# Financialization and its Impact on Oil Market Volatility

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**Abstract**

This paper presents an analysis of financialization on crude oil futures by employing wavelet coherence analysis to better capture the co-movement between oil and the overall market. Firstly, the number of large speculators in the oil market is considered to show the change in the oil market's structure. Wavelet coherence is then performed after observing basic Pearson correlation between crude oil and S&P 500 futures. This analysis provides a more rigorous view of how the S&P 500 affects the oil market, both at the price and volatility level. The resulting coherence for both measures suggest that there is strong co-movement between these markets over multi-year periods and that the S&P 500 leads these movements in crude oil futures.

**Key Words:** Financialization, Commodities, Price Volatility, Markets, Futures, Crude Oil

# I. Introduction

Most people living today remember or were directly impacted from the 2008 recession. This recession was primarily driven by financial causes that were not seen in previous ones. Financialization presents a new challenge for economists in how they approach their analysis and understanding of economic conditions and mechanisms. It has fundamentally altered the way markets operate and, consequently, the way individuals behave and their economic wellbeing.

Financialization of the U.S. economy is a well-established notion with a consensus that it began sometime in the early 1980's. Davis and Kim (2015) define it as a, "historical trend since the late 20$^{th}$ century in which finance and financial considerations became increasingly central to the workings of the economy." The change in economic composition towards greater financial services has peaked in recent years. So, while awareness of this rapid shift is there, the true scope of its consequences is perhaps yet to be seen. Much of the literature surrounding financialization as it relates to markets and volatility looks at the period from the mid 1990's to present; this timeframe marks a shift in investor composition towards greater involvement from financial institutions. This potential spillover of volatility and price movement can impact prices of other markets that directly affect consumers and producers, thus the study of this area proves to be of interest. It also impacts investment decisions given how it changes the dynamics of markets.

The objective of this paper is to establish a link between increased participation by non-commercial traders, like financial institutions, and the increased correlation in price and volatility seen in the crude oil futures market with the overall market. The methodology used in this analysis will be akin to that used in similar studies but will also look at more sophisticated methods of showing co-movement, specifically wavelet coherence. Firstly, prior research on the topic to establish a base from which research may be conducted will be reviewed and analyzed. Once established, futures market data of crude oil (CL contracts) and S&P 500 (ES contracts) along with relevant data on market conditions prior to and after the start of financialization will be analyzed. Wavelet coherence analysis will be introduced and explained to setup the research methods. In a similar vein to previous research, correlations and co-movements between percent returns of crude oil and the overall equities market (S&P 500) will be studied to see if they comport with the results found by others. Lastly, correlation and co-movement testing between the volatility of the two assets will be done to examine if they are truly independent from one another now versus in previous decades.

The findings of this research present evidence of noticeable co-movement between oil and the overall market with respect to price and volatility, notably around the time large speculators have entered the oil market in large numbers. In the analysis of these tests it is concluded that the S&P500 futures have an impact of crude oil futures, and that volatility from the former spills into the latter.

## II. Literature Review

Financialization and its varying effects on markets have been well researched for some time. Much of this research is done from a quantitative perspective to clearly measure the extent, if any, of financialization in markets. As a necessary precept to market volatility there must be some cause to initiate it. Thus, studying the variable components of markets (types of investors, supply/demand, risk, rates, information, etc.) allow for an analysis of a markets sensitivity to changes in these variables. In the wake of financialization, the central thesis among these studies is: increased involvement of financial institutions in the futures markets has had a quantifiable effect on volatility and correlation to non-commodity markets and the overall market.

Cheng and Xiong (2013) examine the economic mechanism by which commodity markets are affected. They review previously established theoretical frameworks such as risk-sharing, theory of storage, and index speculation and set up empirical frameworks around these to see if they hold up. By analyzing data from the CFTC (Commodity Futures Trading Commission) and Bloomberg, they were able to quantify changes in commodity prices by measuring their correlation to speculative indices and the overall market, growth of open interest and rate of growth, and change in composition of market participants. Cheng and Xiong’s work provides a robust preliminary framework to conduct further quantitative research on the matter. Their concluding remarks establish that research should focus on how financialization alters economic mechanisms of commodities, rather than these mechanisms being static as suggested by the theoretical models.

Tang and Xiong (2012) make use of similar empirical frameworks to the previous study. They look at the co-movement between oil and non-energy commodities over time by analyzing the correlation between the rolling returns of oil with varying non-energy commodities in the S&P GSCI index. By excluding commodities not included in the GSCI they are able to examine whether financial instruments like the GSCI index have a spillover effect into the commodities themselves and thus establish a link between financialization and commodity prices. While their study was thorough in its quantification of these correlations, it leaves room for further research into correlation between the overall market’s volatility and the volatility of these commodities.

Mayer and Gareis (2010) address the topic by looking at commodity volatility and how it impacts developing economies. They chose to look at both unconditional and conditional price volatility of an assortment of commodities over incremental time periods. In doing so, any trends that may be attributed to financialization become apparent. Use of conditional volatility (GARCH Modeling) enabled them to conclude that changes in recent commodity volatility are not merely transitory but structural alterations to volatility of commodities. As with Tang and

Xiong (2012), the authors here have noted spillover effects between commodities and the equities market. As with the previously mentioned works, this presents a compelling method by which volatility may be measured and correlated to other markets, namely the use of GARCH to measure any link between commodities and equities given the increased participation of non-commercial traders.

As a point of contention, the results found by Bhardwaj et al. (2015) counter that found by the aforementioned research. They looked at a larger dataset going back to 1959 whereas the other studies look at a much shorter time span. In their findings, correlations between commodities and the overall market varied greatly over time and tended to be highly correlated during times of high economic risk or crisis only. They also make use of CFTC data on commodity futures traders and conclude that the composition of traders has not changed much, hence financialization does not seem to have as large an impact as it is made out to have.

## III. Results

To understand the implicit changes to a market caused by financialization, it is important to first delineate the types of participants in the futures market. Within the commodities market, there are both commercial traders, who have a business use for the traded commodity, and non-commercial traders, those who seek to profit from speculatively trading the commodity. Given the central premise of financialization, it would be expected to see increased non-commercial traders in commodity markets. Indeed, Cheng and Xiong (2013) find through data from the Commitment of

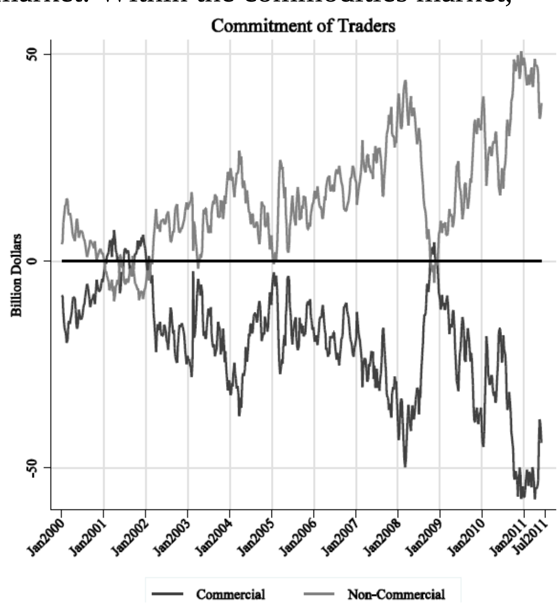


Figure 1. Commercial vs. Non-Commercial traders in GSCI (Cheng, I., & Xiong, W. (2013))

Traders report that the aggregate net notional value of 18 GSCI commodities exhibits a steady increase of non-commercial traders and decrease of commercial from January 2000 to July 2011 seen in figure 1.

The drastic increase of non-commercial money into commodity futures suggests an increase in speculative interest in the domain. Indeed, even when looking at these commodities one by one, this noticeable gain in commodity speculation is apparent. Yardeni and Quintana (2018) report on all commodities and their respective non-commercial net positions. Figures 2 and 3 from Yardeni et al. echo this information in the crude oil market with the increase in speculators and decrease in commercial interests.

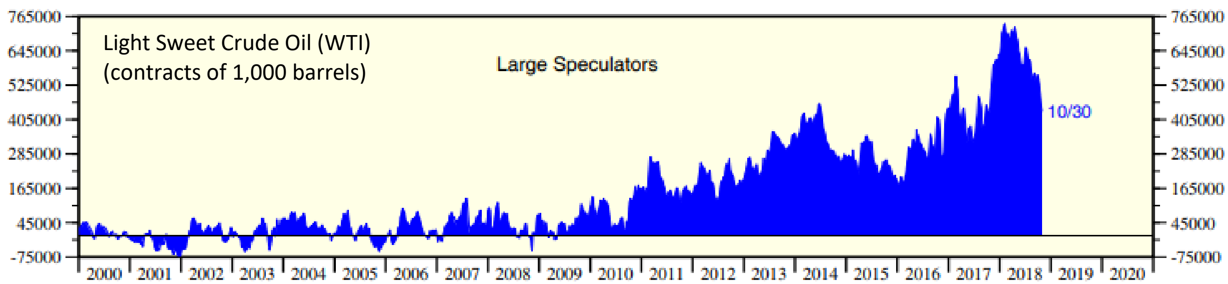


*Figure 2. Large Speculators in WTI Crude Oil, Yardeni and Quintana (2018)*

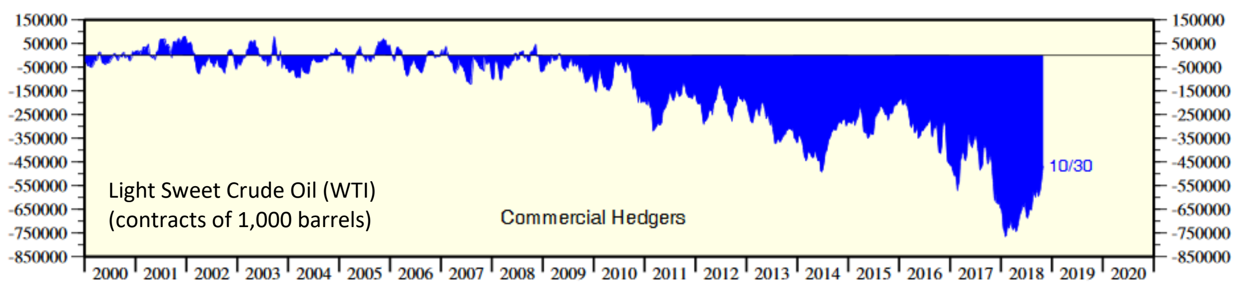


*Figure 3. Commercial Hedgers in WTI Crude Oil, Yardeni and Quintana (2018)*

However, it is important to note this is not the case in all markets, such as the Wheat market, where the opposite is true. Figure 4 shows an inverse case, where large speculators have generally left the wheat market and commercial hedgers have maintained the majority.

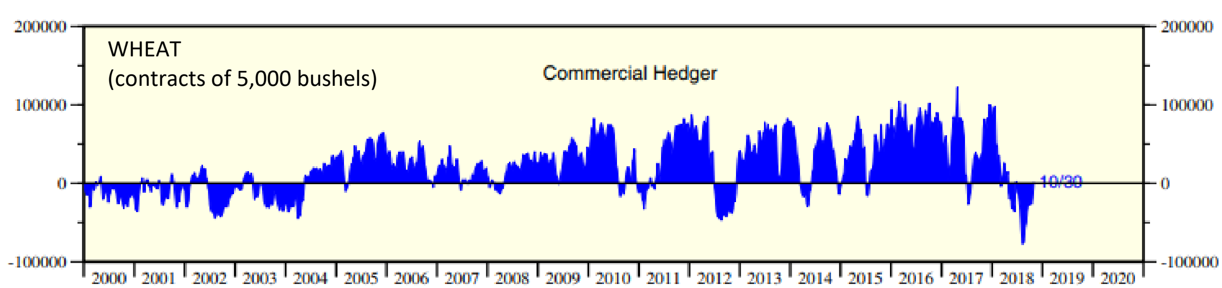

*Figure 4. Large Speculators in Wheat, Yardeni and Quintana (2018)*

In determining a link between crude oil (CL) and S&P 500 (ES) futures, a preliminary test of correlation is performed between the two assets. Using Quantopian's platform, daily historical data on each asset dating back to 2002 is collected. A simple daily percent change is done to normalize each data set, and the rolling 252-day Pearson correlation coefficient between similar elements in each set defined as:

$$r_i = \frac{\sum_1^{252}(x_j - \bar{x})(y_j - \bar{y})}{\sqrt{\sum_1^{252}\left(x_j - \bar{x}\right)^2 * \sum_1^{252}\left(y_j - \bar{y}\right)^2}}$$

Where $r_i$ is the rolling correlation coefficient at row *i* for *i = 1, …, length(data),* $\bar{x}$ and $\bar{y}$ are the means at every 252-day interval, $x_j$ and $y_j$ are *x* and *y* values for *j = 1, …, 252.* A simple Ordinary Least Squares model is fitted to display a basic trend. The results are as follows:

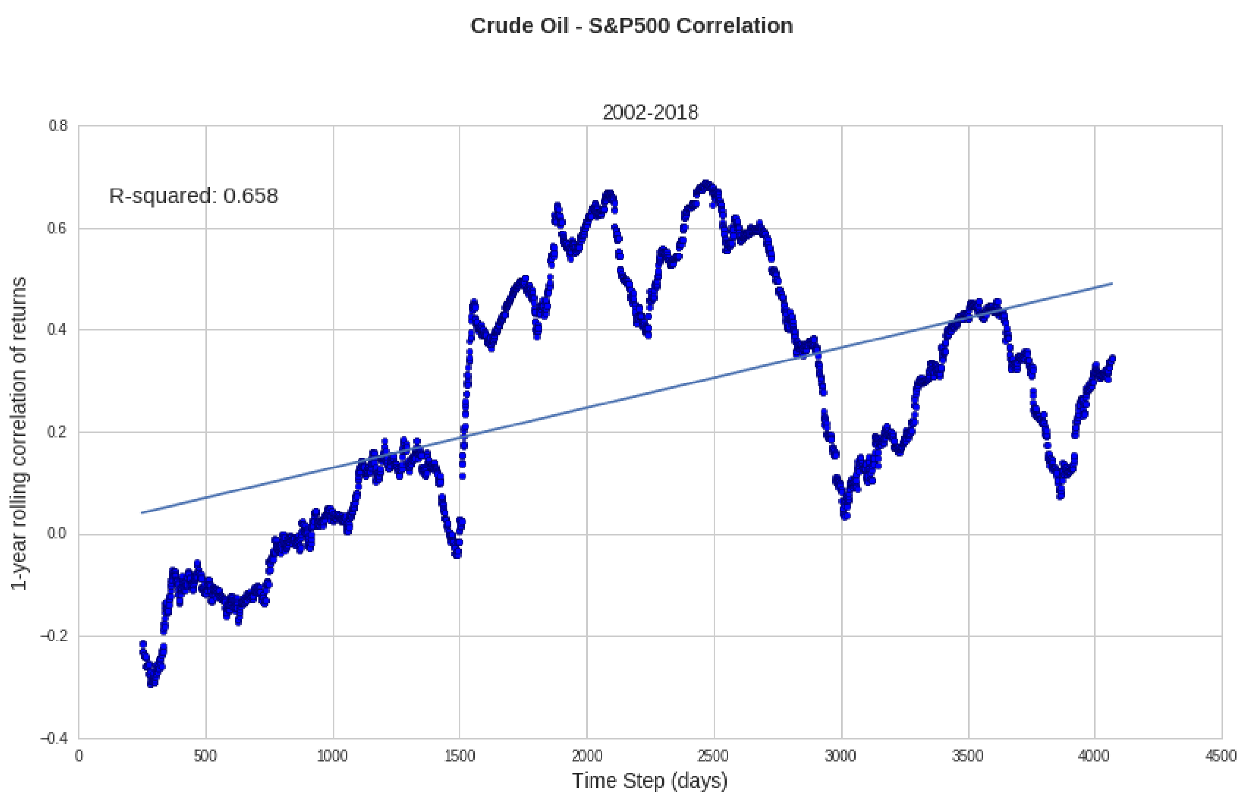

*Figure 5. One-year rolling correlation between CL and ES future contracts*

A noticeable upward trend in the correlation between crude oil and S&P 500 futures is present in figure 5, maxing out in November of 2012 with a coefficient of 0.689. The line of best fit displays the continual upward trend in correlation over the past 16 years. There is also a significant drop off in correlation around the start of 2015 and again at 2017 which corresponds to drop offs in large speculators seen in Figure 2 and the increases in commercial traders in Figure 3 at similar times. While this preliminary analysis shows the two assets are indeed correlated, it does little in the way of presenting evidence that they co-move; this basic correlation does not prove causality or that one asset's movements affects the others.

To more definitively prove co-movement, wavelet coherence analysis will be introduced. Wavelet coherence is a method by which two time-series may be studied in time frequency space to determine any co-movement between the them. A wavelet as defined by Valens (1999) is as follows:

$$\Psi_{s,\tau}(t) = \frac{1}{\sqrt{s}}\Psi\left(\frac{t-\tau}{s}\right)$$

Where $\Psi(t)$ is a single basic wavelet or "mother wavelet", s is a scaling factor, and $\tau$ is a translation factor. This wavelet signal is scaled and transformed to express parts of a time series on a given interval in a similar fashion to Fourier transformations as stated by Torrence & Compo (1998). From this, the continuous wavelet transformation is expressed as:

$$\gamma(s,\tau) = \int f(t)\psi^{*}_{s,\tau}(t)dt$$

Here, $f(t)$ is the function to be transformed, * denotes complex conjugation, $\psi^{*}_{s,\tau}(t)$ is the set of wavelets used to decompose $f(t)$, and $\gamma(s,\tau)$ is the transformed series with scaling and translation factors $(s,\tau)$ respectively. In the conventions presented by Torrence and Compo

(1998), this continuous wavelet transform can be reformed as the convolution of $f(t)$, which will be restated as a discrete sequence $x_n$ with $n = 1, \dots, N$, and normalized:

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} * \sum_{n'=0}^{N-1} x_{n'} \psi^* \left[\frac{(n'-n)\delta t}{s}\right]$$

In this case, s is still a scaling factor, $\delta t$ is a uniform time step, $n'$and $n$ are localized time indices, and $\sqrt{\frac{\delta t}{s}}$ is the normalizing factor in this form. If another function $g(t)$ is introduced and expressed as a discrete sequence, $y_n$ with $n = 1, \dots, N$ then $W_n^Y(s)$ is the continuous wavelet transform of this new sequence. With this, we can define a cross wavelet transformation between the two sequences $x_n$ and $y_n$ as $W_n^{XY}(s) = W_n^X(s) * W_n^{Y*}(s)$ where * again signifies complex conjugation. Finally, we can use this cross wavelet transform to construct the wavelet coherence described by Grinsted et al (2004)

$$R_n^2(s) = \frac{\left|S\left(s^{-1} W_n^{XY}(s)\right)\right|^2}{S(s^{-1}|W_n^X(s)|^2) * S(s^{-1}|W_n^Y(s)|^2)}$$

where S is a smoothing operator. Grinsted et all (2004) also comment on the resemblance of the coherence to the Pearson correlation coefficient, however, the coherence is localized in time and frequency allowing it to better capture co-movements between sequences.

In the wavelet coherence between crude oil and S&P500 futures, each time series is first made stationary through first-order log differencing and their stationarity is confirmed by an augmented Dickey-Fuller test. The coherence is calculated using the *biwavelet* library for R created by Gouhier et al (2018). Once the coherence is calculated a contour plot can be constructed as such:

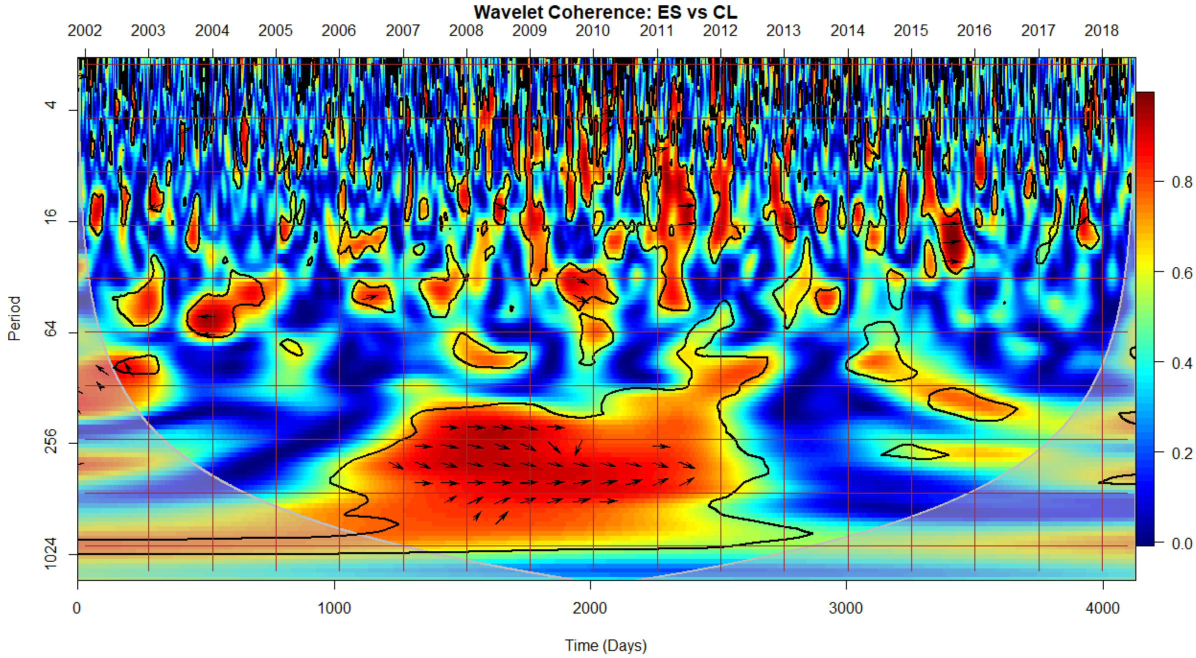


*Figure 6. Wavelet Coherence contour plot of ES on CL*

Figure 6 displays the coherence between CL and ES. The warmer colors indicate high co-movements while cooler colors show the opposite. The shaded parabolic cone is the cone of influence that filters out areas that are not significant at the 95% level. The Period axis represents the intervals for which coherence is measured (e.g. daily, weekly, yearly, multi-yearly, etc.) while the Time axis is a simple time-step of one day. The directional arrows indicate the phase lag (how much and in what direction ES leads CL) of CL futures with respect to ES futures implying that CL follows ES as time progresses. There is a clear band of high coherence at the 256 to 1024 period levels suggesting that the yearly and multi-yearly co-movement between CL and ES is very strong. Even at smaller periods there is banding of high coherence although it is more intermittent signifying there is more correlation during certain time intervals and decays shortly after. This data does a reasonable job at displaying evidence for co-movements in price, but to see if there is volatility spillover from ES into Cl a coherence between each of their respective volatilities can be constructed.

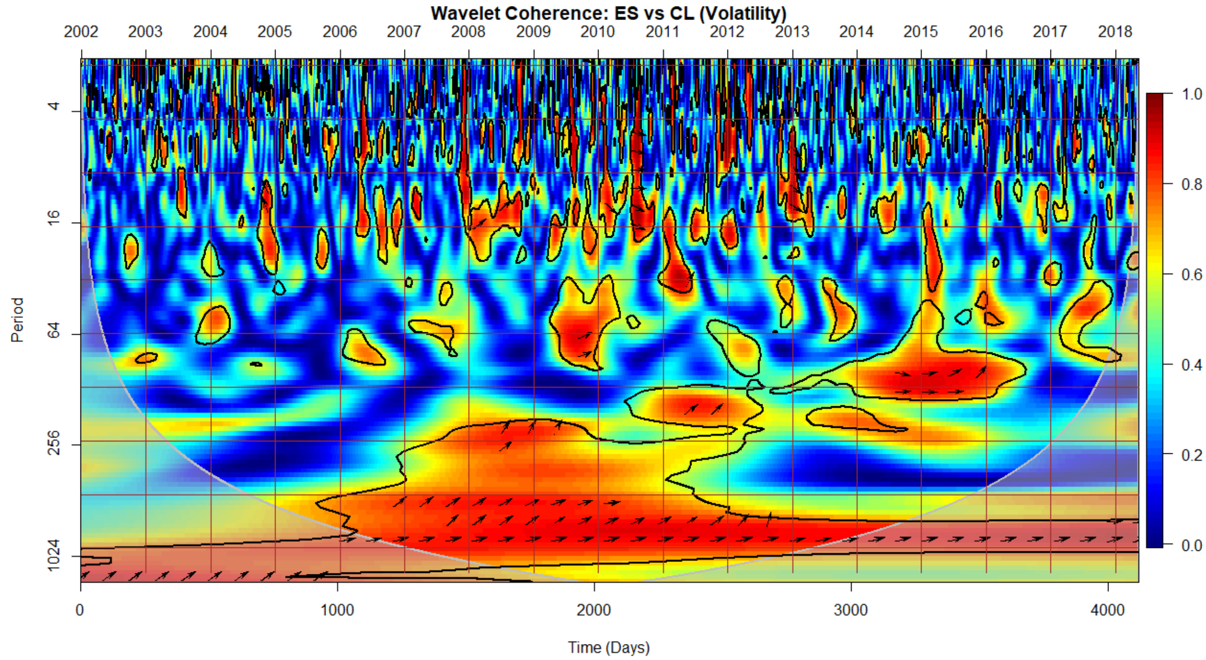


*Figure 7. Wavelet Coherence contour plot of ES on CL (Volatility)*

Figure 7 is the contour plot of ES volatility on CL volatility calculated identically as in figure 6. The volatility for each futures contract is a simple 252-day (yearly) volatility. Each contract's volatility is already stationary, thus no detrending is necessary. The contour plot visibly shows a significant band of coherence from the 256 to 1024 period with the 1024 period being the most spread out. As with figure 6, there is intermittent high coherence at lower periods from 1 to 64 period levels.

## IV. Conclusions

The findings from this research seems to be in congruence with findings from many of the previously established notions of financialization's effects on markets. The rising correlation between crude oil and the S&P500 prices seen in figure 5 is an interesting point and can be useful in guiding investment decisions. This alone, however, is not enough to convincingly state that the two contracts are indeed strongly linked or that there is spillover from one market into the other. The major thing to be taken from figure 5 is the relationship between directional movements has seen a general increase over the past 16 years suggesting deeper analysis be done.

In the wavelet coherence analysis, a deeper and more robust method is employed to determine whether these two contracts co-move and which one drives the movement. Figure 6 displays the coherence between ES and CL and suggests that, at the price level, when the two are highly correlated, ES moves before of CL implying that the S&P500 futures influence crude oil movements. The contour plot also shows how there is a strong yearly coherence between the two assets that has been consistent over time (denoted by the red contour plot at the 256 period). The directional phase implies in this case that ES prices lead CL prices. It is also apparent from the results that there is recurrent coherence between the two assets at the 4 through 16 period levels meaning there are times when this coherence falls in and out of effect. Figure 7 shows the results from the coherence analysis of each asset's volatility which lead to similar conclusions. There is a strong multiyear coherence in their volatilities around the 1024 period level with the phase lag (arrows) once again indicating ES leads CL even in volatility. From this, we can say that there is a lasting spillover effect of volatility from ES into CL. Even at smaller periods there is once again recurrent spillover from ES into CL as depicted by the alternating bands of high and low coherence at the 1 to 16 period levels.

The implications of these findings propose a new view of investment. For those who are commercial hedgers in industries dependent on oil, they must analyze volatility from the overall market – given that the ES futures represent to a high degree the overall market – to better understand the long-term effects of their hedging and better optimize their strategy. Even from the perspective of speculators, their increased presence in the oil market has clearly altered its behavior and so they must also revise their investment strategies to better optimize returns.

Given that the drastic increase in large speculators has occurred alongside this more recent co-movement between these two assets, it may be cause for legislators to review this link. Since oil prices can affect consumers and oil-dependent producers, it may prove beneficial to limit the exposure of the oil market to large speculators. This brings up the first limitation to this research, namely that the results of this study do not necessarily show whether this strong co-movement in price and volatility is bad or not. An industry-level study of commercial hedgers might be more useful to that end. This study also looks at one pairing of assets and doesn't not imply this as a trend amongst commodity futures. While other research mentioned in the literature review finds correlations between other commodities and the overall market, more rigorous proof of co-movements has not been presented in the discussed literature. In this regard, further research perhaps utilizing wavelet coherence analysis could be conducted for other commodity futures. It could also be an area of interest to investigate more high frequency connections between commodities and the market by analyzing market microstructure of commodities for a given change in the overall market.

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