DEVELOPMENT OF THE CRUDE OIL PRICES AND THE STOCK MARKET

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Abstract:

In this paper we analyze the development of the Crude Oil Prices and the Stock Market since the decade of the 70´s. We identify the cycles and the upward and downward phases of these series and analyze a number of their features: the period or length of cycle, the duration of the upward and downward phases, the relative position of the high, the percentage of return during periods of upward and downward phases and the percentage of retracement of movement from low to high. We also analyze the degree of correlation between the Oil Prices and the Stock Market. We will find if the crude oil prices will explain what "drives" the stock market.

Time series theory is of interest primarily for this analysis because they help identify market cycles and turning points in those market cycles. In this work we extract the trend and the cycle with the Hodrick Prescott (HP) Filter.

The paper is organized as follows. Section 1 is an introduction. Section 2 uses the Hodrick-Prescott Filter to find the lows or turning points of the cycles. Section 3 develops a battery of measures of the behaviour of crude oil prices during the cycles and shows the results of applying these techniques to the cycles of the crude oil prices. Also, offers some comments on the similarities or differences of these phases with those of stock market. Section 4 concludes.

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1. Introduction

Crude oil prices behave much as any other commodity with wide price swings in times of shortage or oversupply. The notion that "higher energy prices are bad for the stock market" is very used in the financial markets but the evidence beyond a reasonable doubt. Figure 1 shows monthly prices of the S&P 500 stock index and Crude Oil over the past 27 years. If we study the respective price trends we observe that at times they appear to move inversely, such as when oil spiked up to 39.99 in 2003 as the S&P was near a low. In other long periods, they appear to move in union, such as the time leading to crude's $37.80 peak in 2000, when the S&P was also near a top. So there's no apparent relationship visually. In the inner window of the same figure we identify a statistical correlation in the S&P 500 and crude oil in 12-month segments. A true correlation would show up as a relatively flat line in either the upper (positive) or lower (negative) range of the correlation panel. Instead we see erratic, random swings, which is what it should see if there is no correlation whatsoever.
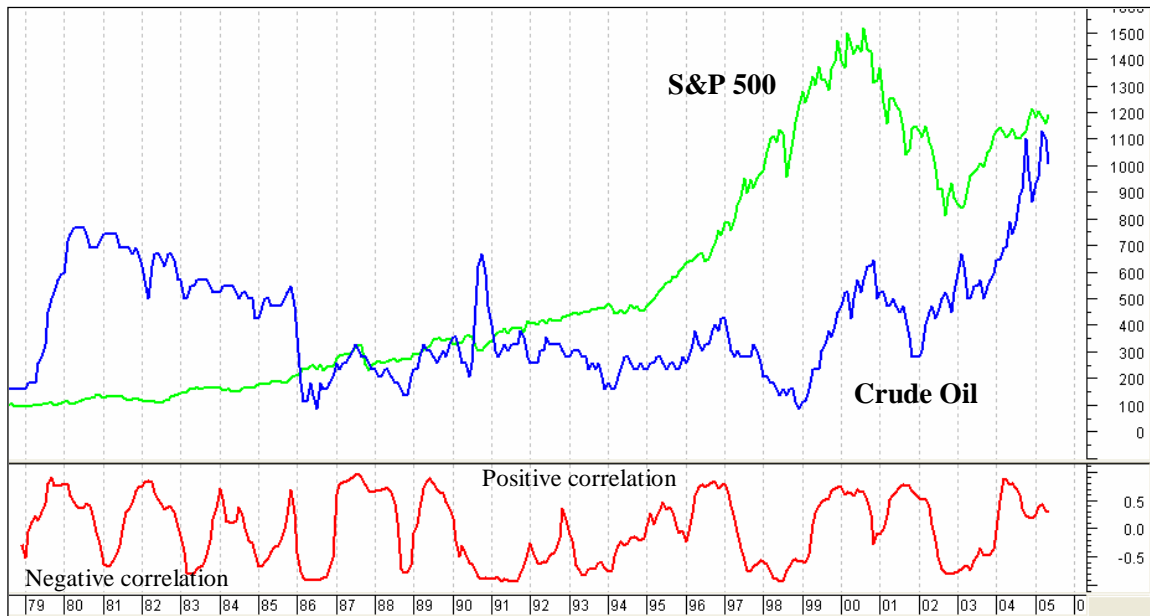
Figure 1

In this paper we want analyze the development, trend and the cycles of the Crude Oil Prices and the Stock Market since the decade of the 70´s to study the possible relationship. A viewing of the graphs suggests the presence of a cycle in the series. In the financial series, we consider a classic cycle exists when the price starts low (point A), rises smoothly to a high (point B) over a length of time, and then smoothly falls back to the another low (point C) over the same length of time. See Figure 2.

Market Cycle
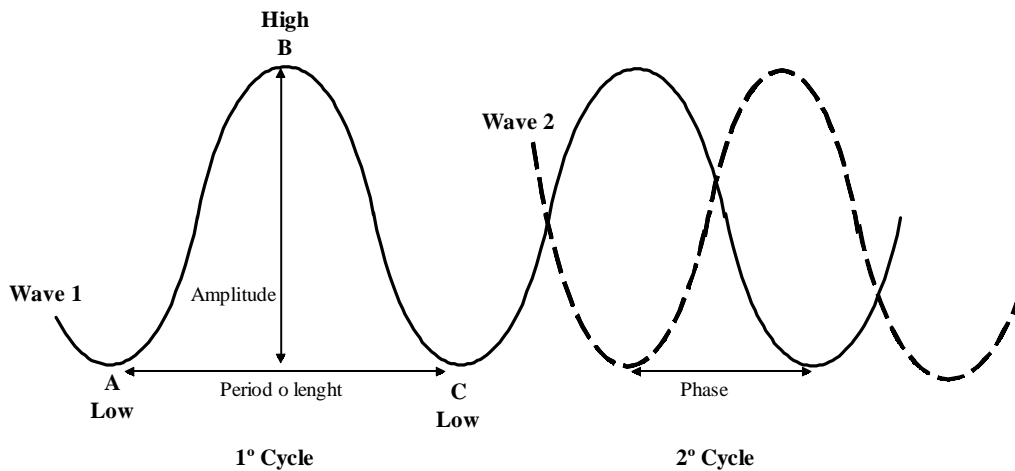
Figure 2

The three qualities of a cycle are period, amplitude and phase. The period of the cycle or the cycle length is the time required to complete the cycle or the time between lows. Amplitude is the range of the cycle from low (troughs) to high (crests) measured in whatever units the cycle is in. Phasing allows the cycle lengths and is a measure of the time location of a wave trough. Once the amplitude, period, and phase of a cycle are known, the cycle can theoretically be extrapolated into the future. Assuming the cycle remains fairly constant, it can then be used to estimate future peaks and troughs.

Time series theory is of interest primarily for market analysis because they help identify cycles and turning points in those market cycles. Every time series can be separated or decomposed in four types of components: Seasonality, Trend, Cycling and Irregularity. The first three components are deterministic which are called "Signals", while the last component is a random variable, which is called "Noise".

Short definitions of the major components:

Seasonal variation (S): Seasonalities are regular fluctuations which are repeated from year to year with about the same timing and level of intensity. When a repetitive pattern is observed over some time horizon, the series is said to have seasonal behavior.

Trend (T): Trend is growth or decay that is the tendencies for data to increase or decrease fairly steadily over time. A time series may be stationary or exhibit trend over time. Long-term trend is typically modeled as a linear, quadratic or exponential function.

Cyclical variation (C): Cyclic oscillations are general up-and-down data changes; due to changes e.g., in the overall economic environment (not caused by seasonal effects) such as recession-and-expansion.

Irregularities (I): Are any fluctuations not classified as one of the above. This component of the time series is unexplainable; therefore it is unpredictable. Estimation of I can be expected only when its variance is not too large. Otherwise, it is not possible to decompose the series. If the magnitude of variation is large, the projection for the future values will be inaccurate.

Mathematically and additively a time series, can be expressed as:

$$Y_t = S_t + T_t + C_t + I$$

When we want study a temporal series in the long time, because we are interested in long term cycles, the first and the last components do not have importance and we can express the series like the sum of the trend and the cycle. Smoothing data removes random variation and shows trends and cyclic components. We can extract the trend and the cycle with different techniques like Hodrick Prescott (HP) Filter, the moving averages and the spectral analysis. In this work we are going to use only the Hodrick Prescott (HP) Filter.

It is desirable to have certain characteristics in data before it is analyzed for cycles. One of these is that the fluctuations are of similarly meaningful amplitude of the time period. When series with a lot of years is constructed we find that, partly due to inflation, the series has grown in a compound manner. For data of this type taking logarithms before looking for cycles is highly desirable. Like the cycle in a series Y_t can be expressed in terms of its turning points, which are local maxima and minima in its sample path. So we work with $y_t = \ln(Y_t)$ rather than Y_t. Turning point in Y_t and y_t are identical so that the transformation loses no information.

2. Hodrick-Prescott Filter

The Hodrick-Prescott filter or H-P filter is a smoothing mechanism used to obtain a long term trend component in a time series. It is a way to decompose a given series into stationary and non-stationary components in such a way that their sum of squares of the series from the non-stationary component is minimum with a penalty on changes to the derivatives of the non-stationary component.

Let's suppose that the original series is composed of a trend component (t_t) and a cyclical component (c_t).

That is,

$$y_t = t_t + c_t \ , \ t = 1,\ldots,N$$

Hodrick and Prescott (1997) suggest a way to isolate c_t from y_t solving this equation:

$$\min_{\{t_t\}_{t=0,\ldots N+1}} \left\{ \sum_{t=1}^{N}(y_t - t_t)^2 + \lambda \sum_{t=2}^{N-1}[(t_{t+1} - t_t) - (t_t - t_{t-1})]^2 \right\}$$

where λ is the penalty parameter. The first term in the loss function, penalizes the variance of c_t, while the second term puts a prescribed penalty to the lack of

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smoothness in t_t. Put it differently, the HP filter identifies the cyclical component c_t from y_t by the trade-off to the extent to which the trend component keeps track of the original series y_t (good fit) against the prescribed smoothness in t_t. Note that as λ approaches to 0, the trend component becomes equivalent to the original series, while as λ diverge to ∞, c_t approaches to the linear trend. It is customary to set λ to 1,600 for quarterly data. For monthly and annual data, recommended to use 14,400 and 100, respectively.

By taking derivatives of the loss function with respect to c_t, t = 1, · · ·, T and rearranging them, it can be shown that the solution to the first tern can be written as following matrix form $y_T = (\lambda F + IT)t_T$. We can resolve it with an informatics program like excel and we obtained the trend component (t_t) that we denominated "HP-Trend".

In figure 3, we present the results of this filter to the natural logarithm of the evolution of the oil prices from 1978 (West Texas Intermediate Spot Price; source Dow Jones Energy Service). At the inferior part of the same figure we present the cyclical component (c_t) that we denominated "HP-Cycles". To insolate this cycles the HP-Trend is plotted as a "zero line" and prices are plotted above and below that zero centerline.

 In order to identifying the oil prices cycles we first need to identify the most significant lows or turning points consecutives which correspond to local minima in the series and second we calculate the high between this lows. To ensure that we do not identify shorts or spurious cycles we eliminate lows if the cycle is less than 2.5 year.
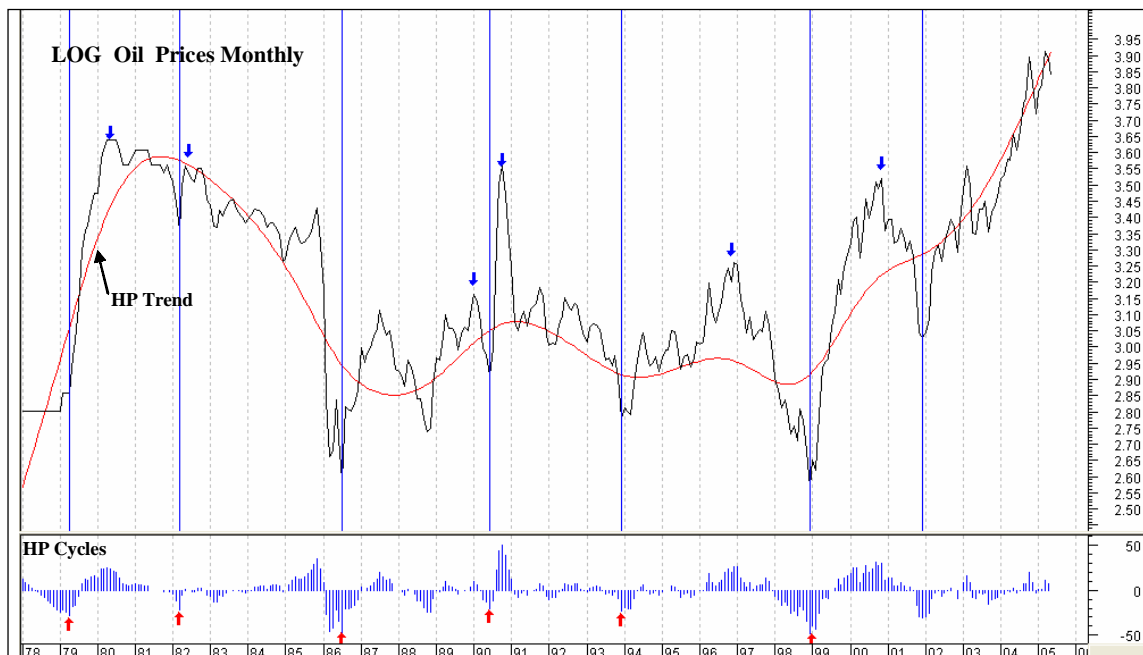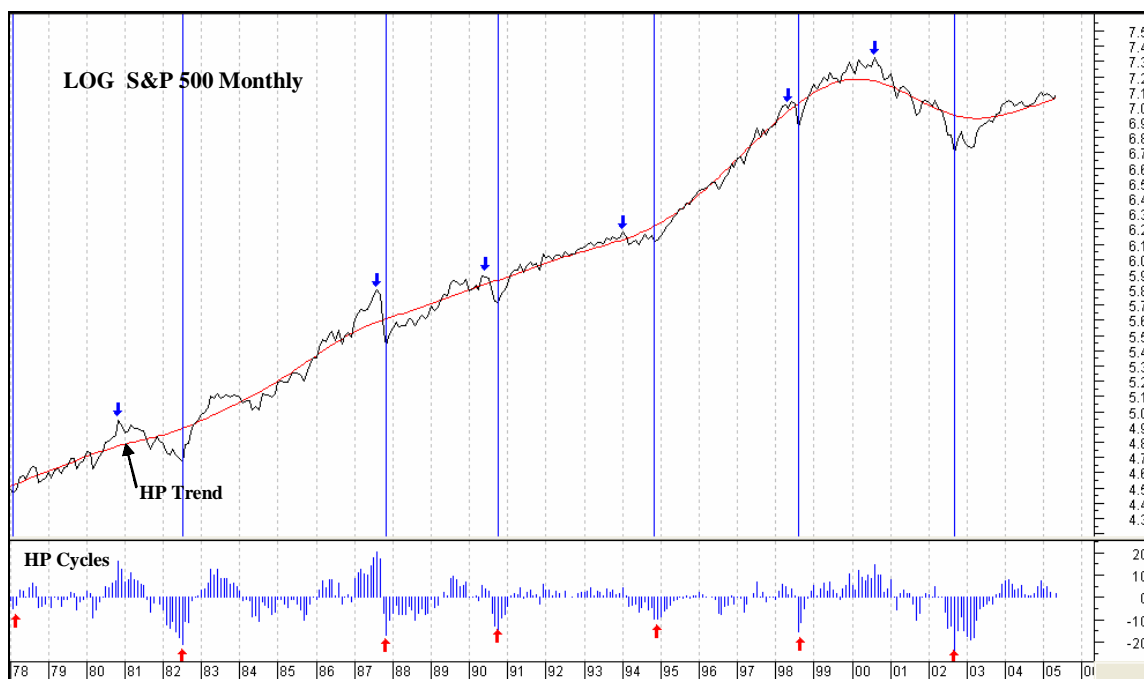
Figure 3

Following these rules, we have detected the lows that fulfilled these conditions and we have marked them by upwards arrows. Once we have detected the dates of these minimums in the HP-Cycles, we looked for the corresponding value in the series. The date of the lows in HP-Cycles are generally exactly with the one of the prices series, though in some occasions a small variation exists. When it is not similar we have taken the nearest price data. Once the lows have been detected the high in the series between these lows can be found easily, and normally agree with a maximum in HP-Cycles. We have marked them, in figure 3, by downwards arrows.

Table 1 presents the results of the cycles in oil prices from 1978. The averages at the bottom of the table show that the cycles averaged 3.8 years from low-to-low (the period or length of cycle).

Date of Low Close	Low Close	Low HP Cycle	Date of High Close	High Close	Cicle Moves	Period Cycle (years)
abr-79	15,85	-29,56%	abr-80	39,50	Up	2,9
mar-82	28,48	-22,66%	may-82	35,93	Down	4,3
jul-86	11,58	-49,48%	ene-90	22,64	Up	3,9
jun-90	16,87	-22,48%	oct-90	35,92	Down	3,5
dic-93	14,51	-22,31%	dic-96	25,39	Down	5,0
dic-98	11,28	-49,24%	nov-00	34,40	Up	3,0
dic-01	19,33	-32,46%				
					Averages	3,8

Table 1

The same previous study has been applied on the evolution of the S&P 500 from 1978, obtaining figure 4 and table 2. The averages show that the longer-term cycle in the U.S. Stock Market averaged 4.1 years from low-to-low, near to those of the Oil Prices. Nevertheless it is possible to observe that the moths of low close are not near in all the cases, suggesting that both markets are not quite synchronous. At the present time, as it shows in figure 3, a new cycle of 4 years has formed, that could extend until the 2005-6.
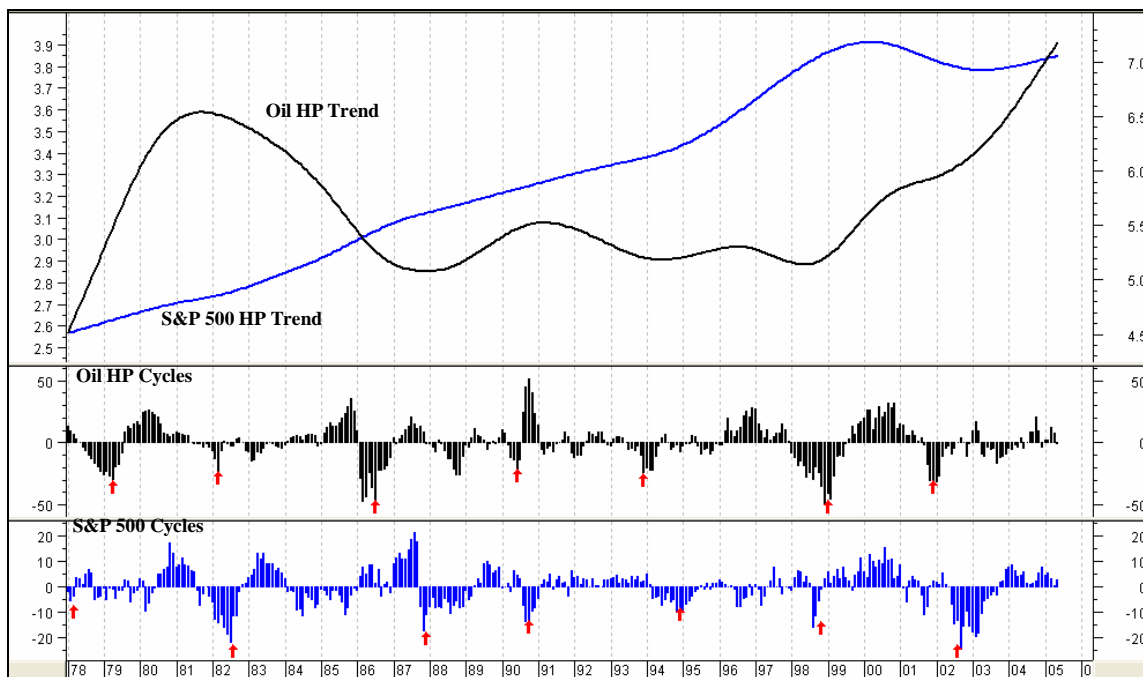

Figure 4

Month of Low Close	Low Close	HP Cycle	Month of High Close	High Close	Cicle Moves	Period Cycle (years)
feb-78	87,04	-5,36%	nov-80	140,52	Up	4,4
jul-82	107,09	-21,56%	ago-87	329,80	Down	5,3
nov-87	230,30	-17,16%	may-90	361,23	Up	2,9
oct-90	304,00	-14,82%	ene-94	481,61	Down	3,7
jun-94	444,27	-7,24%	jun-98	1133,84	Down	4,2
ago-98	957,28	-16,02%	ago-00	1517,68	Up	4,1
sep-02	815,28	-24,20%				
					Averages	4,1

Table 2

Figure 5 summaries the trends and the cycles in both series. Visually there's no apparent relationship.

Figure 5

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3. Describing cycle characteristics and statistics.

Once the cycles have been identified, a battery of statistics is calculated which describe the behaviour of series in each of the cycles. This behaviour can then be compared across series and across cycles, in search for relevant differences that may shed light on the determinants of oil prices and stock market evolution. The eight characteristics of the phases of the market under study are:

- The period or length of cycle (years from low-to-low)
- The duration of the upward phases (years from low-to-high)
- The duration of the downward phases (years from high- to-low)
- The relative position of the high
- The percentage of advance or decline during the length of cycle (percentage of the advance/decline from low-to-low).
- The percentage of return during periods of upward phases (percentage of the advance from low-to-high).
- The percentage of return during periods of downward phases (percentage of the decline from high-to-low).
- The percentage of retracement of movement from low-to-high (decline/advance).

Table 3 presents the cycles of the Oil Prices. The statistics in this table can be summarized as follows. Firstly, the averages at the bottom of the table show that the cycles averaged 3.8 years from low-to-low, 1.7 years from low-to-high, 2.1 years from high-to-low and the high occurs in 43% of length of the cycle. Secondly, the average advance during the length of cycle (from low-to-low) was 16.9 %, the average advance or return during periods of upward phases (from low-to-high) was 110.6 % and the average decline or return during periods of downward phases (from high-to-low) was 46.7 %. Thirdly, the retracement of movement from low-to-high (decline/advance) implies an average of 122.2 %.

Month of Low Close	Period Cycle (years)	Years Low to High	Year High to Low	Position High	% Move L-L$_{next}$	% Advance L-H	% Decline M-L$_{next}$	% Decline/ % Advance
abr-79	2,9	1,0	1,9	0,34	79,7%	149,2%	27,9%	46,6%
mar-82	4,3	0,2	4,2	0,04	-59,4%	26,2%	67,8%	326,9%
jul-86	3,9	3,5	0,4	0,89	45,8%	95,6%	25,5%	52,1%
jun-90	3,5	0,3	3,2	0,09	-14,0%	112,9%	59,6%	112,4%
dic-93	5,0	3,0	2,0	0,60	-22,3%	75,0%	55,6%	129,7%
dic-98	3,0	1,9	1,1	0,64	71,4%	205,0%	43,8%	65,2%
dic-01								
Averages	3,8	1,7	2,1	0,43	16,9%	110,6%	46,7%	122,2%

Table 3

Table 4 presents the cycles of U.S. Stock Market from 1978. The cycle averaged 4.1 years from low-to-low, 3.3 years from low-to-high, 0.8 years from high-to-low and the high occurs in the 80 % of length of the cycle. The average advance from low-to-low was 52.8 %, the average advance from low-to-high was 99.7 % and the average decline from high-to-low was 23.2 %. Finally, the retracement of move from low-to-high (decline/advance) implies an average of 53.8 %.

| Month of Low Close	Period Cycle (years)	Years Low to High	Year High to Low	Position High	% Move L-L$_{next}$	% Advance L-H	% Decline M-L$_{next}$	% Decline/ % Advance
feb-78	4,4	2,8	1,7	0,62	23,0%	61,4%	23,8%	62,5%
jul-82	5,3	5,1	0,2	0,95	115,1%	208,0%	30,2%	44,7%
nov-87	2,9	2,5	0,4	0,86	32,0%	56,9%	15,8%	43,7%
oct-90	3,7	3,3	0,4	0,89	46,1%	58,4%	7,8%	21,0%
jun-94	4,2	4,0	0,2	0,96	115,5%	155,2%	15,6%	25,6%
ago-98	4,1	2,0	2,1	0,49	-14,8%	58,5%	46,3%	125,3%
sep-02								
Averages	4,1	3,3	0,8	0,80	52,8%	99,7%	23,2%	53,8%

Table 4

Table 5 summarizes the results on the basic measures of both stock markets. If we have a look across those Oil Prices and Stock Market cycles observe that are very different in all the characteristics, which suggests that both markets are not synchronous.

CYCLES	OIL	S&P 500
Years from low-to-low	3,8	4,1
Years from low-to-high	1,7	3,3
Years from high-to-low	2,1	0,8
Position of the high	0,43	0,80
Percentage of the advance from low-to-low	16,9%	52,8%
Percentage of the advance from low-to-high	110,6%	99,7%
Percentage of the decline from high-to-low	46,7%	23,2%
Percentage of the advance/percentage decline	122,2%	53,8%

Table 5

If a correlation analysis is carried out statistically the relationship between the two series can be measured. In the inner window of figure 6 the resulting value of this analysis, the "correlation coefficient", shows that changes in the Oil Prices not always will result in changes in the Stock Market. In some periods the correlation is positive and in other is negative. Instead we see erratic, random swings, which is what it should see if there is no correlation whatsoever. So, if we analyze the charts we can conclude that higher energy prices are not always bad for the stock market.
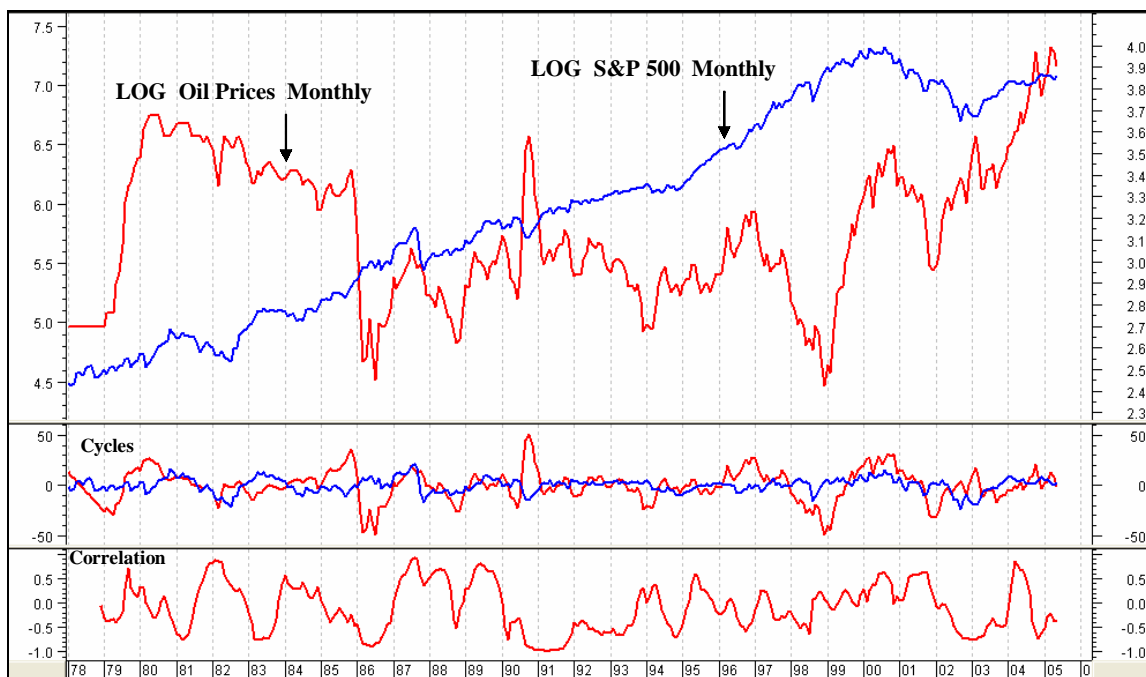
Figure 6

4. Conclusion

In the previous sections, we have seen the development, trend and the cycles of the Crude Oil Prices and the Stock Market during the period 1987-2005. In order to detect cyclical patterns in stock price movements the HP filter are employed. Visually there's no apparent relationship in both series. In addition, some characteristics in the series are identified, such as the period or length of cycle, the duration of the upward and downward phases, the relative position of the high, the percentage of return during

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periods of upward and downward phases and the percentage of retracement of movement from low to high. We observe that there are many differences in all the characteristics, suggesting that both markets are not synchronous. The correlation analysis shows that there is no correlation whatsoever. So, we can conclude that higher energy prices are not always bad for the stock market and oil prices can't be used like an "indicator" that "drives" the stock market.

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