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Dating Breaks for Global Crude Oil Prices and Their Volatility: A Possible Price Band for Global Crude Prices

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ABSTRACT

This paper applies the structural change testing method of Bai and Perron (1998, 2003) to the problem of locating and identifying significant changes in the global oil market. We use this method to investigate daily WTI spot prices from January 2, 1986 to December 30, 2004 as collected by the DOE. Our empirical results indicate that a significant structural change took place on November 12, 1999. The average WTI price was U$19.02 per barrel before the structural change and U$30.90 per barrel after the change. This higher price may well reveal clues for revising the current price band as claimed by OPEC. Moreover, the issue of volatility is also examined by following the same method. We find two structural breaks for the price volatility, and price is rather stable in the middle period. This interesting result is valuable in evaluating the current argument regarding the more volatile world crude oil prices.

JEL classification: Q41

Keywords: Crude oil price; WTI; Structural change; Volatility

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1. INTRODUCTION

The WTI (West Texas Intermediate) spot prices have hit record highs over and over again recently, even jumping to U$73.73 per barrel on April 21, 2006.[1] These record prices have hurt not only the economies of oil-importing countries, but also the future benefits of the major oil exporters. The oil exporters fully recognize that these peaks motivate and accelerate the development of oil-substituting technology, which may counter the long-term demand for their exports.

Although blame for these price peaks is easily placed on such traditional factors as the rapid demand growth from China and India, as well as tight production capacity, political risks, and the depreciation of the US dollar, some experts have begun to doubt the adequacy of these explanations. Stevens (2001) contended that "micro-managing oil markets is becoming more difficult as the information deteriorates and the drivers of oil prices become unpredictable and at times, irrational (p212)." By analyzing the oil price figures in different periods from 1859 to 2002, Lynch (2002) pointed out that a decrease in physical transparency has occurred in the global oil market due to the larger market share of third-world countries that are less acquainted with oil market practices. These critics both argue that the path of oil prices is currently very different from what it was in the past, and that this may imply the existence of some structural changes. The empirical warrant for these arguments can be established by using econometric methods to examine the data to determine whether there were any structural changes in the oil market.

There is an abundance of literature covering the topic of structural change. The famous Chow test (Chow, 1960) and Quandt's statistic (Quandt, 1960) have been used for many years although objections to both of these methods have been raised due to the difficulty in deciding the pre-determined structural turning point (Christiano, 1992; Zivot and Andrews, 1992; Banerjee, Lumsdaine, and Stock, 1992; Perron and Vogelsang, 1992). In the last decade, Quandt's statistic has become more popular since Andrews (1993) and Andrews and Ploberger (1994) found a proper critical value to replace the chi-square critical value, and, of course, there is also the p value calculated by Hansen (1997). However, all of these methods can find and also label only a single turning point, and they are obviously not suitable for cases involving multiple turning points.

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[1]It should be noted that we did not include the data for this date since our empirical dataset ended on December 30, 2004.

Bai and Perron (1998) constructed a new method to find and test the significant structural change for multiple turning points. This method has been applied to date structural breaks in many areas (Caporale and Grier, 2000; Hegwood and Papell, 2002; Rodriguez and Samy, 2003; Rapach and Wohar, 2005). Hansen (2001) claimed a significant role for this method, and Bai and Perron (2003) upgraded the required calculation skills while shortening the calculation time. We use the BP method to represent those contents addressed by Bai and Perron (1998, 2003). More recent papers apply similar methods to find multiple breaks in different time paths (Perron and Qu, 2005; 2006; Huang and Cheng, 2005).

In our empirical work, we use statistical methods developed by Bai and Perron to estimate both the number and location of structural breaks in global oil price series and their volatility. In the 1986-2004 WTI oil price sample, we find one significant structural break in global oil prices, and two breaks in relation to their volatility. After dating the breaks of the oil prices and their volatility, we draw from these interesting policy implications in order to build a world crude price band that is a concern of the oil market.

The remainder of this paper is organized as follows. Section 2 presents the general model developed by Bai and Perron. Section 3 describes specific data types and their characteristics. In Section 4, the breaks for oil prices and their volatility are respectively found. Section 5 concludes.

2. METHODOLOGY

Contrary to relying on the researchers' own background to guarantee objectivity, it is better to base our judgments upon a sound method such as that built up by the BP model to date the structural breaks strictly on the basis of a statistical inference method. To examine the existence of a structural change, traditional models first choose a break based on personal judgment and then test its significance. This approach has, however, been criticized for being less flexible in the current dramatically changing world with its greater fluctuations. Obviously, it is easy to identify a break for a smooth path where there is a jump, but it is difficult to verify the break in a path characterized by many fluctuations. The BP model, however, uses statistical inference to date a break by taking advantage of the computer's superior processing ability. Modern computing power allows for the rapid calculation of thousands of values of the Sum of Squared Residuals (SSE) for different assumptions, in order to find the minimum SSE. Each SSE is calculated by summing up all the squared residuals in all regimes (e.g., there are 6 regimes for a data series with 5 turning breaks). This involves assuming the breaks for a structural change type where each residual represents the difference between an observed data series and its corresponding mean in a regime. It is clear that the SSE will be minimized if we date the exact structural change breaks for a data series. This concept implies that the turning breaks are selected by repeatedly checking all possible points according to the relevant significance level of some statistical test. We illustrate this concept in Section 2.1 and the corresponding three tests in Section 2.2.

2.1 Model

The BP method (Bai and Perron, 1998; 2003) can be described by the equation below:

$$y_t = x_t'\beta + z_t'\phi_j + \varepsilon_t \qquad t = T_{j-1}+1,\ldots,T_j,$$

$$j = 1,\ldots,m+1,$$

$$T_0 = 0, \quad T_{m+1} = T, \tag{1}$$

where,

y_t : the dependent variable at time t,

x_t : a ($p \times 1$) vector,

z_t : a ($q \times 1$) vector,

β and ϕ_j are the corresponding vectors of coefficients,

ε_t is the disturbance,

T_j could be the beginning, the turning, or the end points of the whole observed period,

m is the number of structural changes,

j represents regime j; a regime is a set of data between two turning points,

T is the sample size.

The elements in vector x_t represent those factors unaffected by structural change over time, while the elements in vector z_t are those factors affected by structural change. When p equals zero (i.e. no x_t), we obtain a pure structural change model where all the coefficients are subject to structural change.

The method of estimation considered is that based on the least squares principle. For each m regimes $(T_1,\ldots,T_m)$, the associated least squares estimates of β and ϕ_j are obtained by minimizing the sum of squared residuals as below:

$$\sum_{j=1}^{m+1}\sum_{t=T_{j-1}+1}^{T_j}[y_t - x_t'\beta - z_t'\phi_j]^2 . \tag{2}$$

Let $\hat{\beta}(\{T_j\})$ and $\hat{\phi}(\{T_j\})$ represent the estimates based on the given m regimes $(T_1,\ldots,T_m)$ denoted $\{T_j\}$. Substituting these in the objective function and the resulting sum of squared residuals is denoted as $S_T(T_1,\ldots,T_m)$, we can estimate the break points $(\hat{T}_1,\ldots,\hat{T}_m)$ by following the suggestion by Bai and Perron (1998, 2003). Then the regression parameter estimates are the estimates associated with the m regimes $\{\hat{T}_j\}$, i.e. $\hat{\beta} = \hat{\beta}(\{\hat{T}_j\})$, $\hat{\phi} = \hat{\phi}(\{\hat{T}_j\})$.

2.2 Test statistics for multiple structural changes

The BP method addresses three test statistics, the $SupF$ test, the Double maximum test and the Sequential test to determine the significant multiple structural changes. We briefly discuss these tests as follows.

2.2.1 *SupF* test

In a way similar to the F test, Bai and Perron (1998, 2003) used the *SupF* test to consider the problem of asymmetry. The null hypothesis of the *SupF* test is defined as no turning point (i.e. m=0, no structural change), and the alternative hypothesis is defined as k turning points (i.e. m=k, m structural changes). Letting $(T_1,\ldots,T_m)$ represent the divided intervals, and $\lambda_j = T_j / T$, $j = 1, 2,\ldots, m$, then $T_j = [T\lambda_j](j = 1,\ldots,k)$, and thus we can define,

$$F_T(\lambda_1, \lambda_2, \ldots, \lambda_k; q) = \frac{1}{T}\left(\frac{T-(k+1)q-p}{kq}\right)\hat{\phi}' R'(R\hat{V}(\hat{\phi})R')^{-1} R\hat{\phi}, \quad (3)$$

where R is the conventional matrix such that $(R\phi)' = (\phi_1' - \phi_2', \ldots, \phi_k' - \phi_{k+1}')$. $\hat{V}(\hat{\phi})$ is an estimate of the variance covariance matrix of $\hat{\phi}$ that is robust to heteroskedasticity and serial correlation. Finally Bai and Perron defined the *SupF* type test statistic as shown below (p.12, Bai and Perron, 1998):

$$SupF_T(k; q) = F_T(\hat{\lambda}_1, \hat{\lambda}_2, \ldots, \hat{\lambda}_k; q), \quad (4)$$

where $(\hat{\lambda}_1, \hat{\lambda}_2, \ldots, \hat{\lambda}_k)$ minimizes the global sum of squared residuals under the specified trimming.

2.2.2 Double maximum test

Bai and Perron (1998, 2003) propose two tests of the null hypothesis of no structural break against an unknown number of breaks given some upper bound M. They call these the double maximum tests. The $UD\max$ and $WD\max$ are defined as

$$UD\max F_T(M, q) = \max_{1 \le m \le M} F_T(\hat{\lambda}_1, \hat{\lambda}_2, \ldots, \hat{\lambda}_k; q), \quad (5)$$

$$WD\max F_T(M,q) = \max_{1\le m\le M} \frac{c(q,\alpha,1)}{c(q,\alpha,m)} F_T(\hat{\lambda}_1,\hat{\lambda}_2,\ldots,\hat{\lambda}_k;q). \tag{6}$$

The difference between $UD\max$ and $WD\max$ is the weights, where $UD\max$'s weight is unity, and $WD\max$'s weight setting $c(q,\alpha,m)$ denotes the asymptotic critical value of the test $F_T(\hat{\lambda}_1,\hat{\lambda}_2,\ldots,\hat{\lambda}_k;q)$ for a significance level α. The weights are then defined as $a_1 = 1$ and for m>1 as $a_m = c(q,\alpha,1)/c(q,\alpha,m)$. In other words, when the obvious candidate is to set all weights equal to unity, we label this version of the test as the $UD\max$ test. Furthermore, if we consider a set of weights such that the marginal p-values are equal across values of m, we label this test the $WD\max$ test.

2.2.3 Sequential tests

The sequential test $SupF_T(\ell+1\mid\ell)$ is the third test, which is more important than the previous two tests. Bai and Perron (1998, 2003) present a test for ℓ versus $\ell+1$ breaks, labeled $SupF_T(\ell+1\mid\ell)$. Basically, it amounts to the application of $\ell+1$ tests of the null hypothesis of ℓ structural breaks against the alternative hypothesis of $\ell+1$ breaks. If the $SupF_T(\ell+1\mid\ell)$ statistical test is significant, then there are at least $\ell+1$ structural turning points. In our results, we present the estimates based on the sequential method, in order to determine the parameters of the model and the break points.

Bai and Perron (2003) recognized that all of the above tests have their advantages and disadvantages, and they suggested the best way of combining these three tests. First of all, an investigation of the existence of structural change requires that one first check whether the $SupF$ test and the Double max test are significant or not. Next, it is essential to use a sequential test to determine the numbers related to structural change. This suggestion helps us date the right structural breaks much more easily.

3. DATA AND DATA CHARACTERISTICS

There are numerous indicators of crude oil prices. We chose WTI (West Texas Intermediate) crude oil spot prices as our sample data since the WTI is the most famous and widely used benchmark price and forms the basis of many crude oil price formulae (Liao and Yu, 2000). Thus, the WTI is more representative of global oil prices than any other type of crude oil. Moreover, in comparison with many other prices, WTI data can be easily acquired from the websites of the U.S. DOE (Department of Energy) without charge. Finally, the closely associated derivative products (i.e. the WTI futures prices) are also a likely target of research on related issues that we anticipate looking into in the near future.

With these advantages in mind, we proceeded to collect 4,799 WTI spot price data samples from the EIA (Energy Information Administration) of the DOE, beginning on January 2, 1986 and ending on December 30, 2004. The sample characteristics are summarized in Table 1. Over this 19-year period, the mean of the WTI spot prices is U$22.19 per barrel with a maximum of U$56.37 per barrel and a minimum of U$10.25 per barrel. The mean of the volatility of WTI spot prices is 0.1048, with a maximum of 0.4613 and a minimum of 0.0359. The other statistics also help us to envision an accurate picture of the changes in global crude oil prices during this period. It should be noted that volatility is calculated as the monthly standard errors multiplied by $\sqrt{n}$ (n is the sample size for a month), which is illustrated in Section 4.2. Thus, we acquired only 228 samples of data for volatility.

Table 1: WTI Spot Prices

	P	Volatility
Mean	22.19	0.1048
Std. Dev.	7.08	0.0554
Maximum	56.37	0.4613
Minimum	10.25	0.0359
Skewness	1.43	2.2753
Kurtosis	5.56	11.6772

Note:

P refers to the WTI spot price. Volatility is calculated as the standard errors multiplied by $\sqrt{n}$.

Sources: EIA,DOE

4. DATING STRUCTURAL BREAKS FOR THE GLOBAL OIL PRICE AND ITS VOLATILITY

We applied the method illustrated in Section 2 and used the 4,799 daily WTI data samples and 228 standard error samples to date the breaks for the WTI price and its volatility, respectively.

4.1 Dating the breaks for WTI prices

To implement the above regression analysis for oil prices, we need to check the relationships among the variables in more detail. In a way similar to the paper by Rapach and Wohar (2005), we are unable to find suitable breaks after we mix our price variable with more of the other variables due to the inconsistent trend. When considering the world oil market, the independent variables (e.g., world demand and world supply) apparently move very inconsistently in relation to the world oil price. Therefore, Eq. (7) below is more suitable when it comes to analyzing the issue of oil price structural changes.

$$p_t = \phi_j + u_t \quad \mathrm{t} = T_{j-1} + 1, \ldots, T_j, \tag{7}$$

for $j = 1, \ldots, m+1$, where p_t is the spot price of West Texas Intermediate crude oil in period t, u_t is the error term and coefficient ϕ_j can be regarded as the average spot price, i.e. $\phi_j\,(j = 1, \ldots, m+1)$ is the mean spot price in the j th regime. The $m+1$ regimes will be found for our observed oil price if there are m turning points.

By applying the least squares method of our model setting based on Eq. (7), the global sum of squared residuals is calculated by partitioning the oil price series into m regimes ($T_1, \ldots, T_m$) as below:

$$SSE_T(T_1, \ldots, T_m) = \sum_{j=1}^{m+1} \sum_{t=T_{j-1}+1}^{T_j} (p_t - \phi_j)^2 . \tag{8}$$

The regression coefficients are estimated after we find the best model since global SSE will be minimized in case of a correct structural change. The complete description of this model is articulated in Bai and Perron (1998, 2003).

It should be noted that the model in Eq. (7) is different from the traditional ANOVA analysis or t test, although it is simplified to a simple location scale model. This is because we focus on dating the breaks of a series of data, since we need to find a minimal SSE value by considering all possible combinations of every kind of partition for a data series. Therefore we use the $SupF$ test instead of the F test used in the traditional ANOVA analysis, which emphasizes the test for the significant differences between two groups or among more than two groups. Therefore, our testing method will be much more complicated than the traditional ANOVA analysis as illustrated in Section 2.

Table 2: Test for Structural Breaks

$SupF$ test		$SupF_T(\ell+1 \mid \ell)$ test	
$SupF$ (1)	10.68**	$\ell = 1$	5.21
$SupF$ (2)	9.30**	$\ell = 2$	2.76
$SupF$ (3)	7.75**	$\ell = 3$	0.29
$SupF$ (4)	9.17***	$\ell = 4$	0.06
$SupF$ (5)	7.54***		
UD max test	10.68***		
WD max test	18.88***		

Note:

1. The maximum number of breaks, M, is set to be 5 and the trimming percentage is chosen to be 15% of the sample size.
2. ***, ** represent the 1% and 5% levels of significance, respectively.

The results reported in Table 2 are estimated using three tests that are addressed by Bai and Perron (1998, 2003) to find significant structural changes for WTI prices. To implement the $SupF$ test, the investigator needs to pre-specify a particular number of breaks in order to make a statistical inference. Thus we follow the quantitative recipe suggested in the BP method and assume there are at most five turning points in our first testing regime. This means $SupF$ (m), m =1, 2, 3, 4, and 5. The outcomes in Table 2 show that all of the $SupF$ and Double max tests are highly significant, and we can thus definitely find at least one significant structural break in our data series.

In order to grasp the number of structural breaks, we need to implement sequential tests. The right-hand side of Table 2 shows that $SupF_T(2\,|\,1)$=5.21, which is much smaller than the 5% critical value 10.13 and the 10% critical value 8.51. This insignificant result fails to supply evidence to support a claim regarding the existence of a second structural break. We can thus conclude that there is only one significant structural change in the period from January 1986 to December 2004. Based on these results, we locate the date of the break as November 12, 1999, as shown in Table 3. The 90% confidence interval ranges from January 18, 1996 to February 29, 2000.

Table 3: Estimation Results of the Structural Change Model

Regime	Parameter	Estimate
First	ϕ_1	19.0236*** (0.0802)
[Break 1]		1999/11/12 [1996/01/18 2000/02/29]
Second	ϕ_2	30.8965*** (0.1328)

Note:

1. The end date of the regime and the 90% confidence interval (in the square brackets) of [Break1] can be estimated based on the sequential test.
2. *** represents significance at the 1% level. The standard deviations of the estimates are in parentheses.

Table 3 also provides the average prices in both of the periods separated by the structural break. The average oil price was U$19.02 per barrel prior to the structural change and U$30.90 afterwards. This result can be verified by an examination of the price trend in Figure 1 and also supports the recent contention in reports from Argus that state: "Crude prices have nearly doubled since the nineties. In the 10 years before the Asian financial crash of 1998, WTI averaged just under $20/bl. But the average rose to over $28/bl in 2000-03 and it reached $35/bl in the first quarter of this year."[2] Lynch (2001) argued that U.S. wellhead oil prices have undergone a structural change. He found this price was about U$15.50/barrel in the period 1900-70, in significant contrast to that of U$23/barrel in the subsequent period of 1970-2000.

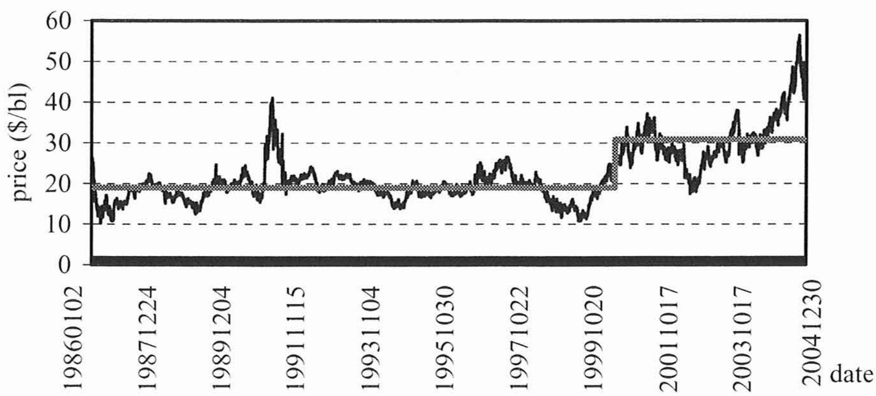

Figure 1: WTI spot prices and means in different periods.

4.2 Dating the breaks for WTI price volatility

This section uses the same method to investigate the problem of price volatility. The most popular way of measuring price volatility is to examine the variance for different data series. Here, we measure volatility following the suggestion of Schwert (1990). It is calculated by multiplying the monthly price standard errors by $\sqrt{n}$ (where n is the sample size for a month). Thus we derive only 228 sample data (standard errors) to implement our analysis of price volatility. Based on Bai and Perron's model, Eq. (7) can be rewritten as Eq. (9) below:

[2] Weekly Petroleum Argus, Global Markets, Volume XXXIV, 14, 5 April 2004, P.1.

$$PV_t = \theta_j + e_t \qquad t = T_{j-1} + 1, \ldots, T_j, \tag{9}$$

where PV_t : volatility for WTI spot prices,

θ_j : average volatility of WTI, $j = 1, \ldots, m+1$,

e_t : error terms.

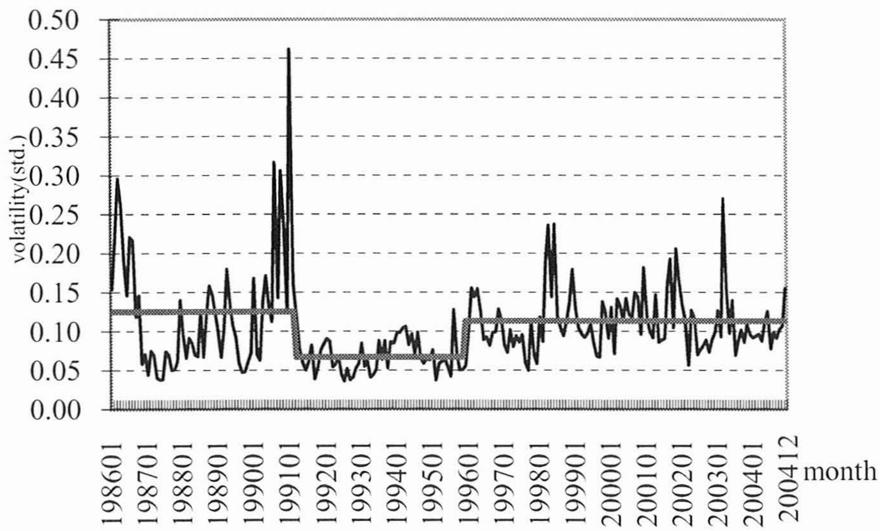

Figure 2: The volatility of WTI spot prices.

The empirical results shown in Table 4 indicate that both the $SupF$ test and Double max test are significant, which implies that there is at least one significant structural change for price volatility.[3] In addition, the insignificant $SupF_T(3\,|\,2)$ and 1% significant $SupF_T(2\,|\,1)$ strongly suggest a reading in

[3] It is possible to find an insignificant Sup F(1) but significant Sup F(2), Sup F(3), Sup F(4), Sup F(5) and Double max tests due to the shortage of Sup F tests. Bai and Perron (2003) suggest that there is at least one structural break in this situation.

which there are two significant structural breaks for oil price volatility. Figure 2 reveals this phenomenon, and Table 5 provides us with more information. We can date the two breaks as March 1991 and December 1995, and the 90% confidence interval is found to range from January 1991 to December 1992 for the first break, and from November 1994 to March 1996 for the second break. Dividing by these two breaks, the volatility measurements in the three regimes are 0.1248, 0.067, and 0.113, respectively. These three digits indicate that prices were more volatile in the first and third regimes, but more stable in the second regime. Such an outcome may well have some bearing on the merit and scope of the recent arguments regarding the relative steepness of the path of oil prices. The consistency of our results depends upon the accuracy of our dating of the structural breaks. Obviously, no significant price volatility would be found if we did not date our break for our observed period.

Table 4: Tests of WTI Spot Price Volatility for Structural Breaks

SupF test		$SupF_T(\ell+1 \mid \ell)$ test	
SupF (1)	3.01	$\ell = 1$	50.64***
SupF (2)	28.82***	$\ell = 2$	1.58
SupF (3)	19.51***	$\ell = 3$	0.51
SupF (4)	15.40***	$\ell = 4$	0.00
SupF (5)	11.10***		
UD max test	28.82***		
WD max test	37.84***		

Note:

1. The maximum number of breaks, M, is set to be 5 and the trimming percentage is chosen to be 15% of the sample size.
2. ***, ** represent the 1% and 5% levels of significance, respectively.

Table 5: Estimation Results of the Structural Change Model

Regime	Parameter	Estimate
First	θ_1	0.1248*** (0.0064)
[Break 1]		1991/03 [1991/01 1992/12]
Second	θ_2	0.0670*** (0.0067)
[Break 2]		1995/12 [1994/11 1996/03]
Third	θ_3	0.1130*** (0.0049)

Note:

1. The end dates of the regimes and the confidence intervals (in the square brackets) of [Break 1] and [Break 2] can be estimated based on the sequential test.
2. *** represents significance at the 1% level. The standard deviations of the estimates are in parentheses.

4.3 Policy implications

The empirical results in the preceding section not only indicate the existence of a significant structural change in global oil prices, but also shed some light in understanding the global price level in recent years. There are many arguments regarding the price band ranging from U$22 to U$28 per barrel announced at the March 2000 OPEC meeting. In order to control market prices, OPEC would increase production if prices were to rise above U$28 for more than 20 days and would decrease production if they were to fall below U$22 for more than 10 days. However, OPEC only applied this mechanism once in October 2001 and never used it again.[4]

There is some consensus that the range U$22-$28 involves a price premium of between U$3 and U$9 (as U$22 equals U$19+U$3 and U$28 equals U$19+U$9) due to OPEC's monopoly power.[5] On this assumption it is not unreasonable, based on our calculation, to see the context in which OPEC

[4] More detailed information can be found from the website of the EIA, DOE.

[5] $22-$28 is the price of the OPEC package, which is always below WTI due to the inferior quality. Thus we use the expected OPEC package as a replacement for the OPEC package by assuming that a premium can be pursued based on the successful intervention of OPEC.

can set its new price band ranging from U$34 (equals U$31+U$3) to U$40 (equals U$31+U$9), nor is it unreasonable to infer that, because March 2000 was very close to our calculated break for the structural change in oil prices (November 12, 1999), the current price band was most likely determined by the average oil price before the structural change took place. If we accept this generalization regarding the earlier price band, then a new price band based on the average price after the structural change should also be applicable.

Moreover, the well-known fact that global oil prices became more volatile after 1995 might suggest to some researchers that we should expand the width of our tolerable price range. For example, the price band in the above subsection may be extended from U$34-U$40 per barrel to a larger band such as U$32-U$42 per barrel. Although our calculated volatility in the third regime (December 1995 to December 2004) is almost twice the volatility in the second regime (March 1991 to December 1995), it is hard for us to conclude that the price band should be so extended (nearly doubled), since we are not able to find a reasonable relationship between our calculations of volatility and the range of the price band.

5. CONCLUSIONS AND FURTHER RESEARCH AREAS

Global oil prices remain one of the most visible of all historical commodity records, yet while more and more people believe we have entered a new era with much higher price levels, no one has been able to tell precisely and with much confidence the exact structural break in the global oil market. Our paper has applied the multiple structural change method of Bai and Perron to the problem, and has successfully located and dated the breaks for both the price of oil as well as its volatility. We have found that the break for the structural change in oil prices occurred on November 12, 1999, where the average oil price was U$19.02 per barrel previously and U$30.90 afterwards. We have also found two breaks for oil price volatility, one in March 1991 and one in December 1995. By dividing by these two breaks, the volatility can be measured in the three regimes as 0.1248, 0.067, and 0.113, respectively. Our reading of this set of mutually-connected research findings is that they offer a rich universe of clues to calculate a more realistic and thus more useful price band. We suggest that a probable price band could be U$34-U$40 or U$32-U$42, compared to the current U$22-U$28.

Although our results constitute a valuable contribution to the argument regarding the oil price band, an insufficient amount of data in the more recent period means that other factors may not yet be visible, which could lead to less satisfactory results. Since oil prices increased more rapidly during the second half of 2004 and 2005, it is possible that another structural break could be found during this period, but any significant statistical value must be verified as more evidence becomes available (sample data). At present, it is hard for us to find another significant break due to the shortage of data during the period characterized by a rapid price upswing. In view of this, we are making every effort to collect more data.

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