001), Park and Ratti

(2008), and Miller and Ratti (2009) have confirmed this view. Jones and Kaul (1996) analyzed oil prices and stock prices in the US, Canada, Japan, and UK, and found that the increase in post-war oil prices was adverse to stock returns. Sadorsky (1999) reported the increase in oil price created negative shocks to the US stock market, particularly in the middle of 1980s. On the other hand, Huang et al. (1996) examined crude oil futures index returns and the United States stock returns, and found no relationship between both. However, Ciner (2001) reexamined the research by Huang et al. (1996) and found a significant nonlinear relation between actual stock returns and crude oil futures prices. Miller and Ratti (2009) suggested that the relationship between stock indices and crude oil prices between 1971 and 1998 was consistent with the negative correlation supported by most literature on the subject. Recently, Sadorsky (1999), Nandha and Faff (2008), Afshar et al. (2008), Park and Ratti (2008) indicated that crude oil prices and stock indices have an asymmetric effect, such as crude oil price and global variables. Afshar et al. (2008) found that between 1990 and 2007 drops in oil prices resulted in more significant shocks to stock prices than an increase in oil prices. Park and Ratti (2008) found that the asymmetric effect only exists in many European countries between 1996 and 2005. A possible reason for their finding is that the total increase in oil prices was greater than the total decrease of oil prices in the middle and end of the 1990s.

As shown in Figure 1, international crude oil prices were stable before 2000. After 2000, international crude oil prices were on the rise. Therefore, this research divided the international crude oil price into stable period (before 2000) and rise period (after 2000), and discusses whether the dependence structure between international crude oil prices and stock markets changed before and after 2000. Moreover, a rise in crude oil prices had different impacts on stock prices of different countries. The different factors were proportion of import crude oil to GDP, dependence degree of import crude oil, and feasibility of energy conversion. Even oil-producing countries such as the United States and the United Kingdom are affected to some extent by a rise in oil prices. In comparison, Asian countries have few oil fields, and are more dependent upon non-renewable energy. Changes in crude oil prices have had a greater impact on Asian countries than European and American countries.

High oil prices have caused greater shocks to developing countries than to developed countries according to studies by the International Energy Agency (IEA), the Organization for Economic Cooperation and Development (OECD), and the International Monetary Fund (IMF). The effect is greatest on poor countries and countries with a high debt ratio. This paper probes the dependence structure between international crude oil prices and major international stock markets, and whether that structure is affected differently by different classifications of countries (developing or developed countries, European or Asian countries, whether countries oil producing net-exporters and net-importers.). The results will provide an understanding of the dependence between crude oil prices and stock indices.

The purposes of this research are to: (1) find the tail dependence coefficient (TDC) during the occurrence of a simultaneous considerable rise of oil price and sharp drop in stock prices and a simultaneous sharp drop in oil price and considerable rise in stock prices; (2) use the TDC to discuss whether an asymmetric dependence exists between international crude oil prices and major stock markets; (3) discuss whether the dependence between international crude oil prices and stock markets changes during different periods (stable period and rise period); (4) find out whether the dependence between international crude oil prices and major stock prices affects different classifications of countries differently (e.g. developing or developed countries, European countries or Asian countries, whether countries produce oil).

This paper is organized as follows. Section 1 is the introduction; Section 2 presents the research method; Section 3 discusses data characteristics and empirical results; Section 4 gives the conclusions.

2 Research Methods

The copula analysis method is mainly applied to discussions of dependence structures between many variances. Under certain conditions the marginal distribution functions of random variables use copula functions to study dependence structures between random variables. Recently, Li (2000) proposed the concept of mixture copula, which is defined as the weighted mean of more than two copulas. If C_1 and C_2 denote two copulas, and w is the weight of C_1, the mixture copula can be expressed as follows:

$$C(u_1,u_2;\alpha_1,\alpha_2,w)=wC_1(u_1,u_2;\alpha_1)+(1-w)C_2(u_1,u_2;\alpha_2) \tag{1}$$

where $u_i=F_i(x_i)$, and α_1 and α_2 denote shape parameters of C_1 and C_2, respectively. Mixture copula can produce tail dependence. For example, if C_1 has left tail dependence, and C_2 has right tail dependence, mixture copula can flexibly capture the left and right tail dependence of joint distribution through estimation using the weight parameter w. Clayton copula (C^C) can capture left tail dependence, normal copula(C^N) can capture regular dependence, and survival Clayton copula can capture right tail dependence(C^{CS}). Furthermore, individual shape parameters α are converted into TDC λ, and are separately defined as follows:

$$C^C(u_1,u_2;\lambda_L)=(u_1^{\frac{\ln 2}{\ln\lambda_L}}+u_2^{\frac{\ln 2}{\ln\lambda_L}}-1)^{1/\frac{\ln 2}{\ln\lambda_L}} \tag{2}$$

$$C^N(u_1,u_2;\rho)=\Phi_G(\Phi^{-1}(u_1),\Phi^{-1}(u_2)) \tag{3}$$

$$C^{SC}(u_1,u_2;\lambda_R)=u_1+u_2-1+[(1-u_1)^{\frac{\ln 2}{\ln\lambda_R}}+(1-u_2)^{\frac{\ln 2}{\ln\lambda_R}}-1)]^{1/\frac{\ln 2}{\ln\lambda_R}} \tag{4}$$

where ρ is parameter of the correlation coefficient, which is used to measure regular dependence, Φ_G and Φ^{-1} are the cumulative probability density function and inverse function of bivariate normal distribution, respectively. λ_L is the tail dependence of the left extreme value, and λ_R is the tail dependence of the right extreme value, and $\lambda_i\in[0,1]$.

In order to measure regular dependence and extreme dependence at same time, this research employed an estimation using weight parameter w to constitute the left and right tail dependences of the joint distribution flexibly obtained by mixture copula. This is expressed as follows

$$C(u_1,u_2;\lambda_L,\rho,\lambda_R,w_1,w_2) \\ = w_1 C^C(u_1,u_2;\lambda_L) + w_2 C^N(u_1,u_2;\rho) + (1-w_1-w_2)C^{CS}(u_1,u_2;\lambda_R) \tag{5}$$

where w are all copula weight parameters, and $w_i \in [0,1]$; the values estimated by different weight parameters may have different mixture copula models. For an estimation of copula functions, the typical Canonical Maximum Likelihood (CML) proposed by Romano (2002) was used. Empirical distributions were applied to estimate marginal cumulative distribution, so the empirical marginal cumulative distribution functions of the T consecutive return observed values ($R_{i,t}$) are as follows

$$\hat{F}_i(r) = \frac{1}{T+1}\sum_{t=1}^{T} I(R_{i,t} \le r) \tag{6}$$

where $I(\cdot)$ is indicator function), when $R_{i,t} \le r$,it is 1, otherwise it is 0; denominator $T+1$ is lower than 1 due to convention. By using $\hat{u}_{i,t} = \hat{F}_i(r_{i,t}), t = 1,2,\ldots,T$, probability values of all observed values $R_{i,t}$ can be achieved. Next, Maximum Likelihood Estimation (MLE) is used to estimate copula parameter vector $\theta = (\lambda_L,\rho,\lambda_R,w_1,w_2)'$, then

$$\hat{\theta} = \arg\max_{\theta} \sum_{t=1}^{T} \ln c(\hat{u}_{1,t},\hat{u}_{2,t};\theta) \tag{7}$$

where $c(\cdot,\cdot)$ are the density functions of mixture copula.

Eq.(5) is used to measure dependence structures between crude oil price and all stock indices. Eq.(6) is used to estimate the crude oil price cumulative density functions u_{oil} and cumulative density functions u_{stock} of all stock indices. Clayton copula and survival Clayton copula cannot measure negative correlation, so let $u_1 = u_{oil}$, $u_2 = 1 - u_{stock}$ to estimate copula parameter vector $\theta = (\lambda_L,\rho,\lambda_R,w_1,w_2)'$. Regular dependence is used to measure the expectation of standardized co-movement between crude oil prices and stock indices, and the correlation coefficient ρ is used for estimation. However, extreme dependence is used to measure co-movement in extreme case which is defined as the possibility of a sharp drop in oil price and a considerable rise of stock prices and a considerable rise of oil price, and a sharp drop in stock prices. The former possibility is estimated by left tail dependence λ_L, and the latter possibility is estimated by right tail dependence λ_R . This is a concept of probability.

On the other hand, Archimedean copula functions have no correlation coefficient parameter ρ , and thus shape parameters α in Clayton copula and survival Clayton copula must be converted promptly (Lai et al., 2009). First, tail dependence λ_L and λ_R in Eq.(5) are converted into shape parameter α , and then the shape parameters α are converted into Kendall's τ

$$\lambda_i = 2^{-1/\alpha}, \quad i = L, R \tag{8}$$

$$\alpha = \frac{2\tau}{1-\tau} \tag{9}$$

Kendall's τ is related to correlation coefficient ρ

$$\tau = \frac{2}{\pi}\sin^{-1}(\rho) \tag{10}$$

The tail dependence λ_L and λ_R of extreme dependence is a concept of probability, so Eqs.(8) and (9) can convert the tail dependence into correlation coefficient ρ to allow comparison with the correlation coefficient measuring the regular dependence correlation coefficient.

3. Data and empirical results

3.1. Data and basic statistic analysis

This research applies the definitions of extreme dependence and regular dependence to discuss the correlation structure between crude oil prices and major international stock prices. The adopted international crude oil spot prices are the prices of West Texas Intermediate (WTI) published by the United States Energy Information Administration. WTI is intermediate crude oil from West Texas, United States, and one of the major crude oil indicators. WTI is indicative of global oil prices because it is the crude oil commodity traded in the New York Mercantile Exchange (NYMEX). WTI is involved in a large number of transactions, and has public and transparent price information.

Twenty countries have adopted stock price indices in major stock markets including Belgium (BE), Brazil (BR), Canada (CA), China (CH), Finland (FI), France (FR), Germany (GM), Hong Kong (HK), India (IN), Italy (IT), Japan (JP), Korea (KR), Netherlands (NE), Norway (NW), Russia (RU), Singapore (SG), Spanish (SP), Taiwan (TW), United Kingdom (UK) and United States (US). The original data are collected from the Datastream database. Except for China, Russia, Finland, Italy, and Belgium, the research data for other countries represent weekly data collected from January 1, 1988 to August 1, 2008. There are 1,074 pieces of observed data, as shown in Table 1.

First, natural logarithm transformation is performed for the stock indices of all countries, and then the logarithm returns are calculated.

$$R_{i,t} = (\ln p_{i,t} - \ln p_{i,t-1}) \times 100 \tag{11}$$

where $p_{i,t}$ is stock index of *i* country in *t* period. The change rate of the oil price is calculated in the same way. According to Figure 1, the trend of international crude oil spot prices indicates that international crude oil prices were stable before 2000 and on the rise after 2000. Thus, the sample period in this research is divided into a stable period and a rise period for crude oil prices. The sample period of the former is 1/1/1988–12/31/1999, and that of the latter is 1/7/2000–8/1/2008.

Table 2 shows the basic statistics for the change rate of crude oil prices and stock index returns for all countries. Before 2000, crude oil prices and average stock index returns for all countries are positive. After 2000, the average stock index returns for Finland, Japan, Taiwan, UK, and US have changed from positive to negative. Based on observation of the standard deviations, before 2000 the greatest variations in return occurred in Russia, Brazil, China, Taiwan, and Korea, in the given order; the smallest variations in return occurred in US, Canada, UK, Belgium and Netherlands. After 2000, the greatest variations in return occurred in Brazil, Finland, Russia, Korea and Taiwan; and the smallest variations in return occurred in United Kingdom, United States, Italy, Canada and Singapore. The skewness coefficient shows that the crude oil price and UK's stock index shifted from a right-skewed distribution to a left-skewed distribution before 2000. Stock index returns in Brazil, Canada, Germany, Netherlands, Russia, Singapore, and US exhibit a left-skewed distribution before and after 2000. Kurtosis coefficients indicate that, except for the stock index return in France is not significant before 2000; the Kurtosis coefficients of crude oil price and stock index returns of all countries are all over 3. The sequence of stock market returns of all countries exhibits a leptokurtic distribution. Jarque-Bera test results indicate that crude oil prices and the stock market returns of all countries are not subject to normal distribution, except for stock market returns in France before 2000.

Table 1 Definitions and periods of the crude oil price and stock prices

Countries	Code	Crude oil price/ Stock price	Sample periods	Sample sizes
United States	WTI	WTI Spot Price FOB (Dollars per Barrel)	1/1/1988-8/1/2008	1074
Belgium	BE	BEL 20	1/2/1990- 8/1/2008	969
Brazil	BR	BVSP	1/1/1988-8/1/2008	1074
Canada	CA	S&P/TSX	1/1/1988-8/1/2008.	1074
China	CH	Shanghai Composite	1/2/1991- 8/1/2008.	917
Finland	FI	FIDOW	1/2/1992- 8/1/2008.	865
France	FR	CAC 40	1/1/1988-8/1/2008	1074
Germany	GM	DAX 30	1/1/1988-8/1/2008	1074
Hong Kong	HK	Hang Seng	1/1/1988-8/1/2008	1074
India	IN	BSE 30	1/1/1988-8/1/2008	1074
Italy	IT	MIBTEL	7/16/1993- 8/1/2008	785
Japan	JP	Nikkei 225	1/1/1988-8/1/2008	1074
Korea	KR	Seoul Composite	1/1/1988-8/1/2008	1074
Netherlands	NE	AEX	1/1/1988-8/1/2008	1074
Norway	NW	NODOW	1/1/1988-8/1/2008	1074
Russia	RU	RTS	9/1/1995- 8/1/2008	674
Singapore	SG	Straits Times	1/1/1988-8/1/2008	1074
Spanish	SP	IBEX 35	1/1/1988-8/1/2008	1074
Taiwan	TW	Taiwan Weighted	1/1/1988-8/1/2008	1074
United Kingdom	UK	FTSE 100	1/1/1988-8/1/2008	1074
United States	US	Dow Jones Industrial	1/1/1988-8/1/2008	1074

Note: The data source from Datastream database.

Table 2 The basic statistics of the crude oil price and stock prices

1/1/1988-12/31/1999

	WTI		BE		BR		CA		CH		FI	
Mean	0.072		0.140		0.430		0.139		0.400		0.6980	
Standard deviation	4.120		2.207		9.330		1.990		8.293		3.750	
Maximum	21.74		10.47		43.14		7.479		88.57		18.38	
minimum	-16.23		-7.507		-58.12		-11.43		-35.07		-13.68	
Skewness	0.171	*	-0.059		-0.319	***	-0.427	***	4.259	***	0.045	
Kurtosis	5.656	***	3.865	***	7.281	***	5.747	***	44.04	***	4.181	***
J-B N test	187.1	***	16.57	***	488.8	***	216.03	***	34342.1	***	24.41	***
ADF(.)	-23.91(0)	***	-24.88(0)	***	-22.94(0)	***	-23.11(0)	***	-19.88(0)	***	-19.33(0)	***
N	626		521		626		626		469		417	

1/7/2000-8/1/2008

	WTI		BE		BR		CA		CH		FI	
Mean	0.346		0.072		0.302		0.182		0.202		-0.080	
Standard deviation	4.062		2.798		5.487		2.723		3.403		4.999	
Maximum	11.15		12.33		16.27		9.304		13.70		19.44	
Minimum	-19.23		-11.59		-24.67		-12.59		-14.59		-25.14	
Skewness	-0.751	***	-0.466		-0.615	***	-0.703	***	0.124		-0.639	***
Kurtosis	4.856	***	4.965	***	4.522	***	5.127	***	5.195	***	5.732	***
J-B N test	106.4	***	88.36	***	71.56	***	121.4	***	91.11	***	169.9	***
ADF(.)	-15.62(1)	***	-19.67(0)	***	-23.38(0)	***	-21.86(0)	***	-20.31(0)	***	-21.67(0)	***
N	448		448		448		448		448		448	

1/1/1988-12/31/1999

	FR		GM		HK		IN		IT	
Mean	0.252		0.275		0.318		0.190		0.284	
Standard deviation	2.580		2.759		3.610		4.260		3.107	
Maximum	9.768		12.60		13.92		17.06		14.725	
Minimum	-9.110		-11.98		-19.85		-19.32		-8.789	
Skewness	-0.088		-0.307	***	-0.769	***	-0.124		0.151	
Kurtosis	3.306		4.675	***	6.947	***	4.773	***	4.351	***
J-B N test	3.270		83.05	***	468.1	***	83.67	***	26.94	***
ADF(.)	-25.00(0)	***	-25.98(0)	***	-15.09 (1)	***	-24.17(0)	***	-17.08(0)	***
N	626		626		626		626		337	

1/7/2000-8/1/2008

	FR		GM		HK		IN		IT	
Mean	0.026		0.079		0.065		0.245		0.032	
Standard deviation	2.786		3.210		3.109		3.649		2.621	
Maximum	10.46		12.31		11.89		11.84		17.22	
Minimum	-10.23		-12.02		-10.62		-13.99		-13.56	
Skewness	-0.206	*	-0.261	**	-0.023		-0.704	***	-0.165	
Kurtosis	4.192	***	4.291	***	4.252	***	5.005	***	9.106	***
J-B N test	29.71	***	36.25	***	29.33	***	112.0	***	698.1	***

ADF(.)	-20.71(0)	***	-20.04(0)	***	-21.94(0)	***	-19.97(0)	***	-19.41(0)	***
N	448		448		448		448		448	
1/1/1988-12/31/1999										
	JP		KR		NE		NW		RU	
Mean	0.006		0.048		0.309		0.177		0.248	
Standard deviation	3.396		5.195		2.256		3.097		9.394	
Maximum	12.80		27.55		11.89		14.14		29.45	
Minimum	-13.53		-54.39		-8.987		-13.30		-37.80	
Skewness	0.252	***	-1.731	***	-0.174	*	-0.081		-0.498	***
Kurtosis	4.588	***	26.93	***	4.618	***	4.983	***	4.854	***
J-B N test	72.45	***	15261.5	***	71.49	***	103.2	***	41.73	***
ADF(.)	-26.97(0)	***	-8.760(6)	***	-25.55(0)	***	-24.83(0)	***	-7.835(1)	***
N	626		626		626		626		226	
1/7/2000-8/1/2008										
	JP		KR		NE		NW		RU	
Mean	-0.093		0.119		-0.020		0.237		0.536	
Standard deviation	3.020		4.356		2.996		3.250		4.580	
Maximum	13.37		15.75		13.01		8.482		16.86	
Minimum	-11.78		-16.05		-11.73		-18.11		-17.60	
Skewness	-0.129		-0.308	***	-0.483	***	-1.137	***	-0.529	***
Kurtosis	4.056	***	4.332	***	4.859	***	6.327	***	4.777	***
J-B N test	22.10	***	40.28	***	81.98	***	303.2	***	79.93	***
ADF(.)	-22.31(0)	***	-23.10(0)	***	-19.69(0)	***	-20.13(0)	***	-20.25(0)	***
N	448		448		448		448		448	
1/1/1988-12/31/1999										
	SG		SP		TW		UK		US	
Mean	0.233		0.182		0.189		0.198		0.284	
Standard deviation	3.446		2.734		5.381		2.140		1.954	
Maximum	19.46		14.32		25.02		11.33		6.342	
Minimum	-28.66		-10.65		-25.75		-6.121		-8.081	
Skewness	-0.759	***	-0.029		-0.212	**	0.220	**	-0.257	***
Kurtosis	13.65	***	4.649	***	5.940	***	4.292	***	3.835	***
J-B N test	3023.9	***	71.03	***	230.2	***	48.60	***	25.1396	***
ADF(.)	-11.92(2)	***	-23.59(0)	***	-15.46(1)	***	-26.38(0)	***	-28.7702(0)	***
N	626		626		626		626		626	
1/7/2000-8/1/2008										
	SG		SP		TW		UK		US	
Mean	0.078		0.096		-0.037		-0.012		-0.003	
Standard deviation	2.745		2.779		3.700		2.302		2.321	
Maximum	9.510		11.25		18.34		10.90		8.089	
Minimum	-12.76		-9.262		-13.45		-8.792		-15.38	
Skewness	-0.477	***	-0.184		-0.051		-0.215	*	-0.815	***
Kurtosis	4.994	***	3.738	***	5.335	***	4.695	**	7.766	***
J-B N test	91.32	***	12.71	***	102.03	***	57.13	***	473.7	***
ADF(.)	-20.22(0)	***	-20.03(0)	***	-20.80(0)	***	-21.57(0)	***	-23.27(0)	***
N	448		448		448		448		448	

*Note: J-B N is the statistic of Jarque-Bera normal distribution test. Augmented Dickey-Fuller (ADF) unit-root test statistic indicating that the regression includes a constant term, values in the parentheses are the optimum delay difference periods that are determined by applying the AIC criterion; the maximum is 10. N is the sample size, *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

Table 3 lists the Pearson correlation coefficients between the change rate of crude oil prices and stock returns, and the periods are 1/1/1988–8/1/2008, 1/1/1988–/12/31/1999, and 1/7/2000–8/1/2008. According to the verification by ρ, only the correlation coefficients in Canada and Norway during the three periods are significantly different from zero; the correlation coefficients in Japan and Russia are significantly different from zero after 2000.

Table 3 The Pearson correlation coefficients between the change rate of crude oil price and stock returns

Periods / Countries	1/1/1988~8/1/2008	1/1/1988~12/31/1999	1/7/2000~8/1/2008
BE	-0.103	-0.130	-0.078
BR	-0.051	-0.064	-0.024
CA	0.095***	0.069*	0.125***
CH	-0.028	-0.031	-0.029
FI	0.027	0.058	0.012
FR	-0.027	-0.045	-0.001
GM	-0.082	-0.078	-0.086
HK	-0.059	-0.046	-0.077
IN	-0.009	0.027	-0.070
IT	-0.002	-0.002	-0.001
JP	-0.025	-0.094	0.085*
KR	0.013	0.034	-0.022
NE	-0.038	-0.053	-0.019
NW	0.172***	0.136***	0.221***
RU	0.084**	0.052	0.128***
SG	-0.082	-0.100	-0.049
SP	-0.049	-0.072	-0.016
TW	-0.098	-0.149	0.006
UK	-0.012	-0.007	-0.015
US	-0.077	-0.025	-0.135

Note: The statistic value of Pearson correlation is $t^0 = r\sqrt{n-2}/\sqrt{1-r^2}$ *, if the absolute values of* $|t^0| >$ $t_{(1-\alpha/2,n-2)}$*, the null hypothesis of 0 correlation coefficient will be rejected. *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

3.2. Mixture copula model estimation

This research first uses the mixture copula model defined by Eq.(5) to estimate parameters of the left tail dependence coefficients (LTDC) and the right tail dependence coefficients (RTDC). The insignificant parameters are then removed for re-estimation in terms of parameter parsimony. If the results estimated by the mixture copula model indicate that Clayton copula parameters are not significant, they will be deleted. Only normal copula and survival Clayton copula remain in the model if that is the case. This means that stock prices and oil prices of some countries only exhibit right tail extreme dependence. If the results estimated by the mixture copula model indicate that both Clayton copula and survival Clayton copula parameters are insignificant, only normal copula can stay in the model. This means that there is no extreme dependence between stock prices and oil prices of a country. Table 4 and Table 5 list the crude oil price and stock price copula parameters estimated for all countries before and after 2000, respectively. If Clayton copula and survival Clayton copula both exist in the mixture copula model, and w_1 is significantly greater than w_2, this means that Clayton copula account for a larger proportion than survival Clayton copula, implying a degree of right tail dependence (or RTDC) of joint distributions combined by oil price and stock markets is higher than left tail (or LTDC).

In the case of extreme dependence, tail dependence λ is multiplied by its weight and LTDC is defined, which represents the probability of the simultaneous occurrence of a sharp drop in oil price and a considerable rise in stock prices. RTDC is defined, which represents the probability of the simultaneous occurrence of a considerable rise of oil price and a sharp drop in stock prices. Then LTDC and RTDC are transformed into the correlation coefficient by Eqs.(8), (9) and (10). ρ_L denotes left tail correlation coefficients transformed from left tail dependence coefficients, and ρ_R denotes right correlation coefficients transformed from right tail dependence coefficients. They are used to compare correlation coefficients measuring regular dependence. This research discusses extreme negative tail dependence, so transformed tail correlation coefficients are marked with negative signs to clarify the correlation. In the case of regular dependence, its model parameter ρ implies the correlation coefficient, and is multiplied by regular dependence weight according to extreme dependence method. ρ_N denotes the general correlation coefficient. Table 6 shows the results estimated by correlation coefficients of extreme dependence and regular dependence. For instance, the correlation between crude oil prices and stock prices is generally positive 0.171 in UK after 2000. In the extreme case, the simultaneous occurrence probability of a sharp drop in oil price and a considerable rise of stock prices is 0.099, and the correlation is approximately 0.203. According to the results in Table 6, if extreme dependence exists in a country (except for Russia) its extreme dependence correlations are greater than those of regular dependence.

Table 4 The crude oil price and stock prices copula parameters estimated before 2000 (1/1/1988~12/31/1999)

Parameter / countries	w_1	λ_L	ρ	w_2	λ_R
BE			0.108 **		
			(0.048)		
BR			0.057		
			(0.035)		
CA			-0.097 **		

countries	w_1	λ_L	ρ	w_2	λ_R
			(0.042)		
CH			0.028		
			(0.047)		
FI			-0.062		
			(0.054)		
FR			0.027		
			(0.037)		
GM			-0.019	0.064 **	0.895 ***
			(0.053)	(0.032)	(0.046)
HK			0.007		
			(0.038)		
IN			-0.042		
			(0.037)		
IT			-0.007		
			(0.046)		
JP			0.042		
			(0.035)		
KR			-0.051		
			(0.038)		
NE			0.034		
			(0.041)		
NW			-0.188 ***		
			(0.035)		
RU			-0.040		
			(0.050)		
SG			0.040		
			(0.034)		
SP			0.037		
			(0.036)		
TW	0.182 ***	0.503 ***	-0.318 ***	0.401 ***	0.178 *
	(0.043)	(0.135)	(0.082)	(0.069)	(0.103)
UK			-0.019		
			(0.040)		
US			-0.042	0.059 *	0.772 ***
			(0.043)	(0.034)	(0.141)

Note: $C(u_1,u_2;\lambda_L,\rho,\lambda_R,w_1,w_2) = w_1 C^C(u_1,u_2;\lambda_L) + w_2 C^{CS}(u_1,u_2;\lambda_R) + (1-w_1-w_2)C^N(u_1,u_2;\rho)$. *Values in the parentheses are the stansard deviation. *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

Table 5 The crude oil price and stock prices copula parameters estimated after 2000 (2000-2008)

Parameter / countries	w_1	λ_L	ρ	w_2	λ_R
BE			0.028		
			(0.044)		
BR			0.019		
			(0.058)		
CA			-0.132 ***		
			(0.036)		
CH			-0.049	0.091 **	0.778 ***
			(0.063)	(0.044)	(0.113)
FI			-0.019		
			(0.041)		
FR			-0.041		

			(0.050)
GM	0.104 **	0.620 ***	-0.033
	(0.048)	(0.151)	(0.053)
HK			0.054
			(0.045)
IN			0.050
			(0.049)
IT			-0.075
			(0.056)
JP			-0.070
			(0.047)
KR	0.113 **	0.672 ***	-0.091 *
	(0.048)	(0.153)	(0.049)
NE			-0.021
			(0.044)
NW			-0.243 ***
			(0.040)
RU	0.303 ***	0.329 *	-0.429 ***
	(0.116)	(0.172)	(0.092)
SG			0.041
			(0.046)
SP			-0.012
			(0.044)
TW	0.154 *	0.482 *	-0.093
	(0.083)	(0.271)	(0.067)
UK	0.376 ***	0.265 **	-0.275 ***
	(0.079)	(0.121)	(0.077)
US	0.113 ***	0.854 ***	0.008
	(0.036)	(0.057)	(0.052)

Note: $C(u_1,u_2;\lambda_L,\rho,\lambda_R,w_1,w_2) = w_1 C^C(u_1,u_2;\lambda_L) + w_2 C^{CS}(u_1,u_2;\lambda_R) + (1-w_1-w_2)C^N(u_1,u_2;\rho)$. *Values in the parentheses are the standard deviation. *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

Table 6 The correlation coefficients of extreme dependence and regular dependence

periods	parameter / countries	ρ_L	*LTDC*	ρ_N	ρ_R	*RTDC*
Before 2000	TW	-0.197	0.092***	0.132***	-0.181	0.071*
	GM			0.018	-0.169	0.058***
	US			0.039	-0.158	0.046***
	NW			0.188***		
	CA			0.097**		
	BE			-0.108**		
	BR			-0.057		
	JP			-0.042		
	SG			-0.040		
	SP			-0.037		
	NE			-0.034		
	CH			-0.028		
	FR			-0.027		
	HK			-0.007		
	IT			0.007		
	UK			0.019		
	RU			0.040		
	IN			0.042		

	KR			0.051		
	FI			0.062		
	RU	-0.204	0.099*	0.299***		
	UK	-0.203	0.099**	0.171***		
	US	-0.202	0.097***	-0.007		
	KR	-0.185	0.076***	0.081*		
	TW	-0.183	0.074*	0.078		
	GM	-0.175	0.064***	0.030		
	CH			0.045	-0.181	0.071***
	NW			0.243***		
	CA			0.132***		
After 2000	HK			-0.054		
	IN			-0.050		
	SG			-0.041		
	BE			-0.028		
	BR			-0.019		
	SP			0.012		
	FI			0.019		
	NE			0.021		
	FR			0.041		
	JP			0.070		
	IT			0.075		

*Note: *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

3.3. Comparison of empirical results

3.3.1 Tail dependence coefficient (TDC)

According to Table 6, among 20 countries, no regular dependence and negative extreme dependence exists between crude oil prices and stock indices for more than half of the countries, which implies that there is no dependence between crude oil prices and stock indices. Only seven countries, which are China, Germany, Korea, Russia, Taiwan, UK and US, have asymmetric tail dependence. For the relation between international oil prices and stock indices during the stable period (1/1/1988-12/31/1999) , more countries have RTDC. For the same relationship during the rising period (/1/7/2000-8/1/2008), more countries have LTDC. Before 2000, RTDC existed in the countries, but LTDC instead of RTDC exists after 2000. Moreover, left tail dependence occurs in countries without extreme dependence before 2000.

Tables 4 to 6 show that LTDC exists only in Taiwan when crude oil prices are in the stable period, and the simultaneous occurrence probability of a sharp drop in oil prices and a considerable rise in stock prices is 0.09. RTDC exists in Taiwan, Germany, and US, and the simultaneous occurrence probability of a considerable rise in oil prices, and a sharp drop in stock prices is 0.04–0.07. When crude oil prices are in the rising period most countries have LTDC, and the simultaneous occurrence probability of a sharp drop in oil prices and a considerable rise in stock prices is 0.06–0.10. RTDC exists only in China, and the simultaneous occurrence probability of a considerable rise in oil prices and a sharp drop in stock prices is 0.07. If observing the degree of correlation, tail dependence in Taiwan is the strongest before 2000, followed by Germany and US. After 2000, only LTDC exists: the strongest is in Russia, followed by UK and US, the left tail correlation coefficients of three countries are proximity; the correlation is approximately 0.20. The left tail correlation coefficient of other countries is about 0.18.

Regarding asymmetric dependence, this research found that RTDC only exists in Germany and US before 2000. Although extreme dependence exists in Taiwan, the TDC and the correlation coefficient (ρ_L, ρ_R) are approximate, and there is no significant asymmetric dependence. No extreme dependence is found in the other countries. After 2000, RTDC is changed to LTDC in Germany and US. The RTDC that existed previously in Taiwan disappeared. LTDC also occurs in other countries such as UK, Russia and Russia. This means that after 2000 crude oil prices increased and the tail dependence of changes in oil prices and stock prices was transformed from an original RTDC, or independence, into LTDC.

Asymmetric tail dependence exists between oil prices and stock prices. Since the shocks to crude oil prices are different, RTDC is transformed to LTDC. When crude oil prices are stable, almost tail dependence is RTDC. However, after 2000 crude oil prices rose and the tail dependence for changes in oil and stock prices was transformed from RTDC into LTDC. One possible reason for no existence of RTDC after 2000 could be that oil price hit the top point in short time when the past oil crisis took place, and the cause for the existence of LTDC could be that investors anticipated oil prices to increase, so the good news of oil price drops exceeded the adverse impacts of an increase in oil price. This conclusion is consistent with Park and Ratti (2008).

3.3.2. Comparison of extreme dependence and regular dependence with different periods

This research sequences correlation coefficients which are listed in Table 7. The left and right extreme dependence of the correlation coefficients are greater than the correlation coefficients of regular dependence in Taiwan before and after 2000. This represents extreme shocks in crude oil prices impacting Taiwan's stock index. The extreme dependence in Germany and US is transformed from RTDC to LTDC before and after 2000. Furthermore, the left tail correlation coefficients are greater than right tail correlation coefficients after 2000. The regular dependence both in Germany and US is not significant. This means that their stock indices are affected only when crude oil prices experience extreme shocks. No extreme dependence or regular dependence originally existed in Korea, but they are significant after 2000. A possible cause is continuous rise of crude oil prices. The psychological expectations cause investors consider oil price drop is more important than a rise of oil price, and LTDC is significant. In addition, left tail correlation coefficients are significantly greater than general correlation coefficients. It represents the extreme downward pressure caused by the increase in the price of crude oil impacting the stock index in Korea after 2000. No extreme dependence and regular dependence originally existed, but after 2000 LTDC and regular dependence appear. Left tail correlation coefficients are significant and over 0.2, and the general correlation coefficients are significant and over 0.17. This means that after 2000, not only extreme downward shocks of crude oil price affect stock indices; a high correlation exists between crude oil prices and stock indices.

China originally had no extreme dependence or regular dependence, bu after 2000 only China remains RTDC. The inferred reason is that China's economy growth ranks first, and its crude oil demands are very sizeable. Moreover, China is the main reason for the rise in oil prices after 2000. Even if all countries anticipated oil price increases, a rise of oil price is not conducive to China's development. As a result, after 2000 oil price increased and stock prices dropped sharply. Regular dependence exists in Canada and Norway before and after 2000. Moreover, general correlation coefficients for these countries increased significantly in 2000. This implies that regardless of the trend of crude oil prices affecting stock indices, the correlation is higher when oil prices continuously increase.

Table 7 Comparison of the extreme dependence and regular dependence with different periods

	Before 2000			After 2000		
	ρ_L	ρ_N	ρ_R	ρ_L	ρ_N	ρ_R
TW	-0.1979***	0.132***	-0.181*	-0.183*	0.078	
GM		0.018	-0.169***	-0.175***	0.030	
US		0.039	-0.158***	-0.202***	-0.007	
KR		0.051		-0.185***	0.081*	
RU		0.040		-0.204*	0.299***	
UK		0.019		-0.203**	0.171***	
CH		-0.028			0.045	-0.181**
CA		0.097**			0.132***	
NW		0.188***			0.243***	
BE		-0.108**			-0.028	
BR		-0.057			-0.019	
FI		0.062			0.019	
FR		-0.027			0.041	
HK		-0.007			-0.054	
IN		0.042			-0.050	
IT		0.007			0.075	
JP		-0.042			0.070	
NE		-0.034			0.021	
SG		-0.040			-0.041	
SP		-0.037			0.012	

*Note: *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

3.3.3 Dependence structure based on classification of countries

A joint survey by IEA, OECD, and IMF indicated that high oil prices have a greater impact on developing countries than developed countries. Since there are few oil fields in Asian countries, the influence of oil price fluctuations on Asian countries is greater than European and American countries. Thus, this research classifies major stock markets according to the degree of development, geographic location, and whether they produce oil. Firstly, according to the classification based on development degrees of countries: this research divides the investigated objects into developed countries and developing countries in terms of data by World Bank, IMF and UK and world overview by CIA of USA, and observes whether dependence of crude oil price and stock indices of all countries change with the different development degrees of countries. Table 8 shows the estimated results. Before 2000, extreme dependence and regular dependence in developed countries have no consistency. After 2000, the RTDC that originally existed in countries is not seen. In addition, LTDC appears in one quarter of countries. This implies a continuous increase in crude oil prices makes investors regard a drop in crude oil prices as good news, leading to the occurrence of a sharp drop in oil prices and a considerable rise of stock indices. Again, all the developing countries had no extreme dependence and regular dependence before 2000, and start to appear extreme dependence after 2000, which coincides with the emergence of BRIC countries (Brazil, Russia, India and China). In addition, LTDC and RTDC exist in China and Russia, respectively. This implies the four countries belong to the same category, but the results are different due to their different economic structures and degrees of dependence on crude oil. Among the BRIC countries, China has the highest amount of imported crude oil, and its net imports of crude oil ranked third in the world in 2007. Contrarily, Russia is a petroleum product exporting country. In 2007, its annual net exports of crude oil ranked the second in the world. It has not only LTDC but also positive regular dependence. This indicates that crude oil prices are conductive to a rise of stock indices. Furthermore, extremely large drops in crude oil prices are helpful to Taiwan's economic development, and for raising their stock indices.

Table 8 Comparison of extreme dependence and regular dependence with different development degrees of countries

		Before 2000			After 2000		
		ρ_L	ρ_N	ρ_R	ρ_L	ρ_N	ρ_R
				OECD countries			
Developed countries	BE		-0.108 **			-0.028	
	CA		0.097**			0.132***	
	FI		0.062			0.019	
	FR		-0.027			0.041	
	GM		0.018	-0.169***	-0.175***	-0.030	
	IT		0.007			0.075	
	JP		-0.042			0.070	
	KR		0.051		-0.185***	0.081*	
	NE		-0.034			0.021	
	NW		0.188***			0.243***	
	SP		-0.037			0.012	
	UK		0.019		-0.203**	0.171***	
	US		0.039	0.158***	-0.202***	-0.007	
				Non OECD countries			
	HK		-0.007			-0.054	
	SG		-0.040			-0.041	
	TW	-0.197 ***	0.132***	-0.181*	-0.183*	0.078	
Developing countries	BR		-0.057			-0.019	
	CH		-0.028			0.045	-0.181 ***
	IN		0.042			-0.050	
	RU		0.040		-0.204*	0.299***	

*Note: *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

Table 9 shows the classification results based on geographical positions. Before 2000 all European and American countries have no LTDC, and only a few countries have RTDC. This is contrary to the conditions after 2000. It implies when oil prices are stable, the correlation between a sharp drop in crude oil prices and a considerable rise in stock prices in European and American countries is not significant. In addition, the correlation between a considerable rise in crude oil prices and a sharp drop in stock indices appears in a few countries. The dependence structure is the opposite of that when oil prices increase. By contrast, dependence structures in Asian countries seem to exhibit no consistent change before and after 2000.

Table 9 Comparison of extreme dependence and regular dependence with geographical positions

		Before 2000			After 2000		
		ρ_L	ρ_N	ρ_R	ρ_L	ρ_N	ρ_R
Euro-American countries	BE		-0.108**			-0.028	
	BR		-0.057			-0.019	
	CA		0.097**			0.132***	
	FI		0.062			0.019	
	FR		-0.027			0.041	
	GM		0.018	-0.169 ***	-0.175 ***	-0.030	
	IT		0.007			0.075	
	NE		-0.034			0.021	
	NW		0.188***			0.243***	
	SP		-0.037			0.012	
	UK		0.019		-0.203 **	0.171***	
	US		0.039	-0.158 ***	-0.202 ***	-0.007	
Asian countries	CH		-0.028			0.045	-0.181 ***
	HK		-0.007			-0.054	
	IN		0.042			-0.050	
	JP		-0.042			0.070	
	KR		0.051		-0.185 ***	0.081*	
	RU		0.040		-0.204 *	0.299***	
	SG		-0.040			-0.041	
	TW	-0.1979***	0.132***	-0.181 *	-0.183 *	0.078	

*Note: *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

To verify the classification based on whether to produce oil, this research calculated the average values of the data published by US EIA for crude oil output, consumption, and net exports/imports in all countries during 1988–1999 and 2000–2007. This was combined with the data for ranks of global crude oil producing countries, crude oil consumers, net exporters of crude oil, and net importers of crude oil in 2007 issued by EIA. The investigated subjects were divided into three categories, including oil producing countries and net exporters, major oil producing countries and top five largest net importers, non-major oil producing countries or non-oil-producing countries and net importers:

Panel A of Table 10 shows the estimated results based on the category of oil-producing countries and net exporters. Norway and Canada are among the global top 15 largest net exporters; the significant and positive general correlation exists in both countries before and after 2000. The positive general correlation exists in four net exporters after 2000. Those countries are Russia, Norway, UK and Canada, and they are ranked by their correlation degree from strong to weak. The data of stock indices in Russia was collected from September 1, 1995, so the amount of data before 2000 may be not adequate to give significant results. Nevertheless, the significant and positive general correlation exists in Russia after 2000. Their correlation is the highest among all countries in the study. The general correlation coefficients of all four countries after 2000 are better than their correlation coefficients before 2000; the correlation between crude oil prices and the stock indices of net exporters is closer when oil prices rise continuously or demand for oil increases. The UK and Russia simultaneously have LTDC after 2000, and the tail correlation coefficients for both countries are about 0.204.When crude oil prices drop sharply, it is conducive for Taiwan's economic development and increases to their stock market.

Table 10 The correlation coefficients of extreme dependence and regular dependence based on oil-producing net exporters and net importers

	Before 2000			After 2000		
	ρ_L	ρ_N	ρ_R	ρ_L	ρ_N	ρ_R
Panel A The oil-producing countries and net exporters						
UK		0.019		-0.203 **	0.171 ***	
RU		0.040		-0.204 *	0.299 ***	
NW		0.188 ***			0.243 ***	
CA		0.097 **			0.132 ***	
Panel B The major oil producing countries and top five largest net importers						
US		0.039	-0.158 ***	-0.202 ***	-0.007	
GM		0.018	-0.169 ***	-0.175 ***	0.030	
CH		-0.028			0.045	-0.181 ***
Panel C The non-major oil producing countries or non-oil-producing countries and net importers.						
KR		0.051		-0.185 ***	0.081 *	
TW	-0.197 ***	0.132 ***	-0.181 *	-0.183 *	0.078	
BE		-0.108 **			-0.028	
BR		-0.057			-0.019	
FI		0.062			0.019	
FR		-0.027			0.041	
HK		-0.007			-0.054	
IN		0.042			-0.050	
IT		0.007			0.075	
JP		-0.042			0.070	
NE		-0.034			0.021	
SG		-0.040			-0.041	
SP		-0.037			0.012	

*Note: *, **, and*** denotes10%, 5%, and 1% significant level, respectively.*

Panel B of Table 10 shows the estimated results based on the category of major oil producing countries and the top five largest net importers. The US and Germany were among top five net importers before 2007, where changes in the dependence structure are the same before and after 2000, from RTDC to LTDC. Furthermore, no correlation exists between LTDC and LTDC before and after 2000, and the tail correlation coefficients have almost no differences. The only difference is that the US's net imports of crude oil increased from 8.18 million barrels/day before 2000 to 11.55 million barrels/day after 2000. Germany's net imports of crude oil decreased from 2.74 million barrels/day before 2000 to 2.54 million barrels/day after 2000. This explains why the US has a greater left tail correlation coefficient than Germany after 2000. It should be noted that China's net imports of crude oil increased from 140,000 barrels/day before 2000 to 2.41million barrels/day after 2000. China's increase in oil consumption is the highest among all countries. Empirical results from this research show that after 2000, only China has RTDC. The reason for this can be inferred from the fact that China's economic growth ranks first among the world, and its crude oil demands are growing rapidly as a result. China is the main cause of the rise in oil prices after 2000.Increased oil prices are not conducive to China's development. The increased stress cause by China's growth has raised the price of oil world wide and caused a significant drop in China's stock prices after 2000.

Panel C of Table 10 shows the estimated results based on the category of non-major oil producing countries or non-oil-producing countries and net importers. Taiwan's daily average crude oil consumption was ranked 19th in the world during 2007. Taiwan's daily average net imports of crude oil ranked 10th overall, and the total value of imported oil accounted for 8.89% of Taiwan's GDP. The degree of dependence upon crude oil may cause Taiwan have LTDC and RTDC in stable period of crude oil price. In addition, the tail correlation coefficients have no great difference. During the rise period of crude oil prices, psychological expectations caused LTDC. Korea's daily average crude oil consumption ranked 9th in the world in 2007, and their daily average net imports of crude oil ranked 5th. Korea's total value of imported oil accounted for 5.92% of their GDP. No tail dependence existed in Korea before 2000, but after 2000, LTDC appears. Additionally, its left tail correlation coefficients are similar to Taiwan's.

4. Conclusions

The findings of this research are different from the conclusion that drastic changes resulting in increased oil prices are greater than the changes caused by a sharp drop in oil prices. When international crude oil spot prices are in the rising period, a significant LTDC exists between oil prices and stock indices in UK, US, Germany, Russia, Taiwan and Korea. A sharp drop in oil prices and a considerable rise in stock prices are more important than a considerable rise in oil prices and a sharp drop in stock prices. Furthermore, the general correlation between oil prices and stock indices in the oil producing countries of Norway and Canada is significant and positive, regardless of the trend in oil prices. This significant and positive general correlation also exists in Russia and the UK while oil prices are in the rise period. The correlation between a sharp drop in oil prices and a considerable rise in stock prices is also high in these countries. Therefore, investors can observe the stock market of a country and add to their investment portfolio when oil prices are on the rise, or when crude oil demands increase.

REFERENCES

[1]**Afshar, T. A., G. Arabian and R. Zomorrodian (2008),** ***Oil Price Shocks and The U.S Stock Market*** *.IABR & TLC Conference Proceedings*, San Juan, Puerto Rico, USA, 9;
[2]**Ciner, C. (2001),** ***Energy Shocks and Financial Markets: Nonlinear Linkages***. *Studies in Non-Linear Dynamics and Econometrics*, 5(3): 203-212;
[3]**Clayton, D. G. (1978),** ***A Model for Association in Bivariate Life Tables and its Application in Epidemiological Studies of Familial Tendency in Chronic Disease Incidence***. *Biometrika*, 65: 141-151;
[4]**Hammoudeh, S., S. Dibooglu and E. Aleisa (2004),** ***Relationships among U.S. Oil Price and Oil Industry Equity Indices***. *International Review of Economics and Finance*, 13: 427-453;
[5]**Huang, R. D., R. W. Masulis and H. R. Stoll (1996),** ***Energy Shocks and Financial Markets*** *.Journal of Futures Markets*, 16(1): 1-27;
[6]**Jones, C. M. and G. Kaul (1996),** ***Oil and the Stock Market***. *Journal of Finance*, 51(2): 463-491;
[7]**Lai, Y. H., C. W. S. Chen and R. Gerlach (2009),** ***Optimal Dynamic Hedging via Asymmetric Copula-GARCH Models***. *Mathematics and Computers in Simulation*, 79(8): 2609-2624;
[8]**Li, D. X. (2000),** ***On Default Correlation: A Copula Function Approach***. *Journal of Fixed Income*, 9: 43-54;
[9]**Miller, J. I. and R. A. Ratti (2009),** ***Crude Oil and Stock Markets: Stability, Instability, Bubbles***. *Energy Economics*, 31(4): 559-568;
[10]**Nandha, M. and R. Faff (2008),** ***Does Oil Move Equity Prices? A Global View*;** *Energy Economics*, 30(3): 986-997;
[11]**Park, J. and R. A. Ratti (2008),** ***Oil Price Shocks and Stock Markets in the U.S. and 13 European Countries***. *Energy Economics*, 30(5): 2587-2608;
[12]**Romano, C. (2002),** ***Calibrating and Simulating Copula Functions: An Application to the Italian Stock Market***. *Centro Interdipartimentale sul Diritto e l'Economia dei Mercati*, *Working paper*;
[13]**Sadorsky, P. (1999),** ***Oil Price Shocks and Stock Market Activity***. *Energy Economics*, 21(5): 449-469.