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On the effect of oil price in the context of Covid-19

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Abstract
This article studies the impact of oil price change on the stock market, the exchange rate and the real estate market in the US over the last decade. To this end, we model the dynamics of the returns for these markets and test the effect of oil market volatility on their dynamics. Through different econometric investigations, we show, in the context of Covid-19, that oil price has experienced significant effects on the US stock market and the US dollar exchange rate, while it has no significant impact on the US real estate market. In particular, we highlight, first, a positive and significant reaction of the stock market toward an oil price shock, which might be explained by the effect of high oil financialization over the last decade. Second, we show an adverse effect of the oil price change on the US dollar, suggesting a negative relationship between the oil price and the US dollar. Accordingly, the information provided by the oil sector might help to improve the forecast of the Dow Jones and the US$–€ exchange rate.

Keywords
forecasting, oil price, real estate market, stock market, US dollar

JEL Classification
C22; G10; Q47

1 INTRODUCTION

Over the last decade, the oil price has known important changes and shown a high volatility excess. This volatility can be associated to three different episodes and factors. The first period is related to the aftermath of global financial crisis (2007–2008). Indeed, from 1999 to 2008, the oil price has increased significantly, reaching $US145 in July 2008, in particular in reason of the important increase of Chinese oil demand, but on December 23th, 2008 the oil price dropped to $US30.28 given the economic recession induced by the 2008 financial crisis, and it moved to $US82 in 2009. After being relatively stable in the $US90–$US120 range for some times, the oil price has again known an important decrease in 2014 reaching a level of US$36 on December 11th, 2015 because of the US shale revolution. The latter has implied a major change for the oil industry structure as the USA have become an important oil producer sharing the market with the OPEC+, which has affected the oil supply and therefore the oil price. The third episode of oil price volatility is the on-going period for which the Covid-19 has induced a double oil price shock: On the one hand, a supply shock in March 2020 when Saudi Arabia and Russia fail to agree on a common deal about the reduction of oil production. Accordingly, Saudi Arabia decided abruptly to innode the whole world by its own oil production, while increasing its production by 25% reaching 12.3 million barrels/day, and to sell its barrels at low prices, inducing an immediate 30% decline of oil price. On the other hand, the covid-19 has implied a strict confinement of several months in different developed and emerging countries,
stopping the activities of different industries, machines and transportation services, which has implied a vital reduction of oil demand. Indeed, this shock has implied the most important oil demand shock since 2008–2009 as the Chinese oil demand has decreased of more than 20% (about less 3 million barrel/day); the oil demand by transportation services has also decreased by 1 million barrel/day. Consequently, the oil price has experienced the most important decrease since the 1980s and the situation was not improved even after the historical deal of the countries of the OPEC+ to cut their productions of about 10 million barrels/day on April 12th, 2020. Furthermore, besides these oil supply and demand shocks, it is important to recall that oil has become subject of an important financialization and therefore depend on market speculation and investor’s behaviour. Indeed, investors can take “call” or “put” positions on oil prices and therefore speculate on the evolution of oil prices. However, given that, the US companies have pursued their productions and that most oil installations were overfull, there was an important risk for the delivery of invested oil barrels because of the space constraints. Thus, when oil contracts approached maturity, sellers have tried to get rid of the oil barrels, and consequently, the price oil barrel turns to negative (around -$US40) for the first time in the oil history, which means that sellers have proposed to pay buyers when selling their barrels to them and this is mainly to avoid high storage costs of these barrels. These speculative behaviours have stimulated the oil price volatility over the last period and the situation has become particularly unsustainable for oil producer’s countries. Indeed, Saudi Arabia, Russia, Qatar and Kuwait show a significant and time-varying financial dependency to the oil sector that reaches 78%, 25%, 80% and 80%, respectively. Accordingly, the required oil price is estimated to be around US$80 for Saudi Arabia, US$50 for Irak, Koweit and Qatar, and US$100 for Nigeria and Venezuela. This suggests the complexity associated with the pricing of oil barrels in the world.

Taking this excess of oil price volatility and the ongoing Covid-19 into account, the world is expected to experience in 2020 a serious economic recession exceeding in its severity the economic recession of 1945, even the important response of different governments through distinct rescue financial programs. This recession is characterized by an enormous drop in gross domestic production, large losses of financial markets and a rapid and substantial increase of unemployment and public deficit for several developed and emerging countries. Accordingly, several real and financial markets have not been safe too. Indeed, they react to this excessive oil price volatility, which have affected them through at least two channels: Uncertainty and the inflation. Indeed, higher is the oil price volatility, higher is the economic policy uncertainty. Furthermore, this oil price volatility may imply an unstable the inflation, which addresses less credibility to monetary authority to cover this oil price volatility, pursuing investors to intervene frequently on the financial markets and to substantially impact asset prices by their actions.1

In the literature, to better understand the relationship between oil price and the economic conjecture, the main related reference is Hamilton (1983, 1985, 2003, 2008) who showed a significant relationship between oil price changes and economic recessions. Accordingly, Hamilton work’s show that while oil price changes in the 1980s are due to an oil supply shock, the oil price variation during the 2007–2008 global financial crisis is induced by and oil demand shock. In the same context, Jones and Kaul (1996) showed that an oil price increase negatively impact stock prices. Gorton and Rouwenhorst (2006) and Nandha and Faff (2008) found a negative correlation between commodity prices and the returns of financial assets. Mignon (2008) also found a significant relationship between oil price and macroeconomic variables. Miller and Ratti (2009) and Filis, Degiannakis, and Floros (2011) showed that the relationship between oil price and stock prices is time-varying as this relationship depends on the state of the economy. However, Manera, Nicolini, and Vignati (2013) found a positive relationship between oil and stock returns, confirming the conclusion of Kilian and Park (2009) for which an unexpected increase of the world demand positively and simultaneously impacted oil and stock markets. Harli, Nalley, and Hudson (2009) pointed to a significant relationship between oil price and exchange rate as the later impact oil imports and exports. Gilbert (1989) and Akram (2009), Jawadi et al. (2019) found a negative relationship between the US dollar and the oil price, which is supported by the law of one price. Indeed, when the value of the US dollar decreases, the demand for oil and commodities that is traded in US$ might increases yielding an oil price increase and vice versa. For example, Frankel (2008) showed that during the period April 2011–July 2012, the exchange rate of the US dollar has increased of 9% and in the same period the oil price decreased of 22%. In the context, Chen, Kuo, and Chen (2010) show that the exchange rate fluctuations might help to improve oil price forecasting and vice versa.

Overall, while most previous studies conclude in term of strong relationship between oil price, financial market and the macroeconomic variables, there is less unanimity about the nature and the sign of this relationship. Furthermore, it is relevant to recall that the Covid-19 was an unexpected shock that has affected this relationship. Indeed, while stock markets have shown high performance in the last decade (i.e., +32% for the NASDAQ,
the on-going pandemic crisis has implied serious cuts for most financial markets. For example, on March 9th, 2020, we noted important losses: −8.4% in Paris, −7.8% in Frankfurt and −11.2% in 1 day in Milan. The Covid-19 crisis has implied through the double shock a high oil price volatility, a breakdown of most financial markets and shows signs of severe economic depression.

This article aims at assessing for the effect of the Covid-19 on three markets in the US: The NYSE, the foreign currency market and the housing market. This is carried out through the investigation of the impact of the recent oil price volatility induced by the Covid-19 on these markets. This research topic is particularly interesting for investors, regulators and policymakers. Accordingly, we show that the oil price volatility has a significant effect on the NYSE and the US$, it affects only marginally the US real state market.

The remainder of this article is organized as follows. The second section is devoted to the data and preliminary tests. The main empirical results are presented in the third section. Finally, the last section concludes the article.

2 | DATA AND PRELIMINARY ANALYSIS

2.1 | Data

The data concerns the US markets. It is monthly and covers the period from March 2010 to March 2020, which is suitable to assess for the effect of oil price changes during the shale revolution (2014–2015) and the on-going Covid-19 crisis. Our sample includes four indexes of prices (closing prices): the Dow Jones stock index, the $US/€ exchange rate, the West Texas Intermediate Crude oil index, and the US national home price index. It also includes the Economic Policy Uncertainty as a proxy for uncertainty. We also use four proxies for volatility. First, the VIX is used as a proxy for the stock market volatility. The VIX is provided by the Chicago Board Options Exchange (CBOE) and it is computed while calculating the average of annual volatilities on option’s calls and puts of the Standard & Poor’s 500 (S&P 500) index. Second, we use the VOX as a proxy for the volatility of oil market. The VOX measures the market’s expectation of 30-day volatility of crude oil prices and is computed through the application of the VIX methodology on options on the United States Oil Fund. Third, the CBOE EuroCurrency ETF Volatility Index is considered as a proxy for the volatility of the US exchange rate. The Cboe EuroCurrency Volatility measures the market’s expectation of 30-day volatility of the $US/Euro exchange rate by applying the VIX methodology to options on the Currency Shares Euro Trust. Fourth, the real estate volatility index is measured by the Wilshire US Real Estate Investment Trust Price Index (Wilshire US REIT). All data are expressed in the $US. The whole data is obtained from the Fred Economic data provided by the Fed Saint-Louis. Accordingly, our data is homogeneous enough and computed through similar methodologies, which has the advantage of dealing with less bias with the data collection.

2.2 | Preliminary analysis

We plot in Figures 1, 2 and 3 the dynamics of the four price indexes under consideration and we note several interesting facts. First, we note that oil price has experienced two serious corrections induced by the US shale revolution in 2014–2015 and the on-going pandemic Covid-19 crisis in 2020, respectively. While the impact of these oil price shocks appears to be insignificant for the real estate market, their effects on the stock and exchange rate markets enter differently. Indeed, for the exchange market, an oil price decrease has implied an appreciation of the US dollar, suggesting a negative relationship between oil price and the US dollar, since an oil price decrease might stimulate oil demand and therefore the demand of the US currency because the whole oil production is traded in US$. As for the stock market, the relationship between oil price and the Dow Jones alternates between negative or weak and positive. Indeed, during the US shale revolution, we simultaneously observe an oil price decrease and an increase of prices for the US shares in the NYSE. However, the relationships becomes positive during the Covid-19 as the recent oil price correction has implied a serious cut of stock prices, which might be associated to the increase of uncertainty provoked by this Coronavirus crisis. Second, the WTI oil price and the US$/€ exchange rates have been more volatile during the last decade suggesting more pressure on the oil and foreign currency market. Finally, both the US stock and real estate markets have been continuously increasing during the last decade and have reached highest levels showing signs of bubble. Accordingly, it would be possible to associate these recent prices breaks induced by the Covid-19 to a natural correction, in particular for the stock market. The effect of the Covid-19 is serious because it happens during a period for which the US stock market has become vulnerable.2

To better analyse these effects of oil price, we model their interactions. To this end, we check for the presence of a unit root in the data through the application of the Augmented Dickey Fuller tests and Philips–Perron tests. Accordingly, we show that the four price indexes (Dow
Jones, Housing Price Index, the US$/€ exchange rate and the WTI oil price) are not stationary in level, but stationary in the first difference. They are integrated of one order (I(1)) and we focus hereafter on their returns series. However, the four series of volatility and the EPU index are stationary in level. Next, we present in Table 1, the main descriptive statistics of the above four series of returns to better analyse their properties. Accordingly, we note that while on average the returns in the stock, real estate and the US foreign currency markets are positive, suggesting a positive tendency of prices, only the oil market shows a negative return, reflecting this serious correction of oil price. Furthermore, the oil market appears much more volatile than the other markets as its volatility is about nine times that of the US$/€ and more than twice that of the US stock and real estate markets. Finally, all markets show signs of asymmetry, leptokurtic excess and non-normality.
Then, in order to provide a first look on the interactions between these three markets and the oil price, we compute and report in Table 2 the matrix of unconditional correlations. Accordingly, we find while the oil market experiences positive correlation with the stock market, the relationship appears negative with the US dollar and weak for the housing market, which is in line with our previous analysis. The highest correlation between the oil and stock market might be explained by the importance of financialization of the oil industry over the last decade. However, as these linkages rely on Pearson correlation, they should be analysed with precaution, and we propose to double check them hereafter using more robust tests.

### 3 | EMPIRICAL ANALYSIS

#### 3.1 | Modelling the effect of oil price

For instance, we focus on the modelling of the dynamics of stock, exchange rate and real estate returns while assessing for the further effect of oil price. To this end, we run first the following augmented autoregressive model:

\[
R_{jt} = \alpha_0 + \sum_{i=1}^{p} \alpha_i R_{jt-i} + \beta \text{EPU}_t + \gamma R_{WIT, t} + \delta \text{VOX}_t + \theta \text{VO}_j + \epsilon_{jt}
\]

Where: \(\alpha_0, \alpha_i, \beta, \gamma, \delta, \theta\) are parameters to be estimated. \(R_{jt}\) is the return of the market \(j\). 
\(\forall j = \text{Stock, US$/€, real estate.} \)

\(\text{VOX}\) denotes the oil market volatility. 
\(\text{VO}_j\) denotes the volatility of the market \(j\). 
\(p\) refers to the number of lags. 
\(\epsilon_{jt} \sim i.i.d(0, \sigma_j)\). 

\(1\)
We report the main results in Table 3 and we show different interesting results. First, regarding the stock market, we show that the oil return has a positive and significant effect on the US stock returns suggesting that higher is the oil return higher is performance of the NYSE and vice versa. This confirms the positive correlation between the oil and US stock markets and justifies the collapse of the US stock market after the oil shock induced recently by the Covid-19 crisis. Furthermore, we find that changes in the VIX have a negative and significant impact on the US stock returns. Indeed, these changes pass through an increase of investor’s anxiety, stress and uncertainty, which negatively affect their investments. Overall, the estimated model shows a good quality of adjustment and their estimated residuals appear normally distributed, do not show neither autocorrelation of one order nor an ARCH effect. Second, as for the US currency market, we point to a negative and significant effect of oil return on the US$/€ exchange rate return, confirming our above analysis of a negative relationship between oil price and the US dollar. Indeed, when the oil becomes cheap, its demand might increase yielding an increase of the demand for the US dollar and therefore its value and vice versa. In addition, as for the NYSE, we find that the increase of the US currency market volatility has a negative and significant impact on the US dollar/€ exchange rate returns. This negative impact of expected volatility also enters through the channel of uncertainty. Indeed, an increase of uncertainty generates a high anxiety and tension for investors who might enter frequently on the market and generate a volatility excess. This is the reason for which the inclusion of economic policy uncertainty does not enter positively because volatility proxies already capture uncertainty. The related estimated residuals also show the appropriate statistical properties. Finally, regarding the US housing market, we confirm our previous analysis as the oil price cut does not seem to affect the US real estate market. Indeed, investing in the real estate market has always been considered as a long-term strategy that aims to hedge investor’s portfolios against short-term shocks as for the oil industry. However, we find that an increase of economic policy uncertainty might negatively affect the returns of the real estate market. Furthermore, the volatility of investor expectations about future contracts for the housing market has a negative and significant impact on the returns of the real estate market. These conclusions should, however, be carefully analysed as the estimated residuals do not show the appropriate statistical properties in reason of the rejection of normality and the presence of an ARCH effect in the estimated residuals.

| Coefficients | Stock market | US/€ exchange rate | Real estate market |
|--------------|--------------|---------------------|-------------------|
| $\alpha_0$ | 0.0087*** (.00) | 0.0013*** (.048) | 0.0049*** (.00) |
| $\alpha_1$ | – | 0.2204*** (.03) | 0.7947*** (.00) |
| $\beta$ | – | – | –1.54 E-05*** (.03) |
| $\gamma$ | 0.0832*** (.00) | –0.0512*** (.00) | – |
| $\delta$ | – | –0.0002* (.09) | – |
| $\theta$ | –0.0053*** (.00) | –0.0014*** (.05) | –6.18E-05*** (.00) |
| $R^2$ | 0.76 | 0.15 | 0.66 |
| LL | 296.99 | 331.84 | 546.66 |
| ARCH test ($q = 1$) | 0.0295 (.86) | 0.894 (.34) | 3.980** (.04) |
| Jarque–Bera test | 0.1930 (.91) | 1.237 (.54) | 145.99*** (.00) |
| DW test | 2.10 | 1.98 | 2.04 |

**Note**: Values in (.) are the p-values of the t-ratios. LL denotes the statistics of the log likelihood. $R^2$ measures the adjusted R-squared. DW denotes the statistics of the Durbin–Watson test. ***, ** and * denote the statistical significance at the levels 1%, 5% and 10%, respectively. Abbreviation: ARX, augmented autoregressive.
In order to double check the robustness of these results and to test whether the information provided from oil market might help to forecast future dynamics of the market under consideration, we also carried out some forecasting tests.

3.2 Forecasting analysis

We carry out in sample forecast for the three market under consideration using the above regressions presented in Table 3. In particular, we check whether taking into account the information provided by the oil industry and taking into account the strong relationship between the oil market and (at least) the stock and the exchange rate markets in the US, it would be possible to forecast their future dynamics. We present the main forecasting results in Figures 4, 5 and 6. Accordingly, we computed the well-known loss functions (mean absolute error, root mean squared error) and we compute the Theil inequality coefficient and the Theil U2 coefficient. Overall, we find that the forecasting performance of our models are less accurate for the housing and the US$ exchange rate, suggesting that other fundamentals might be required to improve the forecasting such as exports and imports flows for the exchange rate and the renting prices for the housing markets. However, our model provides significant accurate forecasts for the US advertising.

FIGURE 4 In-sample forecasting for stock market. RDJO and RDJOF denotes the stock returns of the Dow Jones and its forecast [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 5 In-sample forecasting for the US/€ exchange rate market. RUSDE and RUSDEF denotes the returns of US$/€ its forecast [Colour figure can be viewed at wileyonlinelibrary.com]
stock market, suggesting that our specification appropriately captures the significant effect of oil price collapse on the US stock market, which is illustrated by an estimated value of the Theil Inequality coefficient that is close to zero. This finding is particularly interesting for investors as the inclusion of information provided by the energy sector enables them to improve their forecasts of the stock market and to balance their portfolios. In particular, it is required to have close eyes on the variation of the WTI to better forecast the evolution of the NYSE.

Next, we re-estimate the model 1 for the housing market while taking the ARCH effect into account and we show that our concluding remarks are unchanged confirming the robustness of our results.³

### 3.3 Causality tests

In the next step, we carry out Granger causality tests to check for the presence of causality relationships between the oil price and the three markets under consideration.

#### FIGURE 6 In-sample forecasting for housing market. RHP and RHPF denotes the U housing price index and its forecast [Colour figure can be viewed at wileyonlinelibrary.com]

#### TABLE 4 Results of Granger causality tests

| Null hypothesis                      | Obs | $F$-statistic | Probability |
|--------------------------------------|-----|---------------|-------------|
| RDJO does not Granger cause RWTI     | 119 | 1.39562       | .2399       |
| WRTI does not Granger cause RDJO     | 3.33096 | .0706         |
| RUSDE does not Granger cause WRTI    | 119 | 0.10712       | .7440       |
| RWTI does not Granger cause RUSDE    | 9.48233 | .0026         |
| RHP does not Granger cause WRTI      | 119 | 0.60544       | .4381       |
| RWI does not Granger cause RHP       | 1.70211 | .1946         |
| RUSDE does not Granger cause RHP     | 119 | 0.16492       | .6854       |
| RDJO does not Granger cause RUSDE    | 6.79217 | .0104         |
| RHP does not Granger cause RDJO      | 119 | 0.01349       | .9077       |
| RDJO does not Granger cause RHP      | 0.01257 | .9109         |
| RHP does not Granger cause RUSDE     | 119 | 0.38262       | .5374       |
| RUSDE does not Granger cause RHP     | 0.56584 | .4534         |

Note: Values in bold indicate the rejection of the null hypothesis of non-causality at standard statistical levels.
The non-rejection of Granger causality hypothesis suggests that the use of information provided from the oil sector might help to improve the forecasting of future dynamics of prices in the stock, currency and real estate markets. In particular, we run these tests for one lag \((p = 1)\). We report the main obtained results in Table 4.

Accordingly, we find that oil price has a Granger causality effect on the US stock and Foreign exchange rate markets, suggesting the use of information provided by the WTI might help to forecast the future evolution of the Dow Jones and the US dollar,\(^4\) This is particularly interesting. Indeed, the on-going pandemic Covid-19 has implied an oil price collapse that turns to negative in April 2020. This serious collapse of the oil price would be useful to significantly forecast the future evolution of the Dow Jones and the US dollar, which is particularly relevant for investors to balance their portfolios and hedge their positions against the risk.

Finally, in order to better assess for these causality relationships, we estimate a Vector Autoregressive model with three equations (oil, US$/€, Dow Jones) and we compute the impulse response functions. Each equation is specified in line with the specification presented in Table 1. We report the main results in Figure 7.

Accordingly, we observe that a shock on the oil price has a positive impact on the NYSE, which amortizes in the time and disappears after 6 months. Otherwise, the effect of oil price shock on the US dollar is negative implying a depreciation of the US dollar with a highest value around the second months, while this effect is being cancelled after 4 months. These findings are relevant to better forecast the reaction of stock and foreign exchange markets after an oil shock induced by the Covid-19.

**4 CONCLUSION**

This article studies the effect of oil price change on the US dollar, the NYSE and the real estate markets over the last decade and in the context of the on-going Covid-19 crisis. Through different econometric specifications, we showed that while oil price experiences significant effects on the US stock market and the US dollar exchange rate, there is no significant correlation between the US real estate market and oil price changes. In particular, our findings point to a positive linkage between the NYSEA and oil price, while the latter is negatively correlated with the US dollar. Accordingly, the information provided by
the energy sector might be helpful to forecast the future dynamics of the Dow Jones and the US dollar, while inclusion of oil, the US dollar and housing market funds in the same portfolio appears relevant for investors and hedgers.

ENDNOTES

1 There are other channels explaining the transmission of oil shock to the economy: Income transfers and aggregate demand (Dohner, 1981), the real balance effect (Mork, Olsen, & Mysen, 1994; Pierce & Enzler, 1974), sector adjustment effect (Brown & Yücel, 2002), unexpected effect (Tang, Wu, & Zhang, 2010).

2 The Dow Jones has shown an increase of about 122% during the last decade.

3 We do not present result of the ARX-ARCH specification for the housing market to save space, but results are available upon request.

4 We also find that the Dow Jones Granger causes the US$/€ exchange rate.

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