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Fracking, Wars and Stock Market Crashes: The Price of Oil During the Great Recession

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ABSTRACT

This study analyses how oil prices have been affected by three types of events that took place during the Great Recession: The development of fracking, wars in Libya, Syria and Ukraine and the stock market crash of 2008. To do this, we employ co-integration analysis, using a vector error correction model for a period spanning August 2007 to August 2016. The principal results obtained are: Firstly, that including a variable to represent the increase in production associated to fracking in the US improves the model's long term estimation, as it embraces a new variable co-integrated in the long term; secondly, that the wars in Libya and Ukraine only influenced prices indirectly, insofar as the former sparked a reduction in Organization of Petroleum Exporting Countries production and the latter an increase in OECD oil reserves, both short term; and thirdly, that the stock market crash of 2008 led to a short- term reduction in oil prices.

Keywords: Great Recession, Oil Prices, Fracking, Stock Market Crash, War
JEL Classifications: Q4, Q43

1. INTRODUCTION

When observing the evolution of oil prices in the years after the financial crisis of August 2007 (Figure 1) which, following the stock market crisis of September 2008, led to the worldwide economic crisis known as the great recession, one notable feature is that oil prices experienced a sharp increase, which Kaufmann and Ullman (2009) link to market speculation prior to the stock market collapse in September 2008, and two sharp falls, with an intermediate period of stability between them, of around 90 dollars per barrel.

In addition to the collapse of the financial markets in September 2008 and the subsequent economic recession, there were three wars during that period which, due to the countries involved or their geostrategic situation, might have proved key to the world oil market, namely the conflicts in Libya, Syria and Ukraine.

Together with these endogenous factors, a technical-production development, namely fracking, took place during the period covered by this study. This development has had a decisive influence on oil supply and has altered the balance in the crude oil market, and has also led to the US becoming the main oil producer, overtaking Saudi Arabia.

Thus, if we superimpose the periods of instability linked to the September 2008 stock market crash and the wars in Libya, Syria and Ukraine onto the evolution of oil prices shown in Figure 1 and add a line representing oil production in the US compared to the consumption of crude oil by refineries, we see certain correspondences between the price variation and the three factors cited. Based on this, we propose studying whether there is a significant relationship between oil price and the events cited, based on the following hypotheses: Stock market crashes negatively influence prices (Lahmiri, 2017; Nazlioglu et al., 2015); wars affecting the sector spark price rises (Coleman, 2012; Kilian, 2009; Zhang et al., 2009) and fracking is a supply factor which strongly influences prices (Behar and Ritz, 2017; Fueki et al., 2016).

Few previous studies address these questions and the period considered. Some include the descriptive and non-econometric

Figure 1: Evolution of WTI price and US production/US refineries consumption (August 2007-August 2016)
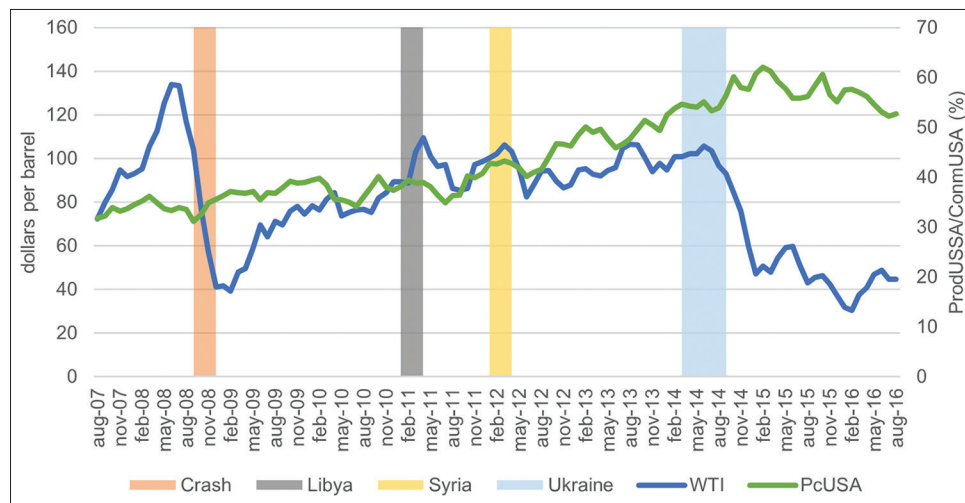
Source: World Bank and EIA

work of Arezki and Blanchard (2014), which deals with the fall in the price of crude oil in 2014, and examines the increase in production of the Organization of Petroleum Exporting Countries (OPEC) leader, Saudi Arabia, and the financial implications of the fall in oil prices, particularly vis-à-vis the positions of oil producing countries and the economic policies which the various countries should adopt in an attempt to offset the effects of the fall; or the work of Kilian (2017), which analyses the effect of fracking and its consequences for Saudi Arabia, reduced imports from the US and the increase in refined products, also from the US. In our view, such a gap in the literature makes the present study necessary.

As regards the methodology, given the non-stationary nature of the data, we perform co-integration analysis using a vector error correction model (VECM) covering the period from August 2007 to August 2016, the final date for which data are available for all the variables.

In the econometric specification, we incorporate variables that are representative of the three factors studied. In chronological order, they are: A qualitative variable to capture the shock caused by the September 2008 stock market crash resulting from the drastic readjustment of expectations; respective qualitative variables representing the initial effects of the expectations arising from the conflicts in Syria, Libya and Ukraine (Coleman, 2012, Kilian, 2008 or Kilian and Park, 2009); and, finally, the relationship between oil production in the United States and said country's oil consumption in order to reflect the improvement brought about by fracking for the national coverage of US demand for crude oil. This latter fundamental variable is novel and has not to date been included in research, such that we focus particular attention on it.

As control variables, we use stocks in OECD countries, whose variations express the adjustment between supply and demand (Coleman, 2012; Dees et al., 2007; Fattouh 2009; Kaufmann et al., 2004; Ye et al., 2002), and OPEC production so as to capture its behaviour in the market and the capacity of OPEC countries to affect the price of crude (Chevillon and Rifflart, 2009; Dees et al., 2007; Hamilton, 2009; Kaufmann et al., 2004, Kaufmann et al., 2008).

Our principal results are as follows. With regard to the stock market crash of September 2008, the estimated model shows that it impacted oil prices significantly and very negatively; in turn, the uncertainty generated by the conflicts studied did not prove relevant to oil prices, although the civil war in Libya did obviously affect OPEC production, and the war in Ukraine led to a major increase in OECD oil reserves. Thus, both might have indirectly and negatively affected prices. Finally, the variable representing the change in the US crude market as a result of fracking is significant in the long-term equilibrium and explains part of the fall in oil prices in 2014.

The article is structured as follows: The second section includes a review of the preceding literature; the third describes the methodology employed and the sources from which the data used in the model were obtained; section four details the results to emerge; and finally, the fifth section presents the conclusions of the study.

2. LITERATURE REVIEW

The first aspect dealt with in the present study, namely the effect of changes in extraction technology as a result of fracking, which is still recent, has been the subject of enquiry. In this regard, the literature is divided. Certain authors argue that the substantial increase in US production of crude is one of the main reasons behind plummeting prices (Behar and Ritz, 2017). In fact, Fueki et al. (2016) consider that the first price fall in June 2014 was linked to the expected increase in production arising from fracking.

However, other authors hold that the drop in price we have witnessed has mainly been triggered by reduced demand. Kilian (2017) studies the effect of fracking on oil prices by first applying a VAR model which includes variables related to the supply of and demand for oil, and then introducing a counterfactual model in which production in the United States maintains its growth at the rate it displayed prior to the arrival of fracking. Results suggest that the effect of the increase in non-conventional production of crude

by the US only contributed to the decrease in oil prices by between 5 and 10 dollars per barrel, with the remaining downturn being attributed principally to the decline in worldwide consumption of crude. Through the VAR model proposed by Kilian (2009), Badel and McGillicuddy (2015) suggest that falling prices were mainly caused by shocks on the demand side. Manescu and Nuño (2015) employ a dynamic stochastic general equilibrium model (DSGE) in which, in addition to the increase in production caused by fracking, they include the behaviour of Saudi Arabia as OPEC leader. Results suggest that increased production in the United States brought down the price by approximately four dollars, since it was anticipated by the market, and attribute the 2014 price fall mainly to increased production by other countries which are not members of the OPEC and to the fall in worldwide demand.

Researchers have also shown an interest in examining the impact of wars involving countries that play a leading role in the oil market, whether on the supply side, due to the destruction of oil fields or cuts in supply, or on the demand side, as the preventive part of the latter increased. Kilian (2009) analyses this type of shock through a VAR model spanning 1973-2005, including different events such as the Yom Kippur war and the Arab oil embargo of 1973-1974, the Iranian revolution in 1979, the Iran-Iraq war in 1980, the Gulf war in 1990 and the war in Iraq in 2003. Results show that shocks which affect supply are less important and have a shorter term effect on prices than those which influence demand. Furthermore, he suggests that the major shocks to take place during the period have mainly occurred on the demand side, and not the supply side, as has traditionally been assumed. Zhang et al. (2009) study the Gulf wars and the war in Iraq in 2003 through an Empirical Mode Decomposition (EMD) based event. Results suggest that oil price volatility increases during wars. When analysing the impact of wars, natural catastrophes and terrorist attacks for the period from 1984 until 2007, Coleman (2012) concludes that such events normally trigger price rises above the level marked by fundamental variables. However, Kilian (2014) considers that many of the price variations prompted by external shocks have an indirect impact on prices, which is not captured by models, as a result of fundamental variables also being influenced by such shocks. Whatever the case, for the purposes of our study, there are no precedents of studies which explore the effects of the most recent wars, coinciding with the Great Recession.

Thirdly, following the stock market crash of 2008 which gave rise to the economic crisis, the influence of financial markets on the oil market and its price has been widely studied. Nevertheless, most of the literature has concentrated on the relationship between interest rates, marked by monetary policy, and the price of crude. How this relationship is materialized remains open to debate. Some authors claim a negative relationship between interest rates and the price of oil, this theory being based on the assumption that a fall in interest rates stimulates the economy, boosting demand for oil and, as a result, sparking a price rise. These results appear in Akram (2009), Askari and Krichene (2010) and Novotný (2012). In contrast, other empirical studies point to a positive relationship between interest rates and the price of crude. The theory supporting this suggests that oil companies are capital intensive and, consequently, interest rates are a part of the costs they assume, such that an increase in

these costs can be transferred to the price of crude. Studies such as those by Bencivenga et al. (2012), Krichene (2006) and Wang and Chueh (2013) support these findings.

Sun et al. (2017) suggest that the relationship between interest rates and oil prices is articulated in two ways: Directly, through their impact on aggregate demand, and consequently on the demand for crude, and indirectly, through the exchange rate. An increase in the interest rate gives rise to an appreciation in the dollar, thus making oil more expensive in other currencies, which negatively affects demand, triggering a price drop.

Another way to examine the relationship between financial markets and oil prices is by studying the effect of financial crises upon volatility and instability in the market price. A financial crisis sparks instability in the financial markets which may bring with it volatility in the price of crude. Such findings are reported by Nazlioglu et al. (2015), who explore how financial stress is reflected in the price of crude using a volatility test. To do this, they use the West Texas Intermediate (WTI) price of oil and Cleveland's financial stress index as variables, and conclude that after the crisis there is a relationship of transmission of volatility from financial markets towards the price of crude. Lahmiri (2017) studies the existence of chaotic behaviours in the oil market prior to and after the crisis. His results show the existence of chaotic behaviour in oil price volatility following the crisis, making it less predictable.

For their part, Kaufmann and Ullman (2009) examine the transfer of the effect of speculation in financial markets to the crude market. To do this, they use an error correction model and analyse the relationships between the various oil reference prices, and between spot and futures prices, in order to study which prices act as references for the rest, and which factors impact on price evolution. They conclude that the sharp increase in oil prices prior to the onset of the 2007-2008 financial crisis was due to a growth in demand and stable supply, and was reinforced by speculators, who took positions in light of the prospect of price rises. On the contrary, Mustapha (2012), studying the role of speculation in the determination of crude oil prices in five majors oil producing countries, suggests a positive, but weak, relationship between speculation and crude oil prices, but concludes that it is not the main driver of rising oil prices before the financial crisis.

In sum, as can be seen, there is a solid base in the literature for exploring the various factors which might have affected oil price during the Great Recession. Nevertheless, no study yet exists which examines the evolution of prices during the Great Recession as a whole, and which considers the three types of factors identified: Financial crisis, wars, and fracking.

3. METHODOLOGY AND DATA SOURCES

The present work aims to examine the evolution of oil prices during the Great Recession and to explore the possible impact of events such as the onset of the financial crisis in 2008, the wars which took place during that period and mass production via fracking. To do this, we use monthly data, from August 2007, which marked the start of the financial crisis that would lead to the global economic

slump, until August 2016, the last month for which data are available for all the variables employed in the model.

Given that time series data are not stationary, as is common in monthly data series of this nature, it is necessary to perform co-integration analysis which determines whether those variables follow a similar evolution and lead to long-term equilibrium. To do this, we employ a VECM, which enables us to study the long-term equilibrium relationship among the variables included in the model, as well as their short term behaviour and how they restore equilibrium after deviating from it. The specification of the model is as follows:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-1} - \Pi Y_{t-1} + \Gamma_l Dummies_t + \varepsilon_t \qquad (1)$$

Where Y_t is a vector of endogenous variables, which includes the price of oil, OECD oil stocks, OPEC oil production and a variable which refers to US dependence on foreign oil. In turn, $Dummies_t$ is a vector of qualitative variables which represent the eruption of the crisis in 2008, the outbreak of war in Libya and Syria and the ongoing conflict in Ukraine, and which are included as exogenous variables in the model. The equation term $\sum_{i=1}^{p} \Gamma_i \Delta Y_{t-1}$ shows the short-term relationships among the variables in the model, while the third term includes both the long-term relationship or level of equilibrium of the variables and the error correction term (ECT) reflecting the speed at which the variables are corrected to reach the level of equilibrium following a shock that diverts them from it.

The first endogenous variable is the real price of oil. Termed WTI, it is defined as the spot price of West Texas Intermediate oil, deflated by the monthly US price index (the CPI). We chose the WTI price as it allows use of a non-elaborated price index, the US inflation rate (CPI), to deflate without the need to construct a synthetic index. Although opting for this price entails losing some information, it should be pointed out that the variations and the WTI and Brent price level follow a similar trajectory.

The next endogenous variable is OECD countries' oil stocks. Defined as OCDE Stocks, it represents the oil stocks held by OECD countries in their reserves, measured in millions of barrels. This has been used in studies such as Coleman (2012), Dees et al. (2007), Kaufmann et al. (2004) and Ye et al. (2002), which employ stocks as a variable to represent the movements of supply and demand in the crude market.

Another endogenous variable in the model is oil production by the OPEC. OPEC's behaviour has been a traditional focus of study, since a certain monopolistic behaviour by this group of countries, whose oil reserves account for 73% of the world total (British Petroleum, 2016), has been suggested. Studies such as Chevillon and Rifflart (2009), Dees et al. (2007) or Kaufmann et al. (2004) have used OPEC production as a variable to determine price evolution. Our study defines this as OPECProd and represents the production of crude by OPEC in thousands of barrels per day.

The final endogenous variable we include in the model has no precedents and refers to production by the US. The technical-production breakthrough which the fracking industry has brought about in the oil market requires us to include a variable illustrating the impact that fracking has had on the oil market and on prices, through the significant increase in the amount of oil available on the market. To do this, we use the variable PcUSA, defined as the proportion between US oil production and oil consumption by refineries. The variable allows us to indirectly measure the effect of fracking through the ratio in which national production covers the demand for crude in the US. This has almost doubled in 4 years as a result of the increase in production via fracking.

All the endogenous variables included in the model are represented in logarithmic form, and thus the coefficients we obtain from the model represent the elasticities that exist among the variables studied. The values in levels of all variables are represented in Appendix.

In addition to these endogenous variables, we include a series of qualitative exogenous variables which refer to various events that took place during the period analysed and which may have affected the normal evolution of the market price of oil. First, in order to gauge the initial impact of the shock associated with the stock market crash following the collapse of Lehman Brothers, we introduce the variable Crash, a dummy variable which covers the period from September 2008, the month in which this stock market crash occurred, to December 2008, the month in which the G20 met at the Washington Summit in an effort to come up with urgent measures aimed at tackling the crisis.

In addition to the financial crisis, during the period studied there were three wars which affected countries or areas that are important to the crude market. To capture their effect, we include a dummy variable in the first three months of the conflict, following the results of Kilian and Murphy (2014), which indicate that the effect of a supply shock reaches its peak 3 months after occurring.

First, there are the two large-scale conflicts which emerged from the so-called "Arab spring," namely the Libyan civil war and the Syrian civil war. The Libyan civil war, which began in early 2011 as a result of an uprising against the government, was important due to the sizeable oilfields owned by certain regions in this country, an OPEC member. In fact, the conflict led to a military intervention of allied countries headed by NATO, aimed at overthrowing the government, bringing the war to an end and safeguarding oil reserves. To include it in the model, we use the variable Libya, a dummy variable covering February to April 2011.

Of the conflicts arising out of the Arab spring, the Syrian civil war is the one to have had the greatest repercussion since, in addition to the Syrian government and its opposition, a large number of countries have been involved, including Iraq. This war witnessed the emergence of the Islamic State, a terrorist group which took control of territories that held major oil reserves. As a result, the US and Russia have intervened in the conflict, supporting the rebels and government, respectively, and taking action against the Islamic state. To capture the impact of the shock caused by the

outbreak of this conflict on oil prices, we use the variable Syria, a dummy variable which takes the value 1 for the months of January, February and March of 2012.

The third shock whose impact we study is the civil war in Ukraine. This is a war with very different characteristics to the previous ones. It began following the overthrow of the Ukraine government and gained international importance due to the uprising in the country's eastern regions which, in the case of Crimea and the city of Sebastopol, led to a declaration of their independence and subsequent annexation to Russia, and in other cases to the independence of territories. The importance this conflict had on oil prices is not due to the influence of Ukraine on this raw material, but rather to Russia's involvement in the conflict. Russia's involvement prompted strong resistance by the US and the European Union, and gave rise to sanctions because of the intervention. One particularly damaging sanction, and one which directly affects the Russian oil sector, involved imposing a ban

on exporting gas or oil exploration and extraction equipment to Russia.

In this case, given that there is a ceasefire date, we opted to extend the variable to the whole period of the conflict, defining the variable Ukraine as a dummy variable which takes the value 1 for the period spanning the war in Ukraine, from its outbreak in February 2014 to September of the same year, when the ceasefire was signed in the Minsk Protocol (Table 1).

4. RESULTS

To study the stationarity of the series, we apply the Augmented Dickey-Fuller test, the Philip-Peron (PP) test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test.

In the case of the first two tests, the null hypothesis to be rejected is the existence of a unit root, while in the case of the KPSS test the

Table 1: Summary of variables

Variable	Definition	Source
WTI	Log of WTI price deflacted by USA CPI	EIA/Federal Reserve Bank of St. Louis
OECDStocks	Log of OECD oil stocks	EIA
PcUSA	Log of proportion between the production of oil by USA and the consumption of oil by USA refineries	EIA
OPECProd	Log of OPEC oil production	EIA
Crash	Stock market crash, from September to December 2008	Authors' compilation
Libya	Outbreak of Libyan war, from February to April 2011	Authors' compilation
Syria	Outbreak of Syrian war, from January to March 2012	Authors' compilation
Ukraine	Ukrainian civil war, from February to September 2014	Authors' compilation

Source: Authors' compilation. OPEC: Organization of Petroleum Exporting Countries

Table 2: Unit root tests

Variable	ADF	ADF *P* value	KPSS	PP	PP P value
OECDStocks	0.5280	0.9870	0.591287**	0.4676	0.9849
D (OECDStocks)	−11.90503***	0.0000	0.349224*	−11.81284***	0.0000
PcUSA	−1.2307	0.6592	1.12125***	−1.1637	0.6881
D (PcUSA)	−8.849026***	0.0000	0.1350	−9.193742***	0.0000
OPECProd	−1.9230	0.3207	0.523599*	−2.1799	0.2148
D (OPECProd)	−9.337299***	0.0000	0.0510	−9.293972***	0.0000
WTI	−1.9459	0.3104	0.450631*	−1.5100	0.5249
D (WTI)	−6.796721***	0.0000	0.1193	-6.662226***	0.0000

Source: Authors' compilation. *Statistical significance at the 10% level, **statistical significance at the 5% level, ***statistical significance at the 1% level. ADF: Augmented Dickey-Fuller, PP: Philip-Peron, OPEC: Organization of Petroleum Exporting Countries

Table 3: Johansen-Juselius cointegration test (trace)

No. of cointegrated equations	Eigenvalue	Max-Eigen statistic	0.05 critical value	P
r=0*	0.2840	54.7442	47.8561	0.0098
r<1	0.0952	18.3255	29.7971	0.5421
r<2	0.0569	7.4203	15.4947	0.5293

Source: Authors' compilation

Table 4: Johansen-Juselius cointegration test (maximum eigenvalue)

No of cointegrated equations	Eigenvalue	Trace statistic	0.05 critical value	P
r=0*	0.2840	36.4187	27.5843	0.0028
r<1	0.0952	10.9052	21.1316	0.6568
r<2	0.0569	6.3820	14.2646	0.5647

Source: Authors' compilation

null hypothesis is the existence of stationarity. The results given in Table 2 show that all the variables studied are integrated in the first order, I(1); that is to say they are not stationary at levels but present stationarity when first differences are analysed.

Since all the series are integrated at the first level, in order to study the existence of a long-term relationship we employ the Johansen-Juselius co-integration test. Before performing it, and since this test is sensitive to the number of lags of the VAR specification, we determine the number of optimum lags which, depending on different information criteria, such as the AIC, HQIC and the FPE, is 2.

We employ both the Johansen-Juselius co-integration test, based on the statistic of maximum eigenvalue and that of the trace. Tables 3 and 4 give the results for both tests, as well as the critical value at 5% and the P-values obtained. The results of the Johansen-Juselius test, based on the two statistics, concur in the existence of a long-term equilibrium among the variables studied. Given these results, an appropriate estimation technique is the VECM, which estimates on the one hand the long-term relationship of the variables, correcting the deviations from equilibrium, and on the

other the impact of the variations of the variables in the short term. In our case, we estimate a VECM with two lags in first difference variables, without a deterministic trend and with a co-integration vector. The model passes the autocorrelation, heteroskedasticity and normality of residuals tests. As a result, its estimation is valid.

We obtain the following co-integration vector:

$$WTI_t = 43{,}08042 - 8{,}9827 OECDStocks_t - 0{,}3283 PcUSA_t - 3{,}5423 \ OPECProd_t \qquad (2)$$

In economic terms, this equation indicates that a 1% increase in the oil reserves of OECD countries would be accompanied by a fall in price of 8.98%, reflecting a decrease in the demand for crude as compared to its supply. The relationship between the PcUSA variable and the price of crude is also negative, such that an increase in US production with regard to the consumption of crude by its refineries would lead to a reduction in the country's dependence on oil and, consequently, a reduction in its demand for crude, triggering a downturn in price. In this case, the coefficient is lower, a 0.3% price drop against a 1% increase in the PcUSA variable. However, this outcome is to be

Table 5: Short-term VECM estimation (WTI y OECDStocks)

	D (WTI)			D (OECDStocks)		
	Coefficient	T-stat	P	Coefficient	T-stat	P
D (WTI(-1))	0.3313***	3.5531	0.0006	0.0052	0.6953	0.4883
D (WTI(-2))	0.2173**	2.2201	0.0285	0.0025	0.3178	0.7512
D (OECDStocks(−1))	−0.8648	−0.7681	0.4441	−0.2209**	−2.4313	0.0167
D (OECDStocks(−2))	1.1739	1.0565	0.2931	0.1021	1.1380	0.2576
D (PcUSA(−1))	0.4788**	2.0877	0.0392	−0.0568***	−3.0720	0.0027
D (PcUSA(−2))	−0.0613	−0.2485	0.8042	−0.0630***	−3.1707	0.0020
D (OPECProd(−1))	−0.0493	−0.0609	0.9515	−0.1074	−1.6442	0.1030
D (OPECProd(−2)	0.0764	0.1017	0.9191	−0.0767	−1.2669	0.2079
ECT(−1)	−0.2092***	−4.1872	0.0000	−0.0133***	−3.3183	0.0012
Crash	−0.1911***	−4.4518	0.0000	−0.0012	−0.3544	0.7237
Libya	0.0740	1.6007	0.1124	−0.0042	−1.1201	0.2651
Syria	−0.0207	−0.4469	0.6558	0.0050	1.3515	0.1793
Ukraine	0.0316	1.0619	0.2907	0.0076***	3.1776	0.0020
C	−0.0022	−0.2616	0.7941	0.0013	1.8846	0.0622

Source: Authors' compilation. *Statistical significance at the 10% level, **statistical significance at the 5% level, ***statistical significance at the 1% level. VECM: Vector error correction model

Table 6: Short-term VECM estimation (PcUSA y OPECProd)

	D (PcUSA)			D (OPECProd)		
	Coefficient	t-stat	P	Coefficient	t-stat	P
D (WTI(−1))	−0.0206	−0.5101	0.6110	0.0330***	3.0493	0.0029
D (WTI(−2))	−0.0760*	−1.7931	0.0758	−0.0044	−0.3878	0.6989
D (OECDStocks(−1))	−0.6104	−1.2513	0.2135	−0.0457	−0.3495	0.7273
D (OECDStocks(−2))	−0.7168	−1.4890	0.1394	−0.1867	−1.4461	0.1510
D (PcUSA(−1))	0.1369	1.3771	0.1713	−0.0515*	−1.9327	0.0558
D (PcUSA(−2))	−0.2495**	−2.3368	0.0213	−0.0858***	−2.9973	0.0034
D (OPECProd(−1))	0.2515	0.7173	0.4747	−0.1207	−1.2839	0.2019
D (OPECProd(−2)	−0.1462	−0.4495	0.6539	−0.0117	−0.1343	0.8934
ECT(−1)	−0.0066	−0.3068	0.7596	0.0045	0.7834	0.4351
Crash	−0.0010	−0.0557	0.9556	−0.0078	−1.5727	0.1187
Libya	0.0050	0.2503	0.8028	−0.0199***	−3.7115	0.0003
Syria	0.0214	1.0683	0.2878	0.0082	1.5185	0.1318
Ukraine	0.0102	0.7895	0.4315	0.0006	0.1738	0.8623
C	0.0044	1.2224	0.2242	0.0024**	2.5250	0.0130

Source: Authors' compilation. *Statistical significance at the 10% level, **statistical significance at the 5% level, ***statistical significance at the 1% level. VECM: Vector error correction model

expected since US production represents only a tiny fraction of worldwide crude oil production. Finally, a 1% increase in the production of crude by the OPEC would be accompanied by a 3.4% increase in the price of crude. This relationship would indicate that, during this period, OPEC adapted its production to the evolution of the market price in the long term, rather than behaving like a monopoly, as it had done in other past episodes in the oil market.

In addition, the short-term estimations of the error correction model are shown in Tables 5 and 6.

Firstly, the error correction terms ETC (−1) for WTI and OCDE Stocks are negative and significantly distinct from zero. This indicates that both variables tend to correct the disequilibria caused by a shock and contribute to long-term equilibrium restoration. In the case of price, it does so very rapidly, at a rate of 20.92% per month, while stock converges more slowly, at a rate of 1.33% per month.

However, the error correction term for the PcUSA and OPEPProd equations does not significantly differ from zero. This means that these variables do not contribute to restoring the long-term equilibrium relationship given by the co-integration equation after deviating from that equilibrium when faced with an unexpected short term shock. In economic terms, this means that when the variables deviate from the trend they share in the long term, it is price and OECD stocks which fluctuate and project the adjustment to return to equilibrium.

With regard to the short-term relationships between variables (Figure 2), it can be seen that neither the variation in OECD stock nor OPEC production have any impact on the evolution of the short-term price of crude. On the contrary, the model detects that the price of crude is affected, in the same direction, by variations in the price itself in the two preceding months. That is to say, the market maintains the direction of the price variation, such that a shock in the price is maintained for at least 3 months. The second variable which affects price in the short term is the PcUSA

variable, such that an increase in the coverage of the demand for crude from the US with production from that country drives up the price and vice versa.

In order to explain this relation, it is necessary to take into account the existence of another inverse relationship between the two variables, such that variations in the price of crude modify the PcUSA rate of coverage in the opposite direction. This forces us to analyse the relation from a dynamic perspective.

Let us assume an upturn in the price of crude. This increase will rapidly increase demand for crude from refineries, since they know that price rises will remain in the following 2 months. They will thus be keen to rapidly increase their stocks. In turn, national crude oil production will also react, but will do so more slowly, as soon as the persistent price rise is confirmed. The result is that, temporarily, the price increase will spark a reduction in the PcUSA coverage rate. Nevertheless, refineries' ability to accumulate stocks is limited, meaning that when they reach the maximum stock in accordance with the price, they will cease purchasing. Since the persistent price increase in the preceding months will also have had an effect on national production, the subsequent result of the reduction in PcUSA must be the short term reduction in the price of crude.

According to our results, the variable PcUSA, included as an innovation in our study, proves crucial in short-term relationships with other fundamental variables. Firstly, it negatively affects OCDE Stocks, which is perfectly reasonable given that increases in the coverage of demand by national production reduce US dependence on foreign oil, thus curbing the risk of shortages and rendering the reserves of crude from the principal OECD country less necessary. Secondly, it is also reasonable to assume that it will negatively affect OPEC oil production, since if the coverage of demand is improved by national production in the US there is a reduction in demand in the international market, where the US is the principal client, forcing OPEC countries to accept a reduction in their market share. Finally, the model detects that the variable has an effect upon itself, although in this case, as in the case of the

Figure 2: Short-term relationships

Source: Authors' compilation

OCDE Stocks variable, the feedback is negative. That is to say, short-term changes tend to cushion preceding changes, which is perfectly consistent with the description provided above.

As the OPECProd variable responds positively in the short term to variations in the price of crude, which means that increases in production occur in times of rising prices when demand increases and vice versa, when prices fall the OPEC reduces production. Furthermore, as already stated, it varies negatively with the rate of coverage of demand in the US. In sum, the model shows that OPEC production is a variable which reacts to other variables, adjusts to circumstances, and which, in the short term, does not influence other variables.

Finally, as regards the variables representative of shocks, excluding the Syria civil war, for which no short-term influence was detected, the rest do display such an effect. The 2008 stock market crash is the only direct influence on the price of crude, which is perfectly consistent with the sharp downturn in demand sparked by the uncertainty of the early months of the crisis. For their part, the wars in Libya and Ukraine had no direct impact, but did have an indirect effect. The Libyan war impacted on OPEC production because Libya is a member of the organization. As a result, the reduction in the country's supply led to a fall in the organization's overall production until such time as supply was replaced by production from other OPEC countries. The war in Ukraine did not directly affect oil prices but meant that OECD stocks reached levels above normal figures, implying that said armed conflict increased market risk, thereby swelling precautionary stock.

5. DISCUSSION OF RESULTS AND CONCLUSIONS

In this study, we examine the evolution of oil prices during the Great Recession and the impact of various facts and events, such as the stock market crash of 2008, the wars in Libya, Syria and Ukraine, and fracking, taking the oil stocks held by OECD countries and OPEC production as fundamental variables in the model.

The results obtained for the long-term fundamental variables concur with those reported in other studies. Firstly, OECD oil stocks maintain a negative relationship with price, a result also to be found in Dees et al. (2007) and Ye et al. (2002). For OPEC production, there is a positive relation between this and price, indicating that during this period OPEC acted as a price taker, rather than imposing its market power, as concluded by other studies, such as those of Coleman (2012), Dees et al. (2007) or Kaufmann et al. (2004) who analyse OPEC's behaviour in previous periods.

Among the results obtained for the factors studied, prominent is the impact of the stock market crash of 2008, sparking as it did a price slump of nearly 20% greater than might otherwise be expected from market variables. From this result, it can be deduced that the uncertainty caused by the crash led to raw material prices, including oil, tumbling dramatically. Although there are no studies exploring the impact of the stock market crash on oil

prices, Coleman (2012) examines the impact of the Asian financial crisis of 1998-1999, and also concludes that oil prices fell during that crisis, a notion fully consistent with our findings.

As regards the effect of the various wars that took place during the Great Recession, results from our study show that these did not have any great impact, which is consistent with the study by Kilian (2009), since they basically affected supply, and not directly but rather tangentially, except in the case of Libya.

In addition, as argued by Kilian (2014), who states that models fail to capture the influence of external shocks since the effects are brought about indirectly through changes in fundamental variables, we report these effects. The war in Ukraine had an impact on the reserves of crude by leading to greater than expected growth. Thus, taking into account that oil reserves influence prices, an indirect negative effect on prices can be deduced. The same is true of the war in Libya which, as it is an OPEC member, triggered a short-term fall in production, doubtless linked to the price of crude although, as we have seen, it is not a variable that determines the return to equilibrium, given that, as stated above, OPEC behaved as a price-taker.

Perhaps the novelest and important consequences lie in the results obtained when gauging the effect of fracking, measured indirectly through the rate of coverage of national production of US demand for crude. Examining the results of the estimation in the model, between June 2014 and February 2015 the rate of PcUSA coverage varied by 5.8%. It thus contributed with a fall of approximately four dollars per barrel, a result close to that obtained by Kilian (2017) who, through a counterfactual model, estimates a fall in oil prices of between 5 and 10 dollars per barrel. Furthermore, the reduction in US dependence on foreign crude had a negative impact on the production of OPEC countries, a result similar to that reported by Kilian (2017) for the case of Saudi Arabia. This suggests that the reduction in dependence on US crude meant less international demand for crude, thereby affecting demand for Saudi oil, and forcing the country to cut the growth of its production.

In sum, the principal events that took place during the Great Recession entailed an array of effects in different directions on oil prices, largely consistent with the expected outcomes. The model has allowed us to quantify the impact of previously unexplored facts and events. Furthermore, the study incorporates a new variable which captures the effect of fracking and which should be considered as a fundamental variable in subsequent studies.

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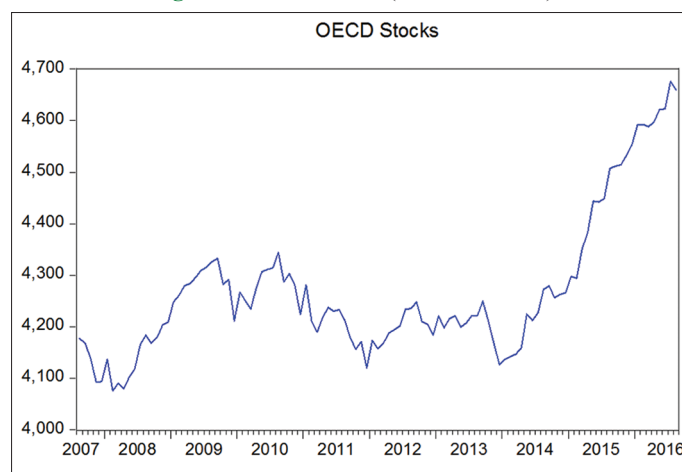
APPENDIX
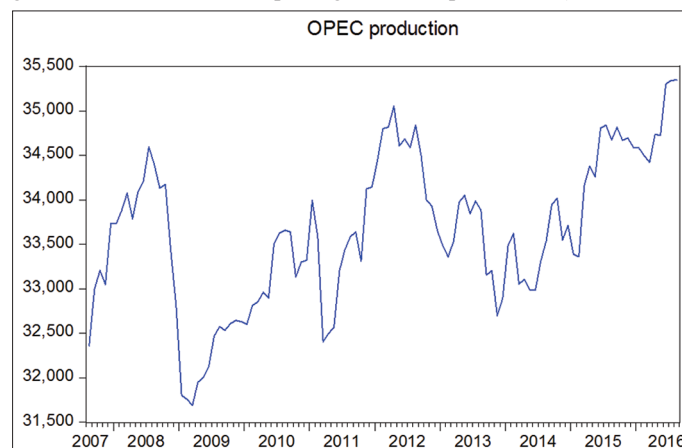
Figure 1: Real WTI price (dollars/barrel)
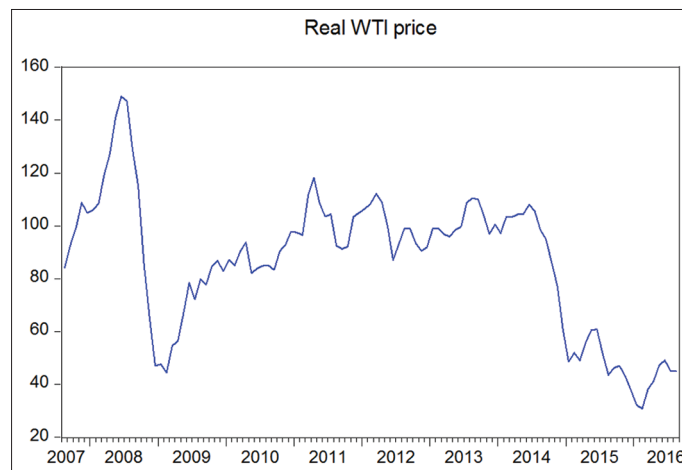
Source: World Bank

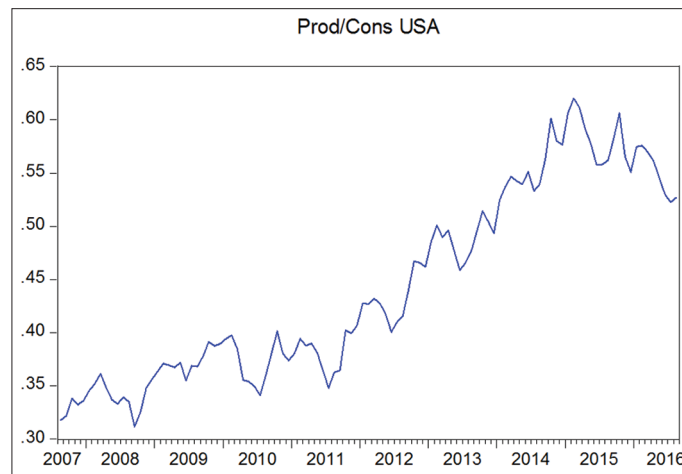**Figure 2:** OECD stocks (millions barrels)

Source: US. Energy Information Administration

Figure 3: Organization of Petroleum Exporting Countries production (thousands barrels per day)

Source: US. Energy Information Administration

Figure 4: US production/US consumption (thousands barrels per day/thousands barrels per day)

Source: US. Energy Information Administration