The Story behind the Wider Spread between WTI and Brent

:Are Crude Oil Market Globalized or Regionalized

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Abstract

This paper uses the quantile unit root test to examine the evolution of WTI and Brent, along with other crude oil prices differentials. We find regionalization in the lower quantiles but globalization in the upper quantiles, and overwhelming evidence supporting the globalization of oil markets. Our empirical results support that WTI, Brent and Dubai are still generally co-integrated in the whole observation period. In general, the globalization still exists in the world oil market from the co-movement of these three benchmark prices WTI, Brent and Dubai although each of them has been deviated to the regionalization.

JEL classification: Q41

Key Words: WTI, Brent, Spread, Quantile Unit Root Test, Globalization, Regionalization.

1. Introduction

The price of WTI (West Taxes Intermediate) should be higher than that of Brent due to its sweet and lighter quality. However, the price of Brent jumped up to be higher than that of WTI occasionally by the end of 2010, and was getting to be higher in the 2011. Starting from the beginning of 2011, some experts expected that the wider spread between WTI and Brent is caused by the war of Libya and would converge or even disappear soon after the cease-fire. Opposite to this expectation, the spread did not disappear but got bigger since war in Libya continued for more months than most experts had expected, while, the opening of the keynote pipeline in February of 2011 enlarger the spread of WTI and Brent. This pipeline transports more and more crude oil from the oil sand fields in Canada and Bakken oil to the main refinery city, Oklahoma, and thus cumulated too much crude oil supply in Oklahoma. Since the city of Oklahoma is the delivery point for WTI crude futures, the limitation of storage facilities and the lack of pipeline access from Oklahoma to other crude oil demanded areas (e.g. Houston) brought huge crude oil supply that induced lower local prices (i.e. WTI) and widen the spread of WTI and Brent. This insufficient outflow infrastructure in mid-west area of US, combined with the slow economic rebound in North American and the stricter exchange regulation of futures markets in US are believed to be the most important reasons to explain the wider spread of WTI and Brent. Although more and more paper concerns this issue of wider spread (Hammoudeh, et al., 2010; Kao and Wan, 2011), as our knowledge, none of the papers or experts tackle the issue of "globalization and localization" played by the stable relationship of WTI and Brent. WTI and Brent are two important benchmark prices in the world oil market. Although WTI and Brent are selected to be the representatives of the market of America and Europe, their long term stable relationship makes people believe that the futures of WTI and Brent can be almost fully replaceable. Any traders (i.e. an Asian buyer) can use the WTI futures to hedge its crude oil imported from Europe by just considering an acceptable price premium between WTI and Brent. However, the wider and unstable spread of WTI and Brent brings lots of confuse for most traders. More and more arguments are raised to discuss the leadership of WTI (Koyama, 2011a; 2011b). People calls in question the globalization of WTI, especially for those buyers in Asia area. They begin to challenge the leadership of WTI.

It is not easy to challenge the leadership of WTI since it has been built for a long while. WTI is regarded as an important indicator not only because the earliest build in the crude oil future market but also the biggest trade volume and most visible characteristics. Many traders (i.e. traders outside the mid-west area of U.S. market) may be forced to give up a good tool if WTI can no longer maintain its good role for hedge. It is pity to give up such a good hedge (or speculative) tool in the oil market. Thus the judgment of the suitability of the leadership (or the globalization representative) of WTI must be widely acceptable and fairness. Any personal complaints, arguments or experiences tend to be treated as biased judgment or narrow mind views. All of these are not persuasive. Based on these considerations, this paper tries to use a statistical tool to find a fair result. Since the Quantile Unit Root analysis is much capable in capturing the asymmetric dynamic evolution, we will use this analysis to seek out some evidences for suitable evaluation of the role of WTI.

The Quantile Unit Root analysis will be explained in Section 2. Data and empirical results will be illustrated in the Section 3. Conclusions and Remarks are in the Section 4.

2. Methodology

2.1 Globalization and Unit Root Test

There are some definitions (or arguments) for the globalization. Here, in our paper, we just choose the simplest definition: accepted by the whole world. Since WTI, Brent and Dubai are the three most important benchmark crude oil prices in the world, each of them representing the market dynamics in the oil market of America, Europe and Asia, we use these three indicators to examine the globalization in the world market. Apparently, in the world of globalization, every buyers and sellers are able to reach their best options in the world. For example, an Asian buyer can easily reach the market in Europe or American through physical or paper trade. Since all buyers and sellers can arbitrage the oil trade in the world market all the times, the price level of these three benchmark prices would then converge to a stable level and move stationary. Based on the characteristics of stationarity, the test of Unit Root can helps us to examine the globalization of oil market. If the data series of the spread of WTI and Brent reject the Unit Root test, then the data series of the spread of WTI and Brent are stationary, which represents that WTI and Brent is co-integrated. Thus, the world oil market is globalized. On the other hand, if the data series of the spread of WTI and Brent does not reject the Unit Root test, then the data series of the spread of WTI and Brent are non-stationary. WTI and Brent move in different ways, thereby, regionalization exists in the world oil market.

Except simple Unit Root test, this paper would also implement the Quantile Unit Root test. A recent publication investigating the asymmetric inflation dynamics (Tsong and Lee, 2011) sheds us some new light in exploring the phenomenon of asymmetric dynamics. Current world oil market evolves quickly as time changes. Sometimes, it changes so quickly that the simple Unit Root test may not be able to capture some dynamic movements. In order to compensate the shortage of simple Unit Root test, this paper would follow the idea addressed by Koenker and Xiao(2004) to implement the Quantile Unit Root test. Since Unit Root test is too popular in too many papers, this paper would only introduce the methodology of Quantile Unit Root Test in next subsection.

2.2 Quantile Unit Root Test

We follow very closely the description of Tsong and Lee (2011) on how to perform the quantile unit root test. Consider that,

$$y_t = \alpha_1 y_{t-1} + \sum_{j=1}^{q} \alpha_{j+1} \Delta y_{t-j} + u_t, \quad t = 1,2,\ldots,n, \qquad (1)$$

where $y_t = s_t - \mu,$ with s_t and μ denoting the spread between WTI and Brent oil prices and its long-run equilibrium value, respectively; u_t is iid random variable with zero mean and constant variance. In the specification, the autoregressive coefficient α_1 measures the persistence of y_t. If $\alpha_1 = 1,$ y_t is said to be a unit root process, and if $|\alpha_1| < 1,$ the behavior of y_t is said to be mean reverting. Following Koenker and Xiao (2004), the τ th conditional quantile of y_t, conditional on the information set up to t-1, ie., $\Im_{t-1}$, can be expressed as a linear function of y_{t-1} and lagged values of Δy_t as follows:

$$Q_{y_t}(\tau \mid \Im_{t-1}) = x_t^{'} \alpha(\tau), \qquad (2)$$

where $x_t = (1, y_{t-1}, \Delta y_{t-1}, \ldots, \Delta y_{t-q})'$ and $\alpha(\tau) = (\alpha_0(\tau), \alpha_1(\tau), \ldots \alpha_{q+1}(\tau))^{'}$, with $\alpha_0(\tau)$ representing the τ th quantile of u_t. It is noticeable that $\alpha_1(\tau)$ assesses the speed of mean reversion of y_t within each quantile, and depends upon the τ th quantile under investigation.

For a given τ, the parameter vector $\alpha(\tau)$ in Eq. (2) is estimated by minimizing sum of asymmetrically weighted absolute deviations:

$$\min \sum_{t=1}^{n} (\tau - I(y_t < x_t^{'} \alpha(\tau))) \mid y_t - x_t^{'} \alpha(\tau) \mid, \qquad (3)$$

where I is an indicator function, i.e., $I = 1$ if $y_t < x_t^{'} \alpha(\tau)$, and $I = 0$, otherwise. Given the solution of Eq. (3), denoted by $\hat{\alpha}(\tau)$, Koenker and Xiao (2004) suggest testing the time-series properties of y_t within the τ th quantile by using the following t ratio statistics:

$$t_n(\tau) = \frac{\hat{f}(F^{-1}(\tau))}{\sqrt{\tau(1-\tau)}}(Y_{-1}^{'}P_x Y_{-1})^{1/2}(\hat{\alpha}_1(\tau)-1), \qquad (4)$$

where $\hat{f}(F^{-1}(\tau))$ is a consistent estimator of $f(F^{-1}(\tau))$, with f and F representing the density and distribution function of u_t in Eq. (1), Y_{-1} denotes the vector of lagged dependent variables (y_{t-1}), and P_X denotes the projection matrix onto the space orthogonal to $X = (1, \Delta y_{t-1}, \ldots, \Delta y_{t-q})$. According to Koenker and Xiao (2004), $\hat{f}(F^{-1}(\tau))$ can be re-written as $\hat{f}(F^{-1}(\tau)) = (\tau_i - \tau_{i-1}) / x_t^{'}(\hat{\alpha}(\tau_i) - \hat{\alpha}(\tau_{i-1}))$ with $\tau_i \in \Gamma$. We choose $\Gamma = \{0.1, 0.2, \ldots, 0.9\}$ in our empirical study. Besides, define QKS=sup $t_n(\tau)$.

Moreover, given $\hat{\alpha}_1(\tau)$, we can calculate the half-lives (HLS) of a shock hitting the spread within the quantile using the formula $\ln(0.5)/\ln(\hat{\alpha}_1(\tau))$.

3. Data and Empirical Results

3.1 Data Sources and Data Characteristics

We collect the data series of the price of WTI, Brent and Dubai from EIA, DOE. The observation period is beginning from January 2, 1997 to October 31, 2011. In order to find more detail information, we calculate not only the spread of WTI and Brent but also the spread of WTI and Dubai, and the spread of Dubai and Brent for all the daily, weekly and monthly data. All related data characteristics are listed in Table 1. The weekly, daily and monthly spread of WTI and Brent are listed in the first three columns for easier comparison. Two weekly spread data of WTI and Dubai, and Dubai and Brent are listed in final two columns. The spread trend of all these data series are also drawn in Figure 1, Figure 2 and Figure3. These basic statistics are consistent to our common sense. In order to reveal more information, more empirical tests are implemented as we will discussed in the following sections.

Table 1: Basic Statistics

	Spread				
	WTI minus Brent (weekly)	WTI minus Brent (daily)	WTI minus Brent (monthly)	WTI minus Dubai (weekly)	Dubai minus Brent (weekly)
Mean	0.362	0.352	0.374	2.8461	−2.4822
Median	1.490	1.510	1.520	3.0800	−1.8600
Maximum	10.210	22.18	6.880	17.0900	4.1700
Minimum	−28.330	−29.59	−27.310	−23.8300	−13.2400
Std. Dev.	4.931	5.011	4.819	4.8178	2.4755
Skewness	−3.595	−3.450	−3.710	−1.9768	−0.9093
Kurtosis	17.184	16.557	17.737	10.8381	4.1682
Jarque-Bera	8165.701***	35594.20***	2019.013***	2482.1773***	150.4801***
Obs.	775	3692	178	773	773

† All the data are taken from the EIA website.

3.2 Empirical Results from Unit Root Test

Table 2 lists the empirical results from several Unit Root tests. We find inconsistent results from different tests. All data series of the spread of Dubai and Brent (final column in Table 2) show consistent results (very significant rejection for null hypothesis) for all Unit Root tests. Since the rejection of Unite Root test represents the stationary relationship between Dubai and Brent. The inconsistent outcome coincides to the popular sense in world oil market today. These inconsistent results showing for the comparisons between the spread WTI and Brent, and the spread of WTI and Dubai, indicates the necessity for further analysis.

Table 2: Unit Root Tests

	Spread				
	WTI minus Brent (weekly)	WTI minus Brent (daily)	WTI minus Brent (monthly)	WTI minus Dubai (weekly)	Dubai minus Brent (weekly)
ADF	−1.196	−3.305**	0.623	−2.233	−4.729***
ERS DF-GLS	−1.140	−3.170***	0.617	−2.119**	−4.657***
PP	−1.910	−4.526***	1.135	−3.614***	−8.073***
KPSS	0.864***	1.792***	0.568**	0.638**	0.774***
ERS	5.432	2.191**	11.549	3.146**	0.415***
NP (MZ_a)	−6.496*	−26.048***	3.070	−14.931***	−44.124***
NP (MZ_t)	−1.276	−3.203***	0.652	−2.322**	−4.688***
NP (MSB)	0.197*	0.123**	0.213**	0.156***	0.106***
NP (MPT)	5.376	2.226**	11.103	3.128**	0.581***

† 'ADF' is the Augmented Dickey-Fuller test statistic. 'ERS DF-GLS' is the Elliott-Rothenberg-Stock DF-GLS test statistic. 'PP' is the Phillips-Perron test statistic. 'KPSS' is the Kwiatkowski-Phillips-Schmidt-Shin test statistic. 'ERS' is the Elliott-Rothenberg-Stock Point Optimal test statistic. 'NP' is the Ng-Perron (2001) test statistics.

3.3 Empirical Results from Quantile Unit Root Test

To clarify our complicated issue, in the first stage, we only implement the Quantile Unit Root Test for the weekly spread of WTI and Brent and list the results in Table 3. Comparing to Table 2, Table 3 reveals a lot of interesting information. The insignificant test results in the lower 4 quantiles indicate that the spread of WTI and Brent is non-stationary, while the significant test results in the upper 5 quantiles support that the stationarity of the spread of WTI and Brent. According to our inference in Section 2, we can conclude that the regionalization is found in the lower 4 quantiles, while globalization exists in the upper 5 quantiles. These empirical results coincide with our findings in the world oil market. From Figure 1, we can find that most of the data of lower quantiles comes from recent period where the leadership of WTI is challenged more severely. Recent wider spreads are mainly due to 2 reasons. One is the war of Libya, and the other one is the insufficient outflow infrastructure in mid-west area of US. The former reason results in the supply disruption in the market of Europe and Asia while the latter reason bring glut of oil supply in the mid-west of US. Since the benchmark price of Brent and Dubai are more connected to the market of Europe and Asia, the supply disruption will pull up the oil market price in these two markets, and then push up the price of Brent and Dubai. In the normal cases, the arbitrage trade in the physical oil market and paper market will balance the price difference among WTI, Brent and Dubai. Unfortunately, the shock of Libya is too big to be balanced in the short period of time. Moreover, the unbalance among WTI, Brent and Dubai is enlarged by the huge supply in the mid-west of US.

The most helpful empirical result in Table 3 comes from the QKS index. QKS represents the general perspectives of the mean-reverting behavior of the WTI-Brent spread. Significant rejection result in Table 3 indicates that the overwhelming evidence in favor of the mean-reverting characteristics for the WTI- Brent spread. In a word, the data series of the WTI- Brent spread is stationary. This result helps us to clarify the leadership argument of WTI. Although the benchmark price of WTI in recent period moves deviated from the other two benchmark prices. However, from a fair point of view, WTI and Brent are still co-integrated well in the whole observation period.

Table 3: Quantile Unit Root Tests for Weekly Spread of WTI minus Brent

τ	10%	20%	30%	40%	50%	60%	70%	80%	90%
$\alpha_0(\tau)$	-1.210^{***}	-0.740^{***}	-0.376^{***}	-0.159^{***}	0.022	0.242^{***}	0.376^{***}	0.688^{***}	1.158^{***}
$t_{\alpha_0(\tau)}$	−8.141	−8.562	−7.032	−3.372	0.519	5.352	8.016	8.047	11.029
$\alpha_1(\tau)$	1.083	1.053	1.035	1.009	0.980^{**}	0.946^{***}	0.939^{***}	0.904^{***}	0.872^{***}
$t_{\alpha_1(\tau)}$	4.563	4.415	3.760	1.088	−2.805	−7.463	−7.496	−7.894	−7.765
HL					34.310	12.486	11.013	6.868	4.977
QKS					7.894^{***}				

† 'ADF' is the Augmented Dickey-Fuller test statistic. 'ERS DF-GLS' is the Elliott-Rothenberg-Stock DF-GLS test statistic. 'PP' is the Phillips-Perron test statistic. 'KPSS' is the Kwiatkowski-Phillips-Schmidt-Shin test statistic. 'ERS' is the Elliott-Rothenberg-Stock Point Optimal test statistic. 'NP' is the Ng-Perron (2001) test statistics.

In order to ascertain our findings, we also implement the Quantile Unit Root Test for the daily and monthly spread of WTI and Brent, and list the results in Table 4 and Table 5. Except having more or less insignificant lower quantiles in different data, all results are similar, and all these results deliver same messages: regionalization in the lower quantiles but globalization in the upper quantiles, and overwhelming evidence supporting the globalization of oil market.

Table 4: Quantile Unit Root Tests for Daily and Monthly Spreads of WTI minus Brent

	Daily Spread of WTI minus Brent								
τ	10%	20%	30%	40%	50%	60%	70%	80%	90%
$\alpha_0(\tau)$	-1.113^{***}	-0.609^{***}	-0.328^{***}	-0.135^{***}	0.012	0.164^{***}	0.359^{***}	0.587^{***}	1.037^{***}
$t_{\alpha_0(\tau)}$	−28.567	−20.978	−18.479	−9.051	0.952	12.681	20.650	26.983	28.605
$\alpha_1(\tau)$	1.033	1.017	1.017	1.003	0.994^{*}	0.982^{***}	0.957^{***}	0.952^{***}	0.925^{***}
$t_{\alpha_1(\tau)}$	4.318	3.268	4.834	1.025	−2.205	−6.277	−13.385	−11.153	−11.411
HL					115.178	38.161	15.771	14.091	8.891
QKS					13.385^{***}				
	Monthly Spread of WTI minus Brent								
τ	10%	20%	30%	40%	50%	60%	70%	80%	90%
$\alpha_0(\tau)$	-1.836^{***}	-1.154^{***}	-0.825^{***}	-0.509^{***}	−0.178	0.197	0.589^{***}	1.005^{***}	1.759^{***}
$t_{\alpha_0(\tau)}$	−4.583	−3.959	−3.522	−2.811	−1.042	1.044	2.537	3.515	4.112
$\alpha_1(\tau)$	1.119	1.093	1.093	1.089	1.013	0.897^{***}	0.874^{***}	0.848^{***}	0.639^{***}
$t_{\alpha_1(\tau)}$	1.868	2.760	3.242	3.267	0.455	−3.354	−3.724	−4.169	−7.337
HL						6.377	5.147	4.204	1.548
QKS					7.337^{***}				

† 'ADF' is the Augmented Dickey-Fuller test statistic. 'ERS DF-GLS' is the Elliott-Rothenberg-Stock DF-GLS test statistic. 'PP' is the Phillips-Perron test statistic. 'KPSS' is the Kwiatkowski-Phillips-Schmidt-Shin test statistic. 'ERS' is the Elliott-Rothenberg-Stock Point Optimal test statistic. 'NP' is the Ng-Perron (2001) test statistics.

Table 5: Quantile Unit Root Tests for Weekly Spreads of WTI minus Dubai and Dubai minus Brent

τ	10%	20%	30%	40%	50%	60%	70%	80%	90%
Weekly Spread of WTI minus Dubia									
$\alpha_0(\tau)$	-1.759^{***}	-0.941^{***}	-0.482^{***}	-0.206^{***}	0.014	0.216^{***}	0.585^{***}	0.987^{***}	1.722^{***}
$t_{\alpha_0(\tau)}$	−9.402	−10.686	−6.591	−4.022	0.304	3.482	7.756	11.258	12.266
$\alpha_1(\tau)$	0.987	1.001	0.968^{*}	0.979^{*}	0.966^{***}	0.977	0.945^{***}	0.926^{***}	0.922^{***}
$t_{\alpha_1(\tau)}$	−0.340	0.068	−2.343	−2.035	−3.443	−1.957	−4.053	−4.105	−2.889
HL	52.972		21.312	32.659	20.038	29.789	12.253	9.016	8.535
QKS					4.105^{***}				
Weekly Spread of Dubai minus Brent									
τ	10%	20%	30%	40%	50%	60%	70%	80%	90%
$\alpha_0(\tau)$	-1.476^{***}	-0.867^{***}	-0.493^{***}	-0.242^{***}	0.060^{*}	0.283^{***}	0.560^{***}	0.894^{***}	1.330^{***}
$t_{\alpha_0(\tau)}$	−11.617	−10.155	−8.169	−5.388	1.374	8.297	11.574	14.200	12.589
$\alpha_1(\tau)$	1.072	1.044	1.033	0.991	0.918^{***}	0.872^{***}	0.801^{***}	0.752^{***}	0.693^{***}
$t_{\alpha_1(\tau)}$	1.390	1.486	1.390	−0.407	−3.888	−6.095	−9.247	−10.408	−7.496
HL				76.669	8.101	5.061	3.124	2.432	1.890
QKS					10.408^{***}				

† 'ADF' is the Augmented Dickey-Fuller test statistic. 'ERS DF-GLS' is the Elliott-Rothenberg-Stock DF-GLS test statistic. 'PP' is the Phillips-Perron test statistic. 'KPSS' is the Kwiatkowski-Phillips-Schmidt-Shin test statistic. 'ERS' is the Elliott-Rothenberg-Stock Point Optimal test statistic. 'NP' is the Ng-Perron (2001) test statistics.

4. Conclusion and Remarks

WTI and Brent are two important benchmark prices for oil market. Their long-term co-integrated relationship helps them to be a good location spread in the world oil market (Dempster, et al., 2008). Many sellers and buyers count on these two benchmark prices to judge the market situations and make better decision. The abnormally wider or narrower spread between these two benchmark prices would distort the market information and raise more cost for traders. Recent articles challenge the leadership of WTI. More and more experts believe that WTI has lost its leadership, and the world oil market move to the stage of regionalization. Rather than joint with this argument, these authors use a fair test tool to examine the evolution of world oil market. The Quantile Unit Root test is used and we find regionalization in the lower quantiles but globalization in the upper quantiles, and overwhelming evidence supporting the globalization of oil market. Since WTI has been an important hedge tool in the world oil market. An unfair evaluation for WTI is not only harmful for the US oil market but also hurt all the traders in the world. Our research results find WTI, Brent and Dubai are still generally co-integrated in the whole observation period. In general, the globalization still exists in the world oil market from the co-movement of these three benchmark prices WTI, Brent and Dubai although each of them has been deviated to the regionalization.

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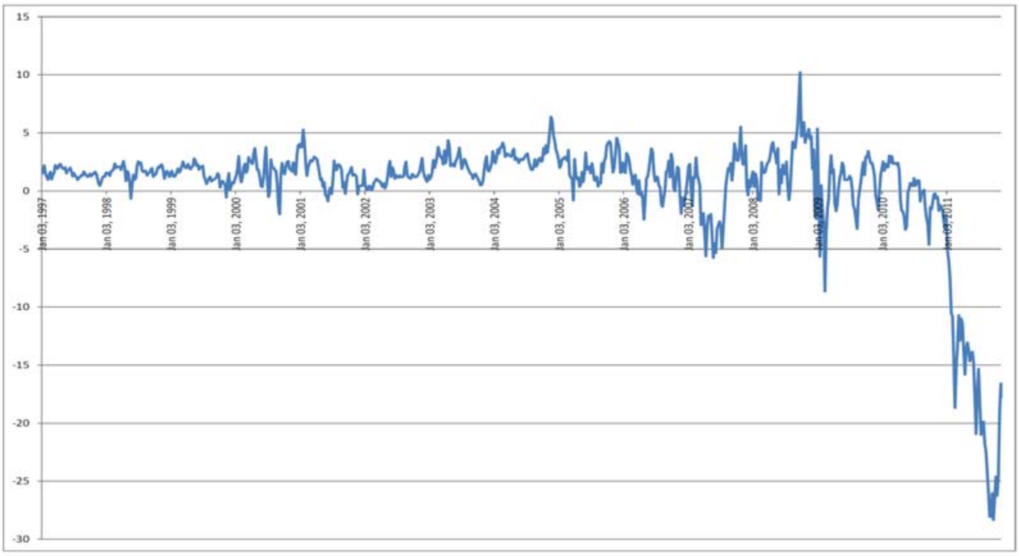

Figure 1: Time series plot of weekly differentials of WTI and Brent oil prices.

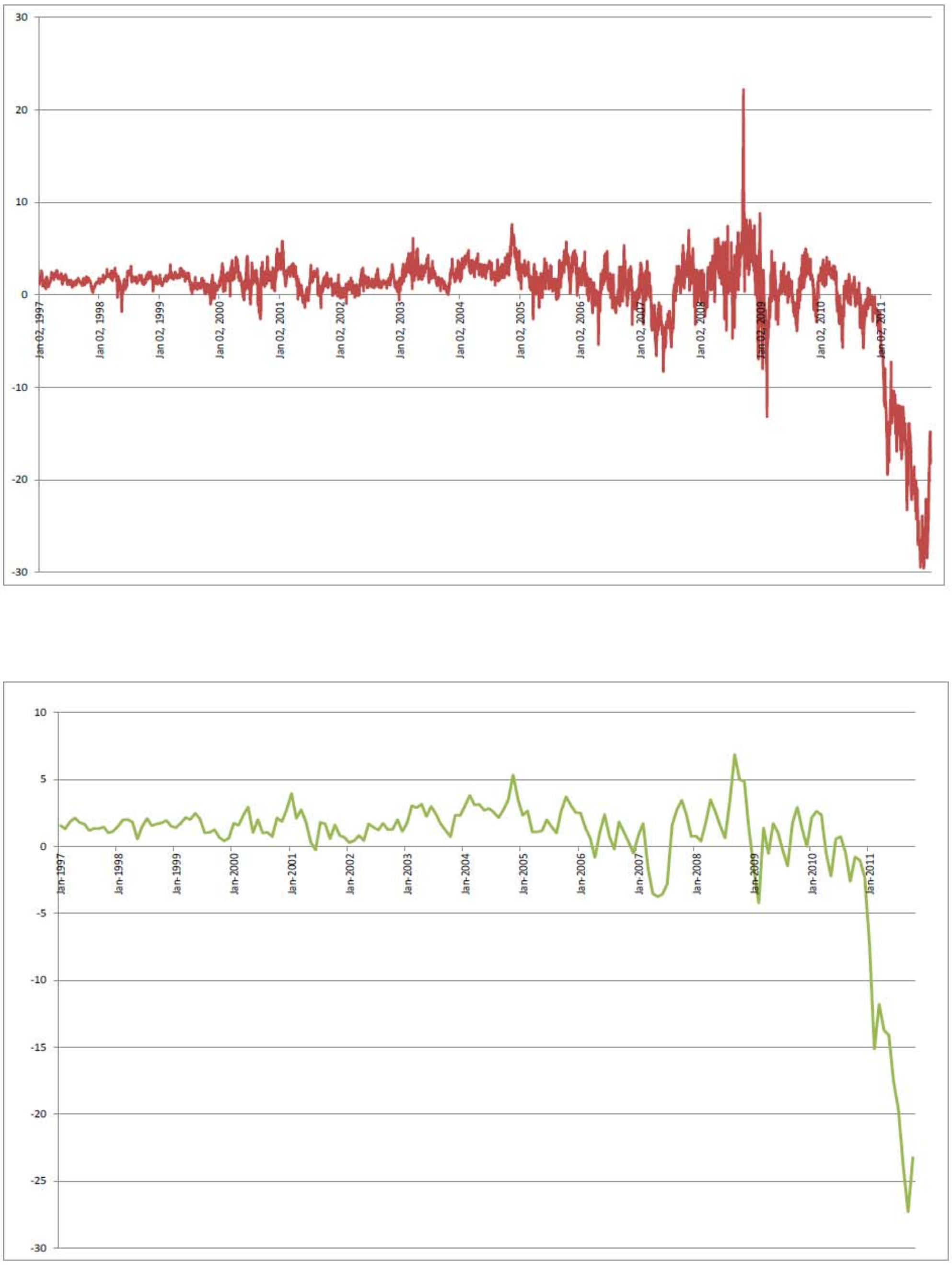

Figure 2: Time series plots of daily (top panel) and monthly (bottom panel) differentials of WTI and Brent oil prices, respectively.

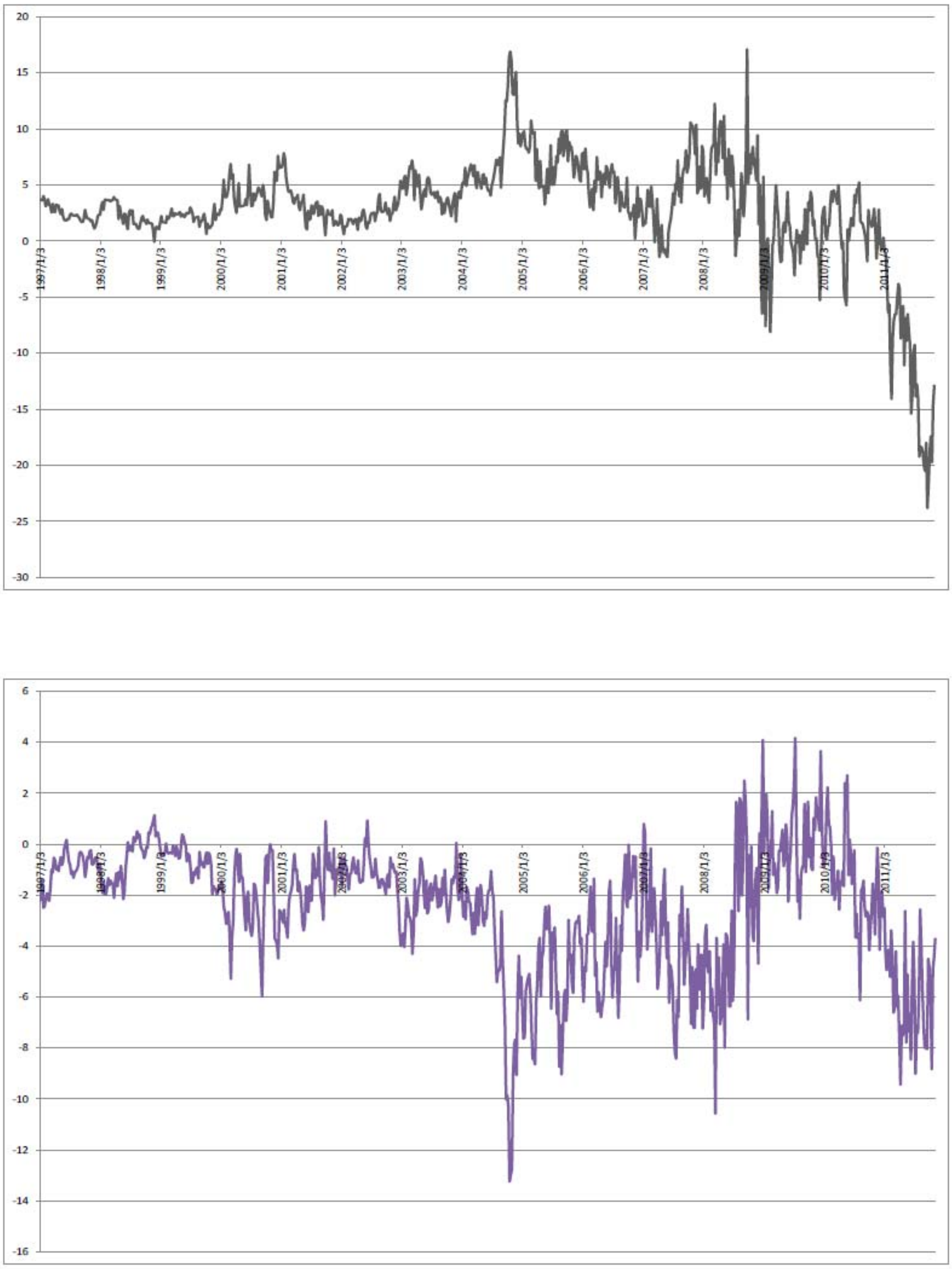

Figure 3: Time series plots of weekly differentials of WTI and Dubai (top panel) and Dubai and Brent (bottom panel) oil prices, respectively.