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Crude Oil Price and Inflation in the US since Covid-19

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Abstract: Focusing the period of Covid-19 since January of 2020, this research empirically study how inflation and the price of crude oil are related within the US data. The linear regression with ARCH(1) model is employed and our empirical results illustrate the significantly positive correlation between these two factors. We find that the CPI increase 9% with one unit increase in the crude oil price during Covid-19 period. Crude oil price, however, does not show such a significant effect on the other macroeconomic variable in the US during Covid-19 period, for example, real consumption and GDP.

Keywords: crude oil price, inflation, relationship, significantly positive, Covid-19 period

1. Introduction

Oil is not only the motivation of industrial production, but also a crucial driver of consumption. Oil price volatility is a complex and important issue, which basically results from changes of the balance between demand and supply. For example, a sudden rise in the price of oil is always accompanied by the decrease of oil supply, which even could drive the oil crisis. Oil crisis can endanger the stability of economy and politics, the effect of which even spreads to the whole world, as oil is a key component for production.

The post-WWII period has experienced three major oil crises. The first occurred in 1973, when OPEC (Organization of the Petroleum Exporting Countries) decided to quadruple the price of oil to almost $12 a barrel. Oil exports to western Europe, United States and Japan, were also prohibited. OPEC's decision was made in response to depreciation of U.S. dollar and also in retaliation for Western support of Israel against Egypt and Syria. This oil crises accompanied with a serious recession accompanied by the rise of inflation, which forces US military action to secure the free energy access. The oil embargo was proposed in 1974, oil prices still remained at high level, which make the industrial countries continue to be trapped into stagnation throughout the 1970s.

The second oil crisis happened in 1979, because of Iranian Revolution (1978–79). The situation becomes even worse next due to the outbreak of the Iran-Iraq War (1980–88), during which oil production in Iran nearly stopped, and Iraq's oil production was severely cut as well. Oil prices decline gradually as the shortfalls from Iran and Iraq began to be filled by other countries. Particularly, the more-efficient methods of production has been adapted, the oil shortage during the 1970s then was transformed into a relative oversupply of oil.

The third oil price shock occurred in response to the Iraqi invasion of Kuwait in 1990, which causes the decrease in the oil production. As the US-led coalition experienced military success against

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Iraqi forces, concerns of long-term supply shortages reduced and prices of crude oil began to fall. The economic conjecture and geopolitical tension could directly and indirectly affect the oil price.

Between 2014 and 2015, the whole crude oil industry has experienced a profound change of the shale revolution, which originally generated the US. This technology innovation currently contributes more than a third of onshore crude oil production [1]. This technology revolution has led to a boom in US domestic crude oil production. In addition to Russia and OPEC, America is another important oil producer. The US produces and consumes the largest amount of oil in the world and play a significant impact on the oil trade and pricing. Due to the large production of shale oil in Canada and US, the supply shock of crude oil becomes less often. This structural change introduces more complexity of oil pricing policy [2]. For example, US joined the oil producers' cartel, which makes the oil producing countries experience considerable difficultly in reaching a common agreement on oil supply that is directly affected the oil prices. On the other hand, the oil production is still limited within several countries and regions, and its supply quite depends on those oil producing countries.

Covid-19 brings new challenges of crude oil market and creates much more volatility of crude oil prices. The wide spread of Covid-19 occurred in the early of 2020. As shown in Figure 1, the price of the West Texas Intermediate (WTI) crude plummeted to $16.8 per barrel, marking an unprecedented 300% drop in price, in April 2020. The pandemic halted global economic activities, and reduce the demand of oil to the least. In other words, the demand shock due to Covid-19 which is the main factor for the plummet of oil price. Narayan et al. summarize three specific government responses brought by COVID-19, including travel ban, lockdown, and stimulus package [3]. Particularly, lockdown and travel ban directly halted economic activities, including travelling across countries, thus reducing the demand for oil. Devpura and Narayan propose that global demand for oil has fallen impacting both the oil price and uncertainty surrounding it, as shown in oil price volatility [4]. They establish the connection between oil price volatility and COVID-19.

In figure 1, we can see that the post-April 2020 period witnesses a persistent increase in crude oil price, despite the significant volatility. The crude oil price WTI has increase almost 6 times since Covid-19, from the bottom $16.8 per barrel in April 2020 to the top $114.84 in June 2022. With the success of vaccine for Covid-19, there are less fears and more optimistic projection of economy. It takes one year for the oil price to recover to pre-covid period. The escalating tension between Russia and Ukrainian becomes a Russo-Ukrainian War, generating a supply shock and further rise of oil price. The histogram in figure 1 illustrates that the largest density of WTI crude oil price since Covid-19, lie within $ 40-70 per barrel, and the extreme prices distribute within $ 20-30 per barrel and $ 100-120 per barrel.

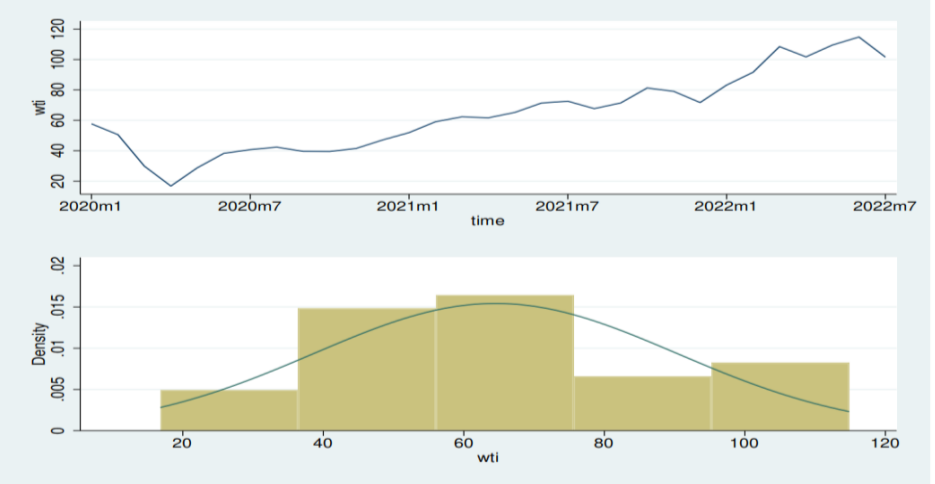

Figure 1: WTI crude oil price since Covid.

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The similar dynamics of crude oil prices of Brent can be seen in figure 2, as follows. Since Covid-19, Brent crude oil price decrease from $ 65 per barrel in December 2019 to $ 23.33 per barrel in June 2022, and then the price increases to $ 122 per barrel within 18 months. The density of Brent crude oil price distributes also consistent with the one of WTI.

The transmission channels from crude oil price volatility to macroeconomy are proposed in existing literature. First, the increases in oil price may lead to increases in the overall price level, thereby reducing real money balances and purchasing power of households and firms, which ultimately affect aggregate demand. This process is called the real balances and monetary policy channel. Second, income-transfer channel emphasizes the effect of crude oil price volatility is different among the oil-importing and oil-exporting countries, as the income from oil-importing countries transfers to oil-exporting countries. Third, energy prices may also affect labor and capital productivity, which is another possible channel to affect the economic activity. It is worth noting that the US is a unique existence, as the country to produce and consume oil with the largest amount in the world. This paper is aimed to explore the effect of volatile oil price since Covid on US economy, particularly inflation.

During the post-Covid period, developed economies are facing challenges of high pressure of inflation. For example, the rising oil prices recently increases the consumption and production cost, which push inflation to the highest rate since 1981. The rising cost of production and living has been squeezing business and households, which put high pressure on policymakers to take responsible actions. The US central bank began to increase interest rates since March, and the moves seem effective to cool economic activity and ease the price pressures. The conflict and tension between Russia and Ukraine, is another challenge that increases of the price of crude oil and commodities like wheat as it disrupts exports from the two countries. Compared to May 2021, food prices were up more than 10% in April, while energy surged more than 34%. Overall, as shown in figure 3, CPI of the US has increased about three times currently compared to the pre-Covid period.

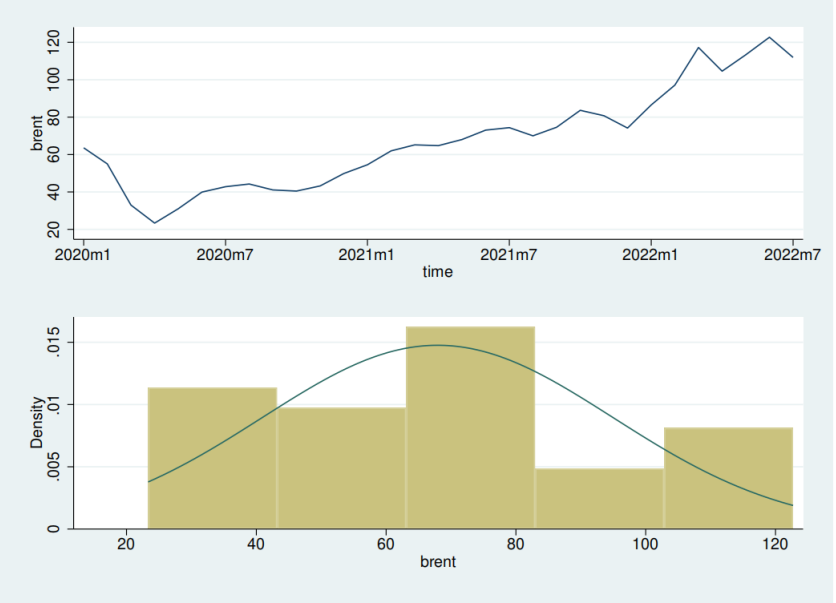

Figure 2: Brent crude oil price since Covid.

Compared with inflation, the real consumption is less volatile, which recovers significantly since Covid-19. As shown in Figure 4, from the bottom in April 2020, the real consumption increases gradually consistently and currently has even reached even higher level than that of pre-covid period.

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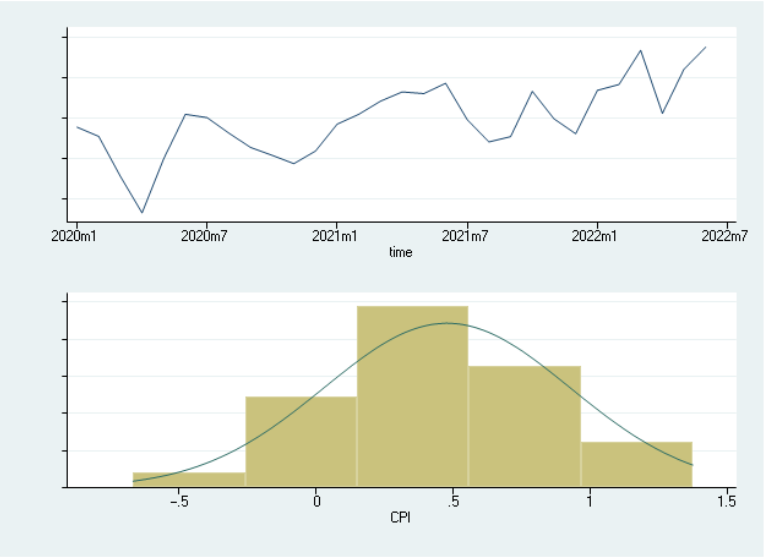

Figure 3: Real consumption of US since Covid.

This research using the US data since Covid to study whether the oil price affects inflation and to what extent inflation is affect by price rise since Covid. The paper is arranged as follows: section 2 presents the data and methodology, section 3 illustrate the empirical results and discussion, section 4 is conclusion and future work.

2. Data and Methodology

2.1. Data

In order to gather more time points as possible, we use monthly data. Five variables, including WTI and Brent crude oil prices, CPI, real consumption and GDP indicators. It is worth noting that here we choose GDP indicator, rather real GDP itself, in order to be consistent with the other variables, like CPI and crude oil prices. And there is not monthly data for the real GDP, although it is a better choice as a general macroeconomic variable. This research focuses the study since Covid. Therefore the time period chosen is from 2020 January to 2022 July for each variable.

2.2. Methodology

Our dataset is panel data, and considering the feature of time series, we choose the Arch(1) variance regression model. An ARCH (autoregressive conditionally heteroscedastic) model structures variations of a time series. The basic regression through least squares model assumes the same expected value of all error terms at any given point, which is called homoskedasticity. The error terms' variances are not necessarily equal, and instead they could be reasonably larger or smaller for some ranges or points. Thus, the homoskedasticity assumption in least squares model is questioned and heteroskedasticity assumption is proposed. Even if the heteroskedasticity existing, the OLS regression coefficients are still unbiased. However, the standard errors and confidence intervals estimated by conventional methods can be too narrow, leading to a false precision. ARCH and GARCH models treat heteroskedasticity as a variance to be modeled. Through ARCH and GARCH models, the deficiencies of least squares can be corrected, and also the variance of each error term can be better predicted.

This paper utilizes the ARCH model to describe time-varying variances, as discussed previously. ARCH model can capture short periods of increased or decreased variations. The advantages of ARCH model are appropriate for our data set. Suppose one variable with time series y_t. The

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ARCH(1) model considers one-lag auto-regressive correlation, namely the variance of y_t is conditional on y_{t-1}, as follows:

$$Var\ (y_t \mid y_{t-1}) = \sigma_t^2 = a_0 + a_1 y_{t-1}^2 \quad (1)$$

where the coefficient a0 and a1 are non-zero to avoid negative variance. We have tested the ARCH (1) for each variable. The significant correlation has been found between yt and y_{t-1} for each time series.

Then ARCH (1) is incorporated into the regression estimates. Regression model estimates to what extent and how the independent variables affect dependent variable (target variables). The linear regression, the most basic regression, can be written as follows:

$$y_t = \beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \beta_0 \quad (2)$$

where $x_n t$ is the independent variables andy_t is the dependent variable. In this paper, the independent variable is the crude oil price and dependent variable are the macroeconomics ones, such as inflation, real consumption and GDP. Particularly, we take the auto-regression correlation as estimated by ARCH(1) into the general regression estimate.

3. Empirical Results

Firstly, we regard crude oil price as the independent variable and estimate its effect on inflation as shown in figure 5, while using GDP indicators and real consumption as the control variables.

In the table above, the overall model assumed is significant as shown by the overall P value that is close to zero smaller than 1%. Meanwhile we find that the P values for variable crude oil price WTI is 0.014, which is smaller than 5%, indicating the significance of oil price is at 5% level. Thus, we conclude that that crude oil price positively affect CPI. When the crude oil price increases by one unit, CPI increases by about 9%, if we control all the other factors constant.

As the significant positive effect of crude oil price on CPI has been confirmed, we examine whether inflation measured by CPI can in turn affect crude oil price as shown in figure 6. As estimated by P value, the model assumed is significant overall. The P value for crude oil price WTI is closed to zero with the positive coefficient 17. 723. This result indicates that the CPI affects crude oil price WTI positively. The other variables, however, do not show a significant relationship with the changes of CPI (inflation).

Two regression results together confirm the significantly positive relationship between crude oil price and inflation. Those two factors interact each other significantly. Such results confirm that the crude oil price is an important force driving inflation rise since Covid-19, and the inflation pressure in return pushes the crude oil price increase further. The existing literature has reached an agreement on the volatility of crude oil prices on overall price level and other macroeconomic variables. Its effects, however, may vary across countries. Bruno and Sachs (1982) found that increase of oil price leads to rise in the level of price and real output [5]. The study from IMF (2000) illustrated that the increase of oil price by $5 leads to increase in inflation by 1.3% after a year. On the other hand, the effective monetary policy and other policy adjustments are also efficient ways to reduce the negative effect of the increase in crude oil prices on macroeconomy. Hamilton empirically confirmed the significant correlation between oil price increase and economic slowdown since during 1948–1972 [6]. In further, Davis and Hamilton [7] found nonlinear and asymmetric relationship between oil price and inflation. Hooker concluded that the effect of oil price on inflation has reduced because of reduced dependency on oil [8].

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The findings of this paper are consistent with the conclusions in current literature. While existing literature focuses on the long-run relationship between crude oil price and inflation, this research narrow the study window into the period over Covid-19. Covid-19 as an exogenous shock, a black swan imposes great effect on crude oil price volatility, and the demand shock on price become supply shock now.

Meanwhile, the rise of inflation is great challenge rising in the same period. This research focuses the relationship between those two factors during Covid-19. Our results show that increase of crude oil price a key driving inflation rise.

ARCH family regression

Sample: 2020m1 thru 2022m5 — Number of obs = 29
Log likelihood = 3.367225 — Wald chi2(3) = 51.59 — Prob > chi2 = 0.0000

cpi	Coefficient	OPG std. err.	z	P>|z|	[95% conf.	interval]
cpi						
wti	.0091162	.0036993	2.46	0.014	.0018657	.0163667
gdp_indicator	-.0938127	.0448672	-2.09	0.037	-.1817508	-.0058746
real_consumption	.0004777	.0002425	1.97	0.049	2.50e-06	.000953
_cons	2.775526	2.90734	0.95	0.340	-2.922756	8.473807
ARCH						
arch						
L1.	.07579	.4291986	0.18	0.860	-.7654238	.9170038
_cons	.0428979	.031301	1.37	0.171	-.0184509	.1042466

Figure 4: Regression result (independent variable: crude oil price WTI).

Sample: 2020m2 thru 2022m5 — Number of obs = 28
Log likelihood = -95.25769 — Wald chi2(3) = 175.00 — Prob > chi2 = 0.0000

wti	Coefficient	OPG std. err.	z	P>|z|	[95% conf.	interval]
wti						
cpi	17.72559	4.524546	3.92	0.000	8.857645	26.59354
gdp_indicator	3.196341	.6689251	4.78	0.000	1.885271	4.50741
g_real_consumption	21.70219	44.78315	0.48	0.628	-66.07118	109.4756
_cons	-268.4859	64.34855	-4.17	0.000	-394.6067	-142.365
ARCH						
arch						
L1.	1.404329	1.318934	1.06	0.287	-1.180734	3.989392
_cons	1.451463	9.963203	0.15	0.884	-18.07606	20.97898

Figure 5: Regression result (independent variable: crude oil price WTI).

4. Conclusion

This research studies the relationship between inflation and crude oil price since Covid-19 with the empirical study of US data. The US produces and consumes the largest amount of crude oil, which makes us to study this topic with US data. Our regression results confirm the significantly positive relationship between those two factors. The the rise of crude oil price is confirmed as a key driver of

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current high inflation. We also realise that such results are limited with in the US, and the other countries do not necessarily show the exact same correlation between inflation and crude oil price. The heterogeneous effect of individual country could be an extension for this research in the future. For example, we will examine this relationship within other developed and developing countries and identify whether there is such difference in current findings across countries .

In the future, we will also estimate the non-linear and asymmetric relationship between oil price and inflation, as proposed by Davis and Hamilton [7]. Recently Shitile (2020) have illustrated a long-term asymmetric relationship between those two factors using the nonlinear autoregressive distributed lag method [9].

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