NEXIASEARCH

The new determinants of the Dollar-Oil link.

Souhaib KLOUZ

THINK SMART ACT DIFFERENT

TABLE OF CONTENTS

ABSTRACT

Since 2014, the oil markets experienced several crashes. At the same time, the US dollar strongly fluctuated even if it has mainly increased since 2014. For the last fifteen years, we can clearly see that a persistent correlation exists between the US dollar and the oil price. Those facts drive us to wonder about the oil-US dollar relationship: is there any correlation between US dollar and oil prices? In order to study the question, we estimate a fully identified structural VAR (SVAR) using AB model, allowing bipartite co-movement between US dollar (against Euro) exchange rate and oil prices on a short run. We will then study the long run relationship using Granger causality tests. We estimate the SVAR model on the 15 years sample period. In addition, we introduce exogenous factors in our model in order to measure the effect of global economic development on US dollar and oil prices. We consider the 5-Year Breakeven Inflation Rate as the main exogenous factor. This factor aims at measuring the effect of global economic development on US Dollar and oil prices. Our findings indicate the following: i) there is a negative co-movement between oil prices and US Dollar for the 15 years period; ii) a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short run (within the same week), while an increase on the oil prices leads to an appreciation of the US dollar exchange rate. Both effects are estimated to be unequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates; iii) a different picture emerges over longer horizons: the US Dollar exchange rate Granger-cause oil prices but not the opposite; and the US interest rates Granger-cause both oil prices and exchange rates; iv) this relationship in both short and long run as well as regarding the Oil-US Dollar correlation are varying over time: the negative correlation between the US Dollar and oil prices is getting less and less strong since the end of 2018. Moreover, there is a clear change of paradigm between the pre and the post 2018 oil crisis periods.

INTRODUCTION

Since 2014, the oil markets have experienced several periods of turmoil. In the 2014-2016 periods, the decrease is mainly due to an imbalance in the oil market: oil was overproduced during this period and the offer was then stronger than the demand. This decline in prices was also the consequence of a tense geopolitical and economic context: slowdown of the Chinese economy, Iran's return to international trade, the rivalry between the United States and Saudi Arabia for controlling the oil market, etc... Then, the 2018 oil market crisis came. The crisis was caused by an increased production of oil from the Organization of the Petroleum Exporting Countries (OPEC) in order to contain the increase of the oil prices while, at the same time, the United States kept a high production of shale oil and Iran could still export oil. The United States kept sanctions on Iran but applied an eased embargo. Finally, between early March and late April 2020, barrels of Brent and WTI lost 71% and 73% of their dollar value, respectively. Two concomitant shocks are at the origin of this collapse. First, due to the Covid-19 pandemic crisis, the demand shock began with the decline in Chinese growth from the end of January 2020 and was amplified by the global extension of containment measures from March. At the same time, a supply shock, originated from dissension within OPEC+ (OPEC members plus ten oil producing countries including Russia), intervened in early March, worsening the imbalance between supply and demand.

At the same time the US dollar strongly fluctuated, but mainly increased since 2014: the currency is supported by the stability and the good health of the US economy and by the yield on US bonds, which remains high despite falling interest rates. Those facts drive us to address the question of the Oil-US dollar relationship: is there any correlation between US dollar and oil prices.

For the last fifteen years, we can clearly see in Figure 1 that there is a correlation between US dollar and oil prices. Using daily data of oil prices and US dollar (against Euro), Figure 2 shows the evolution of correlation on the last 15 years, where correlation is computed over a 6-month moving window. Regarding this figure, we distinctly find a correlation between oil prices and US dollar.

This paper studies the correlation between oil prices and US dollar, and tries to answer the following question: what drives dollar-oil correlation? Do oil prices affect US dollar? Is it the opposite or are they both influencing each other? Are there any exogenous factors impacting this relation? And finally do determinants of the dollar-oil link change over time?

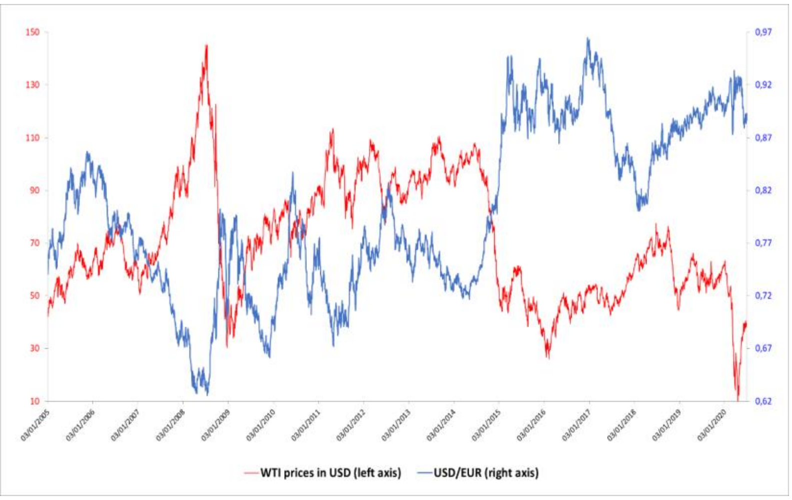


Figure 1: Oil prices and trade-weighted US Dollar (against Euro) – Data source: ECB and Thomson Reuters

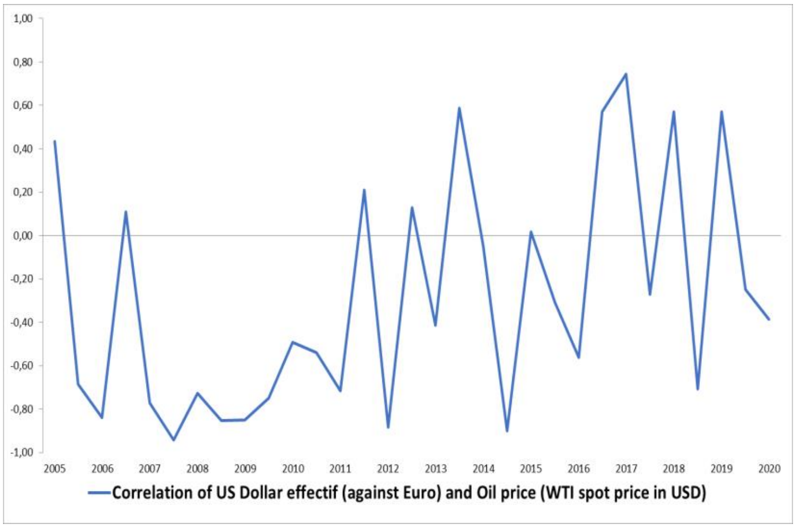


Figure 2: Correlation of daily Oil prices and daily US Dollar (against Euro) computed over 6 month moving windows for the last 15 years. – Data source: ECB and Thomson Reuters

In order to study those questions, we estimate a fully identified structural VAR (SVAR) using AB model following Sims (1980) and Kozluk and Mehrotra (2009), allowing bipartite co-movement between US dollar (against Euro) exchange rate and oil prices on a short run. We will then study the long run relationship using Granger causality tests. We estimate the SVAR model on the 15 years sample period, but also, we compare estimation of the model on a pre and a post 2018 crisis period to detect the presence of changes over these periods.

In addition, we introduce exogenous factors in our model in order to measure the effect of global economic development on US dollar and oil prices. We consider the 5-Year Breakeven Inflation Rate as the main exogenous factor. This factor aims at measuring the effect of global economic development on US Dollar and oil prices and is extracted from the online Saint Louis Federal Reserve. The breakeven inflation rate represents a measure of expected inflation and is derived from 5-Year Treasury Constant Maturity Securities (BC_5YEAR) and 5-Year Treasury Inflation-Indexed Constant Maturity Securities (TC_5YEAR). The price of this last security gives the expectation of market participants towards the level of inflation in the next 5 years, on average; the 5-Year Breakeven Inflation Rate seem to be a good measure to control the influence of the global economic development of US dollar and oil prices for our model.

Our findings indicate the following:

- There is a negative co-movement between oil prices and US Dollar over the 15 years period;

- A depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short run (within the same week), while an increase on the oil prices lead to an appreciation of the US dollar exchange rate. Both effects are estimated to be inequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates;

- A different picture emerges over longer horizons: the US Dollar exchange rate Granger-cause oil prices but not the opposite; and the US interest rates Granger-cause both oil prices and exchange rates;

- This relationship in both short and long run as well as regarding the Oil-US Dollar correlation are varying over time: the negative correlation between the US Dollar and oil prices is getting less and less strong since the end of 2018. Moreover, for the first period studied, a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an appreciation of the US Dollar exchange rate. For the second period, a depreciation of the US Dollar is associated with a contemporaneous decrease in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an depreciation of the US Dollar exchange rate. Regarding the long run causality using Granger causality tests, we notice changes over periods: oil prices Granger-cause the US Dollar exchange rate for both periods but not the opposite for the first period while for the second period we observe that the US Dollar exchange rate also Granger-cause the oil prices.

The remaining part of the paper is organized as follows. Section 1 is a review of literature on the topic. Section 2 defines the data base used and the methodology. Section 3 describes our empirical findings. And finally, section 4 concludes.

I. LITERATURE

LITERATURE REVIEW

Following the initial work of Hamilton (1983), a series of papers investigates the relationship between oil prices and exchange rate. Hamilton (1983) shows that oil price significantly affects US macroeconomic variables: he finds a significant relationship between oil prices and output. Various studies in the literature have focused on the relationship between oil prices and dollar exchange rates (Krugman, 1983a and 1983b; Golub, 1983; Rogoff, 1991; Zhou, 1995). Using Granger causality test on daily data spanning over twenty years, Samanta and Zadeh (2011) find that oil price and exchange rates are likely to be influenced by other variables such as gold price, stock price, real exchange rate for dollar and the oil price of crude oil. Anjum (2019) shows that, if structural breaks are ignored in the model, there is no evidence of volatility transmission between oil prices and the US dollar exchange rate. However, after accounting for structural breaks in the GARCH variance model under study, significant volatility transmission channel appears between oil prices and the US dollar exchange rate.

There are many empirical studies that contribute to the causality comportment between oil price and exchange rates and their results are mixed.

Using monthly data over almost forty years, Zhang (2013) finds that there is no significant co-integration between the oil price and the value of the US dollar exchange rate unless the effects of two structural breaks (November 1986 an February 2005). A branch of the literature finds a positive correlation between oil prices and exchange rate. Among others, Amano and van Norden (1998 a, b) demonstrate the existence of a positive relationship between oil prices and the dollar: an increase in crude oil prices coincides with a rising dollar in the long run. Chen and Chen (2007) show that the dominant character of oil prices in exchange rate movements by applying panel co-integration techniques for the G-7 countries. They find that an increase in oil prices depreciates the domestic currency against the US dollar. Using a causality tests, Coudert, Mignon and Penot (2008) find that the causality is running from oil prices to exchange rates and that the relationship between them is transmitted through the U.S. net foreign asset position. In fact, in the long run, an increase in oil price is linked to a dollar appreciation.

On the other hand, another branch of the literature demonstrates negative co-movements in oil prices and dollar exchange rates. Using co-integration test on monthly data over forty years, Arouri and Jawadi (2010) show that the US dollar exchange rate and oil prices are not co-integrated, thereby the long-run relationship between them is not significant. Then using a vector auto regressive model (VAR), they find that in the short run the oil price and the US dollar exchange rate are strongly linked negatively.

Finally, using smooth transition regression models, they affirm that there are some signs of non-linearity detected in the oil–exchange rate link. Using also co-integration test on monthly data over more than twenty years, Tamakoshi and Hamori (2012) find that real oil prices are co-integrated and affected negatively by the real value of the US dollar. They also find that there is no significant causality detected from real value of the US dollar to real oil price using Granger non-causality tests. Using a detrended cross-correlation analysis (DCCA) on daily observation over twelve years, Reboredo, Rivera-Castro and Zebende (2013) find that correlations were negative and low between oil price and the US dollar exchange rate (longer time scales having in general lower values). They also find that this negative correlation increased after the financial crisis (2008), showing for them an evidence of both interdependence and contagion.

Chen, Choudhry and Wu (2013), using copula model, highlight an asymmetric dependence structures between the US dollar exchange rate and the oil price: when the US dollar depreciates, oil prices are more negatively associated with the US dollar, versus to when it appreciates. Finally, we have to mention Reboredo (2011), which using correlation and copulas on daily data over ten years, finds that between oil prices and exchange rates, there is no extreme market dependence. He shows also that the negative co-movement between oil prices and the US dollar exchange rate is weak, the intensity of this relation diverges across currencies.

Then the logical question to ask about the oil-US dollar relationship is about the sense of this relationship? There are three possibilities that literature worked on: the causality is running from the oil to the US dollar, or from the US dollar to the oil, or simply it is a bidirectional causality.

The first part of the literature affirms that oil prices lead the US dollar exchange rate. Amano and van Norden (1998 a, b) study the direction of causality and find that oil prices Granger cause exchange rates but not vice versa in the long run. Chen and Rogoff (2003) use an empirical study to find that movements in oil prices affect exchange rates. Using a cointegration test and a VAR model with monthly observations covering a large lapse of time (1970s to 2008), Lizardo and Mollick (2010) find that oil prices explain significantly US dollar movements: they put forward a relationship between the US dollar exchange rate and oil prices on the long run. In fact, increases in real oil prices lead to an important depreciation of the USD against net oil exporter currencies, but an appreciation against oil importers. Basher, Haug and Sadorsky (2011), using a SVAR model on monthly data, show that in the short run, positive shocks tend to press down the US dollar exchange rate. Using daily data, Wang and Wu (2012) find that before the 2008 financial crisis, there are only linear causality relationships that are running from oil prices to the US dollar exchange rate. But this causality can vary over time. Using a vector autoregressive (VAR) on monthly data, Atems, Kapper and Lam (2015) find that there is an asymmetric response of US exchange rates to shocks on crude oil prices: this response depends "on whether the shocks are large versus small, or positive versus negative".

Finally, Rahmanifard, Safarzadeh and Zeinali (2016) apply a cointegration and causality tests on variables within the 1990-2013 period and show that causality direction is from oil price variable to US dollar price. Moreover, they find a negative relationship such that if the real price of crude oil increases up to 10%, dollar real value decreases to 1.7%

The second part of literature confirms that oil prices are led by the US dollar exchange rate. Bloomberg and Harris (1995) find that, empirically the negative correlation between commodity prices and the US dollar increased after 1986. Moreover, they show evidence on the effect of a weak dollar on the increase in oil prices. Zhang, Fan, Tsai and Wei (2008) find that the US dollar exchange rate has a significant influence on international oil prices in the long run, but effects are limited in the short-run. Using a structural vector autoregressive model (SVAR) estimated on quarterly data over the period 1990–2007, Akram (2009) finds that a weaker US dollar leads to higher oil prices. Obadi (2012) shows, using monthly data over more than fifteen years, that there is between the US dollar exchange rate and oil price a high negative correlation. He finds also that it is the US Dollar exchange rate that impacts oil price. Using recent advancements in panel data estimation techniques, De Schryder and Peersman (2012) find that appreciation of the US dollar exchange rate gives a significant decrease in oil demand and so a drop in oil prices.

Finally, Novotný (2012) investigates and quantifies the effect of the US dollar exchange rate on the Brent oil price using monthly data from January 1982 to September 2010. The findings show that there is a negative correlation coefficient between the US dollar exchange rate and the Brent oil price. More precisely, the causality sense is going from the US dollar exchange rate to the Brent oil price: a depreciation of 1% of the US dollar will give an increase of 2,1% of the Brent oil price. Finally, Coudert and Mignon (2015) review the empirical relationship between the price of oil and the US dollar effective exchange rate for the 1974-2015 period. Results show that both variables are linked by a negative relationship, going from the dollar exchange rate to the oil price. However, using a nonlinear, smooth transition regression model, findings show that the relationship turns positive when the dollar hits very high values.

The last part of literature declares that the co-movement is inducted in a bidirectional way: oil prices and the US dollar are inferring in each other. After the recent crisis, between the US dollar exchange rates and crude oil prices, Wang and Wu (2012) find both bidirectional nonlinear causality relationships. With Markov-Switching vector error correction model (MS-VECM) using monthly data from 1974, Beckmann and Czudaj (2012) find that on the one hand changes in nominal oil prices affect the real nominal exchange rate. However, there is also reversed causality: in fact, shocks in exchange rates influence oil prices. Chang, Huang and Chin (2013), using a Granger causality test, find that there is a two-way feedback relationship between oil price and the US dollar exchange rate. Using a structural vector autoregressive (SVAR), Fratzscher, Schneider and Robays (2014) show that the causality runs negative in both directions for oil prices and exchange rates relationship. Thus, they quantified this relationship: 10% increase in the price of oil causes a depreciation of the US dollar exchange rate by 0.28%, while a decrease of 1% of the US dollar leads oil prices to rise by 0.73%. Finally, Wen, Xiao, Huang and Xia (2018) find, using linear and nonlinear Granger causality test, that there is bi-directional mean spillover between the oil prices and US dollar exchange rate. While changes in the USD exchange rate do linearly Granger-cause fluctuations in crude oil price, there is also a nonlinear Granger causality going from the crude oil prices to the US dollar exchange rate.

But the nature of the relationship between oil prices and the US dollar can change depending on the time scale. Using a combination of nonlinear causality tests and wavelet analysis, Benhmad (2012) finds that depending on frequency bands, the linear and nonlinear causal relationships between the oil price and the US Dollar exchange rate is varying as it is depending on the time scales. Over large time horizons, there is a strong bidirectional causal relationship between the US dollar exchange rate and the oil price, but for shorter horizons, the causality runs only from the oil prices to the US dollar exchange rate.

We then have to discuss transmission channels that may engender this relationship between oil prices and the US dollar and so permit the co-movement. Let us see first how the transmission can be done from the US dollar exchange rate to oil prices. The US dollar is the base currency of the oil market, in fact oil purchases from international companies is done in dollars, so the US dollar has an exceptional role as settlement currency. We can easily understand that movement in the exchange rate will affect oil supply and oil demand. Regarding demand side of the oil market, Bloomberg and Harris (1995), highlight the potential importance of exchange rates for oil price movements. Their explanation is based on the law of one price for tradable goods: since oil is an internationally traded commodity priced in USD, the depreciation of the US dollar makes oil relatively cheap for countries whose currencies are not pegged to the dollar. Overall, the US dollar depreciation tends to increase the real income of the consumer countries, increasing their purchasing power and oil demand, and so pushing up the oil price in USD[1].

With regards to the oil supply side, as per Wirjanto and Yousefi (2003, 2005), oil producers might limit oil supply in order to stabilize the purchasing power value of their export revenues in US dollars when the US dollar is depreciating, and thus increase oil prices. According to Mignon (2009), as drilling operations are strongly linked to oil prices, the link between them is positive: an increase in oil prices tends to increase the profitability of deposits previously considered unprofitable and, therefore, the production capacity. Furthermore, the US dollar depreciation causes inflation in oil-producing countries, and a reduction in their purchasing power. Rising inflation and declining purchasing power have the effect of reducing the real income available to drill. It follows that the depreciation of the US dollar leads to a decline in supply and thus a rise in oil prices. Finally, the US dollar depreciation tends to cause an increase in oil demand and a reduction in oil supply, which has the effect of contributing to the rise in oil prices.

Let us see now how the transmission can be done from oil prices to the US dollar exchange rate. A first branch of the literature shows that oil prices can affect exchange rates via wealth effects. In fact, higher oil prices will lead, as per Krugman (1983) and Golub (1983), to a wealth transfer from oil importers to oil exporters. Through portfolio reallocation and current account imbalances, this wealth transfer leads to a change in the exchange rate of the oil-importing country. With contrary finding, Krugman (1983) shows that it is necessary to distinguish the short-term impacts (where most relevant approach is the financial one) from the long-term impacts (where the real approach is the most appropriate). The final impact will depend on the share of exports to oil-exporting countries and the dependence on oil of importing countries. The terms of trade are the second transmission channel from oil prices to exchange rates. For oil-importing countries, a rise of oil prices will conduct to a deterioration of the trade balance of those countries. So subsequently this will cause a decrease of oil-importing countries currencies[2].

[1] See De Schryder and Peersman (2015) for more details about this channel of transmission.
[2] See Backus and Crucini (2000) for more details about this channel of transmission.

nexialog CONSULTING

II. DATA & METHODOLOGY

THE DATA

In order to conduct this study, we use endogenous variables as oil prices, US dollar exchange rate and short-term US interest rate data. Daily observations, mainly from 2005:01 to 2020:06 are used. In order to study potential changes in the oil-US Dollar relationship due to the 2018 oil crisis, we consider three different samples: one for the whole period from 2005:01 until 2020:06, one for the period from 2005:01 until 2018:10:16, and the last one for the period 2018:10:17 until 2020:06.

Oil prices, referring to WTI, are obtained from Thomson Reuters using the EIA database and correspond to the spot prices of crude oil-West Texas Intermediate (WTI) spot cushing US$/bbl. US dollar exchange rate comes from the ECB online database and correspond to the ECB reference exchange rate, Euro/US dollar. Finally, short-term US interest rates are extracted from the online Saint Louis Federal Reserve and are referring to 3-month US T-bill Sec market middle rate. Figure 3 shows time-series of these three variables on the studied period. Our sample contains 4042 observation dates for each variable.

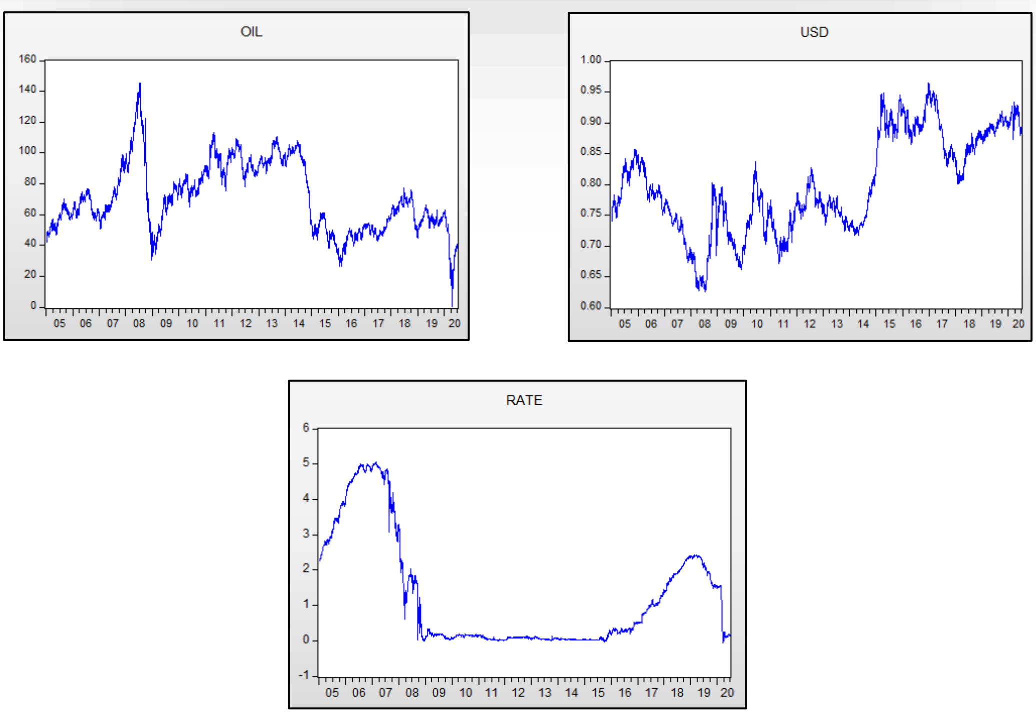


Figure 3: US Dollar (against Euro), Oil prices and 3 months US T-bill interest rate – Data sources: ECB, FED, Thomson Reuters

We also consider the 5-Year Breakeven Inflation Rate as an exogenous factor of our model. This factor aims at measuring the effect of global economic development on US Dollar and oil prices and is extracted from the online Saint Louis Federal Reserve. The breakeven inflation rate represents a measure of expected inflation and is derived from 5-Year Treasury Constant Maturity Securities (BC_5YEAR) and 5-Year Treasury Inflation-Indexed Constant Maturity Securities (TC_5YEAR). The price of this last security gives the expectation of market participants towards the level of inflation in the next 5 years, on average. Here again we have 4042 observations.

In order to reduce variance and so to remove heteroscedasticity, we express our series in logarithmic terms. As some values of the interest rate variable are negative, we only turn oil prices and trade-weighted US dollar exchange rate in logarithmic terms. We first plot both series on the same graphic (see appendix 1a). There are two important remarks highlighted by this graphic: first oil prices seem to be more volatile than US dollar exchange rate. On the other hand, both series are likely to be non-stationary in the level. In order to control variables stationarity, we apply a unit root test using the Augmented Dickey-Fuller test that confirm the non-stationary in the level of both series (see appendix 1b). In order to make them stationary, we use the first difference filter on both series multiplied by 100 but also on the interest rate series (see figure 4) and control them using the Augmented Dickey-Fuller test (see appendix 2). We notice extreme values for the oil that describe the oil prices' crash of the oil prices of April 2020. All endogenous variables are now stationary, according to the results. We now have 4041 observations after applying those filters.

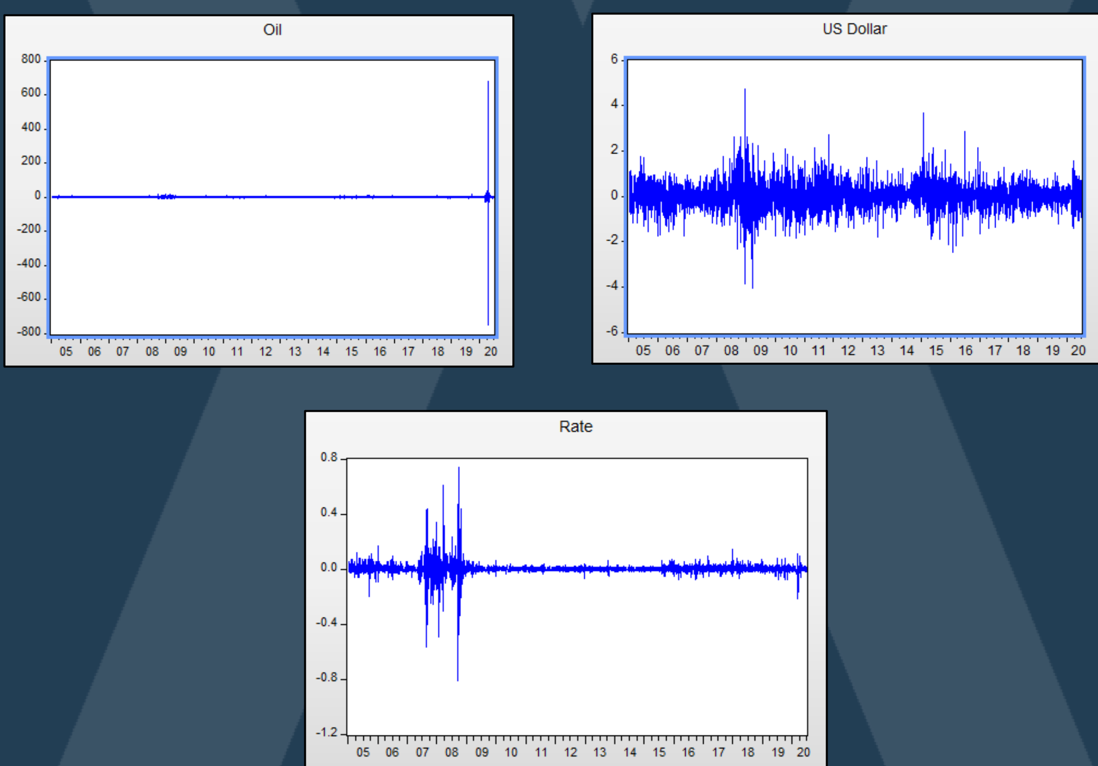


Figure 4: EUR/USD and Oil prices in logarithmic first difference (multiplied by 100) and 3-month US T-bill interest rate in first difference only – Data sources: ECB, FED, Thomson Reuters

Table 2 shows the main descriptive statistics of US dollar, oil prices and interest rate series, computed on original prices level. Table 3 shows the covariance and correlation matrices matrix associated with these three series. As can be seen on Table 3, the oil-US dollar correlation strongly change from one period to another: while being at a correlation level of - 0,75 for the whole sample, it goes from - 0,73 in the first period to - 0,49 in the second period.

Sample: 1/03/2005 6/30/2020
Included observations: 4042

	OIL	USD	RATE
Mean	70,92	0,80	1,27
Median	66,83	0,78	0,28
Maximum	145,31	0,96	5,05
Minimum	0,01	0,63	-0,05
Std. Dev.	22,58	0,08	1,59
Skewness	0,36	0,08	1,14
Kurtosis	2,57	2,00	3,00
Jarque-Bera	115,77	172,32	882,97
Probability	0,00	0,00	0,00

Sample: 1/03/2005 10/16/2018
Included observations: 3597

	OIL	USD	RATE
Mean	73,38	0,79	1,22
Median	70,97	0,77	0,20
Maximum	145,31	0,96	5,05
Minimum	26,19	0,63	-0,02
Std, Dev,	22,32	0,08	1,65
Skewness	0,31	0,31	1,22
Kurtosis	2,37	2,37	3,00
Jarque-Bera	115,36	115,69	897,29
Probability	0,00	0,00	0,00

Sample: 10/17/2018 6/30/2020
Included observations: 445

	OIL	USD	RATE
Mean	51,06	0,90	1,67
Median	54,99	0,89	1,95
Maximum	69,63	0,93	2,43
Minimum	0,01	0,87	-0,05
Std, Dev,	12,58	0,01	0,81
Skewness	-1,53	0,33	-1,04
Kurtosis	4,74	2,31	2,67
Jarque-Bera	230,02	16,79	81,67
Probability	0,00	0,00	0,00

Table 2: Descriptive statistics for US dollar, Oil prices and 3M interest rate – Data sources: ECB, FED, Thomson Reuters

Covariance and correlation Analysis
Sample: 1/03/2005 6/30/2020
Included observations: 4042

Covariance	OIL	USD	RATE
OIL	509,5119		
USD	-1,3438	0,0063	
RATE	-5,4383	-0,0018	2,5215

Correlation	OIL	USD	RATE
OIL	1,0000		
USD	-0,7519	1,0000	
RATE	-0,1517	-0,0143	1,0000

Covariance and correlation Analysis
Sample: 1/03/2005 10/16/2018
Included observations: 3597

Covariance	OIL	USD	RATE
OIL	498,2037		
USD	-1,2317	0,0057	
RATE	-6,0403	-0,0065	2,7307

Correlation	OIL	USD	RATE
OIL	1,0000		
USD	-0,7300	1,0000	
RATE	-0,1638	-0,0522	1,0000

Covariance and correlation Analysis
Sample: 10/17/2018 6/30/2020
Included observations: 445

Covariance	OIL	USD	RATE
OIL	157,8448		
USD	-0,0895	0,0002	
RATE	8,3924	-0,0073	0,6491

Correlation	OIL	USD	RATE
OIL	1,0000		
USD	-0,4861	1,0000	
RATE	0,8291	-0,6207	1,0000

Table 3: Correlation matrix and covariance matrix for US dollar, Oil prices and 3M interest rate for the whole sample, before crisis and after crisis – Data sources: ECB, FED, Thomson Reuters

METHODOLOGY

In our empirical study, we consider the seminal Sims (1980)'s structural vector auto-regression model (SVAR) where additional identifying restrictions have been included to transform VAR errors into uncorrelated structural shocks. The SVAR model is given as

$$Ay_t = A_1^s y_{t-1} + \cdots + A_p^s y_{t-p} + C^s x_t + B\varepsilon_t \qquad (1)$$

where y_t is a 3x1 vector of endogenous variables, the first element being the oil prices, the second being the US dollar exchange rate and the third one being the interest rate. The variable x_t is a 1x1 vector representing the value time-t value of the exogenous variable (5Y breakeven inflation rate). The 3x3 matrix A, in which the diagonal elements are normalized to one, determines the contemporaneous feedback effects among the endogenous variables. The coefficient matrices A_i^s for i = 1, …, p and C^s are structural coefficients and have to be estimated. We assume that the structural errors ε_t is a white noise vector with orthonormal unobserved innovation components, i.e., $E(\varepsilon_i) = E(\varepsilon_i \varepsilon_{p \neq i}) = 0$.

To perform the structural vector auto-regression (SVAR), the reduced form of (1) is estimated. To calculate the reduced form, equation (1) is multiplied by the inverse of A, so that:

$$y_t = A^{-1}A_1^s y_{t-1} + \cdots + A^{-1}A_p^s y_{t-p} + A^{-1}C^s x_t + A^{-1}B\varepsilon_t \tag{2}$$

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Cx_t + u_t \tag{3}$$

where $A_i = A^{-1}A_i^s$ denotes the reduced-form lag matrix and C = $A^{-1}C^s$. The reduced form error structure is given by:

$$u_t = A^{-1}B\varepsilon_t \tag{4}$$

Let us note that u_t is the reduced form residuals and its variance-covariance matrix is:

$$\sum_u = A^{-1}BB^T A^{-1^T} \tag{5}$$

The SVAR is now specified; we have next to set restrictions for the SVAR identification. First, we need to set the normalisation of the SVAR through the error terms:

$$E(u'_t u_t) = I \tag{6}$$

where *I* is the identity matrix. This is done in order to estimate the A and B matrices of the following equation:

$$A\,u_t = B\varepsilon_t \tag{7}$$

We use the AB model to identify A and B, following Kozluk and Mehrotra (2009), where restrictions can be placed on both matrices and where the minimum number of restrictions for identification is K^2 + K*(K-1)/2, K being the number of endogenous variables. Parameter estimation is performed by minimizing the opposite of the concentrated log-likelihood function:

$$lnL_e(A,B) = -\frac{KT}{2}\ln(2\pi) + \frac{T}{2}\ln|\mathrm{A}|^2 - \frac{T}{2}\ln|\mathrm{B}|^2 - \frac{T}{2}\mathrm{tr}(\mathrm{ATB}^{-1^T}\ \mathrm{B}^{-1}\mathrm{A}\tilde{\Sigma}_u) \tag{8}$$

where $\tilde{\sum}_u$ is an estimate of the reduced form residual covariance matrix. We may use the estimated moment $\tilde{\sum}_u$ along with the K(K+1)/2 unique covariance equations in (4), (5) and (7) to estimate the $2K^2$ elements in A and B. Restrictions on A and B take the form of assumptions about the structure of contemporaneous feedback of variables (indeed matrix A captures the direct contemporaneous - intra-week - effects of structural shocks) in the SVAR and assumption about the correlation structure of the errors, respectively. We identify restrictions on A and B matrices as follow:

$$A = \begin{matrix} 1 & * & 0 \\ * & 1 & * \\ 0 & 0 & 1 \end{matrix} \qquad B = \begin{matrix} * & 0 & 0 \\ 0 & * & 0 \\ 0 & 0 & * \end{matrix}$$

where 0 and 1 are restrictions and where * are the parameters to estimate. As K = 3 in our study, we need to restrict 12 values in components of A and B matrices.

The lag-length for the SVAR is selected by minimizing a combination of Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria; in fact Akaike (AIC) is not pertinent in our case as we have a large sample (4041 observations).

$$SC = \ln(n)\,k - 2\ln(L_{\max}) \tag{9}$$

$$HQ = 2\,ln(ln(n))\,k - 2ln(L_{max}) \tag{10}$$

Where $L_{\max}$ is the maximized value of the log-likelihood, *k* here is the number of parameters and *n* is the number of observations. An estimate of the deviance of the model fit is the *-2ln(L_{max})* term that is appearing in each formula.

III. EMPIRICAL ANALYSIS

In this section we analyse results of our SVAR identification using the AB model. Using daily data of US Dollar exchange rate, oil prices and interest rate, the vector of endogenous variables is:

$$y_t = [100 * \Delta \ln o_t \quad 100 * \Delta \ln d_t \quad \Delta r_t]$$

where o_t stands for oil prices, d_t is the US Dollar versus Euro exchange rate and r_t is the US 3 months interest rate. In the SVAR model we consider, the exogenous variables x_t is a 1x1 vector given as the 5-Year Breakeven Inflation Rate as measure of the effect of global economic development on US dollar and oil prices (see Section III.1).

We perform the following two steps statistical analysis. In the first step, we review the model estimation outputs. Among these outputs, the components of matrix A explain the short term relationship between the Dollar and the oil price and capture the direct contemporaneous (intra-week) effects of structural shocks. In addition, we will compute the impulse responses and the variance decomposition of our model. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR. Finally, as a second step, we study the oil-dollar long run relationship using Granger causality tests.

In order to study the change since the 2018 oil crisis, we will consider three different statistical analysis : one for the whole period - from 2005:01 until 2020:06 (see Section IV.1), one for each identified sub-periods to study potential changes in the oil-US Dollar relationship, i.e., period from 2005:01 until 2018:10:16, and the period from 2018:10:17 until 2020:06 (see Section IV.2).

THE WHOLE SAMPLE RESULTS ANALYSIS

Following Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria, our model needs 6 lag-length, as reported in appendix 3a, to minimize the information criteria, so we will have six-day lag as we are using daily data. With data going from 2005:01 until 2020:06, we have 4041 observations after adjustment.

Table 4 presents the results of model estimation outputs for the whole period from the identification procedure, the structural VAR being just-identified. The estimated matrix A shows the coefficients of matrix A in equation (1), which capture the direct contemporaneous (intra-week) effects of structural shocks. The results indicate that a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an appreciation of the US dollar exchange rate. Both effects are estimated to be inequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates.

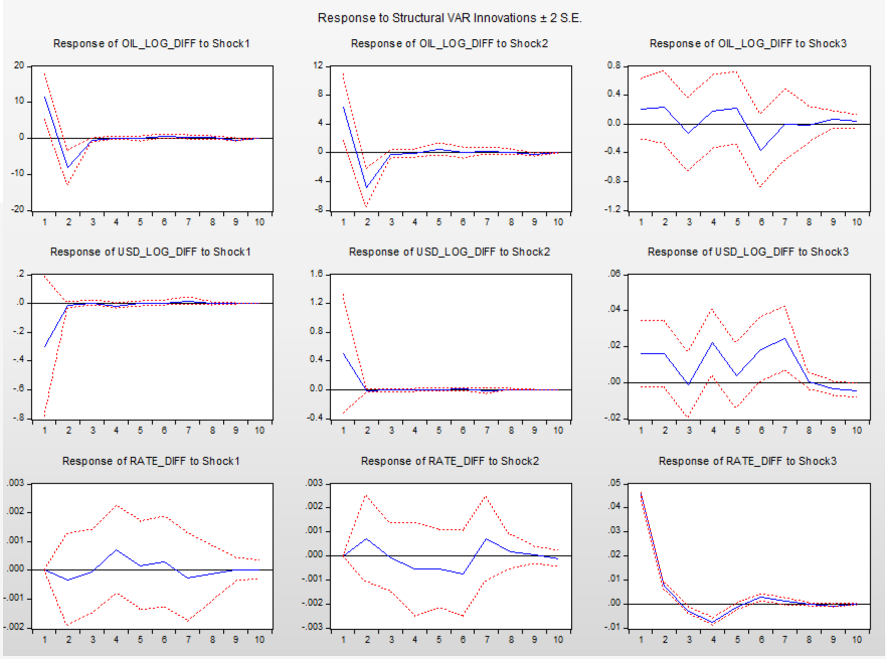
Direct contemporaneous effects (matrix A)

From… *…to*	$\varepsilon_{OIL\_LOG\_DIFF}$	$\varepsilon_{DOLLAR\_LOG\_DIFF}$	ε_{RATE_DIFF}
OIL_LOG_DIFF	1	-12,65454	0
DOLLAR_LOG_DIFF	0,025582	1	-0,466524
RATE_DIFF	0	0	1

Table 4: SVAR model estimation outputs of the matrix A for the whole period. OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

A shock to the i-th variable not only directly affects the i-th variable but is also transmitted to all the other endogenous variables through the dynamic (lag) structure of the VAR model. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. We will use Cholesky that uses the inverse of the Cholesky factor of the residual covariance matrix to orthogonalize the impulses. Structural Decomposition uses the orthogonal transformation estimated from the structural factorization matrices.

In order to study impulse response functions, we first have to determine the order of our variables because the results depend strongly on the order it is set up. We must place from the most exogenous variables to more endogenous, or from the least dependent of others to the most dependent of others. We choose to order them as follow: interest rate, US Dollar and oil. We have reported impulse response functions to structural shocks for the whole period in figure 5. The results indicate that oil will react positively to a structural shock on the US Dollar exchange rate for three days. On the contrary, the US Dollar will respond negatively to a structural shock on the oil prices for two days. The magnitude of the responses is clearly different: the oil will respond strongly to a shock on the US Dollar compared to the response of the US Dollar on the oil prices shocks.



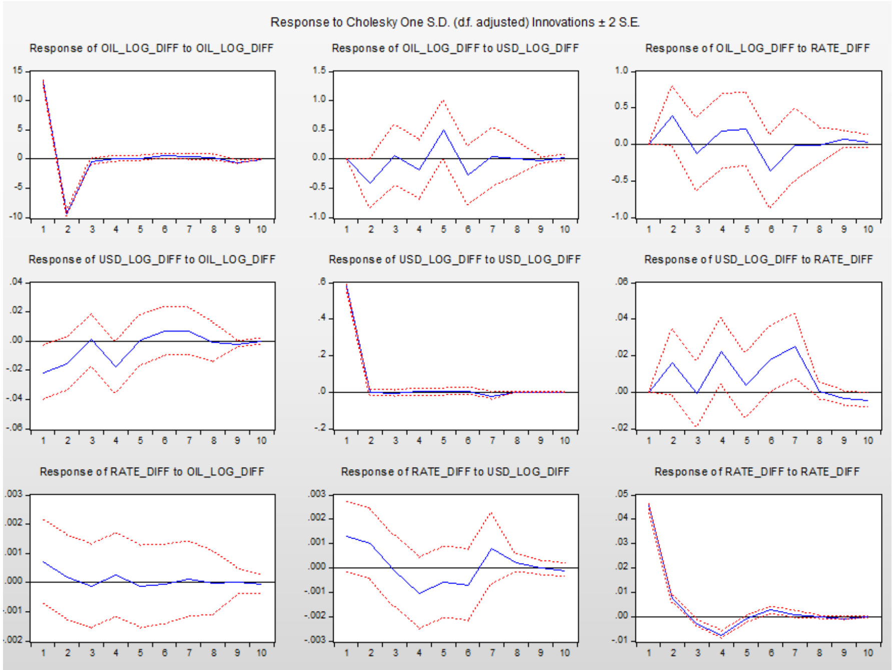


Figure 5: Impulse responses functions (structural decomposition on top and Cholesky one standard deviation decomposition on bottom) for the whole period. OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

This study based on the impulse response functions can be supplemented by an analysis of variance decomposition of the forecast error. The objective is to calculate the contribution of each of the innovations to the variance of the error.

Regarding the variance decomposition (see appendix 4a), summarized in table 5a, the variance of the forecast error of US Dollar is due for 99.21% to its own innovations, 0,20% for those of oil and 0.59% for those of interest rate. The variance of the forecast error of oil prices is due for 99.64% to its own innovations, 0,23% for those of US Dollar and 0.13% for those of interest rate. From the perspective of this test, we can conclude that during a structural shock, the US Dollar exchange rate impacts more the oil prices than a shock of the oil prices on the US Dollar exchange rate, which is consistent with the first results of our study.

If we now look to the long run causality using Granger causality tests reported in table 5b, a different picture emerges over longer horizons. In fact, the US Dollar exchange rate Granger-cause oil prices but not the opposite; and the US interest rates Granger-cause both oil prices and exchange rates.

Variance decomposition

	Whole sample		
	Oil_t	**$Dollar_t$**	**$Rate_t$**
εOil,t	0,9964	0,0023	0,0013
εDollar,t	0,0020	0,9921	0,0059
εRate,t	0,0001	0,0013	0,9986

Table 5a: Variance decompositions for the whole sample period. Fraction of the forecast error variance of the variables listed in the columns, explained by shocks listed in the rows. Oil_t, $Dollar_t$ and $Rate_t$ denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

Granger causality Wald tests

Equation	Excluded	X^2	df	Prob > X^2
OIL_LOG_DIFF	USD_LOG_DIFF	10,27460	6	0,1136
OIL_LOG_DIFF	RATE_DIFF	10,87542	6	0,0923
OIL_LOG_DIFF	All	20,15908	12	0,0641
USD_LOG_DIFF	OIL_LOG_DIFF	8,05993	6	0,2337
USD_LOG_DIFF	RATE_DIFF	21,76353	6	0,0013
USD_LOG_DIFF	All	29,09909	12	0,0038
RATE_DIFF	OIL_LOG_DIFF	0,402785	6	0,9988
RATE_DIFF	USD_LOG_DIFF	4,716523	6	0,5807
RATE_DIFF	All	5,153679	12	0,9526

Table 5b: Granger causality Wald tests. OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

CHANGES OVER PERIODS ANALYSIS

Following Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria, our model needs 3 lag-lengths for the first period, as reported in appendix 3b, to minimize the information criteria, so we will have 3 days lag as we are using daily data. Regarding the second period we need 4 lag-lengths as reported in appendix 3c, so we will have 4 days lag. There is a difference between Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria, but we choose the one that allow the minimum lag-lengths. Using data from 2005:01 until 2018:10:16 for the first period, we have 3593 observations after adjustment while for the second period, using data from 2018:10:17 until 2020:06, we have 442 observations after adjustment.

Direct contemporaneous effects (matrix A)

From... *...to*	ε *OIL_LOG_DIFF*	ε *DOLLAR_LOG_DIFF*	ε *RATE_DIFF*
OIL_LOG_DIFF	1	-9,59696	0
DOLLAR_LOG_DIFF	0,488883	1	-1,612914
RATE_DIFF	0	0	1

Table 6a: SVAR model estimation outputs for the first period (2005:01-2018:10:16). OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

Direct contemporaneous effects (matrix A)

From... *...to*	ε *OIL_LOG_DIFF*	ε *DOLLAR_LOG_DIFF*	ε *RATE_DIFF*
OIL_LOG_DIFF	1	10,83037	0
DOLLAR_LOG_DIFF	-0,001211	1	-1,132332
RATE_DIFF	0	0	1

Table 6b: SVAR model estimation outputs for the second period (2018:10:17-2020:06). OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

Table 6a and 6b presents the results of the SVAR model estimation outputs for both periods from the identification procedure, the structural VAR being just-identified in both cases. The results for the first period, are aligned with the results of the whole sample: a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an appreciation of the US Dollar exchange rate. Both effects are estimated to be inequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates. If we analyse the second period, we notice a change in the variables impact on each other: a depreciation of the US Dollar is associated with a contemporaneous decrease in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an depreciation of the US Dollar exchange rate. Here again, both effects are estimated to be inequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates.

We have reported impulse response functions to structural shocks for both periods in figure 6a and 6b. The results indicate, on the first period, that oil will react positively to a structural shock on the US Dollar exchange rate for two days. On the contrary, the US Dollar will respond negatively to a structural shock on the oil prices for two days. The magnitude of the responses is clearly different: the oil will respond strongly to a shock on the US Dollar compared to the response of the US Dollar on the oil prices shocks. If we focus now on the second period results, a different relationship appears between the oil prices and the US Dollar: the oil prices will respond negatively to a shock on the US Dollar during one day while the US Dollar will respond positively to a shock on the oil prices.

Regarding the variance decomposition (see appendix 4b and 4c), the results are listed in the table 7. We notice here that both period are following the results found with the whole period sample: during a structural shock, the US Dollar exchange rate explains more the oil prices than a shock of the oil prices on the US Dollar exchange rate ; which is consistent with the results found after the estimation of matrix A for both cases.

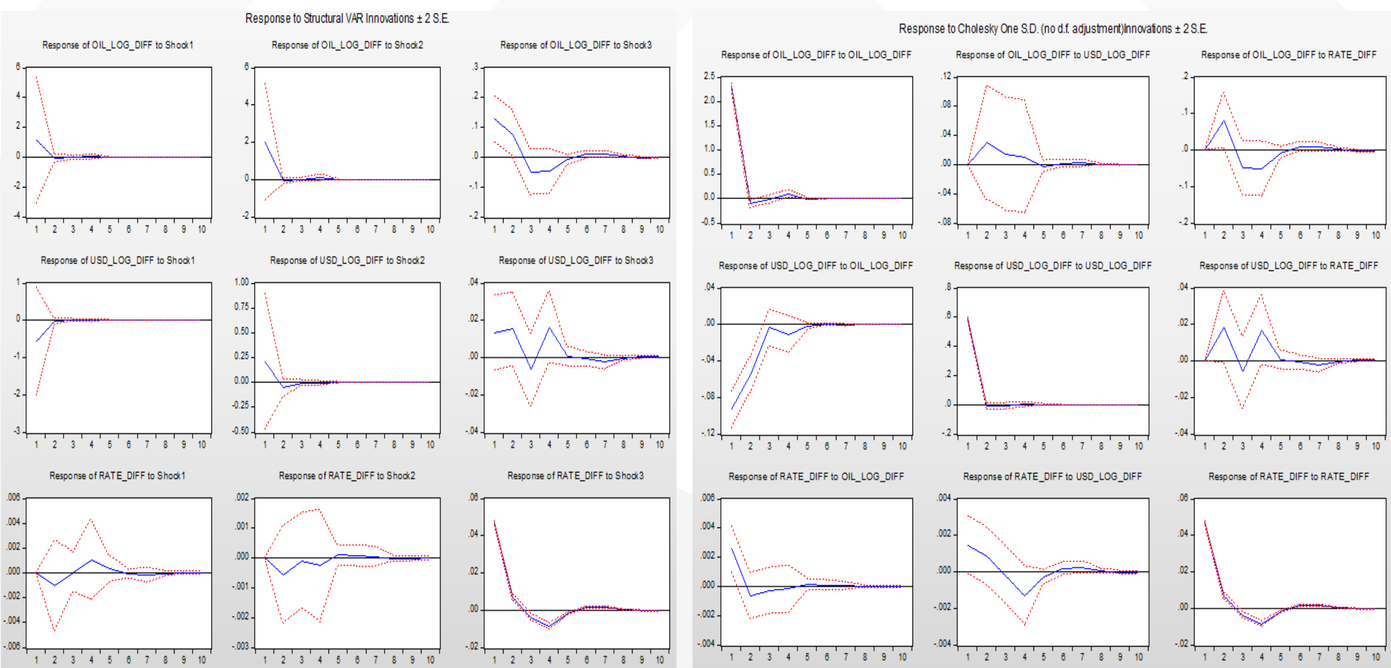


Figure 6a: Impulse responses functions (structural decomposition on top and Cholesky one standard deviation decomposition on bottom) for the first period (2005:01-2018:10:16). OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

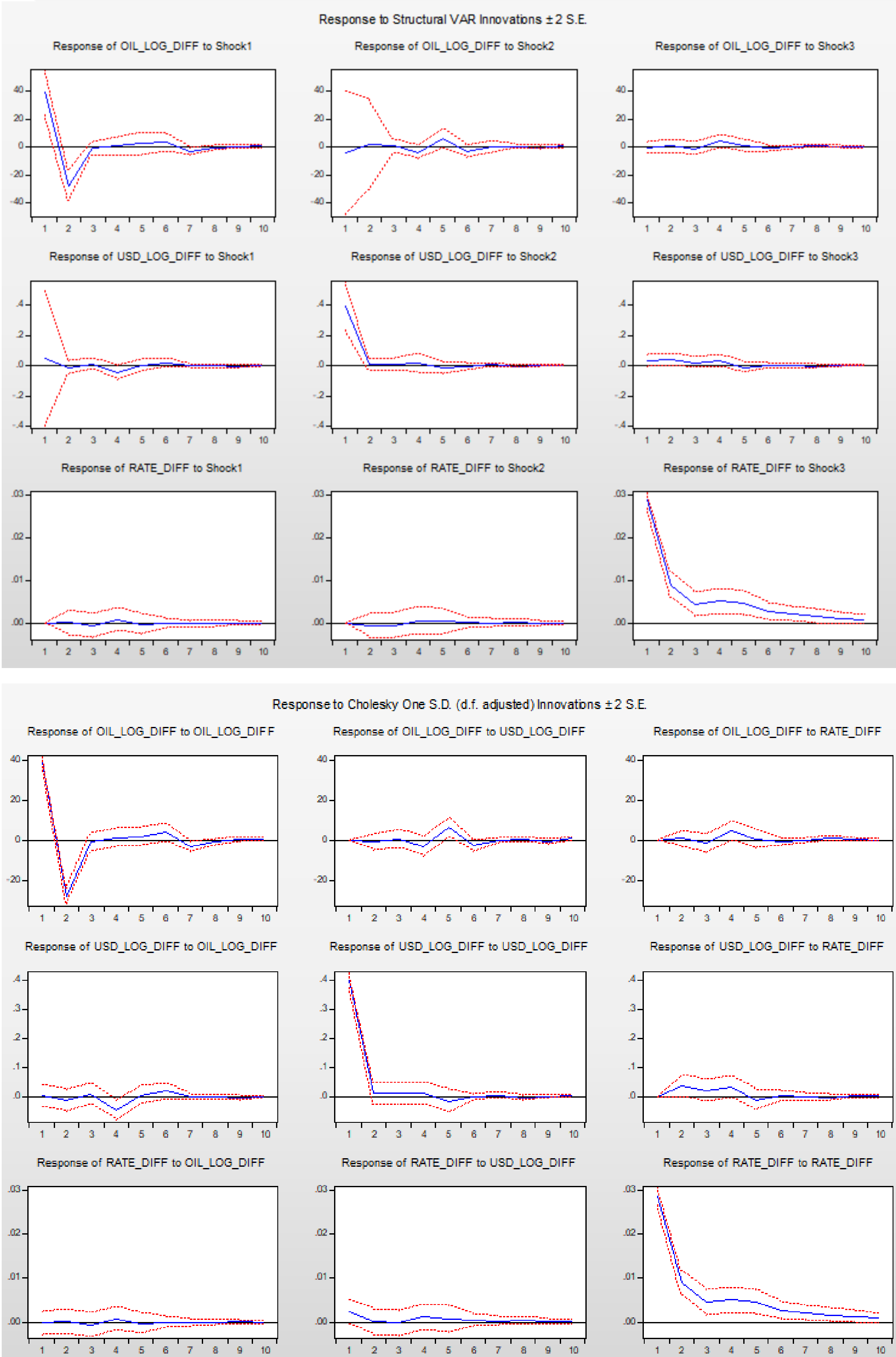


Figure 6b: Impulse responses functions (structural decomposition on top and Cholesky one standard deviation decomposition on bottom) for second period (2018:10:17-2020:06). OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

Variance decompositions

	Period 1		
	Oil_t	$Dollar_t$	$Rate_t$
εOil,t	0,9700	0,0250	0,0050
εDollar,t	0,0095	0,9885	0,0020
εRate,t	0,0004	0,0008	0,9988

	Period 2		
	Oil_t	$Dollar_t$	$Rate_t$
εOil,t	0,9626	0,0271	0,0103
εDollar,t	0,0171	0,9574	0,0255
εRate,t	0,0010	0,0015	0,9975

Table 7: Variance decompositions for the period 2005:01-2018:10:16 (above) and the period 2018:10:17-2020:06 (below). Fraction of the forecast error variance of the variables listed in the columns, explained by shocks listed in the rows. Oil_t, $Dollar_t$ and $Rate_t$ denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: ECB, FED, Thomson Reuters.

If we now look to the long run causality using Granger causality tests reported in table 8a and 8b, we notice for the first period that oil prices Granger-cause the US Dollar exchange rate being significative at over 99,99%, but not the opposite, while US interest rates Granger-cause both oil prices and exchange rates. Regarding the second period, the oil prices Granger-cause the US Dollar exchange rate (but being less significative than for the first period) but here, the US Dollar exchange rate also Granger-cause the oil prices, while the US interest rates Granger-cause both oil prices and exchange rates.

Granger causality Wald tests

Equation	Excluded	X^2	df	Prob > X^2
OIL_LOG_DIFF	USD_LOG_DIFF	0,801434	3	0,8491
OIL_LOG_DIFF	RATE_DIFF	8,140450	3	0,0432
OIL_LOG_DIFF	All	8,887605	6	0,1800
USD_LOG_DIFF	OIL_LOG_DIFF	34,41412	3	0,0000
USD_LOG_DIFF	RATE_DIFF	6,317004	3	0,0972
USD_LOG_DIFF	All	39,93513	6	0,0000
RATE_DIFF	OIL_LOG_DIFF	1,344585	3	0,7186
RATE_DIFF	USD_LOG_DIFF	2,229355	3	0,5262
RATE_DIFF	All	3,995048	6	0,6773

Table 8a: Granger causality Wald tests for the first period 2005:01-2018:10:16. OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: Data sources: ECB, FED, Thomson Reuters.

Granger causality Wald tests

Equation	Excluded	X^2	df	Prob > X^2
OIL_LOG_DIFF	USD_LOG_DIFF	8,394490	4	0,0782
OIL_LOG_DIFF	RATE_DIFF	9,471707	4	0,0503
OIL_LOG_DIFF	All	17,556740	8	0,0248
USD_LOG_DIFF	OIL_LOG_DIFF	7,784528	4	0,0998
USD_LOG_DIFF	RATE_DIFF	7,560073	4	0,1091
USD_LOG_DIFF	All	15,766560	8	0,0458
RATE_DIFF	OIL_LOG_DIFF	0,835568	4	0,9336
RATE_DIFF	USD_LOG_DIFF	0,764389	4	0,9432
RATE_DIFF	All	1,583882	8	0,9912

Table 8b: Granger causality Wald tests for the second period 2018:10:17-2020:06. OIL_LOG_DIFF, DOLLAR_LOG_DIFF and RATE_DIFF denote, respectively, oil price, US Dollar (both in log changes), and changes in the nominal US 3-month interest rate. – Data sources: Data sources: ECB, FED, Thomson Reuters.

To conclude, we can say that:

i) there is a negative co-movement between oil prices and US Dollar over the 15 years period;

ii) a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short run (within the same week), while an increase on the oil prices lead to an appreciation of the US dollar exchange rate. Both effects are estimated to be inequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates;

iii) a different picture emerges over longer horizons: the US Dollar exchange rate Granger-cause oil prices but not the opposite; and the US interest rates Granger-cause both oil prices and exchange rates;

iv) this relationship in both short and long run as well as regarding the Oil-US Dollar correlation are varying over time: the negative correlation between the US Dollar and oil prices is getting less and less strong since the end of 2018. Moreover, for the first period studied, a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an appreciation of the US Dollar exchange rate. For the second period, a depreciation of the US Dollar is associated with a contemporaneous decrease in oil prices in the short-run (within the same week), while an increase on the oil prices lead to an depreciation of the US Dollar exchange rate. Regarding the long run causality using Granger causality tests, we notice changes over periods: oil prices Granger-cause the US Dollar exchange rate for both periods but not the opposite for the first period while for the second period we observe that the US Dollar exchange rate also Granger-cause the oil prices.

IV. CONCLUSIONS

Since 2014, the oil markets experienced several crashes. At the same time, the US dollar strongly fluctuated even if it has mainly increased since 2014. For the last fifteen years, we can clearly see that a persistent correlation exists between the US dollar and the oil price. Those facts drive us to carefully address the question of the oil-US dollar relationship: what determinates dollar-oil correlation? Do oil prices affect US dollar, is it the opposite or are they both influencing each other? Which economic drivers are behind this relationship? Are there any exogenous factors impacting those assets? Finally, do determinants of the dollar-oil link change overtime?

In order to study those questions, we considered a structural VAR (SVAR) that is fully identified following AB model, allowing bipartite co-movement between the US dollar exchange rate (against Euro) and oil prices on a short run but also in a long run using Granger causality tests. We estimated this SVAR model over a 15 years sample period and we perform the same estimation exercise on two sub-period, one pre and one post 2018 oil crisis, to detect whether there have been structural changes over these two subsequent periods. To introduce into our model exogenous factor that can measure the effect of global economic development on US dollar and oil prices, we considered the 5-Year Breakeven Inflation Rate. This factor aims at measuring the effect of global economic development on US Dollar and oil prices.

Our findings indicate the following.

- there is a negative co-movement between oil prices and US Dollar for the 15 years period;
- a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short run (within the same week), while an increase on the oil prices leads to an appreciation of the US dollar exchange rate. Both effects are estimated to be unequal in magnitude, the effect of the US Dollar on the oil is being much stronger than the effect of the oil on the US Dollar exchange rates;
- a different picture emerges over longer horizons: the US Dollar exchange rate Granger-cause oil prices but not the opposite; and the US interest rates Granger-cause both oil prices and exchange rates;
- this relationship in both short and long run as well as regarding the Oil-US Dollar correlation are varying over time: the negative correlation between the US Dollar and oil prices is getting less and less strong since the end of 2018. Moreover, for the first period studied, a depreciation of the US Dollar is associated with a contemporaneous increase in oil prices in the short-run (within the same week), while an increase on the oil prices leads to an appreciation of the US Dollar exchange rate. For the second period, a depreciation of the US Dollar is associated with a contemporaneous decrease in oil prices in the short-run (within the same week), while an increase on the oil prices leads to an depreciation of the US Dollar exchange rate. Regarding the long run causality using Granger causality tests, we notice changes over periods: oil prices Granger-cause the US Dollar exchange rate for both periods but not the opposite for the first period while for the second period we observe that the US Dollar exchange rate also Granger-cause the oil prices.

Our main finding has been to highlight that the determinants of the oil-US Dollar relationship are not constant and change over time. We noticed that during a stressed period the negative correlation between oil and US Dollar markets is getting less strong over time. We can raise the parallel with the studies[3] stating that during a stressed period or an economic recession all assets get correlated positively with markets downturn. Indeed, during an economic crisis all markets will drop that will inevitably create a positive correlation between assets.

In terms of influence between oil and US Dollar, we could observe that shocks in markets do not give the same effect on oil and US Dollar relationship and these interactions strongly depend on the period. There is a clear change of paradigm between the pre and the post 2018 oil crisis periods. Indeed, whereas we noted that, for the whole period sample and the first period studied, the relationship between oil and US Dollar are similar, we however noticed that for the second period (a period where oil markets were very stressed) this relationship changes. For the second period, the SVAR model results exhibit a clear change of direction in the short-term causality of the oil-US Dollar relationship: a depreciation of the US Dollar leads to an increase of the oil prices for the whole sample and for the first period, while a depreciation of the US Dollar leads to a decrease of the oil prices for the stressed period (second period).

Thus, it will be interesting to study the determinants of the Oil-US Dollar relationship for a very stressed short period and see how the variables will react to an extreme shock in all markets. A complementary study focusing on the coronavirus pandemic period and measuring the changes in the relationship with previous periods would be of great interest. We let this study for future research.

[3] We can quote Junior & Franca, 2012 : "Using the eigenvalues and eigenvectors of correlations matrices of some of the main financial market indices in the world, we show that high volatility of markets is directly linked with strong correlations between them. This means that markets tend to behave as one during great crashes."

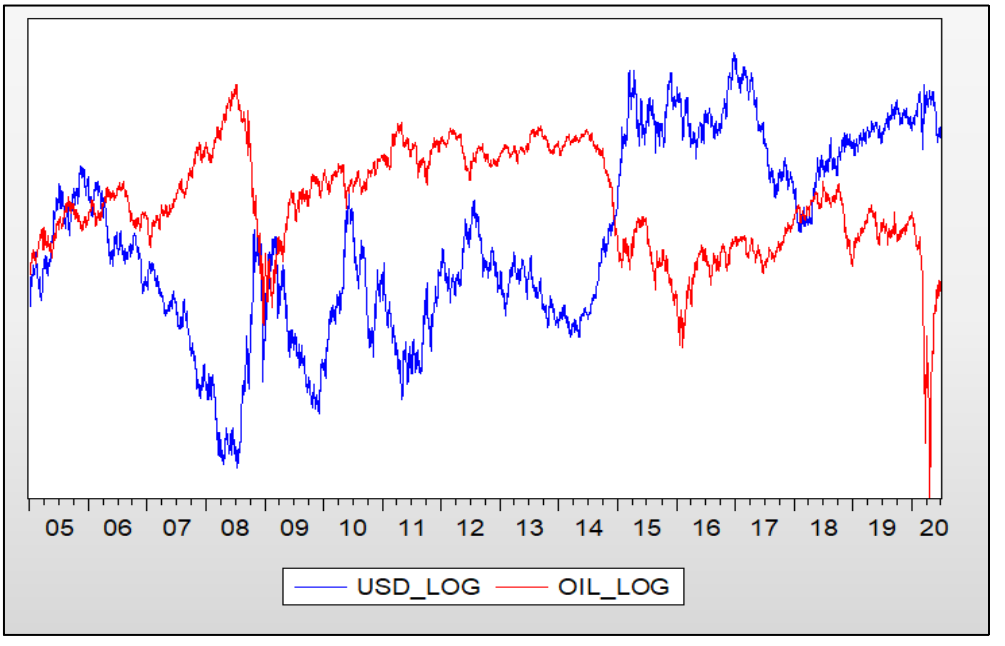
References

- **Akram, Q.F.** (2009). *Commodity prices, interest rates and the dollar*. **Energy Economics,** November 2009, v.31, iss. 6, pp. 838-51
- **Amano, R.A., van Norden, S.** (1998a). *Oil prices and the rise and fall of the US real exchange rate*. **Journal of International Money and Finance** 17, 299–316.
- **Amano, R.A., van Norden, S.** (1998b). *Exchange rates and oil prices*. **Review of International Economics** 6, 683–694.
- **Anjum, H.** (2019). *Estimating volatility transmission between oil prices and the US Dollar exchange rate under structural breaks*. **Journal of Economics and Finance**. February 2019, Vol. 43, p750–763
- **Arouri, M.H. and Jawadi, F**. (2010). *Oil Prices and Exchange Rates: Some New Evidence Using Linear and Nonlinear Models*. **International Symposia in Economic Theory and Econometrics,** vol. 20. Bingley, U.K.: Emerald; distributed by Turpin Distribution, Biggleswade, U.K.
- **Atems, B., Kapper, D. and Lam, E.** (2015). *Do exchange rates respond asymmetrically to shocks in the crude oil market?* **Energy Economics**. May2015, Vol. 49, p227-238. 12p.
- **Backus, D.K. and Crucini, M.J.** (2000). *Oil Prices and the Terms of Trade*. **Journal of International Economics**, 50, 185-213.
- **Basher, S.A., Haug A.A. and Sadorsky P.** (2012). *Oil Prices, Exchange Rates and Emerging Stock Markets*. **Energy Economics**, January 2012, v. 34, iss. 1, pp. 227-40
- **Beckmann, J. and Czudaj, R.** (2013). *Oil Prices and Effective Dollar Exchange Rates*. **International Review of Economics and Finance**, June 2013, v. 27, pp. 621-36
- **Benhmad, F. (2012).** *Modeling Nonlinear Granger Causality between the Oil Price and U.S. Dollar: A Wavelet Based Approach*. **Economic Modelling,** July 2012, v. 29, iss. 4, pp. 1505-14
- **Bloomberg, S., Harris, E.** (1995). *The commodity-consumer price connection: Fact or fable?* **Economic Policy Review**, 21–38 (October).
- **Chang, H.F., Huang, L.C. and Chin, M.C.** (2013). *Interactive Relationships between Crude Oil Prices, Gold Prices, and the NT-US Dollar Exchange Rate-A Taiwan Study*. **Energy Policy**, December 2013, v. 63, pp. 441-48
- **Chen, S.S. and Chen, H.C.** (2007). *Oil Prices and Real Exchange Rates***. Energy Economics,** May 2007, v. 29, iss. 3, pp. 390-404
- **Chen, W.P., Choudhry, T. and Wu, C.C.** (2013). *The Extreme Value in Crude Oil and US Dollar Markets*. **Journal of International Money and Finance**, September 2013, v. 36, pp. 191-210
- **Chen, Y. and Rogoff, K.** (2003). *Commodity currencies*. **Journal of International Economics** 60, 133–160.
- **Coudert, V., Mignon, V.** (2015). *Reassessing the empirical relationship between the oil price and the dollar*. **CEPII Working Paper,** No 2015-25 – December
- **Coudert, V., Mignon, V., and Penot, A.** (2007). *Oil Price and the Dollar*. **Energy Studies Review**, Fall 2007, v. 15, iss. 2, pp. 48-65
- **De Schryder, S. and Peersman, G.** (2015). *The U.S. Dollar Exchange Rate and the Demand for Oil*. **Energy Journal.** Jul2015, Vol. 36 Issue 3, p263-285. 23p.
- **Fratzscher, M., Schneider, D. and Robays, I.** (2014). *Oil prices, exchange rates and asset prices*. **European Central Bank**, Working Paper Series: 1689
- **Golub S.** (1983). *Oil Prices and Exchange Rates*. **The Economic Journal,** vol. 93, n° 371, pp. 576-593.

- **Hamilton, J.D.** (1983). *Oil and the Macroeconomy since World War II*. **Journal of Political Economy** 91 (2), 228–248.
- **Huang, C., Wen, F., Xia, X. and Xiao, J.** (2018). *Interaction between oil and US dollar exchange rate: nonlinear causality, time-varying influence and structural breaks in volatility*. **Applied Economics**, 2018, Vol. 50, No. 3, p319–334
- **Junior, L. S., and Franca, I. D.** (2012). *Correlation of financial markets in times of crisis*. **Physica A** 391, 187–208
- **Kozluk, T. and Mehrotra, A**. (2009). *The impact of monetary policy shocks on East and South-east Asia*. **Economics of Transition**, 17(1), 121-145.
- **Krugman, P.** (1983a). *Oil and the Dollar*. **Economic Interdependence and Flexible Exchange Rates**, MIT Press.
- **Krugman, P.** (1983b). *Oil Shocks and Exchange Rate Dynamics*. **Exchange Rates and International Macroeconomics,** University of Chicago Press.
- **Lizardo, R. and Mollick, A.V.** (2010). *Oil Price Fluctuations and U.S. Dollar Exchange Rates*. **Energy Economics**, March 2010, v. 32, iss. 2, pp. 399-408
- **Mignon, V.** (2008). *Les liens entre les fluctuations du prix du pétrole et du taux de change du dollar*. **Revue d'Économie Financière.** December 2008, Vol. 94, p1-9. 9p. 2 Graphs.
- **Novotný, F.** (2012). *The Link between the Brent Crude Oil Price and the US Dollar Exchange Rate*. **Prague Economic Papers***,* June 2012, v. 21, iss. 2, pp. 220-32
- **Obadi, S.M.** (2012). *To what Extent Do Oil Prices Depend on the Value of US Dollar: Theoretical Investigation and Empirical Evidence*. **Crude Oil Exploration in the World**, Prof. Mohamed Younes (Ed.)
- **Rahmanifard, D., Safarzadeh, E. and Zeinali, L.** (2016*). Estimation of Long-run Relationship between Crude Oil and US' Dollar Value: A Cointegration Analysis*. **International Journal of Management, Accounting and Economics**, Vol. 3, No. 2, February 2016
- **Reboredo, J.C.** (2012). Modelling Oil Price and Exchange Rate Co-movements. **Journal of Policy Modeling,** May-June 2012, v. 34, iss. 3, pp. 419-40
- **Reboredo, J.C., Rivera-Castro, M.A. and Zebende, G.F.** (2014). *Oil and US Dollar Exchange Rate Dependence: A Detrended Cross-Correlation Approach*. **Energy Economics**, March 2014, v. 42, pp. 132-39
- **Rogoff, K.** (1991). *Oil Productivity, Government Spending and the Real Yen-Dollar Exchange Rate*. **Federal Reserve Bank of San Francisco**, Working Paper, n° 91-06.
- **Samanta, S.K., and Zadeh, A.H.M.** (2012). *Co-movements of Oil, Gold, the US Dollar, and Stocks*. **Modern Economy**, January 2012, v. 3, iss. 1, pp. 111-17
- **Sims, C.A.** (1980). *Macroeconomics and Reality*. **Econometrica**, No. 48, p1–48.
- **Tamakoshi, G. and Hamori, S.** (2012). *Real Oil Prices, Real Economic Activity, Real Interest Rates, and the US Dollar: A Cointegration Analysis with Structural Breaks*. **Journal of Reviews on Global Economics**, 2012, v. 1, iss. 1, pp. 41-46
- **Wang, Y. and Wu, C.** (2012). *Energy Prices and Exchange Rates of the U.S. Dollar: Further Evidence from Linear and Nonlinear Causality Analysis*. **Economic Modelling**, November 2012, v. 29, iss. 6, pp. 2289-97
- **Wirjanto, T.S. and Yousefi, A.** (2003). *Exchange Rate of the US Dollar and the J-curve: The Case of Oil Exporting Countries*. **Energy Economics,** 25, 741-765.
- **Wirjanto, T.S. and Yousefi, A.** (2005). *A Stylized Exchange Rate Pass-through Model of Crude Oil Price Formation*. **OPEC Energy Review**, 29 (3), 177-197.
- **Zhang, Y.** (2013). *The Links between the Price of Oil and the Value of US Dollar*. **International Journal of Energy Economics and Policy**, 2013, v. 3, iss. 4, pp. 341-51
- **Zhang, Y.J., Fan, Y., Tsai, H.T. and Wei, Y.M.** (2008). *Spillover Effect of US Dollar Exchange Rate on Oil Prices*. **Journal of Policy Modeling**, November-December 2008, v. 30, iss. 6, pp. 973-91
- **Zhou, S.** (1995). *The Response of Real Exchange Rates to Various Economic Shocks*. **Southern Journal of Economics**, pp. 936-954.

APPENDICES

Appendix 1



Appendix 1a: Oil prices and US Dollar exchange rate in logarithmic term – Data source: ECB and Thomson Reuters

Null Hypothesis: USD_LOG has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.744603	0.4086
Test critical values:	1% level	-3.431783	
	5% level	-2.862059	
	10% level	-2.567089	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: OIL_LOG has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.743834	0.0036
Test critical values:	1% level	-3.431786	
	5% level	-2.862060	
	10% level	-2.567090	

*MacKinnon (1996) one-sided p-values.

Appendix 1b: Unit root Augmented Dickey-Fuller test on US Dollar exchange rate versus Euro (upper table) and Oil prices (lower table) in logarithmic term – Data source: ECB and Thomson Reuters

Appendix 2

Null Hypothesis: USD_LOG_DIFF has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-63.53806	0.0001
Test critical values:	1% level	-3.431784	
	5% level	-2.862059	
	10% level	-2.567089	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: OIL_LOG_DIFF has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-39.59243	0.0000
Test critical values:	1% level	-3.431786	
	5% level	-2.862060	
	10% level	-2.567090	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RATE_DIFF has a unit root
Exogenous: Constant
Lag Length: 21 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.41568	0.0000
Test critical values:	1% level	-3.431792	
	5% level	-2.862062	
	10% level	-2.567091	

*MacKinnon (1996) one-sided p-values.

Appendix 2: Unit root Augmented Dickey-Fuller test on US Dollar exchange rate against Euro (1st table) and Oil prices (2nd table) are in logarithmic first difference while 3 month US T-bill interest rate (3rd table) is in first difference only – Data source: ECB, FED, Thomson Reuters

Appendix 3

Lag	0	1	2	3	4	5	6	7	8	9	10
SC	6,8928870	6,657475	6,572929	6,525192	6,510718	6,509701	**6,508158***	6,534189	6,544288	6,559667	6,570159
HQ	6,8868310	6,642334	6,548704	6,491882	6,468324	6,458222	**6,457595***	6,464542	6,465555	6,471851	6,473259

Appendix 3a: Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria for ten periods for the whole sample period - Data source: ECB, FED, Thomson Reuters

Lag	0	1	2	3	4	5	6	7	8	9	10
SC	3,115271	3,099853	3,100597	**3,092502***	3,109044	3,119307	3,135285	3,147946	3,157365	3,176869	3,188633
HQ	3,108611	3,083204	3,073959	**3,055874***	3,062426	3,0627	3,068689	3,07136	3,07079	3,080304	3,082079

Appendix 3b: Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria for ten periods for the first period (2005:01-2018:10:16) - Data source: ECB, FED, Thomson Reuters

Lag	0	1	2	3	4	5	6	7	8	9	10
SC	7,321395	7,332086	7,364334	7,413865	7,482613	7,568874	**7,214183***	7,751641	7,800603	7,877304	7,877304
HQ	7,554699	7,236331	7,195983	7,177192	**7,175684***	7,193394	7,228616	7,272886	7,309306	7,307229	7,332892

Appendix 3c: Schwarz–Bayes (SC) and Hannan Quinn (HQ) information criteria for ten periods for the second period (2018:10:17-2020:06) - Data source: ECB, FED, Thomson Reuters

Appendix 4

Variance Decomposition of OIL_LOG_DIFF: Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	13.20396	99.83445	0.141861	0.023685
2	16.18435	99.86758	0.096639	0.035779
3	16.19271	99.85827	0.099370	0.042362
4	16.19482	99.83282	0.113233	0.053952
5	16.20426	99.72470	0.202632	0.072672
6	16.21799	99.64583	0.231950	0.122220
7	16.22249	99.64586	0.231983	0.122162
8	16.22379	99.64581	0.231960	0.122234
9	16.23382	99.64472	0.231710	0.123566
10	16.23392	99.64409	0.231978	0.123935
11	16.23397	99.64405	0.231984	0.123965
12	16.23409	99.64377	0.232097	0.124133
13	16.23422	99.64346	0.232206	0.124336
14	16.23422	99.64345	0.232208	0.124345
15	16.23424	99.64343	0.232208	0.124365
16	16.23428	99.64342	0.232208	0.124376
17	16.23428	99.64341	0.232210	0.124376
18	16.23428	99.64341	0.232210	0.124378
19	16.23428	99.64341	0.232210	0.124380
20	16.23428	99.64341	0.232210	0.124380

Variance Decomposition of USD_LOG_DIFF: Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.580691	0.000000	99.92353	0.076471
2	0.581130	0.074076	99.77343	0.152499
3	0.581170	0.074181	99.77303	0.152790
4	0.581887	0.172713	99.52940	0.297891
5	0.581907	0.172888	99.52480	0.302310
6	0.582264	0.186180	99.41293	0.400889
7	0.583242	0.194833	99.22673	0.578441
8	0.583243	0.195054	99.22642	0.578523
9	0.583257	0.196272	99.22171	0.582017
10	0.583275	0.196260	99.21549	0.588251
11	0.583276	0.196441	99.21514	0.588422
12	0.583278	0.196500	99.21482	0.588680
13	0.583280	0.196574	99.21457	0.588858
14	0.583280	0.196585	99.21447	0.588941
15	0.583280	0.196592	99.21444	0.588968
16	0.583280	0.196609	99.21440	0.588992
17	0.583280	0.196609	99.21439	0.588997
18	0.583280	0.196609	99.21439	0.588997
19	0.583280	0.196611	99.21439	0.588997
20	0.583280	0.196611	99.21439	0.588997

Variance Decomposition of RATE_DIFF: Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.045564	0.000000	0.000000	100.0000
2	0.046163	0.000377	0.028841	99.97078
3	0.046261	0.000670	0.028781	99.97055
4	0.046883	0.005763	0.061007	99.93323
5	0.046902	0.006703	0.074677	99.91862
6	0.046982	0.007532	0.101763	99.89071
7	0.046997	0.008425	0.127541	99.86403
8	0.046998	0.008429	0.129756	99.86182
9	0.047005	0.008500	0.129732	99.86177
10	0.047005	0.008633	0.130367	99.86100
11	0.047006	0.008642	0.130452	99.86091
12	0.047006	0.008643	0.130754	99.86060
13	0.047006	0.008653	0.130754	99.86059
14	0.047006	0.008662	0.130755	99.86058
15	0.047006	0.008663	0.130767	99.86057
16	0.047006	0.008664	0.130767	99.86057
17	0.047006	0.008664	0.130768	99.86057
18	0.047006	0.008664	0.130768	99.86057
19	0.047006	0.008664	0.130768	99.86057
20	0.047006	0.008664	0.130768	99.86057

Cholesky Ordering: RATE_DIFF USD_LOG_DIFF OIL_LOG_DIFF

Appendix 4a: Variance decomposition for the whole sample period. LN_DIFF_OIL, LN_DIFF_DOLLAR and L_DIFF_RATE denote, respectively, oil price, US dollar (both in log changes), and changes in the nominal US 3-month interest rate. Data source: ECB, FED, Thomson Reuters

Variance Decomposition of OIL_LOG_DIFF:

Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	2.320229	97.21806	2.478787	0.303149
2	2.324327	97.08340	2.506685	0.409911
3	2.324935	97.03415	2.511022	0.454824
4	2.327617	97.00113	2.505505	0.493369
5	2.327657	96.99982	2.505425	0.494756
6	2.327678	96.99804	2.505427	0.496531
7	2.327702	96.99633	2.505403	0.498266
8	2.327703	96.99627	2.505403	0.498325
9	2.327705	96.99617	2.505401	0.498433
10	2.327705	96.99609	2.505401	0.498508
11	2.327705	96.99609	2.505401	0.498509
12	2.327706	96.99608	2.505401	0.498515
13	2.327706	96.99608	2.505400	0.498518
14	2.327706	96.99608	2.505400	0.498518
15	2.327706	96.99608	2.505400	0.498519
16	2.327706	96.99608	2.505400	0.498519

Variance Decomposition of USD_LOG_DIFF:

Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.597996	0.000000	99.95045	0.049551
2	0.600913	0.902372	98.98397	0.113656
3	0.601015	0.907242	98.96753	0.125232
4	0.601355	0.943124	98.85830	0.198579
5	0.601359	0.944295	98.85706	0.198645
6	0.601360	0.944303	98.85686	0.198840
7	0.601365	0.944353	98.85498	0.200665
8	0.601365	0.944353	98.85494	0.200707
9	0.601366	0.944353	98.85490	0.200745
10	0.601366	0.944352	98.85484	0.200811
11	0.601366	0.944352	98.85484	0.200813
12	0.601366	0.944352	98.85483	0.200815
13	0.601366	0.944352	98.85483	0.200818
14	0.601366	0.944352	98.85483	0.200818
15	0.601366	0.944352	98.85483	0.200818
16	0.601366	0.944352	98.85483	0.200818

Variance Decomposition of RATE_DIFF:

Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.046975	0.000000	0.000000	100.0000
2	0.047469	0.035905	0.028362	99.93573
3	0.047660	0.035893	0.028306	99.93580
4	0.048461	0.035512	0.077250	99.88724
5	0.048496	0.037291	0.080060	99.88265
6	0.048516	0.037334	0.080454	99.88221
7	0.048547	0.037299	0.082173	99.88053
8	0.048549	0.037360	0.082315	99.88032
9	0.048550	0.037362	0.082351	99.88029
10	0.048551	0.037361	0.082423	99.88022
11	0.048551	0.037364	0.082429	99.88021
12	0.048551	0.037364	0.082431	99.88020
13	0.048552	0.037364	0.082434	99.88020
14	0.048552	0.037364	0.082435	99.88020
15	0.048552	0.037364	0.082435	99.88020
16	0.048552	0.037364	0.082435	99.88020

Cholesky Ordering: RATE_DIFF USD_LOG_DIFF OIL_LOG_DIFF

Appendix 4b: Variance decomposition for the first period (2005:01-2018:10:16). LN_DIFF_OIL, LN_DIFF_DOLLAR and L_DIFF_RATE denote, respectively, oil price, US dollar (both in log changes), and changes in the nominal US 3-month interest rate. Data source: ECB, FED, Thomson Reuters

Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
Variance Decomposition of OIL_LOG_DIFF:				
1	39.21986	99.98268	0.009461	0.007857
2	48.08488	99.86711	0.090493	0.042393
3	48.12205	99.75020	0.120637	0.129160
4	48.46979	98.39638	0.668389	0.935231
5	48.93434	96.65838	2.381517	0.960107
6	49.17136	96.32313	2.676495	1.000375
7	49.28325	96.33697	2.666831	0.996202
8	49.30363	96.29865	2.671410	1.029937
9	49.31095	96.28572	2.683003	1.031280
10	49.32249	96.26141	2.706696	1.031894
11	49.32335	96.25915	2.708633	1.032215
12	49.32579	96.25831	2.709549	1.032142
13	49.32651	96.25688	2.709590	1.033530
14	49.32674	96.25674	2.709573	1.033684
15	49.32704	96.25664	2.709686	1.033672
16	49.32705	96.25662	2.709701	1.033674
17	49.32713	96.25660	2.709726	1.033674
18	49.32714	96.25656	2.709724	1.033713
19	49.32716	96.25655	2.709731	1.033721
20	49.32716	96.25655	2.709731	1.033721
21	49.32717	96.25655	2.709732	1.033721
22	49.32717	96.25655	2.709733	1.033722
23	49.32717	96.25654	2.709733	1.033723
24	49.32717	96.25654	2.709733	1.033723
25	49.32717	96.25654	2.709733	1.033723
26	49.32717	96.25654	2.709733	1.033723
27	49.32717	96.25654	2.709733	1.033724
28	49.32717	96.25654	2.709733	1.033724
Variance Decomposition of USD_LOG_DIFF:				
Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.399011	0.000000	99.35281	0.647191
2	0.401181	0.107789	98.32843	1.563780
3	0.401864	0.159063	98.04538	1.795557
4	0.406025	1.464258	96.08839	2.447347
5	0.406542	1.475406	95.98602	2.538572
6	0.406995	1.689306	95.77406	2.536631
7	0.407036	1.691702	95.77194	2.536356
8	0.407095	1.691222	95.76560	2.543181
9	0.407129	1.706151	95.74963	2.544216
10	0.407140	1.706060	95.74789	2.546047
11	0.407154	1.712246	95.74182	2.545931
12	0.407154	1.712241	95.74183	2.545928
13	0.407155	1.712737	95.74135	2.545913
14	0.407156	1.712934	95.74114	2.545922
15	0.407156	1.712959	95.74106	2.545979
16	0.407157	1.713087	95.74094	2.545976
17	0.407157	1.713087	95.74093	2.545979
18	0.407157	1.713117	95.74090	2.545979
19	0.407157	1.713121	95.74090	2.545981
20	0.407157	1.713125	95.74089	2.545982
21	0.407157	1.713128	95.74089	2.545982
22	0.407157	1.713128	95.74089	2.545982
23	0.407157	1.713129	95.74089	2.545982
24	0.407157	1.713129	95.74089	2.545982
25	0.407157	1.713129	95.74089	2.545982
26	0.407157	1.713129	95.74089	2.545982
27	0.407157	1.713129	95.74089	2.545982
28	0.407157	1.713129	95.74089	2.545982
Variance Decomposition of RATE_DIFF:				
Period	S.E.	OIL_LOG_...	USD_LOG...	RATE_DIFF
1	0.028720	0.000000	0.000000	100.0000
2	0.030090	0.004126	0.045041	99.95083
3	0.030421	0.031888	0.076807	99.89131
4	0.030867	0.098315	0.129516	99.77217
5	0.031212	0.101761	0.141603	99.75664
6	0.031333	0.100976	0.144545	99.75448
7	0.031404	0.100955	0.143971	99.75507
8	0.031448	0.101205	0.148059	99.75074
9	0.031471	0.102104	0.148074	99.74982
10	0.031483	0.102035	0.148247	99.74972
11	0.031490	0.102030	0.148425	99.74955
12	0.031493	0.102020	0.148399	99.74958
13	0.031496	0.102007	0.148500	99.74949
14	0.031497	0.102012	0.148519	99.74947
15	0.031497	0.102008	0.148524	99.74947
16	0.031498	0.102009	0.148530	99.74946
17	0.031498	0.102008	0.148531	99.74946
18	0.031498	0.102008	0.148534	99.74946
19	0.031498	0.102007	0.148535	99.74946
20	0.031498	0.102007	0.148535	99.74946
21	0.031498	0.102007	0.148536	99.74946
22	0.031498	0.102007	0.148536	99.74946
23	0.031498	0.102007	0.148536	99.74946
24	0.031498	0.102007	0.148536	99.74946
25	0.031498	0.102007	0.148536	99.74946
26	0.031498	0.102007	0.148536	99.74946
27	0.031498	0.102007	0.148536	99.74946
28	0.031498	0.102007	0.148536	99.74946
Cholesky Ordering: RATE_DIFF USD_LOG_DIFF OIL_LOG_DIFF				

Appendix 4c: Variance decomposition for the second period (2018:10:17-2020:06). LN_DIFF_OIL, LN_DIFF_DOLLAR and L_DIFF_RATE denote, respectively, oil price, US dollar (both in log changes), and changes in the nominal US 3-month interest rate. Data source: ECB, FED, Thomson Reuters

NEXIALOG CONSULTING

STRATÉGIE I ACTUARIAT I GESTION DES RISQUES

Nexialog Consulting est un cabinet de conseil spécialisé en Stratégie, Actuariat et Gestion des risques qui dessert aujourd'hui les plus grands acteurs de la banque et de l'assurance. Nous aidons nos clients à améliorer de manière significative et durable leurs performances et à atteindre leurs objectifs les plus importants.
Les besoins de nos clients et les réglementations européennes et mondiales étant en perpétuelle évolution, nous recherchons continuellement de nouvelles et meilleures façons de les servir. Pour ce faire, nous recrutons nos consultants dans les meilleures écoles d'ingénieur et de commerce et nous investissons des ressources de notre entreprise chaque année dans la recherche, l'apprentissage et le renforcement des compétences.
Quel que soit le défi à relever, nous nous attachons à fournir des résultats pratiques et durables et à donner à nos clients les moyens de se développer.

CONTACTS

Ali Behbahani

Associé, Fondateur
Tél : + 33 (0) 1 44 73 86 78
Email: abehbahani@nexialog.com

www.nexialog.com
Retrouvez toutes nos publications sur Nexialog R&D

Christelle BONDOUX

Associée, Directrice commerciale
Tél : + 33 (0) 1 44 73 75 67
Email : cbondoux@nexialog.com

Paul-Antoine DELETOILLE

Responsable de Compte Banque et AM
Tel. : +33 (0)1 44 73 75 70
Mob. : +33 (0)7 64 57 86 69
padeletoille@nexialog.com

Adrien Misko

Responsable R&D
Tél : + 33 (0) 6 69 27 62 26
Email : amisko@nexialog.com

Jehan AZZOPARDI

Responsable de Compte Assurance
Tel. : +33 (0)1 44 73 75 66
Mob. : +33 (0)6 25 60 98 61
jazzopardi@nexialog.com