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On the Interaction between the Crude Oil Market and the Macroeconomic Activity: How do the 2000s differ from the 70s?

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Abstract

In this paper, the Cheung-Ng procedure and the rolling correlation method are used to examine how the connection between the crude oil market and the macroeconomic fundamentals of the 2000s differs from the 70s. Our findings show that the economic meltdown (e.g. 2007-08) becomes positively correlated with oil price changes. Indeed, from the 90s the role of oil supply shocks is attenuated compared with the role of aggregate demand to drive the oil price volatility. Hence, the US economic recession leads to rising oil price volatility in the long-term. Therefore, the earlier macroeconomic dynamics permit better forecast of oil market volatility. Inversely, during the 2000s, the macroeconomic variables are found to be strongly and positively influenced by the crude oil price changes in the short-run. Interestingly, the connection of oil prices with the inflation is not really weakened in the 2000s compared with the 1970s in the US.

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Keywords: Rolling correlation, Cheung-Ng procedure, Crude oil, Macroeconomic cycle, Volatility spillovers.

1 Introduction

An extensive literature emerged increasingly from the 1970s on the subject of the impact of oil price volatility on the real economy. Since the pioneering study of Hamilton (1983), many previous empirical investigations including those of Burbidge and Harrison (1984),

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Grisser and Goodwin (1986), Mork (1989), Mory (1993) Mork et al. (1994), Mussa (2000), have commonly argued that oil shocks have a large negative impact and an asymmetric effect on the economic activity. Lardic and Mignon (2008) used the asymmetric cointegration technique developed by Balke and Fomby (1997), Enders and Dibooglu (2001), Enders and Siklos (2001) and Schorderet (2004). The results showed that there is a long-run relationship between oil prices and GDP. The authors emphasized the existence of a nonlinear asymmetric cointegration between these two variables and rejected the standard cointegration evidence. In this line, Naifar and Al Dohaiman (2013) studied the impact of oil price changes on stock returns in the Gulf Cooperation Council (GCC) countries using Markov regime-switching model. They also examined the non-linear interaction between the three variables, namely oil price, interest rates and inflation rates during the period of the subprime crisis applying Archimedean copula models. The results prove that the connection between GCC stock returns and OPEC oil price volatility is regime dependent. Moreover, during the recent financial crisis, the authors detected a symmetric dependence between oil markets and the short-term interest rate, whereas they found an asymmetric dependence between oil markets and the inflation rates.

Although the positive oil shocks contribute to the major economic recessions in the U.S. Hamilton (1983), this finding is not obvious in the recent literature. In fact, Blanchard and Gali (2007) confirmed that recently the oil crises influence moderately the global economy. Obviously, the authors noted that this assertion is due to some plausible causes, namely the decline of the rigidity of the real wage, the improved credibility of the monetary policy and the abatement of oil share in production and consumption. In this line, Zaouali (2007) studied the case of China, which is ranked the second largest consumer of oil in the world. The author proved that the rising price of oil affects moderately the China’s economy. This finding is justified through two evident strengths, which are the investment and the flow of foreign capital. More recently, Cavalcanti and Jalles (2013) investigated the impact of oil shocks on inflation rate and rhythm of economic activity in Brazil and the United States during the last 30 years. The authors found that both inflation and output growth rate volatility has been decreasing in the US. Although the Brazilian and the United States economies differ in terms of path on the oil import dependence rate, the results show that the contribution of oil price shocks to output growth volatility has been decreasing over time in both Brazil and the United States. In addition, oil price shocks account for a large fraction of inflation volatility in the US, whereas oil shocks account for a small fraction of inflation volatility in Brazil. In a recent study in Turkey, Çatık and Önder (2013) investigated the asymmetric connection between the economic activity and oil markets by means of a Threshold VAR (TVAR) model. Their paper contradicts the existing studies and proves the existence of nonlinear and asymmetric linkage between oil prices and macroeconomic activity in Turkey. The analysis results suggest that the significant effects of oil price shocks on the macro activity as measured by inflation and output depend on a certain threshold level. Indeed, only the oil shocks exceeding an optimal threshold level lead to a contraction in the Turkish economy.

While the impact of the volatility of oil prices on the global economy is mitigated, the economic slowdown and the recessions remain the common consequences of the oil shocks Hamilton (2009a). In a more recent paper, Chen et al. (2014) applied the Kilian's two-step approach and found that the exogenous shocks that arise from the movements in financial market conditions create changes in oil prices, which have a valuable impact on the macroeconomic fluctuations. In fact, the authors identified the financial shock as a main source of macroeconomic changes.

Sadorsky (1999) studied the bidirectional relationship between the oil price dynamics and the economic activity in the case of the U.S, as the biggest oil consumer on the international scale. The author strongly supported that there is an asymmetric effect running from the oil prices to the real economy. Inversely, Sadorsky (1999) neglected the effect of the real economic activity on the oil market returns. Moreover, the majority of studies neglected the exogeneity of macroeconomic activity dynamics with respect to the oil price movements. Interestingly, this assumption has been substantiated in a few existing studies (see Bloomberg and Harris (1995), Sadorsky (2000), Barsky and Kilian (2004) and Ewing and Thompson (2007)). In fact, the exogeneity of macroeconomic activity dynamics with respect to oil price movements was essentially modeled in the supply-demand framework. In this respect, on the demand side, it is well proved that the global economic activity influences the CO prices (see Askri and Krichene (2008), Wirl (2008), Hamilton (2009a), Fattouh (2007b) and He et al., (2010)). Thence, He et al. (2010) noted that many researches including those of Pesaran et al. (1998), Gateley and Huntington (2002), Griffin and Schulman (2005) and Krichene (2006) examined the dynamic responses of oil price movements to the economic activity.

In this paper, we investigate the bidirectional relationship between oil price changes and some selected macroeconomic determinants. We underline the exogeneity assumption of macroeconomic activity dynamics with respect to the oil price movements. Blanchard and Gali (2007) determined the causes behind which the macroeconomic effects of oil shocks of the 2000s are different from the 1970s and our study aims at examining how the connection between the crude oil market and the macroeconomic fundamentals of the 2000s differs from the 1970s.

In the existing literature, a number of studies considered that the macroeconomic effect of oil price shocks is linear (see for example Finn (2000) and Leduc and Sill (2004)). Other studies found that the macroeconomic response of oil shocks is nonlinear (see Kim (2009), Herrera et al. (2010) and Engemann et al. (2010)). According to Hamilton (2011), this difference is due to numerous causes: (1) Different data sets (2) Different measure of oil prices (3) Different price adjustment (4) Inclusion of contemporaneous regressors (5) Number of lags (6) The contribution of each factor and (7) Post-sample performance. Kilian and Vigfusson (2009) suggested including both the linear and nonlinear terms.

Our study is to analyze the nonlinear causal relationship between the crude oil (CO) prices and some key macroeconomic indicators. Specifically, we attempt to answer two key questions. First, do the two nonlinear causality directions exist between the CO market and the macroeconomic variables? Second, how does the interaction between the oil price movements and the macroeconomic dynamics of the 2000s differ from the 1970s? Our empirical methodology involves adopting the two-stage methodology suggested by Cheung and Ng (1996), in addition to the rolling correlation method. Our investigations focus on the U.S economy. The sample contains two CO prices, namely European Brent (Brent) and Conventional Gasoline (CG). The CG is expressed in Cents per Gallon and the Brent crude oil is libeled in U.S. dollars per Barrels. The energy data set are collected from the U.S Department of Energy named the Energy Information Administration (EIA) database. The data also include three key macroeconomic variables[3], namely the Industrial Production (IP), Inflation Rate (IF) and Unemployment (unemp) series. The sample period ranges from May 1987 to February 2009. The frequency of observations is monthly. The study period

[3]The macroeconomic indicators are collected from http://www.econstats.com/

allows to differentiate between the two periods of crises, namely the period of the 70s and the period of the 2000s.

The remainder of this study is organized as follows. In section 2 we provide some theoretical background. Then, we expose the methodological design in section 3. Thereafter, we reveal the empirical results in section 4. Section 5 reports the economic implications. In the final section, we give the summary and some concluding remarks.

2 Theoretical Channels Review

Numerous academic researches have established an appropriate theoretical framework to study the different mechanisms of transmission through which oil prices influence economic activity. Therefore, several theoretical channels are to be emphasized in order to prove that oil price dynamics affect negatively the economic activity. In this line, many authors, including Ferderer (1996), Brown and Yϋcel (2002), Bénassy-Quéré et al. (2007), Ewing and Thompson (2007), and Lardic, and Mignon (2008) distinguished different sides of these channels as follows.

2.1 The Money Supply-sides

Ferderer (1996) noted two money supply-sides. First, the inflation generated by the rising in oil prices reduces real balances, which causes the recession[4]. Second, the real output decreases are due to the counter-inflationary responses of the monetary policy to the positive oil shocks. In addition, many researchers, including Pierce and Enzler (1974), Mork (1994) and Lardic and Mignon (2006), also described the channel related to the role of the real balance. More precisely, the authors explained how the rises in oil prices cause the deceleration in the output growth. In fact, the augmentation in the oil price creates a growing money demand. As the monetary authorities could not respond adequately to the increasing money demand in presence of a growing supply, a deceleration of the economic growth happens with an increase in the interest rates[5].

2.2 The Demand-side Channel

In his seminal study, Ferderer (1996) noted, according to the demand-side channel, that there is a significant negative correlation between the oil price changes and the movements in the economic activity. The author argued that the increases in oil prices lead to the reduction of the aggregate demand. As regards this reduction, it is due to the transmission of wealth to the oil exporter countries at the expense of the net oil importer countries (see also Krugman (1980), Golub (1983), Bénassy-Quéré et al. (2007) and Ewing and Thompson (2007)). So, the importer countries are forced to cut down on their spending of consumption. In this respect, by reference to Dohner (1981), Lardic and Mignon (2008) explained that the income transfer from the oil importer to the oil exporter countries is due to the deterioration of the terms of trade of the affected countries after the oil price increases. This is because oil is the principal determinant of the terms of trade Bénassy-Quéré et al.

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[4]For more details about the theoretical issue, which is why the increases in oil prices coincide with the deceleration of the output growth and the rising inflation, see Brown and Yϋcel (2002).

[5]In this line (Brown and Yϋcel, 2002) give details concerning the role of the monetary policy.

(2007).

Additionally, according to Hui-Siang Brenda et al. (2010), it is shown that the loss of income in the net importing countries leads to a slowdown of the aggregate demand, which is likely to be reduced with the purchasing power. In such severe and difficult conditions, the investors await the improvement of the investment environment. This behavior could decelerate the investment because of the uncertainty regarding the future performance of the economic activity Bernanke (1983). At this regard, it is needed to comprehend the oil price behavior in order to avoid the investment risk in oil inventory. The possible adverse consequences and the negative effects are accentuated when the oil is the essential and the only energy source in the economy. In following this line, Bernanke (1983) and Ferderer (1996), explained the channel related to oil price uncertainty. Indeed, the authors found that the oil price uncertainty grows when the firm faces the dilemma: investing in oil-incentive sectors or in non-oil-incentive sectors. This leads to augment the value of option and reduce the motivation to invest. As a result, in order to make the profitable choice of investment the firm awaits the pertinent information which makes costs to the firm. (See also Lardic and Mignon (2006)).

2.3 The Supply-side Channel

It is well documented in the existing theoretical survey (see Hamilton (1988), Ferderer (1996), Bénassy-Quéré et al. (2007) and Hui-Siang Brenda et al. (2010) that oil price changes influence the economic activity via the supply channel. Indeed, in the case where oil is the basic input in the process of production, the increase in oil prices leads to increase the cost of production. At this regard, the availability of oil declines since the oil producers diminish their energy consumption. As a result, the productive capacity of the economy decreases. Given the inefficiency of the productivity the potential output decreases. Furthermore, according to Hamilton (1988), it is considered that the drop in the production output that happened after the increase in oil prices is likely to decline the labor demand in the sectors that are facing difficulties. Then, the inefficiency of the productivity leads to the output growth deceleration.

2.4 The Oil Price Level

Ferderer (1996) to explain how changes in oil prices determine the economic activity underlines another channel derived from the role of oil price level. This channel is based on the sectoral shocks literature. Hence, by reference to Hamilton (1988), Ferderer (1996) indicated that the aggregate employment decreases after the relative price shocks. Indeed, motivating workers to stay unemployed is better for the economy than integrating them in domains different from theirs. It is also "*costly to shift capital input between sectors*" (Ferderer (1996, p. 3). Consequently, Ferderer (1996) added according to Lilien (1982) that the excessive changes in the relative price lead to increase the aggregate unemployment. Additionally, many previous studies examined the impact of changes in oil prices on the labor market (For a review of the literature, see (Loungani (1986), Caruth et al. (1998), David and Haltiwanger (2001), Keane and Prasad (1996) and Kandil and Mirzaie (2003)). Thus, Keane and Prasad (1996) and Ewing and Thompson (2007) found that there is a negative (positive) relationship between the oil price rises and the total employment in the short run (in the long run). Differently, Kandil and Mirzaie (2003) disapproved any impact from the energy price movements on the growth of the aggregate employment.

Exceptionally, they contended that the employment in the manufacturing sectors responds positively to the unexpected movements of energy prices.
Inversely, on the demand-side, it is found that the economic activity is a key determinant of oil price dynamics. In fact, the CO demand is strongly sensitive to the global economic fluctuations (see Fattouh (2007b)). For that reason, the expansion (recession) of the economic activity leads to the growth (decline) in the oil demand which is likely to increase (decrease) oil prices given the low elasticity of the supply. Thence, on the international scale, it is noticed that during the Asian crisis of 1997 the economic meltdown caused a dramatic drop in the oil prices, especially as the crisis coincided with high oil production from the OPEC (see He et al. (2010)). Others, like Wirl (2008) and Hamilton (2009a), noted that the oil demand component plays a key role in increasing the CO prices for the period ranging from 2004 to 2008.
To conclude, Krichene (2006) argued that there is a bi-directional relationship between the monetary policy and the oil price shocks. The direction of interaction depends on whether the shock is an oil-demand or an oil-supply shock. Indeed, in the case of a supply shock[6], the oil price fluctuations influence the interest rates. Conversely, in the case of a demand shock[7], the interest rate fluctuations influence the oil prices.
In sum, there is a variety of empirical methodologies that focused on the interactive relationship between the oil price movements and the macroeconomic activity. These methodologies used different samples with different economic determinants. Therefore, diverse results are obtained from the active academic researches (Ewing and Thompson (2007)).

3 Methodological Considerations

In this study, the Cheung and Ng approach is used in order to estimate the lead/lag relationships between the CO market and the macroeconomic fundamentals. The nonlinear approach reveals new information that are not taken into account in the traditional linear tests of causation to the extent that the necessary time to assess the new information and coordinate the economic policies are estimated by means of the causality in variance. The CCF methodology developed by Cheung and Ng (1996) consists of a two-stage method, which extends the procedure developed in Haugh (1976) and McLeod and Li (1983) Cheung and Ng (1996, p. 34). The first stage is to estimate the univariate time series models in order to allow for time variation in conditional means and variances. In the second stage, the residuals and squared residuals standardized by conditional variances are then constructed. Their cross-correlations are used in order to test the null of no causality in mean and no causality in variance, respectively. Hence, for modeling of the time-varying volatility, an estimation of nonlinear ARCH-type models needs to be conducted.
So, according to the methodology suggested by Box and Jenkins (1970), ARMA type processes are estimated to analyze the stationary series in order to estimate the mean equation. Equation (1) illustrates the ARMA model expression as follows:

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[6]The shock of oil-supply happens when in ordinary conditions of demand, exogenous events could lead to oil supply instability (see Krichene (2006)).
[7]The shock of oil-demand happens when in ordinary conditions of supply; some endogenous events could lead to oil demand disturbances. (See, Krichene (2006)).

$$X_t = C + \sum_{i=1}^{2} \rho_i X_{t-i} + \sum_{i=1}^{2} \theta_i \varepsilon_{t-i} + \varepsilon_t \tag{1}$$

The ARCH process proposed by Engle (1982) tests the null hypotheses of no conditional heteroscedasticity. Therefore, the residuals $\widehat{\varepsilon_t}$ obtained from the estimation of the ARMA model are then analyzed using the following regression:

$$\widehat{\varepsilon_t^2} = C + \sum_{i=1}^{q} \alpha_i \, \widehat{\varepsilon_{t-\imath}^2} \tag{2}$$

Once the alternative of no conditional heteroskedasticity is rejected, the mean and the variance equations are estimated simultaneously by adopting the maximum likelihood technique. Five models are estimated, namely the ARCH (p), GARCH(1,1), GARCH(1,1)-M (GARCH in mean), EGARCH model (exponential GARCH model) of Nelson (1991) and TGARCH model (Threshold GARCH model) introduced by Zakoian (1991). EGARCH and TGARCH models are applied to test for asymmetric volatility. The diagnostic statistics and the criterions:$\overline{R^2}$, Log Likelihood, Akaike and Schwarz are used to select the appropriate model for each time series.

The use of the ARCH-family models for analyzing movements in the volatility of time-series data is interesting insofar as it permits to estimate with accuracy the parameters by correcting for outliers. In fact, if no corrections are made, the problem of spurious regression may occur.

The GARCH (p,q) process can be written as follows:

$$\sigma_t^2 = C + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{3}$$

The GARCH-M model is under the form below:

$$\begin{aligned} \phi(L) Y_t &= \Theta(L) \varepsilon_t + \delta \sigma_t^2 \\ \sigma_t^2 &= C + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \end{aligned} \tag{4}$$

The EGARCH (1, 1) model is given by:

$$\ln \sigma_t^2 = C + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta ln \sigma_{t-1}^2 \tag{5}$$

The TGARCH (1, 1) model can be specified as follows:

$$\sigma_t = C + \alpha_1^+ \varepsilon_{t-1}^+ - \alpha_1^- \varepsilon_{t-1}^- + \beta \sigma_{t-1} \tag{6}$$

The standardized residuals: ε_t and ξ_t for the crude oil price returns and the macroeconomic variables, respectively are given, according to Cheung and Ng (1996), as follows:

$$U_t = \left[\frac{(r_t - \mu_{r,t})^2}{\sigma_{r,t}^2}\right] = \varepsilon_t^2 \quad (7)$$

$$V_t = \left[\frac{(r_t - \mu_{r,t})^2}{\sigma_{r,t}^2}\right] = \xi_t^2 \quad (8)$$

Where $\hat{r}_{UV}(k)$ and $\hat{r}_{\varepsilon\xi}(k)$ are the sample cross-correlation of both the squared standardized residual and the standardized residual series at lag (k), respectively. The causality in variance (CV) and the causality in mean (CM) tests are given by: $r_{UV}(k)$ and $r_{\varepsilon\xi}(k)$, respectively. Under the null hypothesis of non-causality in variance (in mean) against the alternative of causality in variance (in mean) at a specified lag (k), the corresponding CCF test statistics can be written respectively as follows:

$$CCF - statistic = \sqrt{T} r_{UV}(k) \quad (9)$$

$$CCF - statistic = \sqrt{T} r_{\varepsilon\xi}(k) \quad (10)$$

With T the number of observations.

The term ‘lag’ indicates the number of periods that the petroleum price returns lag behind the macroeconomic indicators whereas the term ‘lead’ indicates the number of periods that the petroleum prices lead the macroeconomic indicators. The non significance of the CCF statistics in the “lag” line is an indicator of non causality which runs from CO product prices to the macroeconomic indicators. Likewise, if the CCF statistics in the “lead” line are not significant, this indicates that the macroeconomic variables do not cause the petroleum price returns. The squared standardized residuals and the standardized residual “levels” are used to test the causality in variance (CV) and the causality in mean (CM) hypotheses, respectively. The CCF test statistics are calculated for 15 “leads” and 15 “lags”.

4 Empirical Analysis Results

4.1 Preliminary Analysis

The results of Table 1 indicate that there is a strong positive correlation between crude oil products and macroeconomic determinants. Contrarily, there is a weak negative correlation between oil prices and unemployment.

Table 1: Correlation matrix between US CO product spot prices and macroeconomic indicators

	Brent	CG
IP	0.646	0.659
IF	0.705	0.715
unemp	-0.180	-0.202

In order to determine the order of integration of series three tests are applied, namely the Augmented Dickey Fuller (1981) (ADF), the Phillips-Perron (1988) (PP) and the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests. The (ADF) and the (PP) take into account the heteroskedastic errors. They both reject the null hypothesis of unit root for the series in first difference. However, they fail to reject the null of unit root for the series in level. Therefore, all the series in level are I(1). These findings are confirmed by the KPSS test results. Indeed, the LM statistics of the series in level are greater than the critical values but those of the series in first difference are less than the critical values at 1%, 5% and 10% significance levels. This is for both specifications. So, we reject the null hypothesis of stationary series in level. Nonetheless, the KPSS test fails to reject the null hypothesis of stationary series in first difference. The results are displayed in Table 2. For the rest of the analysis, we use the first differences for all the variables. Therefore, we consider the form below for all the series under investigation:

$$r_t = 100 \times ln\left(\frac{P_t}{P_{t-1}}\right) \quad (11)$$

Table 2: ADF, PP and KPSS test results for US CO product spot prices and macroeconomic indicators

	Brent	CG	IF	IP	unemp
			Series in levels		
ADF					
CT	-2.6028	-3.092	-2.541	0.562	-2.498
C	-1.3870	-1.860	-2.805	-1.891	-2.7064
None	0.3116	0.183	6.689	3.0036	0.0376
Lag	p=4	p=1	p=1	p=2	p=1
PP					
CT	-2.6678	-2.766	-2.598	-1.215	-1.459
C	-1.5197	-1.652	-3.488	-1.7107	-1.819
None	0.2100	0.283	11.019	2.284	0.3305
KPSS					
CT	0.7783	0.770	0.714	0.6118	0.321
C	2.9331	2.913	4.350	4.303	1.01406
			Series in first difference		
ADF					
CT	-10.1624***	-9.338***	-7.935***	-11.280***	-15.822***
C	-10.1779***	-9.357***	-7.383***	-11.071***	-15.789***
None	-10.1865***	-9.360***	-4.370***	-10.604***	-15.814***
Lag	p=1	p=2	p=2	p=2	p=0
PP					
CT	-12.0135***	-13.954***	-10.226***	-31.072***	-16.690***
C	-12.0354***	-13.984***	-9.876***	-30.572***	-16.591***
None	-12.0498***	-14.0037***	-6.497***	-29.3005***	-16.621***
KPSS					
CT	0.04466***	0.0448***	0.135***	0.131***	0.120***
C	0.05601***	0.049***	0.862***	0.373***	0.265***

Notes: (CT) corresponds to the estimation of the model with constant and linear trend. (C) corresponds to the estimation of the model with constant but no linear trend and (None) corresponds to the estimation of the model without constant or trend. (p) represents the lag length. The truncation lag is set to 4 in the Philips-Perron test. The truncation parameter value is set to 5 in the KPSS test. *, **, *** significant at 1%, 5% and 10% critical levels, respectively.

Table 3 reports the descriptive statistics for all the return series. The results show a strong evidence of high volatility that evolves over time and changes the σ^2. This finding suggests that all the data set exhibit a conditional heteroskedasticity process. According to the mean and the standard deviation results, we deduce that the CO prices are more volatile than the macroeconomic indicators. The skewness statistic results are consistent with an asymmetric distribution. Indeed, the distributions of most of the return series are skewed to the left. This finding can also be an indicator of nonlinearity. In addition, the kurtosis statistics show that all the data set are highly leptokurtic. According to the Jarque-Béra (1979) test statistics and their corresponding *p-values*, the null hypothesis of normality is strongly rejected for the entire sample.

Table 3: Descriptive statistics

statistic	Brent	CG	IF	IP	unemp
N	261	261	261	261	261
Mean	0.325400	0.309819	0.047934	0.175633	0.144737
Median	0.144823	1.136947	0.047481	0.198798	-1.801851
Std. dev.	9.230529	10.60056	0.051020	2.062701	6.816836
Skewness	-0.034500	-0.450480	-1.405216	-0.005909	1.017565
Kurtosis	5.546803	4.240093	14.55421	3.201455	4.263888
Minimum	-31.09554	-40.35870	-0.313903	-4.889300	-19.84509
Maximum	45.89497	31.73241	0.258876	5.501214	23.92297
J-B	70.58925	25.55148	1537.706	0.442872	62.41340
Probability	0.000000	0.000003	0.000000	0.801367	0.000000

Notes: For N time series observations we consider, Std. dev., which is the standard deviation. J-B is the Jarque-Béra test statistics of normality.

4.2 Cheung-Ng approach and the rolling correlation method

4.2.1 ARCH type model estimation

In this subsection, the non linear ARCH-type models are employed for modeling the time varying volatility. So, the mean equation is estimated using the ARMA type processes (See equation 1). From the results in Table 4, it is found that an MA (1) is chosen for Brent and Inflation rate series. MA (2) is chosen for Conventional Gasoline prices, whereas AR(1) and AR (2) processes are selected for WTI crude oil spot prices and industrial production series, respectively. In addition, ARMA (2, 2) process is chosen for unemployment series. The residuals $\widehat{\varepsilon_t}$ generated from the ARMA model estimation are then tested for the presence of homoskedasticity using the ARCH model proposed by Engle (1982) (see the regression in equation 2).

The estimation results indicate that we reject the null hypothesis in favor of the alternative of conditional heteroskedasticity for all data series. Thus, the mean and the variance equations are simultaneously estimated using the maximum likelihood technique (See Table 4).

According to the diagnostic statistics and $\overline{R^2}$, Log Likelihood, Akaike and Schwarz criteria, the ARCH(1) model is chosen for Brent, WTI, CG and unemp returns, whereas, GARCH(1,1) is selected for Inflation rate. Moreover, GARCH(1,1)-M is chosen for

Industrial production data set.

In the existing literature, GARCH (1,1) model is found to be the best fit for modeling the monthly inflation rate in Turkey (Nas and Perry (2000)). In addition, GARCH (1,1)-M provided the best-fitting model for the monthly data of real output (Nas and Perry (2001)). Khalafalla (2010), found that EGARCH (1,1) is chosen among ARCH-M, GARCH, and EGARCH models to estimate the uncertainty of inflation. For modeling the unemployment rate, Ewing et al. (2005), used the ARCH-class models, namely ARCH, GARCH and TGARCH models.

Table 4: ARMA-ARCH/GARCH/GARCH-M processes for US CO prices and macroeconomic indicators

	Brent	CG	IF	IP	unemp
C	0.605071 (0.923229)	0.509904 (0.923880)	0.047190 (16.70316)	-2.903846 (-6.47562)	0.060134 (0.145233)
C	54.12766 (7.583166)	88.11260 (12.72525)	2.76E-05 (1.072516)	0.828139 (3.444510)	45.12262 (10.00961)
Φ_1				-0.711711 (-14.9117)	0.116530 (0.184843)
Φ_2				-0.150436 (-3.40727)	-0.008223 (-0.01653)
Θ_1	0.273428 (4.168602)	0.109098 (1.520407)	0.389917 (6.145377)		-0.209481 (-0.33416)
Θ_2		-0.235941 (-3.41680)			-0.132457 (-0.25198)
GARCH in mean				2.735749 (6.923142)	
α_1	0.321111 (3.600038)	0.142759 (2.102061)	0.160458 (5.045467)	-0.073863 (-5.57943)	-0.079616 (-3.14730)
β_1			0.858733 (31.71157)	0.761191 (8.360644)	
R^2	0.068717	0.040600	0.192205	0.311856	0.020791
LL	-929.8439	-972.2358	471.3161	-502.5358	-850.8784
AIC	7.155892	7.488397	-3.573303	3.934640	6.624544
SIC	7.210521	7.556683	-3.505018	4.030770	6.720674
Q(15)	24.622 [0.038]	21.980 [0.056]	38.246 [0.000]	16.046 [0.247]	269.60 [0.000]
$Q^2(15)$	14.181 [0.436]	8.5103 [0.809]	7.7999 [0.899]	23.801 [0.033]	175.14 [0.000]
LM	0.205823	0.247559	0.087355	0.355677	1.479252

Notes: Numbers in parentheses are t-Student statistic. Numbers in brackets are *p*-values. Q(15) and $Q^2(15)$ are the Ljung–Box statistics for the first 15 autocorrelations of the standardized residuals and squared standardized residuals, respectively. R^2 , LL, AIC and SIC are the Adjusted R-squared, Log Likelihood, Akaike criterion and Schwarz criterion, respectively.

4.2.2 The Rolling correlation results

The object of this part is to test for the possible presence of nonlinear dependence between the U.S crude oil market and the macroeconomic cycle. In order to study how the correlation between the two sets of filtered data Cajueiro and Tabak (2004) evolves over time, the rolling correlation method is then applied to the standardized residuals from GARCH-type models. This method computes the correlation coefficient for the first window of a fixed-length (in this case the length of window contains 50 observations) and then the sample is rolled in order to calculate the second coefficient for the second window, and so forth. In our case, the second window is obtained by eliminating the first observation and taking the observations ranging from the second month until month number 51. This procedure continues up to the last window. This latter includes the last fifty observations. Hence, new time series are then obtained. Interestingly, contrarily to the single correlation coefficients, the rolling correlation method is useful because it examines how the correlation between the macroeconomic activity and the crude oil price cycle evolves in the long term (about twenty years in this study). Figure 1 illustrates the evolution of the correlation between each crude oil return and the three macroeconomic variables. As can be seen from the figure, the correlation is found to be relatively volatile mainly during the global economic crisis of 2007-2010. In addition, the rolling correlation coefficients change sign frequently over time. Indeed, there is evidence of a time-varying correlation between the crude oil product returns and the macroeconomic variables. In particular, it is clearly noticed that the periods of notable positive correlations are more prolonged than the periods of negative correlations.

More precisely, the single correlation coefficients with the medians of the rolling correlation results are reported in Table 5. From the reported results, it is found that there is evidence of a strong positive correlation between the two crude oil returns and the two macroeconomic variables, namely the inflation rate and the industrial production series. Not surprisingly, a week negative correlation between the crude oil prices under investigation and the unemployment rate is detected. In sum, the results regarding the industrial production are similar to those of Farzanegan and Markwardt (2009). In fact, they found a positive relationship between the oil prices and the industrial production.

Our findings contradict those of Blanchard and Gali (2007) on the evidence of moderate effect of oil shocks on the global economy. Indeed, we detect a strong positive correlation between the CO market and the macro cycle.

Subsequently, in order to be sure that the variation of the correlation over time is not caused by the presence of white noise, the descriptive statistics for the rolling correlation results are displayed in Tables 6. In fact, most of the obtained time series are left-skewed, and platykurtic (i.e. Kurtosis less than three). Unsurprisingly, according to the Jarque-Béra (1979) test statistics, the null hypothesis of normality is rejected. In view of the above, it can be concluded that the correlation between the crude oil market and the macroeconomic cycle tends to vary over time. While the rolling correlation method indicates the presence of nonlinear correlation that evolves over time between the oil market and the macroeconomic activity, it doesn’t indicate the direction of this interaction. In this regard, the Cross Correlation Function (CCF) methodology suggested by Cheung and Ng (1996) is then used to examine the two-way nonlinear relationship between the crude oil market and the macroeconomic cycle. Besides, the Cheung and Ng approach is employed to investigate the inter-temporal causal dynamics between the oil market and the macroeconomic activity. It is also used to explain the variations in the correlation.

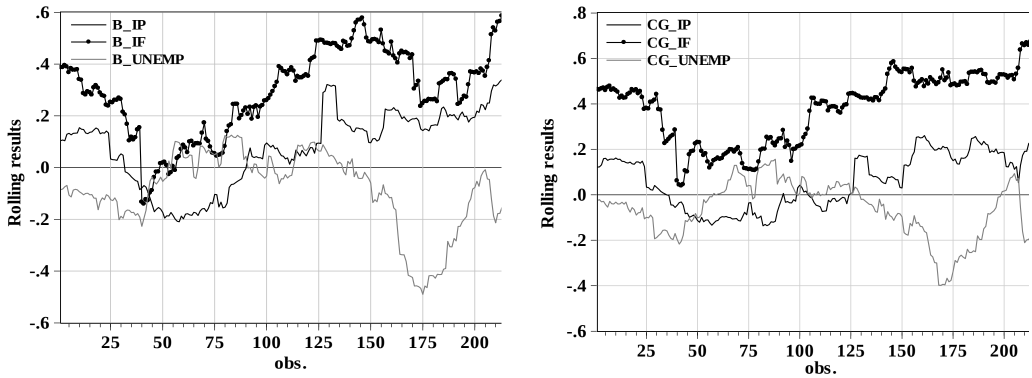

Figure 1: The rolling correlation result plots

Table 5: The single correlation coefficients and the medians of the rolling correlation results

	Brent	CG
IF	0.6461 (0.3131)	0.6596 (0.4253)
IP	0.7058 (0.1042)	0.7156 (0.0531)
unemp	-0.1805 (-0.0524)	-0.2026 (-0.0415)

Notes: The values in parenthesis (.) are the medians of the rolling correlation coefficients.

Table 6: Descriptive statistics for rolling correlation results

	Brent			Conventional Gasoline		
	IF	IP	unemp	IF	IP	unemp
Mean	0.290	0.073	-0.086	0.378	0.056	-0.065
Median	0.313	0.104	-0.052	0.425	0.053	-0.041
Maximum	0.586	0.339	0.125	0.673	0.260	0.155
Minimum	-0.140	-0.209	-0.489	0.039	-0.136	-0.398
Std. dev.	0.167	0.143	0.150	0.152	0.119	0.123
Skewness	-0.498	-0.432	-0.953	-0.436	-0.031	-0.642
Kurtosis	2.598	2.231	3.314	2.055	1.621	3.019
J-B	10.26	11.89	33.178	14.68	16.89	14.66
Probability	0.005	0.002	0.000	0.0006	0.0002	0.000
N	213	213	213	213	213	213

Notes: For N time series observations we consider, Std. dev., which is the standard deviation. J-B is the Jarque-Béra test statistics of normality.

4.2.3 The CCF methodology results

By introducing the causality in mean and the causality in variance, the CCF approach developed by Cheung and Ng (1996) complements the previous set of studies on the interactive nonlinear relationship between the US oil market and the macroeconomic activity. The CCF test statistics obtained for 15 lags and 15 leads are presented in Tables

7-8. The results show that the causal link between the crude oil market and the macroeconomic determinants is dynamic and intricate. With regard to the results of causality-in-mean (See Table 7), the significant cross correlation coefficients indicate that the crude oil price returns are lagging the cycle of the unemployment rate by a period of 1 month. Exceptionally, the Conventional gasoline is lagging the labor market, as measured by the unemployment rate, from 1 to 11 months. Regarding “leads” effects, there is no causality-in-mean running from the unemployment to the Brent crude oil returns. However, the unemployment rate is found to lead the Conventional gasoline prices by 10 months.

Given that the labor market sectors are substitutable and complementary, Keane and Prasad (1996) and Ewing and Thompson (2007) argued that in the long run there is a positive relationship between the aggregate employment and the rise in oil prices. Conversely, in the short run, the relationship between the employment and the oil price increases is found to be negative[8]. This latter finding suggests that the labor market could respond faster than planned[9].

Thereafter, the CCF statistics are significant at 1 lead time from the industrial production to the crude oil prices. The results also indicate that there is a causality in mean running from the Conventional gasoline price returns to the industrial production (at time lags 4 and 15). Interestingly, crude oil prices are found to lead the economic output, as measured by the industrial production, by 1 month. Therefore, similarly to Ewing and Thompson (2007), we deduce that crude oil prices are strongly sensitive to the industrial production. In fact, oil price movements are positively linked to the production decisions taken by the industrial firms with lag of about 1 month. Actually, we prove in this present study that crude oil prices could be considered as a potential indicator of the industrial production.

Furthermore, the evidence of instantaneous interaction is found between crude oil prices and the inflation rate. Moreover, we detect a causality in mean running from the crude oil market to the inflation rate (at time lag 12). Inversely, CCF statistics are significant at 1 lead time from the inflation rate to crude oil prices. Therefore, oil prices are found to lead the inflation cycle from 1 month and to lag it by 12 months. In this sense, the crude oil price could be considered as a viable indicator for conducting an effective monetary policy. These findings are similar to those of Ewing and Thompson (2007). Figure 2 shows the causality in mean between the Conventional gasoline returns and the macroeconomic indicators under consideration. It is clearly noticed from the Figure that there are delays in the response of crude oil prices to the variations in the macroeconomic indicators.

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[8]Job destruction is more responsive than the job creation to the oil price shocks, thus contradicting the sectoral-shifts hypothesis. In fact, shifting capital inputs and skilled labor from one sector to another is more pricey for the economy than motivating workers to stay unemployed until the improvement of the conditions of their sectors (for more details see Ferderer (1996), Keane and Prasad (1996) and Davis and Haltiwanger (2001)).

[9]Ewing and Thompson (2007) suggested that it is recently found that the use of some measures other than the civilian unemployment rate (which considers all the employees in both service and manufacturing sectors), could lead the labor market for the workforce employed in the service sector to adjust more rapidly than the manufacturing sector to the macroeconomic shocks.

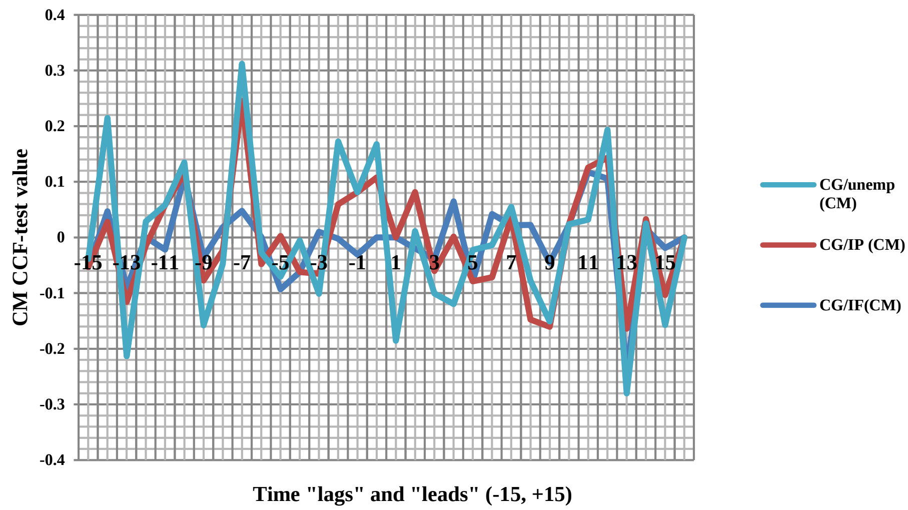

Figure 2: Causality in mean between Conventional Gasoline returns and macroeconomic indicators

Table 7: Mean causality test: Cross correlation between standardized residuals

	Brent returns and macro indicators			CG returns and macro indicators		
K	IF	IP	unemp	IF	IP	unemp
-15	-0.0051	-0.0698	-0.0350	-0.0530	-0.137*	0.0143
-14	0.0095	-0.0506	0.0808	0.0470	-0.0191	0.1868
-13	-0.0937	0.0057	-0.0806	-0.0904	-0.0256	-0.0973
-12	-0.152*	-0.0156	-0.0247	-0.127*	-0.0146	0.043
-11	0.0458	0.1052	-0.0336	-0.0219	0.0801	-0.172*
-10	0.0150	-0.0293	-0.0004	0.1098	0.0061	0.0190
-9	-0.0229	-0.0462	-0.0453	-0.0360	-0.0414	-0.0806
-8	0.0695	-0.0755	0.0384	0.0184	-0.0418	-0.0244
-7	0.0422	0.0783	0.0417	0.0480	0.1973	0.0668
-6	-0.0444	-0.0181	0.0686	0.0010	-0.0489	0.0204
-5	-0.0829	0.0093	-0.1017	-0.0932	0.0959	-0.0732
-4	-0.0001	-0.0544	0.0361	-0.0622	-0.128*	0.0565
-3	-0.0395	-0.0172	-0.0501	0.0103	-0.0755	-0.0360
-2	-0.0227	0.0589	0.0172	-0.0023	0.0621	0.1126
-1	-0.0811	0.1209	-0.165*	-0.0308	0.1120	-0.177*
0	0.4463*	0.0962	-0.0119	0.5173*	0.1078	0.0599
+1	0.2867*	0.2443*	-0.0854	0.2971*	0.1960*	-0.1855
+2	0.0534	0.0874	-0.0594	-0.0194	0.1009	-0.0701
+3	0.0743	-0.0582	0.0086	-0.0394	-0.0208	-0.0405
+4	0.0162	-0.1275	-0.0109	0.0649	-0.0634	-0.1210
+5	-0.1194	0.0562	0.0791	-0.0788	0.1690*	0.0564
+6	0.0376	-0.0702	0.1000	0.0421	-0.1137	0.0578
+7	0.0301	-0.0635	-0.0722	0.0221	0.0141	0.0189
+8	0.0043	-0.0584	0.0525	0.0224	-0.1700	0.0699
+9	-0.0519	-0.0354	-0.0150	-0.0454	-0.1152	0.0097
+10	-0.0275	0.0442	0.0545	0.0226	0.0012	0.1730*
+11	0.1575	0.0349	-0.0992	0.1171	0.0084	-0.0935
+12	0.1232	0.0436	-0.0147	0.1056	0.0377	0.0502
+13	-0.1218	0.0977	0.0091	-0.2408	0.0768	-0.1163
+14	-0.0147	-0.0033	-0.0047	0.0155	0.0174	-0.0077
+15	-0.0326	-0.0977	-0.0294	-0.0190	-0.0845	-0.0538

Notes: (-1, -2, … , -15) are time "Lags" and refer to causality in mean from energy commodities to macroeconomic indicators. (+1,+2, … , +15) are time "Leads" and refer to causality in mean from macroeconomic indicators to energy commodities. "*" indicates significance at 5% level.

Turning to the causality-in-variance hypothesis (See Table 8), a two-way volatility transmission is found between the oil market and the macroeconomic activity. Our results provide some evidence of volatility spillovers running in a bidirectional way between crude oil prices and the labor market. Specifically, Conventional gasoline price returns lag the unemployment rate from 5 to 11 months. Conversely, the unemployment rate causes Conventional gasoline in variance up to 10 months.

With regard to the volatility transmission between the crude oil prices and the economic output, as measured by the industrial production, the obtained results reveal evidence that the Brent and Conventional gasoline prices cause the industrial production in variance at lag 5. There is an evidence of feedback effect in variances of the crude oil market and the inflation cycle. We detect the causation pattern in variance from crude oil returns, namely Brent and Conventional gasoline prices to the inflation rate. In particular, the cross correlation coefficients at lags 1, 12 and 13 are significantly different from zero at 5 % level.

Reversely, the inflation rate causes the crude oil returns in variance up to 12 months. Furthermore, the inflation rate and the crude oil prices, namely Brent and Conventional gasoline returns are strongly contemporaneously correlated. For example, Figure 3 shows the lead/lag structure of causality in variance between the Conventional Gasoline returns and the macroeconomic indicators. This Figure shows evidence of an influence from macroeconomic activity dynamics to the long-term volatility of the crude oil market. Hence, the relationship between the oil market and the macroeconomic cycle doesn't reflect solely linkages between returns but it also reflects connections of volatility.

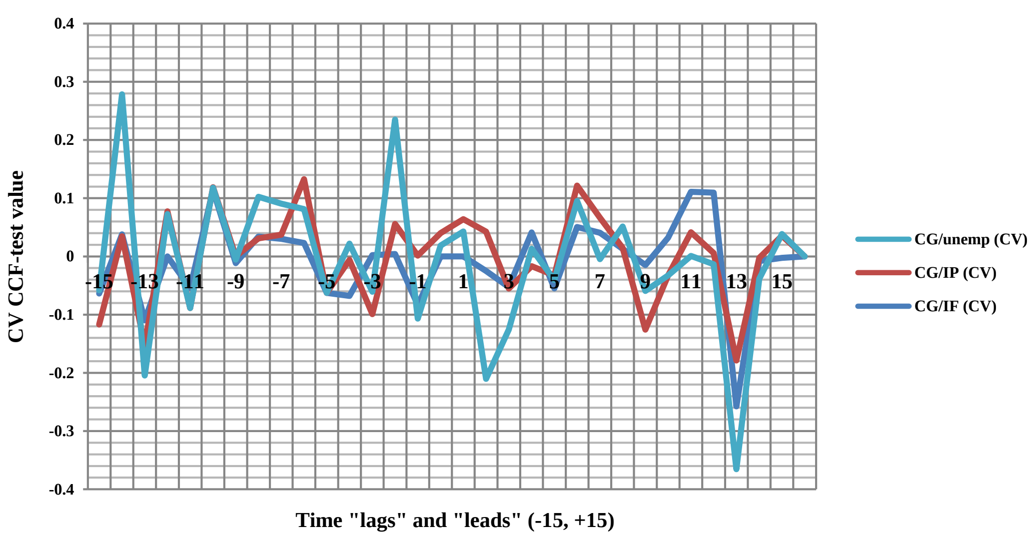

Figure 3: Causality in variance between Conventional Gasoline returns and macroeconomic indicators

In sum, the cross correlation function approach could be a useful tool for understanding the causal patterns in both the mean and the variance, between the crude oil market and the macroeconomic cycle. First, we investigated the lead/lag relationship between the crude oil returns and the inflation rate. This is particularly interesting because policy-makers are preoccupied with establishing an effective monetary policy given the inflationary pressures. Second, the increases in the world oil demand could be the result of increasing oil demand in the US. Given that the industrial production is highly dependent on the global oil demand, information on the causation pattern between the crude oil price cycle and the industrial production could assist in improving production management and inventory planning. Finally, understanding the interactive relationship between the labor market and the crude oil prices is important for obtaining accurate models for economic forecasting. Hence, an effective labor market policy could be conducted as to decrease volatility and to reduce the risk of macroeconomic shocks.

Table 8: Variance causality test: Cross correlation between squared standardized residuals

	Brent returns and macro indicators			CG returns and macro indicators		
K	IF	IP	unemp	IF	IP	unemp
-15	-0.0035	-0.0091	-0.029	-0.0637	-0.0533	0.0587
-14	0.007	0.0393	0.1308	0.0380	-0.0034	0.2440
-13	-0.138*	-0.079	-0.012	-0.1099	-0.0431	-0.0514
-12	-0.169*	0.1216	-0.019	-0.140*	0.0774	-0.0046
-11	0.0160	-0.0629	-0.091	-0.0543	-0.0343	-0.2294*
-10	-0.0134	0.0371	-0.049	0.1146	0.0043	-0.0009
-9	-0.0145	0.0103	-0.021	-0.0114	0.0117	-0.0057
-8	0.0913	-0.0283	0.0845	0.0341	-0.0030	0.0713
-7	0.0322	0.0572	0.0425	0.0302	0.0071	0.0533
-6	-0.0155	0.0436	0.0418	0.0231	0.1095	-0.0513
-5	-0.0593	-0.153*	-0.110	-0.0625	-0.179*	-0.1347*
-4	0.0061	0.0060	-0.005	-0.0677	0.0616	0.0281
-3	-0.0417	-0.0221	-0.024	0.0022	-0.1012	0.0384
-2	-0.0504	0.0074	0.0693	0.0041	0.0518	0.1792
-1	-0.164*	0.1204	-0.075	-0.0833	0.0848	-0.1083
0	0.3660*	0.0939	-0.025	0.4510*	0.0400	-0.0212
+1	0.2995*	0.0250	-0.127	0.3197*	0.0640	-0.0212
+2	0.0268	0.0800	-0.082	-0.0250	0.0676	-0.2529
+3	0.0771	0.0069	0.0036	-0.0528	-0.0023	-0.0707
+4	0.0185	-0.0730	0.0339	0.0413	-0.0581	0.0301
+5	-0.1091	-0.0488	0.0744	-0.0548	0.0221	-0.0079
+6	0.0514	0.0463	0.0532	0.0506	0.0710	-0.0263
+7	0.0447	0.0224	-0.100	0.0407	0.0259	-0.0711
+8	-0.0111	-0.0071	0.0026	0.0129	0.0016	0.0370
+9	-0.0372	-0.0168	-0.007	-0.0147	-0.1109	0.0663
+10	-0.0234	-0.0321	0.1070	0.0321	-0.0648	0.2375*
+11	0.1774*	-0.0487	-0.024	0.1111	-0.0695	-0.0408
+12	0.1449*	-0.1186	-0.023	0.1095	-0.1038	-0.0191
+13	-0.1285	0.0367	-0.059	-0.2574	0.0788	-0.1868
+14	-0.0416	0.0286	-0.055	-0.0079	0.0056	-0.0362
+15	-0.0249	0.0030	-0.023	-0.0025	0.0381	0.0030

Notes: (-1, -2, … , -15) are time “Lags” and refer to causality in variance from energy commodities to macroeconomic indicators. (+1,+2, … , +15) are time “Leads” and refer to causality in variance from macroeconomic indicators to energy commodities. “*” indicates significance at 5% level.

5 Economic Implications

The rolling correlation results mirror those of Conrad et al. (2012) and reveal that before and throughout the economic meltdown (notably the recent meltdown in 2007-2008), the correlation between the crude oil market and the macroeconomic cycle becomes positive and still be positive during the economic upswings.

Our results contradict those of Hamilton (1983, 1985, 2003) that support the strong exogeneity of oil price shocks to engender negative effects on the US macroeconomic dynamics. Findings from our study contradict the findings of Blanchard and Gali (2007) that recently the oil crises influence moderately the global economy. Actually, according to the rolling correlation method, the macroeconomic variables are found to be strongly and positively influenced by the crude oil price changes in the short-run.

Differently, Barsky and Kilian (2004) and Kilian (2009) prove false the exogeneity of oil shocks with respect to the economic activity in the United States.

The nonlinear causal analysis provides evidence of volatility spillovers between the crude oil prices and the macroeconomic cycle. The exogeneity of macroeconomic cycle movements with regards to the crude oil price changes is verified by means of the Cheung and Ng (1996) approach. Our findings are in accordance with those of Conrad et al. (2012) in the sense that Hamilton (2008) assumption, which stipulates that the earlier dynamics in the macroeconomic activity doesn't allow to predict oil market movements, is called into question. In this respect, the macroeconomic indicators could be used to project the crude oil market volatility. These results are explained according to Hamilton (2009b), Harris et al. (2009), and Kilian and Park (2009) by the fact that from the 1990s, aggregate demand and shocks of oil supply (with a much lower impact) are the drivers of oil price volatility. In fact, since that period, the economic meltdown could be assimilated as a negative shock to aggregate demand that is likely to generate the increase in the long-run volatility of oil prices. This recalls the logic of the leverage effect to the extent that oil price decreases (increases) are accompanied by increases (decreases) of uncertainty in the oil market following a negative (positive) shock of demand.

According to Fattouh (2007a), Hamilton (2009a) and Dakhlaoui and Aloui (2013), the negative shock of demand during the last century, is particularly due to the increasing number of financial operators and speculators on the oil market. These investors take a long position in the oil commodity which leads to decreasing aggregate demand and increasing oil price volatility. In this line, Chen et al. (2014) found that the financial shock is considered as a main source of macroeconomic changes. Indeed, the exogenous shocks that arise from the movements in financial market conditions create changes in oil prices which have a valuable impact on the macroeconomic fluctuations. Hence, the main criticism of the pioneering study of Blanchard and Gali (2007), is that it is rather the impact of oil supply shocks on the global economic activity which is attenuated during the recent period.

In accordance with Ewing and Thompson (2007), the crude oil price cycle is found to lead the inflation and to lag the economic output, as measured by the industrial production.

Similarily to Cavalcanti and Jalles (2013), our study shows that oil price shocks account for a large fraction of inflation volatility in the US. Contrarily to Conrad et al. (2012), we prove that there is an important impact on the uncertainty of oil prices from the inflation. So, in sharp contrast with Miller and Ratti (2009), despite the increasing efficiency of energy systems and the improvement in fiscal and monetary policies, the effect of oil price shocks on the economic activity doesn't tend to decelerate over time. Thus, it is concluded that the connection of oil prices with the inflation is not really weakened in the 2000s compared with the 1970s.

In line with Conrad et al. (2012), the variations in the macroeconomic indicators are found to act on the volatility of oil market in the long-term. Such variations determine the current and the future state of the economy. In fact, the US economic recessions that are reflected in the changes of some macroeconomic variables, such as the decreases in the industrial production and the increases in the unemployment rate, lead to rising oil prices volatility in the long-term.

The analysis of movements in variance could provide further insights into the inter-temporal dynamics of the relationship between the crude oil market and the macroeconomic cycle. In fact, the necessary time to assess the new information and coordinate the economic policies could be estimated. Hence, the Cheung–Ng approach could cover new information that are ignored in the traditional linear tests of causation. Furthermore, the delay in the response of crude oil price volatility to the macroeconomic shock is primarily attributable to the delays in the assessing process of new information and in the adjusting policies. The significant results obtained from the CCF methodology analysis give an additional proof that the relationship between the crude oil market and the macroeconomic cycle not only reflects linkages between returns but it also reflects connections of volatility.

6 Summary and Concluding Remarks

This paper studies the nonlinear interaction between the US CO market and some key macro variables from the 1970s until the beginning of the last century. In particular, we examine how the connection between the CO market and the macroeconomic cycle of the 70s differs from the 2000s. The cross correlation function based on the two stage methodology suggested by Cheung and Ng (1996) is applied with the rolling correlation method. The supply-demand framework and the sectoral shocks literature form the theoretical basis of this research.

This paper underlines the apparently conflicting results on the exogeneity of oil price movements with respect to the macroeconomic activity dynamics. In fact, the previous contradictory findings are due to the lack of distinction between different periods. The nonlinear causal analysis provides evidence of volatility spillovers between the CO prices and the macro cycle. The US economic recessions lead to the rising oil price volatility in the long-term. In this respect, the earlier dynamics in the macro activity allow to project the CO market volatility. The delayed response of the crude oil price volatility to the macroeconomic shocks is primarily attributable to the delays in the assessing process of new information and in the adjusting policies. In addition, from the 1990s the role of oil supply shocks is attenuated compared with the role of aggregate demand to drive the oil price volatility. Therefore, in accordance with the logic of leverage effect, the economic meltdown which is assimilated as a negative shock to aggregate demand becomes positively correlated with oil price changes. The negative shock of demand during the last century, is particularly due to the growing role of financial operators on the oil market that is likely to decreasing aggregate demand and to increasing oil price volatility

Actually, the macroeconomic variables are found to be strongly and positively influenced by the crude oil price changes in the short-run. More precisely, the rolling correlation results reveal positive correlation between the CO market and the macro cycle before and throughout the economic meltdown (e.g. 2007-08) and still be positive during the economic upswings. Therefore, there is no moderate impact of oil shocks on the global economy, it

is rather the impact of oil supply shocks on the global economic activity which is attenuated during the recent period.
On the subject of inflation, it is concluded that the connection of oil prices with the inflation is not really weakened in the 2000s compared with the 1970s and oil price shocks account for a large fraction of inflation volatility in the US.

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