8. NONLINEAR RELATIONSHIPS BETWEEN OIL PRICE AND STOCK INDEX – EVIDENCE FROM BRAZIL, RUSSIA, INDIA AND CHINA

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Abstract

Threshold Autoregressive (TAR)/ Momentum-Threshold Autoregressive (MTAR) nonlinear models are used to study the cointegration and causality relationships between WTI crude oil prices and stock indexes of Brazil, Russia, India, and China (BRIC) during January 1996 to June 2015. The Chow breakpoint test and the Quandt-Andrews unknown breakpoint test are used to examine structural changes. The results show that the causality is from WTI spot price to stock indexes in India and Russia before and after the structural breaks, and from stock index to WTI spot price in China after the structural break. There is no causality relationship between stock index and WTI spot price in Brazil. There are long-running cointegration relationships between stock indexes of BRIC and WTI spot prices.

Keywords: oil price, stock index, BRIC
JEL Classification: F10, F30, G10, G20, Q40

I. Introduction

Literature has shown evidence on the relationships between oil price and stock index. The argument is based on the following points. Price per share can be calculated by equity value divided by number of shares. Equity value can be estimated by enterprise value minus interest bearing debt plus cash. Enterprise value is the present value of the company expected free cash flow. Oil price changes affect inflation rate, interest rate, company production, industrial production, and GDP (Chen, Roll, and Ross, 1986; Jones and Kaul, 1996; Sadorsky, 1999; Park and Ratti, 2008, Apergis and Miller, 2009; El Dedi Arouri, Jouini, and Nguyen, 2011). Changes of inflation rate and interest rate

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affect discount rate. Expected free cash flow is affected by changes of company production, industrial production, and GDP. Therefore, oil price changes affect discount rate and expected free cash flow. Changes of discount rate and expected free cash flow affect stock prices. And oil price changes affect stock prices. Attention has been on the study of the relationships between oil prices and stock indexes (Jones and Kaul, 1996; Sadorsky, 1999; Park and Ratti, 2008, Apergis and Miller, 2009; El Dedi Arouri, Jouini, and Nguyen, 2011). The empirical literature shows significant relationships between industrial production growth (percentage change of industrial production index) and stock return (Chen, Roll, and Ross, 1986; Shanken and Weinstein, 2006). From our knowledge, there is no paper that uses the percentage change of industrial production index as the threshold to study the nonlinear relationships between oil prices and stock prices. This paper studies the nonlinear relationships between oil prices and stock indexes by using the industrial production growth as the threshold.

The growth of emerging market has change the structure of the world oil price system. The oil price is significantly affected by the oil demand of China and India, (Li and Lin, 2011). Both China and India are world oil importers. It will be interesting to study the relationships between oil prices and stock indexes for the oil exporters (Brazil and Russia) and importers (India and China). This paper uses the data of Brazil, Russia, India, and China to study the nonlinear relationships between oil prices and stock prices.

Empirical studies have been focused on the relationships between oil prices and stock returns of oil companies, and the relationships between oil prices and stock market returns. The stock market return is negatively associated with the rise of crude oil price in the US (Kling, 1985) and some other countries (Driesprong, Jacobsen, and Maat, 2008). The oil price shocks have negative impacts on the oil import countries, and positive impacts on the oil export countries (Park and Ratti, 2008). Oil prices have significatnt impacts on stock returns of oil companies in the US and Canada (Huang and Masulis, 1996; Hammoudeh, Dibooglu, and Aleisa, 2004; Sadorsky, 2011). The volatility spillover effects between oil futures and stocks are found in the US financial markets (Hammoudeh, Dibooglu, and Aleisa, 2004). Contrary to the empirical study results of developed countries, Cong, Wei, and Liao (2008) show that oil price shocks do not have significant impact on most of the stock indexes of China except for manufacturing index and some oil companies.

China, India, Russia, and Brazil have the second, third, sixth, and seventh largest DGPs in the world[3]. The oil demand from emerging markets has become a significant factor in the world oil pricing system (Li and Lin, 2011). Nonlinear models for unit root tests (Kapetanios, Shin, and Snell, 2003), threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) cointegration tests (Enders and Granger, 1998; Enders and Siklos, 2001) are used in this study. Data for the stock indexes of the four largest emerging markets Brazil, Russia, India, and China (BRIC) and West Texas Intermediate (WTI) crude oil spot price are used for the empirical study.

The results of this study are as follows. The WTI crude oil spot price has impacts on stock indexes in India and Russia before and after the structural breaks. Different from the result of Cong, Wei, and Liao (2008), the stock index has impact on WTI crude oil spot price in China after the structural break. There is no causality relationship between

[3] 2011 World economic outlook database, International Monetary Fund.

stock index and WTI crude oil spot price in Brazil. The TAR and MTAR models show that F_c s are all significant. These indicate that *there are long-running cointegration relationships between stock indexes of BRIC and WTI spot prices.*

The oil price increased from 23 dollars per barrel in May of 2003 to a high of 48 dollars per barrel in March of 2005. Russia had nearly one million barrels per day of new additional oil supplies was the main reason for the largest increase in world oil supply from 2001 to 2004 (Reynolds and Kolodziej, 2007). Oil production is far less than oil consumption for India from the years 1996 to 2014[4] (Table 1). The oil consumption of China increased substantially because of the economic development of China. This has make China become the largest oil net importer in the world. Stock index is the leading economic indicator. Therefore, the stock index has impact on the WTI spot oil price in China after the structural break of China.

Table 1

Oil supply and consumption (thousand barrels per day)

Oil supply																
	1996	1997	1998	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014
Brazil	1106	1172	1282	1534	1757	1846	1839	2038	2164	2282	2439	2560	2718	2692	2694	2950
Russia	6016	6101	6069	6723	7658	8534	9273	9511	9677	9878	9794	9933	10146	10228	10764	10853
India	750	779	761	770	812	815	843	820	847	847	849	835	911	942	982	978
China	3211	3284	3301	3377	3529	3559	3657	3791	3865	3925	3986	3995	4273	4269	4543	4572
Oil Consumption																
Brazil	1904	2031	2096	2166	2132	2056	2123	2206	2287	2355	2387	2421	2560	2793	3003	
Russia	2619	2562	2489	2578	2636	2682	2751	2785	2803	2697	2856	2927	3038	2725	3493	
India	1681	1765	1844	2127	2263	2346	2430	2512	2691	2801	2908	3008	3116	3426	3660	
China	3610	3916	4106	4796	5161	5578	6437	6695	7263	7534	7948	8538	9392	8924	10480	

Data source*: US Energy Information Administration at http://www.eia.gov/.*

This paper is organized as follows. Section 2 presents the data used in the study. Section 3 discusses the empirical results, and section 4 concludes this study.

II. Data

The data of this study are monthly closing prices of Brazil Bovespa Index (BVSP), Russia RTS Index (RTSI), Bombay Sensitive 30 Index (SENSEX), Shanghai Composites Stock Index (SSEC), and WTI crude oil spot price (WTI). The research period is from January 1996 to June 2015. Data of the variables are taken from the Taiwan Economic Journal (TEJ), Cnyes.com and Energy Information Administration.

Table 2 reports the summary statistics of all variables in this study, such as mean, standard deviation, maximum, minimum, skewness, kurtosis, and Jarque-Bera value. Among the four countries' stock indexes, RTSI has the smallest standard deviation and BVSP has the largest standard deviation. Skewness statistics show that all variables

[4] *In the year 2008, India oil production and consumption were 849 and 2,908 thousand barrels per day, respectively. In the year 2009, India oil production and consumption were 836 and 3008 thousand barrels per day, respectively. US Energy Information Administration at http://www.eia.gov/.*

are right-tailed. The Jarque-Bera tests reject the null hypothesis of normal distribution at 1% significance level for all variables.

Table 2

Summary Statistics of Variables

Variables	WTI	BVSP	RTSI	SENSEX	SSEC
Mean	54.99850	34075.38	896.1341	10815.63	2041.545
Median	49.79500	30888.65	711.4000	8263.400	1854.573
Maximum	133.8800	72592.50	2459.880	29361.50	5954.770
Minimum	11.35000	4954.900	43.81460	2810.660	537.3460
Std. Dev.	31.48009	21883.37	654.9420	7569.743	945.1266
Skewness	0.371329	0.179784	0.370947	0.592733	1.397265
Kurtosis	1.852003	1.429225	1.831790	2.129691	5.455086
Jarque-Bera	18.22702***	25.31708***	18.67243***	21.08698***	134.9092***

Notes: ***denote the significant levels at 1%.

III. Results

A. Unit Root Test

The stability analysis of variables is provided before TAR/MTAR cointegration test. ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) methods are used for unit roots test. The null hypothesis (H_0) is tested by the ADF. As H_0 can't be rejected easily by the ADF test when the data are very close to unit roots (Sims, 1988), PP test is also applied for reinforcement. The results of the ADF test and PP test are shown in Table 3. The results show that the BRIC's stock price indexes and WTI spot oil price are all stationary in the first differences.

Table 3

Linear Unit Root Test

Panel A: Level		WTI	BVSP	RTSI	SENSEX	SSEC
Intercept	ADF	-2.001	-1.184	-1.786	0.433	-2.346
	PP	-1.919	-1.272	-1.781	0.276	-2.125
Intercept and Trend	ADF	-3.816**	-1.793	-1.944	-1.979	-3.378
	PP	-2.990	-2.148	-1.982	-2.249	-2.903
Panel B: First difference		WTI	BVSP	RTSI	SENSEX	SSEC
Intercept	ADF	-10.861***	-13.401***	-12.391***	-15.046***	-5.237***
	PP	-10.907***	-13.424***	-12.385***	-15.108***	-15.141***
Intercept and Trend	ADF	-10.854***	-13.383***	-12.396***	-15.133***	-5.234***
	PP	-10.901***	-13.405***	-12.391***	-15.171***	-15.125***

1. Null Hypothesis: has a unit root.
2. ***: denotes rejection of the Null Hypothesis (H0) at the 1% level.

B. TAR/MTAR cointegration test

Nonlinear asymmetric adjustment processes may exist between the nonstationary variables in the linear models. Nonlinear models are better solutions to capture nonlinear cointegration relationships between variables. (Enders and Granger, 1998; Enders and Siklos, 2001). Threshold Autoregressive (TAR)/ Momentum-Threshold Autoregressive (MTAR) cointegration tests are used to study nonlinear cointegration relationships between the oil price and stock index (Enders and Granger, 1998; Enders and Siklos, 2001).

Percentage change of industrial production index is used as the threshold in this study. The TAR/MTAR test results are presented in Tables 4. In the cases of Brazil and Russia, AIC and SBC of MTAR model are all smaller than those in the TAR model. Therefore, MTAR model is better than TAR model in Brazil and Russia. Table 4 shows that, both TAR and MTAR models, F_c are all significant at 1% or 5% level and reject the null hypothesis ($H_0: \rho_1 = \rho_2 = 0$) in Brazil, Russia and India. It means that there is cointegration between each pair of variables. The existence of cointegration relationships indicates that the relationships are stationary in the long-run between each pair of stock index and WTI crude oil spot price in Brazil, Russia and India. F_c of SSEC/WTI is only significant at 10% level in the MTAR model.

F_a ($H_0: \rho_1 \neq \rho_2$) in Table 4 is used to test the symmetrical relationships between each pair of stock index and oil price in the short term. F_a of SENSEX/WTI is significant at 5% level in the MTAR model. This indicates that SENSEX and WTI are symmetrical in the short term. F_a of BVSP/WTI is significant at 10% level only in the MTAR model. F_a of SSEC/WTI and RTSI/WTI are not significant both in the TAR and MTAR models. This indicates that there is no symmetrical adjustment between the residuals of SSEC / WTI and RTSI/WTI.

The results of TAR/MTAR cointegration tests show that the long run relationships between each pair of stock index and oil price are nonlinear for all BRIC countries, especially Russia, India, and Brazil. Therefore, the nonlinear threshold error correction model can be used to examine the relationships between each pair of oil price and stock index for the BRIC countries.

Table 4

TAR/MTAR cointegration test between Stock and Oil

		Threshold	F_c	F_a	*AIC*	*SBC*
BVSP / WTI	***TAR***	0.00000	6.02788***	0.025023	-648.266	-631.098
		-0.15756	6.65228***	1.212004	-655.187	-638.019
	MTAR	0.00000	6.99415***	1.861893	-654.314	-637.145
		0.00292	7.63421***	3.078648*	-655.771	-638.602
RTSI / WTI	***TAR***	0.00000	5.42561***	0.977415	-589.801	-572.632
		-0.27092	6.26169***	2.581295	-585.697	-568.528

		Threshold	F_c	F_a	***AIC***	***SBC***
	MTAR	0.00000	4.96160***	0.087284	-594.731	-577.563
		0.04505	5.91052***	1.907639	-607.396	-590.228
		Threshold	F_c	F_a	***AIC***	***SBC***
SENSEX / WTI	***TAR***	0.00000	3.06173**	1.381487	-669.399	-652.231
		0.26262	4.88291***	4.951011**	-658.495	-641.327
	MTAR	0.00000	3.05996**	1.378007	-663.400	-646.231
		-0.10239	5.35031***	5.867117**	-676.584	-659.415
		Threshold	F_c	F_a	***AIC***	***SBC***
SSEC / WTI	***TAR***	0.00000	1.41592	0.001025	-437.911	-420.742
		0.57202	2.16235	1.475821	-440.410	-423.242
	MTAR	0.00000	1.41609	0.001366	-437.753	-420.584
		-0.10817	2.52908*	2.200399	-445.523	-428.354

1. The critical values of F test for TAR and MTAR are reported in Enders and Siklos (2001).
2. F_c and F_a denotes the cointegration test and asymmetric test, respectively.
3. ***, **, and * denote the significant levels at 1%, 5%, and 10%.

C. Structural changes

The Chow breakpoint test and the Quandt-Andrews unknown breakpoint test are used to examine whether any structural changes occurred during the period studied. The results of the Quandt-Andrews unknown breakpoint test are shown in Figures1 to 4 and the results of Chow breakpoint test are presented in Table 5. The possible breakpoints of these four time series are shown in Figures 1 to 4. In the years 2004 to the early stage of 2006, the international investors invested in the emerging markets, including Brazil, Russia, India, and China, and all these four equity markets increased during the above-mentioned period. Both the China stock index (Shanghai Composites Stock Index, SSEC) and the Brazil stock index (Brazil Bovespa Index, BVSP) increased in the early stage of 2006. However, as the international investors started to withdraw their money away from the emerging markets, both the China stock index (Shanghai Composites Stock Index, SSEC) and the Brazil stock index (Brazil Bovespa Index, BVSP) plummeted at the end of 2006. The Russia stock index (Russia RTS Index, RTSI) increased during the years 2003 to 2007. Because a great recession occurred in 2008, the Russia stock index (Russia RTS Index, RTSI) plummeted after March 2008. The India stock index (Bombay Sensitive 30 Index, SENSEX) experienced a steady increase in the early 2010s because of the money from international investors. However, after the international investors heavily sold shares, the India stock index (Bombay Sensitive 30 Index, SENSEX) decreased after March 2014.

Fig 1: Q-A unknown breakpoint test: BVSP

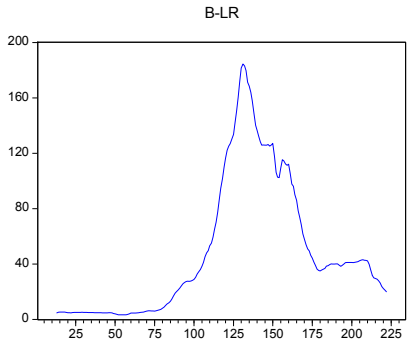

Fig 2: Q-A unknown breakpoint test: RTSI

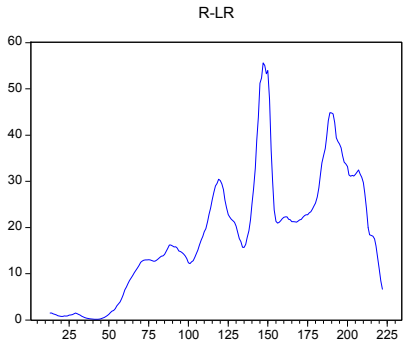

Fig 3: Q-A unknown breakpoint test: SENSEX

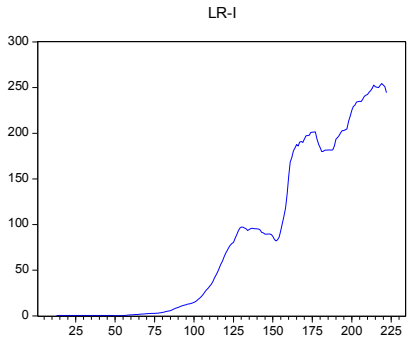

Fig 4: Q-A unknown breakpoint test: SSEC

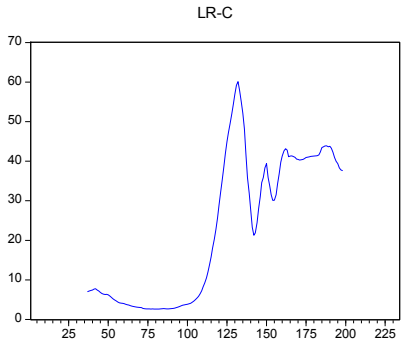

Table 5

Result of Chow Breakpoint Test

	Breakpoint	F-statistic	Log likelihood ratio	Wald Statistic
BVSP	131: 2006.11	184.4560***	223.9463***	368.9120***
RTSI	147: 2008.03	55.59884***	92.28555***	111.1977***
SENSEX	219: 2014.03	254.3400***	273.0278***	508.6800***
SSEC	132: 2006.12	60.12088***	98.40738***	120.2418***

1. Null Hypothesis: No breaks at specified breakpoints.
2. *, **, ***: denotes rejection of the Null Hypothesis (H_0) at the 10%, 5% and 1% level.

D. TAR/MTAR Causality Test

The causality relationships between stock indexes and WTI spot prices are studied both before and after the break points identified by Chow breakpoint test and Quandt-Andrews unknown breakpoint test. The causality test results are shown in Table 6. There is no causality from stock index to WTI spot price before break points of all BRIC countries. There is causality from stock index to WTI spot price after the break point in China. Except China, there is no causality form stock index to TWI spot price after the break points in Brazil, India, and Russia. There is causality from WTI spot price to stock index before the break in India. Except India, there is no causality form WTI spot price to stock indexes before the break points in Brazil, China, and Russia. There is causality from WTI spot price to stock index after the break point in Russia. Except Russia, there is no causality from WTI spot price to stock indexes after the break points in Brazil, India, and China.

Table 6

TAR/MTAR Causality analysis

		BRAZIL	**RUSSIA**	**INDIA**	**CHINA**
Stock Index does not cause WTI-spot - before break point	TAR	0.91724 (0.000)	0.03141 (0.000)	0.90669 (0.000)	0.11365 (0.000)
		0.64929 (0.17746)	0.05118 (-0.52569)	1.00127 (0.22356)	0.18562 (0.29201)
	MTAR	0.86501 (0.000)	0.03224 (0.000)	0.94487 (0.000)	0.08390 (0.000)
		0.85617 (0.06943)	0.03226 (-0.01390)	1.07115 (0.04710)	0.13717 (0.00886)
Stock Index does not cause WTI-spot - after break point	TAR	0.24831 (0.000)	0.47805 (0.000)	0.37414 (0.000)	1.82122 (0.000)
		0.23323 (-0.06976)	0.49542 (-0.07615)	2.32365 (-0.02930)	1.81650 (0.04345)
	MTAR	0.60009 (0.000)	0.41707 (0.000)	1.78492 (0.000)	2.62773 (0.000)
		0.45419 (-0.01688)	0.42079 (0.02396)	1.78492 (-0.00419)	**2.48102* (-0.01699)**
WTI-spot does not cause Stock Index - before break point	TAR	1.37977 (0.000)	0.24210 (0.000)	**4.13355** (0.000)**	0.05507 (0.000)
		1.54572 (-0.12571)	0.25484 (-0.06280)	**3.81734** (0.25509)**	0.05700 (-0.34126)
	MTAR	1.40892 (0.000)	0.49869 (0.000)	**4.38039** (0.000)**	0.04282 (0.000)
		1.18780 (0.04095)	0.38847 (0.11424)	**5.51105*** (0.02660)**	0.10636 (0.10071)
WTI-spot does not cause Stock Index	TAR	0.54096 (0.000)	**2.63669* (0.000)**	0.77704 (0.000)	0.88889 (0.000)

		BRAZIL	RUSSIA	INDIA	CHINA
- after break point		0.49694 (0.54096)	**2.61227*** **(0.14204)**	1.34685 (-0.08852)	0.90195 (0.04986)
	MTAR	0.74569 (0.000)	**2.76726*** **(0.000)**	0.06363 (0.000)	0.45885 (0.000)
		1.04367 (-0.03451)	**2.66691*** **(-0.00495)**	0.97904 (-0.05155)	0.59390 (0.02481)

1. ( ): Threshold -value.
2. ***, **, and * denote the significant levels at 1%, 5%, and 10%.

IV. Conclusion

This paper uses TAR/MTAR nonlinear model to test cointegration relationships and causality relationships between WTI crude oil spot price and stock indexes for Brazil, Russia, India, and China. The data are collected from the Taiwan Economic Journal (TEJ) and Energy Information Administration (EIA) from January 1996 to June 2015. Chow breakpoint test and the Quandt-Andrews unknown breakpoint test are used to test the structural changes.

The causality test results show that only WTI spot price is able to affect the stock indexes in India before the structural break and in Russia after the structural break. Only the stock index is able to affect WTI spot price in China after the structural break. There is no causality relationship between WTI spot price and stock index of Brazil. However, the results of TAR and MTAR models show that F_c s are all significant. This means that there are long-running cointegration relationships between the WTI spot price and stock indexes in BRIC.

The service sector is the largest sector in Brazil. Oil is not as impactful in Brazil as those in Russia, India, and China. Therefore, the oil price is not able to affect the Brazil stock index before and after the structural break.

Russia is the third largest oil exporter in the world. Oil is the largest sector in terms of revenue in Russia. During the bullish stock market and high economic growth time period, i.e., the years before 2008, the oil price was not able to influence the Russia stock index. Contrarily, during the bearish stock market and economic downturn time period, i.e., the years after 2008, the oil price was able to influence Russia stock index.

India is the third largest oil importer and the stock market was influenced by the oil price before 2014. After 2014, India has gradually focused more on computer software industry, film industry, biochemical science industry and relies less on oil consumption industries. Therefore, the oil price is not able to influence the India stock index after 2014.

In China, since the free market reforms in 1979, the average real GDP growth rate was about 10% until 2011. The industrialization of China has made the country the world manufacturing center. The economic stimulus package by China after the 2008 global financial crisis has boosted both the manufacturing output and the domestic consumption. The economic development of China has made China the second largest oil net importer in the world before 2013 and the largest oil net importer from September

2013. The stock index increases before the economic growth, because the stock index is the leading indicator of the economy. Being the second largest oil importer, the stock index will be able to have impacts on the WTI oil spot price after the structural break in China.

The relationships between WTI crude oil spot prices and stock indexes in emerging markets such as Brazil, Russia, India, and China have different patterns depending on the oil production, oil consumption, stock market conditions, and economic development conditions. These results can provide investors and policy maker important information for decision making.

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