LONG-RUN RELATION BETWEEN ECONOMIC GROWTH AND ENERGY PRICES

The United States Case

TRABAJO DE GRADO

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ABSTRACT

This paper shows that long-term relation between the stock market and the oil price can change in time. Those changes could be related to one of the most controversial theories in economics: the long-wave theory. The purposes of this paper are to find if the relationship changes for the U.S. case, the periods in which it changes and the relation those have with the long-wave theory. Using VAR models, a rolling version and a recursive one of the Johansen cointegration test and daily data, this study finds there are indeed changes in the relationship and that those have an interesting pattern that might be related to the long-waves. But perhaps the most interesting finding is that the order of integration of the series changes and that it happens in the period in which the 4th K-wave ends and the 5th starts (around 1994).
KEY WORDS: Cointegration, stock market, Johansen, Kondratieff, Long term relationship.

Este estudio muestra que la relación de largo plazo entre el Mercado accionario y el precio del petróleo puede cambiar en el tiempo. Esos cambios pueden estar relacionados con una de las teorías económicas más controversiales: la teoría de los ciclos económicos largos. Los objetivos de este documento son encontrar si dicha relación cambia para el caso de Estados Unidos, los periodos en los cuales cambia y la relación que estos periodos tienen con los ciclos económicos largos. Empleando modelos VAR, una versión móvil y una recursiva del test de cointegración de Johansen y una muestra diaria, este estudio encuentra que existen cambios en dicha relación y que estos tienen un patrón interesante que puede estar relacionado con los ciclos económicos largos. Sin embargo, tal vez el hallazgo más interesante es que el orden de integración de estas series cambia en el tiempo y que dicho cambio se da en el periodo en el que la cuarta onda larga termina y la quinta comienza (alrededor de 1994).

PALABRAS CLAVE: Cointegración, Mercado accionario, Johansen, Kondratieff, Relación de Largo Plazo.

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1. INTRODUCTION

Today, more and more people agree that we are living in a period of change in the economic structure. Rifkin (2007), for example, affirms that the world is approaching the end of the oil era. This author argues that the world's economy is beginning to struggle because of its fossil fuel dependence, and is convinced that to solve the issue, another great economic revolution is coming in the next years.

On the other hand, Greenwood (1999) states that information technologies (IT) are now changing the world as the steam engine did it with eighteenth-century England, and electricity with nineteenth century America. He concludes that the start of the development of IT around 1974 might have marked the beginning of a third industrial revolution.

Long-run structural changes in the economy have been studied by long-wave theory supporters. Many of those have studied the link between the different bursts of innovations at different epochs with the apparent long-term cycles of the economy, for example Jacob J. Van Duijn. Metcalfe (1983) explains that Van Duijn view the recovery phase of the long-wave as the trigger for the surge in innovations, which are responsible for converting the period into one of sustained prosperity instead of just one of a technical investment recovery.

A structural change of the economy like the one mentioned would mean a probable change in the relationship between oil and economic growth. A large number of works have studied this relationship for the United States economy as well as for other economies. Huang, Masulis and Stoll (1996), for example, mention several authors that find relations between oil prices and variables affecting the economic growth, and, as a consequence that oil plays an important role in the in the U.S. economy.

Stock exchange indexes (like the Dow Jones in the U.S. case) are very good proxies for the value (and its change) of the most important public companies of an economy. For example, Fama (1990) mentions several articles where there is evidence of a strong relation between stock returns, which are related to stock indexes, and future real activity. Schwert (1990) best summarizes the possible three reasons for this to happen: 1) economic agent's expectations of future economic performance may be reflected on stock prices, 2) changes in discount rates might be reflected in real investment later than in stock prices, and 3) stock prices affect wealth and this one is related to consumption and investment. At last, there is enough data available of exchange indexes to make statistic models robust when daily data is used. Furthermore, for some of those indexes there is data available before the 1980's.

On the other hand, energy prices are related to performance (economic growth) through energy efficiency. Saunders (1992) states that energy efficiency gains increase economic growth rate, which directly increases energy use. More important, Kilian and Park (2009) found that a decrease in demand is the primary channel of transmission of oil price shocks, supporting the relationship that exists between stocks (indexes), economic performance and energy prices (oil)[1].

[1] It is important to highlight that Kilian and Park (2009) also found that the relation between stocks and oil prices can change depending on the type of oil shock affecting the oil price in a period of time.

Relationship between stocks and oil prices has been studied by several researchers. As pointed by Alonso (2010), authors like Jones and Gautam (1996), Davis and Aliaga-Diaz (2008), Park and Ratti (2007), using monthly data, and Gogineni (2010), using daily data, among others, have found evidence of a long term relationship between those in the U.S. Oppositely, researchers like Huang, Masulis and Stoll (1996), among others[2], using daily data, have found that there is not such relationship. But probably from all those papers with contradictory results, the most interesting is the one written by Alonso (2010). He discovers that the long term relationship between oil prices and stock indexes can appear and disappear in different periods of time for the same variables (specifically for the Colombian case).

Our hypothesis is that the contradictory results about the long term relationship between the stock indexes and the oil prices for the U.S. economy is explained by the fact that the relationship can appear and disappear, as found by Alonso (2010). Also, if that is true, the changes in the relationship might be related to the long-term structural changes in the economy (the long-wave theory).

To probe our hypothesis we used VAR (Vector Auto Regressive) models on which we tested for Cointegration. The VAR models allow us to include the effects of the variables' past values simultaneously, crucial for the analysis of financial variables, which are variables affected from shocks in the past. On the other hand, we tested for Cointegration, because if the two variables are Cointegrated, it would mean that despite the effects of short term shocks in each variable, there is a relationship

[2] See Alonso (2010) for a summary of researchers who found or not relation between these variables.

between the two that relates the two in the long run. In other words, if the variables are Cointegrated, it would mean that there is a long term relationship between those.

This paper is organized as follows. In the next section the important aspects of the long wave theory are shown. Then, a graphic comparison between the Dow Jones and the Oil price is done. The next section describes the data (its sources and characteristics) and the construction of the VAR models used. Next, the correlation tests to find the optimal lag structure are presented, the order of integration of the series is discussed and the statistical tests based on the VAR framework are undertaken to determine the periods in which there is and there is not a long term relationship between the Dow Jones and the Oil price. A summary of the results and conclusions are also reported.

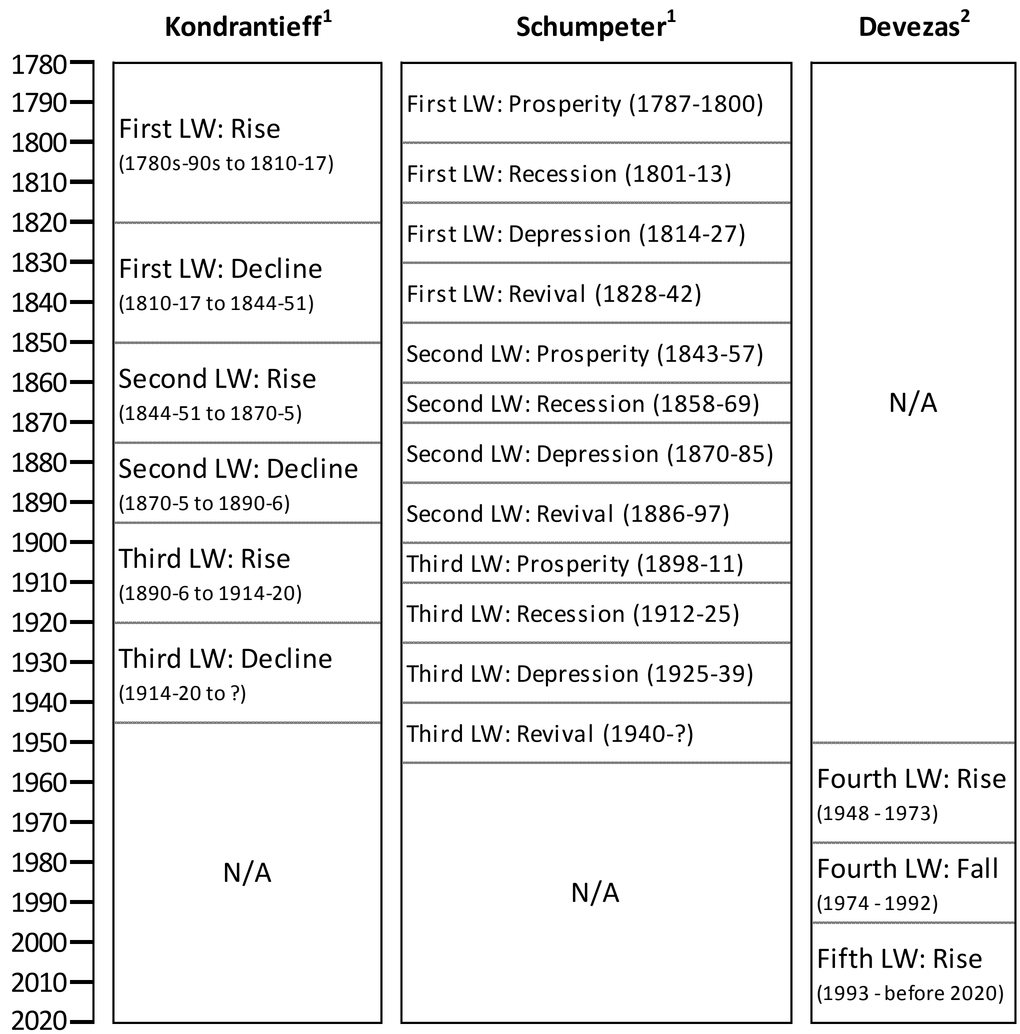
2. THE LONG WAVES

The idea of long term cycles of the economy emerged at the beginning of the last century (Maddison, 1991). These long term cycles are called “long waves” or “K-waves” (named after the economist N.D. Kondratieff, who was one of the first to study this phenomenon) in the economic theory[3]. The period of study of this paper includes what many K-wave adopters associate with part of the down-wave (between 1974 and 1992) phase of the 4th K-wave and what seems to be the up-wave of the 5th K-wave (from 1993 onwards) (Devezas, 2010). Solomou (1986), for example, summarizes the phases of the last K-wave (the 4th K-wave) as the upswing phase being the post-war boom of 1950 to 1973 and the downswing phase, the post-1973 growth retardation. Figure 1 shows a summary of the periods of the long wave phases for different authors.

Two of the main authors in long-wave analysis are N.D. Kondratieff and J.A. Schumpeter (Maddison, 1991). Both Kondratieff and Schumpeter had long-term cycles of 50 years’ duration (waves) and a similar big-wave chronology. Maddison (1991) explains that the difference between both authors is that Kondratieff distinguishes only two phases in each wave (rise and fall), and Schumpeter, four phases (prosperity, recession, depression and revival). Nonetheless, these authors’ studies are prior to the period analyzed in this paper.

[3] There is also a part of the economic theory that relates to shorter term economic fluctuations called business cycles (Maddison, 1991).

Figure 1. Summary of the Long Waves (LW) for different Long Wave Adopters



[1] Information from Maddison (1991)
[2] Information from Devezas (2010)

There are more recent studies of the long term behaviour of the economy. Maddison (1991), for example, criticizes long-wave theorists, as he argues there is no convincing evidence to support regular or systematic long waves in economic life (Devezas, 2010). He therefore distinguishes four non-regular distinct phases, each with its own momentum: 1870-1913, 1913-50, 1950-73, and 1973 onwards (Maddison, 1991). He also finds that system-shocks, unpredicted exogenous variables, cause the move between phases (Maddison, 1991).

Within the most recent studies of long-term economic performance, Devezas' (Devezas, 2010) one might be the most relevant to this paper as it includes data from the 2007-2008 crisis. He finds fingerprints of Kondratieff long waves in the world GDP growth rates, succession of economic expansions–contractions in the US, purchasing power of gold and the historical ratio DJIA/gold price. He proves that economic growth in the long term resembles a sinus series (wave like behaviour) by fitting the data into a sinus equation. The fitting evidences a 50 year periodical movement (Devezas, 2010), reinforcing the long-wave theory supporters' studies.

In his study, Devezas (2010) locates three different sub periods after 1948: The first one (between 1948 and 1973) and the second one (between 1974 and 1992) being the rise and fall of what many authors have associated with the 4th K-wave, and the third one after 1993 being the rise of a 5th wave as an upward trend is observable. He extrapolates his sinus function to find that the 5th K-wave should reach a maximum shortly before 2020, implying that the expansion movement is going to continue despite the recent 2007-2008 crisis. He also finds (using the NBER statistics for the USA) that there exists an increasing trend towards shorter contractions and longer expansions; in other words, the contraction duration in every subsequent wave is shorter than in the previous waves.

An aspect to highlight is that Devezas (2010) finds similarities between the 1907 and the 2007-2008 crises. Both crises occurred in the middle of a strong international growth period and seem to have had self-correction mechanism that brought global output back to its original growth pattern (Devezas, 2010). Nonetheless, he states that the present crisis signals a change in the economic order.

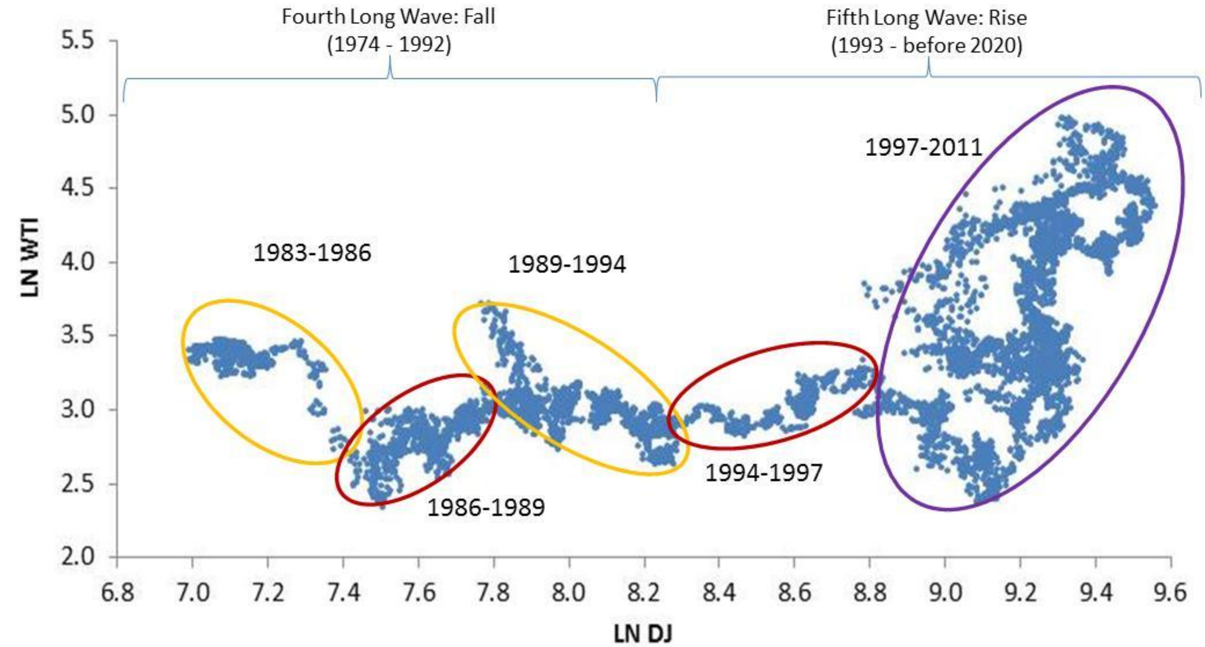
3. PRELIMINARY ANALYSIS

By looking at the graphic results of the daily series, one can see a mixed behaviour between the natural logarithm of the Dow Jones daily closing value (from now on LNDJ) and the natural logarithm of the WTI Oil daily closing price (from now on LNWTI)[4]. It seems that there are periods in which there is a relationship between the two variables and periods in which the relationship disappears.

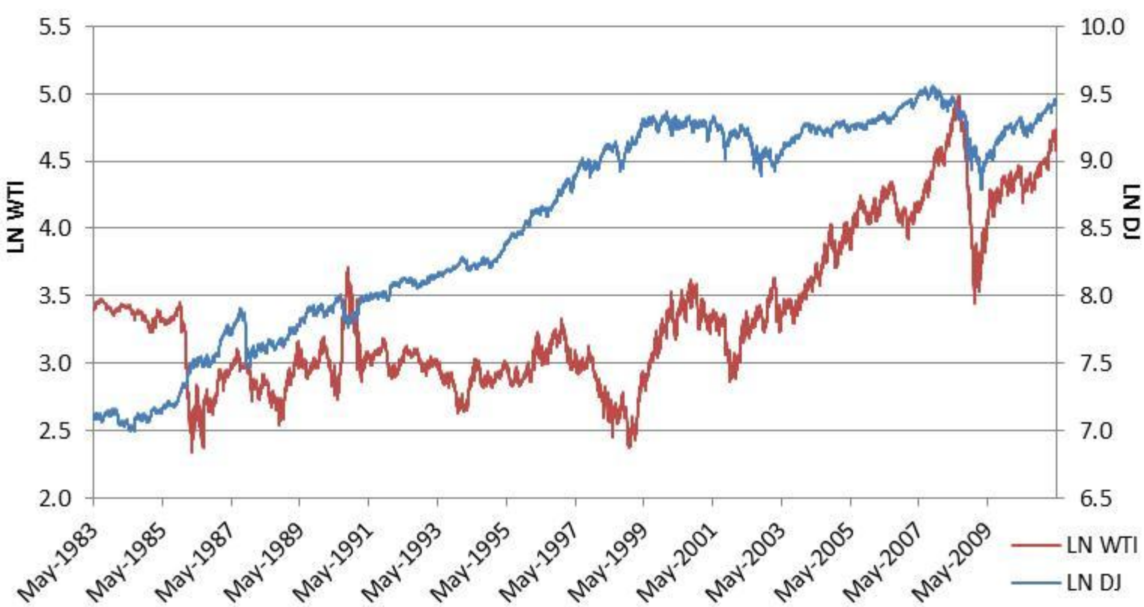
Graph 1 shows that when the LNDJ was below 7.5 (approximately between 1983 and 1986 as shown in graph 2), there appears to be a negative relation between the two variables. Nonetheless, when the LNDJ was between 7.5 and 7.8 (between 1986 and 1989) the relationship seems to disappear or at least change (slightly positive relation). Also, the relation seems to change or disappear when the LNDJ was between 7.8 and 8.3 (approximately between 1989 and 1994) and between 8.3 and 8.8 (between 1994 and 1997). Finally when the LNDJ was over 8.8 (approximately from 1997 to 2011), there seems to be no relation at all.

[4] The details of the data are shown in the next section.

Graph 1. LNDJ vs. LNWTI



Graph 2. LNDJ and LNWTI through time.



By looking at the results above one can intuitively conclude that there is not an apparent change in the relation caused by the end of the 4th K-wave and the rise of the 5th one; K-wave theory states that, around 1994, the fall phase of the 4th wave ends, and the rise phase of the 5th wave starts. However, it is important to notice that at the end of the 4th K-wave and at the beginning of the 5th one, there appears to be a pattern in which every 3-5 years the relation between the variables changes, but there is a rupture of that pattern after 1997. Perhaps this is due to the dependence of the economy on oil in the 4th K-wave, in which the relation between the variables was determined by short term economic cycles which created the patterns. After a couple of years into the 5th K-wave the pattern disappears because the economy was not that dependent on oil.

4. DATA AND MODELS

As mentioned before, the focus of this paper is to find: 1) ruptures in the long term relationship between the U.S. stock exchange indexes and the oil price, 2) the periods in which those changes have happened and 3) if there is a relation between those periods and the long-wave theory. To accomplish this we use a VAR model, constructed with proxies for stock exchanges and oil prices. We conduct the Johansen´s cointegration test over different periods of time.

The Dow Jones Industrial Average Index was picked as the proxy for the stock exchange indexes, mainly because it has been a very stable index in its composition. On the other hand, WTI Oil Price, as the proxy for the oil price in the U.S. economy, as it is the main oil reference used in the United States and the one that has the longest set of data available.

To construct the Dow Jones series we used its daily closing value from May 16th 1983 to May 11th 2011 from Yahoo Finance. For the Oil series, on the other hand, I used the WTI daily closing price from the same period from Bloomberg[5]. The data was tailored by removing the days when the market is closed like weekends and holidays. The series were then smoothed by using the natural logarithm function, basically to avoid the influence of high volatility. The resulting series, the natural logarithm of the Dow Jones daily closing value (LNDJ) and the natural logarithm of the WTI daily closing price (LNWTI), are the ones used in this paper. The total number of observations we ended up with were 6,942.

[5] The period used in this article stops in 1983 because there is no Oil daily data going further than that year.

The VAR model constructed then is similar to the one used by Alonso (2010); i.e. our VAR model will be of the form:

$$Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i Y_{t-i} + \varepsilon_t \tag{1}$$

where Y_t = [$LNWTI_t$ $LNDJ_t$]^T represents the vector of variables for period t and p is the number of lags.

We use two different approaches to conduct the sequential Johansen´s cointegration tests. The two approaches use samples constructed in different fashion: a Recursive sample and a Rolling sample.

The Recursive sample uses a “recursive” window, which implies using a first sample (S_1) of size 1983 and the second sample will we the prior sample plus the observation from the next period. New recursive samples are created until the whole sample is used. For example, the first sample (S_1) in this paper starts with the first observation on May 16, 1983, and ends with Observation 1,983, which corresponds to May 14, 1991, the second sample (S_2) starts with the first observation and ends on May 15, 1991, and so on. In other words, the first sample had 1,982 observations, and each sample increased that number by one until the whole sample is used.

The Rolling sample instead of maintaining the first observation of each period’s sample unmoved, like the Recursive model does, it maintains the sample size unchanged. In this case all the samples are of size 1000, by adding the observation of the next period and dropping the first observation of the previous sample. For example, the first sample (S_1) in this paper starts with the first observation on May 16, 1983, and ends on July 21, 1987 (1000 observations), the second sample (S_2) starts on May 17, 1983 and ends on July 22, 1987, and so on. We ended up with 5,000 recursive and rolling samples. Then the Johansen's Cointegration tests are applied for each sample; both the Lambda Trace and Lambda Max statistics are calculated.

5. LONG-RUN RELATIONSHIP: EVIDENCE FROM COINTEGRATION TESTS

The first step in the analysis implies finding the integration order of the two series. We used all the observations, from May 16th 1983 to May 11th 2011, of each series to do the integration order tests. The tests used were Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS), and those were applied to the series in levels (LNDJ and LNWTI) and in differences (DIFLNDJ and DIF LNWTI). The ADF and PP tests show that for both series in levels one cannot reject the null hypothesis of a unit root with an alpha of 10%, while for both series in differences one can reject the null hypothesis with an alpha of 1%. This means that both series have one unit root or, in other words, that the order of integration for both series is 1. The results from the KPSS test confirmed the results of the ADF and PP tests. The results of the unit root tests are shown in exhibit 1.

After determining that both series were of the same order of integration, we determined the optimal lag structure (p in expression (1)) using all the observations by using three different information criteria (Akaike Information Criterion (AIC), Hannan-Quinn Criterion (HQ), and Schwarz Information Criterion (SC)) and the Final Prediction Error (FPE). The results (shown in exhibit 2) using the four criteria pointed to 3 possible VAR´s specifications: one with 1 lag, other with 3 lags and the last one with 19 lags. To decide which of the three lag structures to use, we perform the Breusch-Godfrey correlation test for the VAR models with each lag structure using all the observations. The tests (the results are shown in exhibit 3) show that one cannot reject the hypothesis of no auto-correlation for the model with 19 lags for an alpha of 10%, but one can reject it for the model with 3 and 1 lags[6]. Thus, a VAR model with 19 lags will be used.

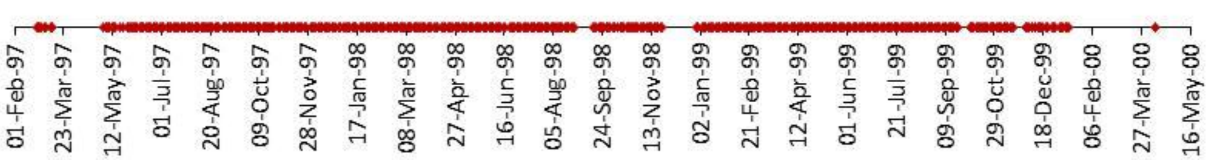
The following step is to construct a VAR with 19 lags for each of the rolling and recursive samples and carryout the Johansen´s Cointegration test on each of the samples.

The first thing we noticed after doing the Johansen tests was the inconsistencies between the results from those tests and the results from the integration order tests regarding the integration order of the two series. The results from the Johansen tests gotten in some of the samples for both models (the rolling and the recursive) showed that the order of integration might have changed in those periods.

[6] For the model with 3 lags, H0 could not be rejected for lags 1 and 2, but it was rejected for lag 3 with 99% confidence level.

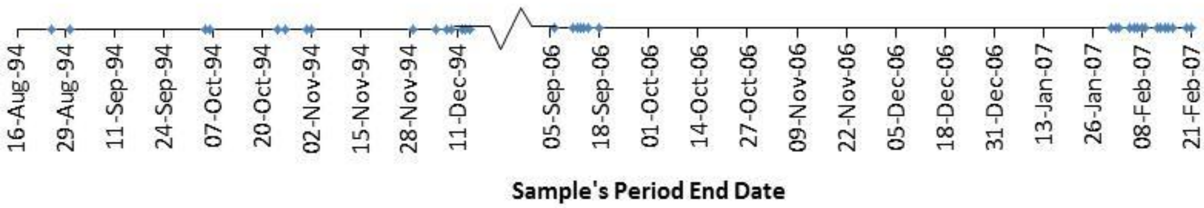
Graphs 3 and 4 show the samples that might have a different integration order according to the evidence found in the Johansen Tests' results. The evidence found was basically: 1) With the lambda trace statistic, one can reject both, the hypothesis of cero relationships and the hypothesis of one relationship, for all the samples shown of both models (recursive and rolling); 2) With the lambda max statistic, one can reject the hypothesis of one relationship for the samples of both models[7]. The graphs clearly illustrate that: 1) The recursive model has more samples in which the order of integration might have changed; 2) Those samples with a possible change in the integration order in the recursive model are more or less equally distributed around a period of two and a half years; 3) Those samples with a possible change in the integration order in the rolling model are concentrated in three periods of time (samples with periods ending around the last semester of 1994, periods ending in September 2006 and periods ending in the first two months of 2007).

Graph 3. Samples from the Recursive Model with Possible Change of Integration Order Timeline



[7] The results for the hypothesis of cero relationships are mixed with the lambda max statistic: whilst one can reject it for all the samples of the recursive model, one can reject it only for some of the samples of the rolling model.

Graph 4. Samples from the Rolling Model with Possible Change of Integration Order Timeline

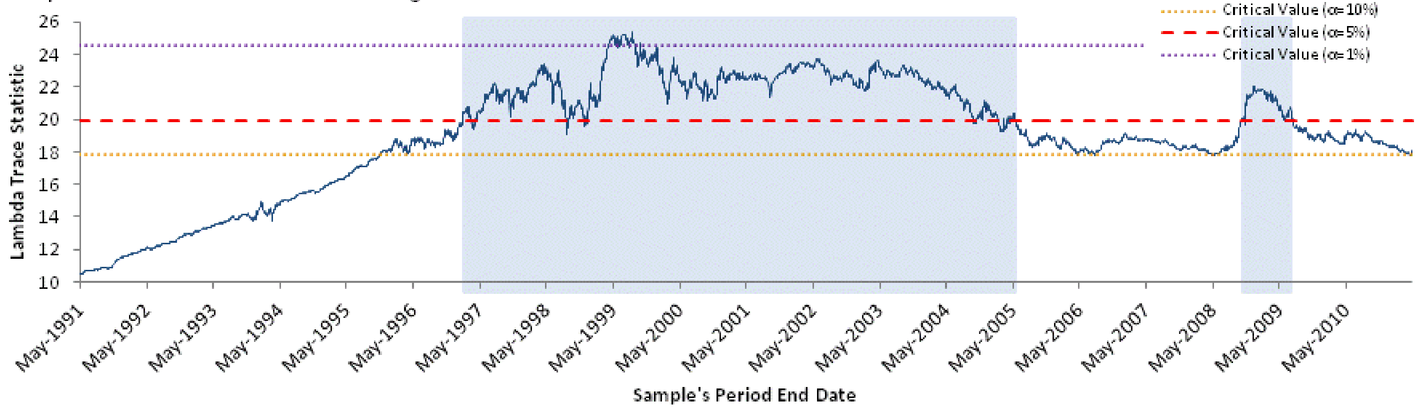


The cointegration tests show that in both types of samples, the recursive and the rolling, the series had periods of cointegration and periods were the relation disappeared. Nonetheless, there is a big difference between both kinds of samples because in the recursive one the periods of cointegration and no cointegration were more permanent. In other words, the periods in the recursive sample, both of cointegration or not cointegration, were longer and had no rapid or abrupt changes in the relationship. The results are shown in graphs 5, 6, 7 and 8. In those graphs, the results of the statistics and the critical values are graphed through time (the X axis is the date in which the samples' periods ended). The blue shadows in each graph highlight the periods in which either there was a clear long term relationship or there was a period of turmoil (periods were the relationship comes and goes, but there is mainly a long term trend).

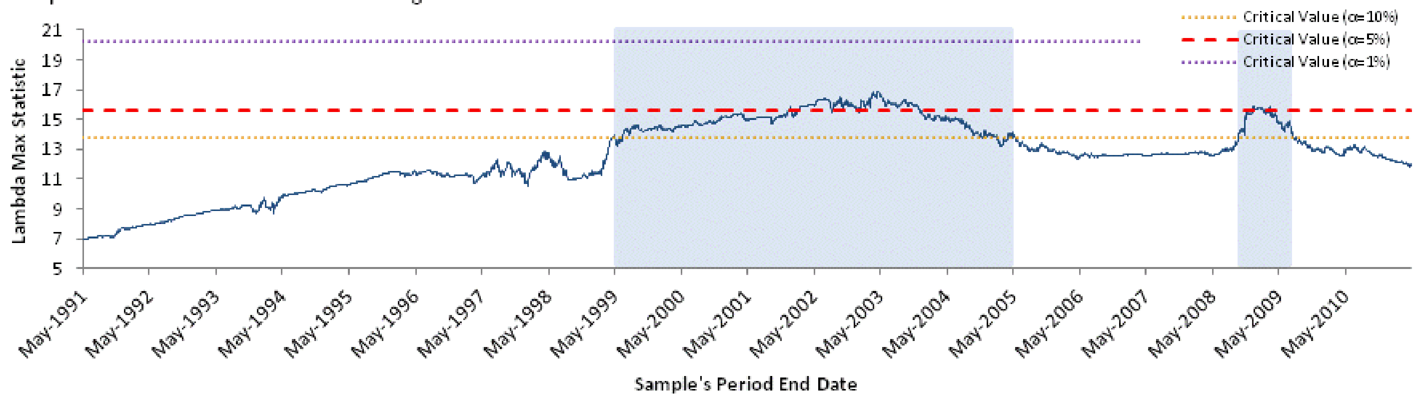
In the recursive model, one can see that before 1997 there is clearly no long-run relationship between the variables, but from around 1997 to around 2005 there is a long-run relationship throughout that period. The relationship disappears or gets weak from 2005 to 2011 for the exception of the years 2008 and 2009 when it seems to appear again but soon disappears (with the lambda max statistic) or weakens (with the lambda trace statistic) in 2010.

On the other hand, in the rolling model before 1996 there appears to be long periods (more than a year) without any long-run relationship followed by periods of turmoil were the long-run relationship comes and goes in small periods of time (less than a year). At the beginning of 1996 there is a long period of turmoil of two and a half years when most of the time there is a long term relationship. After 1998 it follows the same pattern described before 1996: long periods without long-run relationship followed by short periods of turmoil.

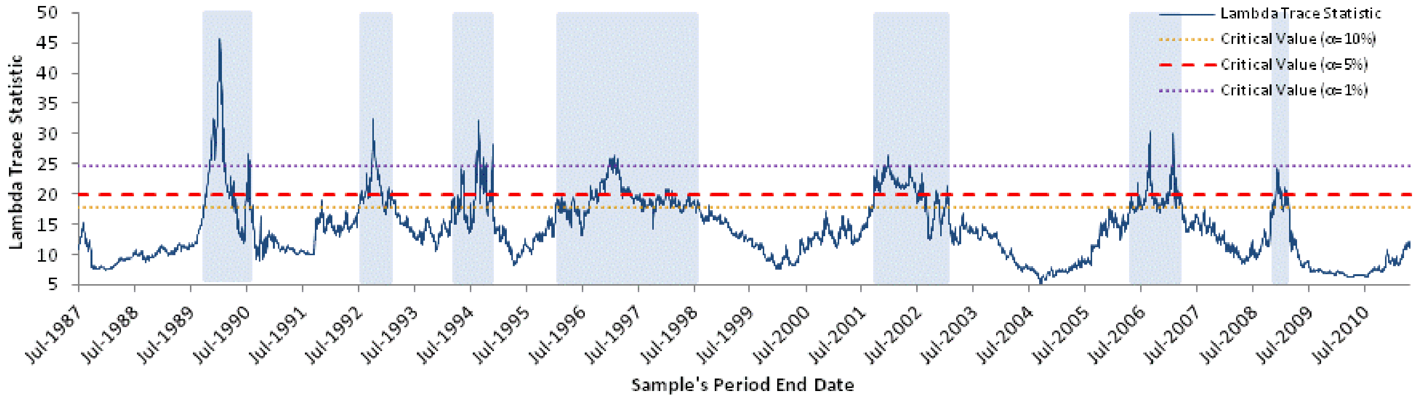
Graph 5. Recursive Model Results: Cointegration Test Johansen's Lambda Trace Statistic for LNWTI and LNDJ



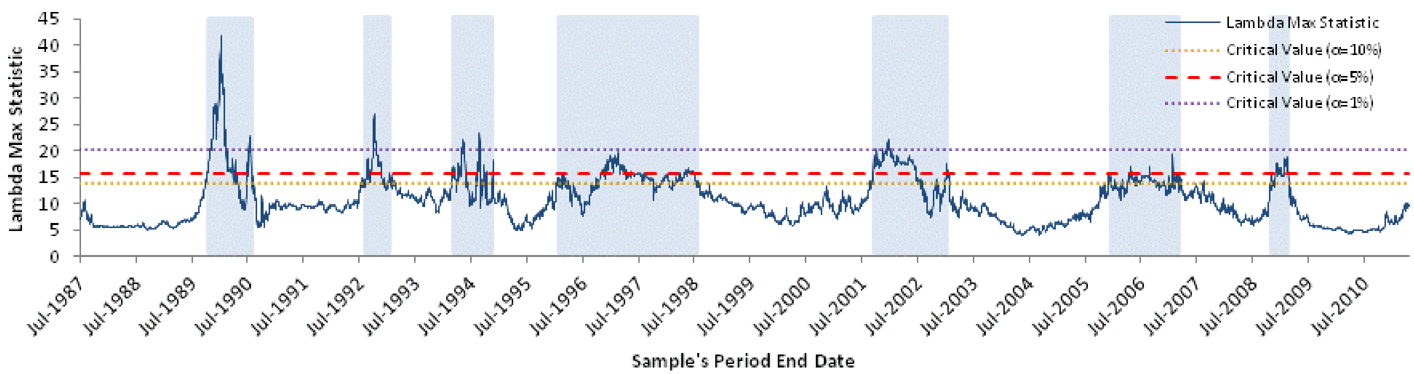
Graph 6. Recursive Model Results: Cointegration Test Johansen's Lambda Max Statistic for LNWTI and LNDJ



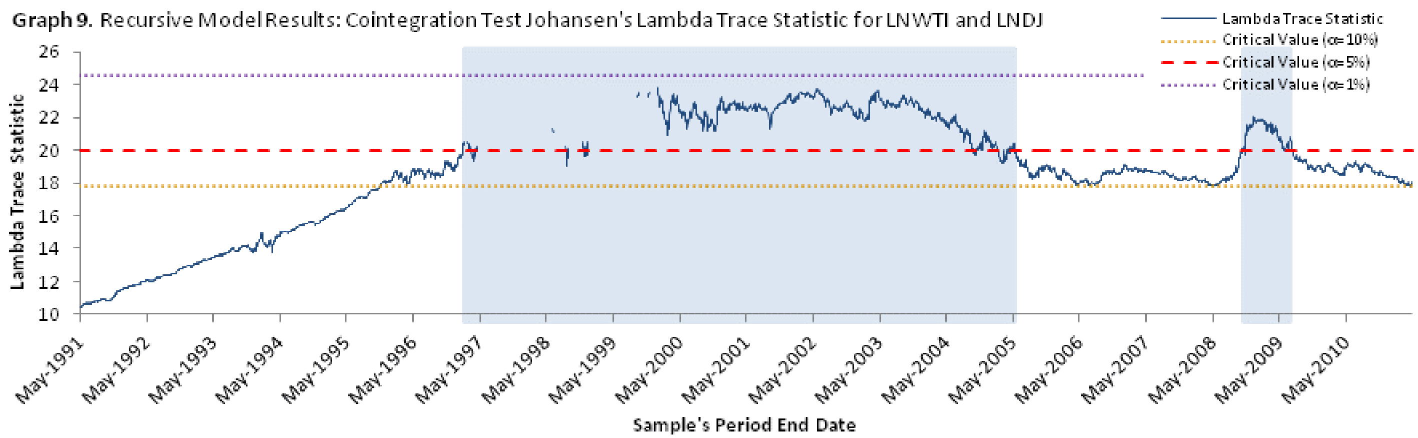
Graph 7. Rolling Model Results: Cointegration Test Johansen's Lambda Trace Statistic for LNWTI and LNDJ



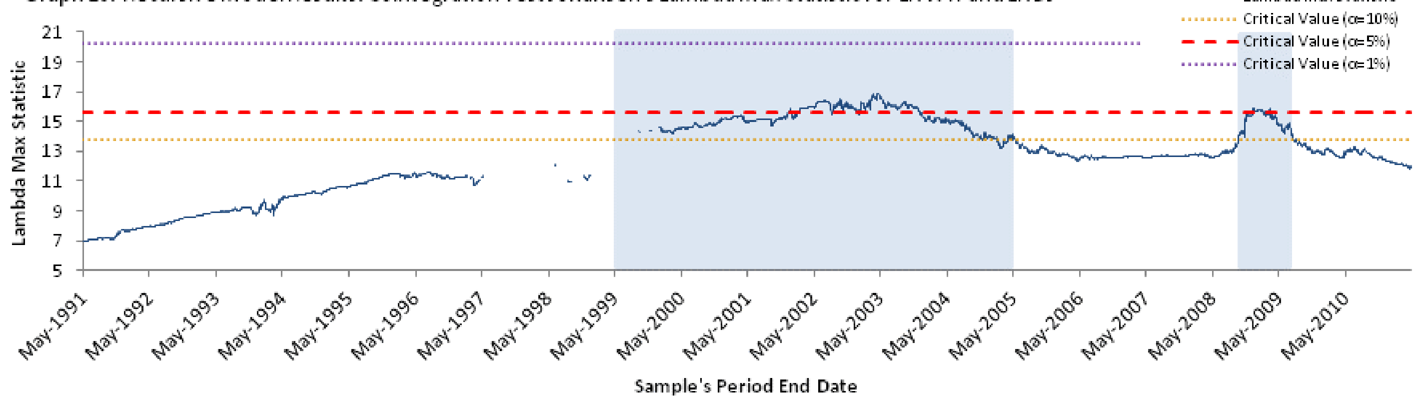
Graph 8. Rolling Model Results: Cointegration Test Johansen's Lambda Max Statistic for LNWTI and LNDJ



Graph 9. Recursive Model Results: Cointegration Test Johansen's Lambda Trace Statistic for LNWTI and LNDJ



Graph 10. Recursive Model Results: Cointegration Test Johansen's Lambda Max Statistic for LNWTI and LNDJ



6. CONCLUSIONS

In this paper we investigated the relationship between the Oil Price and the U.S. Dow Jones index and the main conclusion is that there are periods in which we found evidence of a long term relationship and periods in which that relationship disappeared and the periods in which the relationship changes are not related to the long-wave theory.

Using the recursive model the periods of long-run relationship or no relationship were longer than those found using the rolling model. On one hand, with the recursive sample we found two periods in which there is evidence of long-run relationship: i) a long one that starts at the end of the 90s (between 1997 and 1999) and ends in 2005, and ii) a short one that starts at the beginning of 2009 and ends at the end of the same year. On the other, with the rolling sample we found that it had long periods without long-run relationship followed by short periods of turmoil with no apparent trend. Nonetheless there is a period of two years (between 1996 and 1998) unusually long where there is a long term relationship between the two variables.

Another key finding is that between the last semester of 1997 to the first semester of the year 2000 there is evidence that the order of integration of the variables changes. One can argue that this is related to the long-wave theory as the period in which the order of integration seems to change is very near to the start of the 5th wave.

It is very interesting to observe that, despite the fact that in the 4th K-wave the economy was supposedly more dependent on oil, with the recursive model there is no evidence of long term relationship before 1997, and that it appeared after, when the economy was more dependent on the IT industry. This may imply that during the downward phases of the K-waves there is no relationship (between energy prices and the economy) but during the upward phases it appears, and that the third industrial revolution has not yet arrived, opposite to what Rifkin (2007) mentioned, as oil still has a big effect over the economy.

On the other hand, the results from the rolling model seem to indicate that the appearance and disappearance of the relation is related to shorter cycles of the economy and not to the long waves. Also, those changes might be a consequence of what Kilian and Park (2009) found: the effects of different shocks, demand and supply, in the oil price are different [8] and as “these shocks explain one-fifth of the long-run variation in U.S. real stock returns”, they can be the cause ruptures in the long term relation.

Nonetheless, the most intriguing results are the ones from the samples ending at the end of the 90’s: The unusual long period[9] in which there is a long term relation in the results of the rolling model and the period in which the order of integration of the series changes in the results of the recursive model. This could mean that even if there is no apparent change in the relation between the 4th and the 5th K-wave, it

[8] “The same unanticipated increase in oil prices can be consistent with a sharp decline or a temporary increase in stock prices, depending on the composition of the underlying oil demand and oil supply shocks.” (Kilian & Park, 2009)

[9] In the rolling model the samples ending in 1996 start in 1993 (as there are 1,000 observations in each sample), around the time when the 4th K-wave starts.

seems that there is indeed a change in it in the period in which the 4th K-wave ends and 5th starts. In other words, when a K-wave ends there is a long period when a long term relation appears and when the order of integration of the series changes (the order of integration in the new wave changes compared to the order from the previous wave, but after that period ends, the order in the new wave returns to the one before).

In summary, there could be three important implications for the long wave theory. The first is that energy sources might have different impacts over the economy depending on which phase of the k-wave the economy is at that moment (in the fourth k-wave there was no long term relation between oil prices and the stock market). The second is that the adoption of a new technological model takes some time and so the impact of the model used in a k-wave over the economy goes well beyond into the next k-wave (there is a long term relation between oil prices and the stock market in the fifth k-wave, when the economy is supposedly adopting the IT revolution). The third is that the start of a new k-wave might trigger a temporary change in the economic agents' perceptions over energy sources, causing a temporary change in the order of integration of energy prices.

In conclusion, it is clear that we have not arrived yet to the third industrial revolution and that the IT revolution has not outshined the oil economic model. Nonetheless, there are some interesting patterns in the way the long term relation between oil prices and the Dow Jones behaves and those might be related to the long-wave theory.

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EXHIBITS

Exhibit 1. Unit Root Tests Results

SERIES	ADF		PP		KPSS	
LNDJ	-1.6366		-1.5937		17.9027	+++
LNWTI	-1.0045		-1.0198		17.9027	+++
DIFLNDJ	-14.2051	***	-86.6768	***	0.2083	
DIFLNWTI	-13.3655	***	-83.4845	***	0.2083	

* Rejects null hypothesis of a process with a unit root at α=10%
** Rejects null hypothesis of a process with a unit root at α=5%
*** Rejects null hypothesis of a process with a unit root at α=10%
+ Rejects null hypothesis of a stationary process at α=10%
++ Rejects null hypothesis of a stationary process at α=5%
+++ Rejects null hypothesis of a stationary process at α=1%

Exhibit 2. Optimal Lag Structure Results

Lag	FPE	AIC	SC	HQ
0	0.135504	3.67700	3.67898	3.67768
1	8.45E-08	- 10.61062	-10.60469*	- 10.60858
2	8.45E-08	- 10.61104	- 10.60115	- 10.60763
3	8.41E-08	- 10.61573	- 10.60189	-10.61096*
4	8.41E-08	- 10.61563	- 10.59784	- 10.60950
5	8.42E-08	- 10.61487	- 10.59312	- 10.60737
6	8.38E-08	- 10.61942	- 10.59372	- 10.61056
7	8.38E-08	- 10.61922	- 10.58957	- 10.60900
8	8.39E-08	- 10.61843	- 10.58482	- 10.60685
9	8.38E-08	- 10.61954	- 10.58197	- 10.60659
10	8.38E-08	- 10.61908	- 10.57756	- 10.60476
11	8.38E-08	- 10.61891	- 10.57344	- 10.60324
12	8.38E-08	- 10.61857	- 10.56914	- 10.60153
13	8.36E-08	- 10.62089	- 10.56751	- 10.60248
14	8.37E-08	- 10.62027	- 10.56293	- 10.60050
15	8.37E-08	- 10.62065	- 10.55936	- 10.59952
16	8.36E-08	- 10.62168	- 10.55643	- 10.59918
17	8.35E-08	- 10.62225	- 10.55306	- 10.59839
18	8.35E-08	- 10.62265	- 10.54950	- 10.59743
19	8.35E-08*	-10.62310*	- 10.54600	- 10.59652

* indicates lag order selected by the criterion
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Exhibit 3. Breusch-Godfrey LM Test Results for Models with 1, 3 and 19 lags

	P = 1		P = 3		P = 19	
Lags	**BG**	**p-value**	**BG**	**p-value**	**BG**	**p-value**
1	10.4654	0.0333	7.1430	0.1285	1.4650	0.8328173
2	51.2439	0.0000	9.8056	0.2789	5.1797	0.73821
3	58.4111	0.0000	49.2348	0.0000	11.3452	0.4995898
4	61.1997	0.0000	55.8768	0.0000	18.2079	0.3118654
5	100.6181	0.0000	57.6562	0.0000	20.5691	0.4228732
6	107.0808	0.0000	64.1688	0.0000	21.0119	0.6380226
7	109.6025	0.0000	71.5681	0.0000	22.9112	0.7374708
8	125.0916	0.0000	79.1847	0.0000	23.6581	0.8565227
9	129.9139	0.0000	85.0025	0.0000	30.6690	0.7199139
10	136.7223	0.0000	92.6849	0.0000	33.8013	0.744358
11	142.1875	0.0000	98.1869	0.0000	35.6999	0.8092584
12	166.3837	0.0000	121.5174	0.0000	40.0678	0.7852214
13	170.0557	0.0000	125.8691	0.0000	48.3326	0.6189076
14	180.5832	0.0000	135.3178	0.0000	48.4987	0.7515595
15	195.5629	0.0000	150.1083	0.0000	54.3602	0.6810103
16	207.3608	-	162.4328	0.0000	66.5811	0.3882386
17	217.9850	-	172.9189	0.0000	69.4146	0.4295256
18	228.9625	-	184.6040	0.0000	72.4561	0.462758
19	230.5081	-	186.1313	0.0000	76.5289	0.4614118

BG: Breusch-Godfrey LM Statistic
P = Order of the Autoregressive Model used (lags of the model)