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Predatory oil prices & commercial storage capacity: Pattern of Non-OPEC supplies in oligopoly market conditions

الأسعار السلبية للعقود النفطية وقدرات التخزين: نمذجة إمدادات نفطية خارج الأوبك في ظروف السوق الاحتكارية المدارة

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Abstract

This article attempts to illustrate major interconnections of oil market factors which drove future oil price below zero in 2020, and the implications of both stockpile conditions and exchange traded fund conduct on futures crude contract delivery. We investigated the inverse backward situation occurred in global oil market and forward agreement, and ran quantile unit root tests for spread of WTI minus Brent for better understanding the phenomena.
Observation data confirmed that more over supply came from non-OPEC members' concussion contributed in sending forward commercial contracts below zero instead than stockpile factors. Also, empirical results confirmed that storage capacity alternative values will substitute spread between current tariffs and alternative future in the global oil market.

Keywords : Oil price, OPEC, storage capacity, Contango.

ملخص

يحاول المقال دراسة الارابطات الرئيسية لعوامل سوق النفط التي أنتجت أسعار سلبية للعقود الآجلة للنفط سنة 2020. لقد درسنا الوضع العكسي في سوق النفط، وأجرينا اختبارات الوحدة الكمية لانتشار خام غرب تكساس مقابل البرنت. أكدت النتائج أن زيادة الامدادات مصدره صدمة خارج الأوبك بدلاً من عوامل المخزونات. كما أكدت النتائج التجريبية أن القيم البديلة لسعة التخزين ستحل محل الانتشار بين التعريفات الحالية والتكاليف البديلة في سوق النفط.

الكلمات المفتاحية: أسعار النفط، الأوبك، قدرات التخزين، Contango.

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1. INTRODUCTION

Commonly oil price changes are computed separately from other commodities market due to the oil field imperfect competitive characteristics. Whereas supplies from OPEC-Plus are denominated as Stackelberg initiative, in which large producers like Russia and KSA move first and then the small suppliers follow sequentially. Others proposed Nash-Cournot competition approach for calculating crude prices, where futures price are composed alternatively in perfect competition to oligopolistic conditions scope.

While large crude suppliers might conduct marginal revenues optimization policy, where all producers take advantage from high oil prices in maximizing profits. But at the same time large producers can turn crude market into an oligopolistic structure by supply glut forcing a significant prices decline. As a result small producers that have high marginal cost will be eliminated from the industry due to sub-zero prices and market became an oligopoly for dominant producers.

Otherwise, the scarcity of storage areas that ignited WTI sub-zero price does not seem possibly to recover in the near future contacts delivery, despite the fact that crude prices now can switch below zero likely to help traders avoiding negative prices trap.

1.1 Problem statement and sub-questions

This paper tries to provide detailed explanations upon reasons behind the dramatic drop of futures crude oil contract prices in commodity exchanges through the following key question: **Under which market conditions forwarded commercial oil contracts could be traded negatively in commodity futures exchanges?**

In order to find accurate evidences for the main research problem, we expanded the analysis and investigations to include the following areas:

1- How oil markets arrived to a situation where traders have to pay to get out of crude physical delivery?
2- Could Brent benchmark prices ever fall into negative territory under Contango market conditions?
3- How does stockpile capacity and COVID-19 affected future crude prices?

4- What is the role of floating storages and global corporate strategic petroleum reserves in affecting future oil prices?

1.2. Hypotheses

Under the assumption of no-price discrimination of perfect competition and oligopolistic condition in crude oil market. We would take into account two conjectures: augmenting marginal cost of crude storage for net oil importers, and linear supply chart, in order to calculate global stockpile under alternative market conditions that would be:

$$\delta c\left[Q_{NO}+\Delta Q_{NO}\right]=a-b\left[Q_{O}+Q_{NO}+\Delta Q_{O}+\Delta Q_{O}\right]$$

$$\text{Assuming } \frac{\Delta Q_{NO}}{\Delta Q_{O}}=\frac{-b}{b+c\delta}$$

1.3. Research objectives

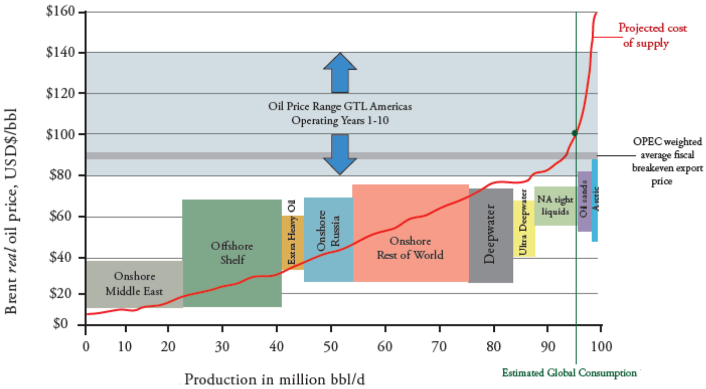
This essay attempts to analyze the pricing mechanisms of crude oil contracts for future delivery, and find out the relations of VLCCs, floating production storage and offloading to the physical delivery. Whereas, modeling onshore storage capacity of net oil importers countries to production levels and prices mainly under perfect competition and oligopolistic market conditions. Finally we try to determine the causality of negative futures crude oil contract.

2. OIL STORAGE ECONOMICS & MARGINAL SUPPLY COST

A large numbers of oil future contacts traders basically try to inquire why we store crude oil in stockpiles in many regions in the world. Simply put, it is essential to understand first the concept of storage economics (Bodenstein M, Guerrieri L, Kilian L, 2015).

Figure.1 shows the breakeven price of crude oil of industry supply marginal cost, it illustrates the production cost per barrel generated by global crude oil suppliers. It is obviously for producers that any price below 65$ per barrel let's say 50$ per barrel would immediately a large part of global oil producers to uncertain prospective.

Fig.1. Projected supply cost curve for global oil in 2030



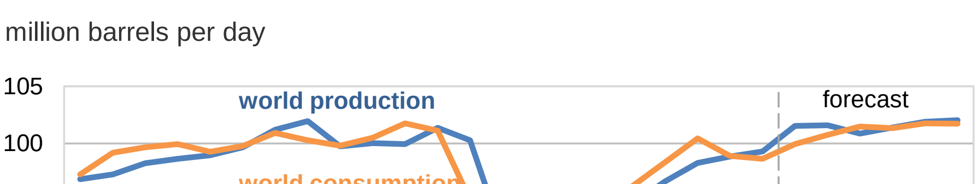
Source: Rystad Energy data May 2022.

If crude oil stockpile spaces are available, commercial traders are making profits from this process. In Oklahoma hub the substantial stockpile storage in the United States, market traders pay monthly 0.75$ per barrel as to store crude oil, therefore when price annually increases by 10$ per barrel they could generate 3.25$ per barrel this means 13% average yearly profit calculated at actual prices range (Degiannakis, S., G. Filis, and V. Arora, 2018). Despite the fact, if there is shortage in demand, suppliers remain holding contacts and storing crude oil while production keeps going and storage capacity commence to give out.

3. SUPPLY DOWNTREND VELOCITY

Alongside with negative oil crisis, market analysts presume that there is no enough evidence to believe production downturn even with prices below zero. According to U.S. Energy Information Administration expectations, U.S. production may decline by 2.75 to 3.15 million barrels per day at the end of 2020, plus a significant decrease of 1.5 million barrel per day decline in the second half of the year due to capital investment spending slash. Which mean removing over around 70 million barrels supply in the next 4 months average from the estimated 950 million barrels per day overflow (International energy agency, 2022).

Fig.2. World liquid fuels production and consumption outrages



Source: US Energy Information Administration, sort-term outlook, July 2022

Jointly, oil industry shrinks by 5.3% this year which is equivalence of 3 million barrels per day of supplies in the first quarter 2020 suppose no attempt to turndown production. Market analysts rely on negative oil prices to shutoff spare production. As a result, assuming no potential would be layout to shut down production from 950 million barrels of market saturation, it would be 800 million barrels accommodating in 2021 (Caldara, D, M. Cavallo, and M. Iacoviello, 2021).

4. WTI VS BRENT DELIVERY REQUIREMENT

While West Texas Intermediate benchmark is moving on the way to maximum storage in Oklahoma stockpiles hub. Other international benchmark as well as Brent and doesn’t have the identical delivery conditions like WTI, which would provide it a significant security from sub-zero prices. But Brent futures contract are being standing by to negative prices in London Intercontinental Exchange, which is the world major supplier of crude oil clearing services and online trading for a wide range of future commodities (Irma Alonso Alvarez, Virginia Di Nino, Fabrizio Venditti, 2020).

Table 1. Quantile unit root tests for spread of WTI minus Brent

T	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
$\alpha_0(t)$	-1.21	-0.74	-0.376	-0.159	0.022	0.242	0.376	0.688	1.158
$t_{\alpha 0}(t)$	-8.141	-8.562	-7.032	-3.372	0.519	5.352	8.016	8.047	11.029
$\alpha_1(t)$	1.083	1.053	1.035	1.009	0.98	0.946	0.939	0.904	0.872
$t_{\alpha 1}(t)$	4.563	4.415	3.76	1.088	-2.805	-7.463	-7.496	-7.894	-7.765
High/low					34.31	12.486	11.013	6.868	4.977
QKS index WTI-Brent spread	7.894								

Source: Huei-Chu Liao, 2021, p6.

At the moment, it is important for traders and producers to understand that current prices might drop below zero for both marketplace benchmarks Brent and WTI. Particularly, with the insufficient storage capacity in Oklahoma stockpiles hub prospective, which does not sending signals to market players to be improved by the end of 2022.

5. STORAGE LEVELS AND FUTURE PRICE IN PERFECT & MONOPOLISTIC MARKET CONDITIONS

First, we can compute future equilibrium prices according to the following linear equation in perfect market condition, which demonstrates the settlement of onshore and offshore crude storage capacity in parallel with production levels.

$$b\left(\Delta Q_{NO}+\Delta Q_0\right)\geq(\alpha-1)c\frac{\Delta Q_0}{Q_0-\Delta Q_0}$$

$$\Delta Q_0\frac{\delta bc}{b+\delta c}\geq(\alpha-1)c\frac{\Delta Q_0}{\left[Q_0-\Delta Q_0\right]}$$

$$Q_0-\Delta Q_0\geq(\alpha-1)c\frac{b+\delta c}{b\delta c}$$

$$\frac{\Delta Q_0}{Q_0}\leq 1-\frac{\left(\delta Q_{NO}-1\right)}{Q_0}\times\frac{b+\delta c}{b\delta}$$

$$\frac{\Delta Q_0}{Q_0}\leq 1-\left[\frac{\delta(a+c)-2\delta c-b}{c\left(\delta(a-c)-b\right)}\right]\times\frac{b+\delta c}{\delta c}$$

In like way, futures crude oil contract divergence comprises setting supplies upper the market demand by ΔQ_0 in order to take control of market prices by large oil suppliers (Irma Alonso Alvarez, Virginia Di Nino,Fabrizio Venditti, 2020) $\left(\Pi_{MST}\geq\Pi_0\right)$.

$$\Delta_{OPECplus}\geq(\alpha-1)c\frac{\Delta Q_0}{Q_0+\Delta Q_0}$$

$$1+\frac{\Delta Q_0}{Q_0}\geq\frac{\delta(a+c)-2\delta c-b}{c\left(\delta(a-c)-b\right)}\times\frac{b+\delta c}{\delta}$$

That being the case of $\frac{-b}{\delta c}\leq\frac{\Delta Q_0}{Q_0}\leq\frac{b}{\delta c}$ which enables indifference market behaviors of Russia and KSA to oligopoly unconsumed crude in storage hubs (see table.2).

Table 2. Linear combination of existing storage and market factors

Factors	**Targeted Market Share**	**Targeted Price**	**Forecasted Demand**	**Market Demand**
OPEC-Plus Supply	-	-	+	+
OPEC Supply	-	+	+	+
Real Price	-		-	+
Speculative Price	+		+	+
Storage fill up	+	-	-	

Source: Observation of the author, most variables have positive reaction to pricing oil market tensions. Otherwise, speculative demand and price target shocks have negative linear impact on existing storage levels.

In order to identify futures crude price based on storages fill ups function, we applied storage factor functions in perfect, monopoly and oligopoly crude market (Federal Reserve Bank of New York, 2022), the result is shown as:

$$\prod{}_{PT} \geq \prod{}_{MST} (PPT - c)[Q_0 - \Delta Q_0] \geq (PMT - c)[Q_0 + \Delta Q_0]$$

$$\left(P_0 + \frac{\delta bc\Delta Q_0}{b - \delta c} - c\right)(Q_0 - \Delta Q_0) \geq \left(P_0 - \frac{\delta bc\Delta Q_0}{b + \delta c} - c\right)(Q_0 + \Delta Q_0)$$

$$\frac{2\delta bc\Delta Q_0}{b + \delta c} + 2c\Delta Q_0 \geq 2P_0\Delta Q_0$$

$$\frac{Q_0}{Q_{NO}} \geq \left(\delta c - \frac{\frac{c}{b + \delta bc}}{a + c}\right)\frac{b + \delta c}{\delta bc}$$

$$\frac{Q_0}{Q_{NO}} \geq \left(\delta - \frac{a + c}{b + \delta bc}\right)\frac{b + \delta c}{\delta bc}$$

Consequently storage factor plays a major role in optimizing futures crude price in oligopoly market condition, as long as total supply above demand (U.S. Energy Information Administration, 2020). Conversely to monopolistic and perfect competition market terms when storage factor has negative effects on futures crude contract prices (see table.3).

Table 3. Correlation of market supply and existing storage indifferences

Correlation	*Model*	*KM**	*CCI***	*BH****
Price correlation to demand	-0.28	-0.08	-0.07	-0.35
Price correlation to commercial storage	0.10	0.03	0.08	0.15
Price correlation to OPEC-Plus supply	0.20		0.19	
Price correlation to OPEC supply	0.06		-0.01	

Source: Irma Alonso, Verginia Di Nino, Fabrizio Venditti, 2022, page 21.

*KM refers to Kilian and Murphy 2019.

**CCI refers to Caladara, Cavallo and Lacoviello 2021.

***BH refers to Baumeister and Hamilton 2022.

6. MARKET EXCHANGE SENSITIVITY

The predominant traders for futures crude oil contracts in Nymex attempted to seek for potential buyers before contracts' expirations, which force price cut to 5 dollar per barrel in the morning trading session. But was not enough for sellers to get out of contracts, as no buyers in the market. As a result, the trading clearance for West Texas Intermediate contracts quickly switched to maximum price cut to approximately 37.36$ below zero (Sadorsky P, 2012).

$\overline{p}_{t+1}$ is identified as the expected future crude contracts invoiced in dollar at time t + 1. Therefore, supply cost expectations for producers are C(e) for euro, C(d) for dollar respectively:

$$C(e)=\left(1-\overline{p_{t+1}}\right)\left[\tau+i\left(p_t\right)\right]+\overline{p_{t+1}}\left[i\left(p_t\right)\right]+\varepsilon_t^e$$

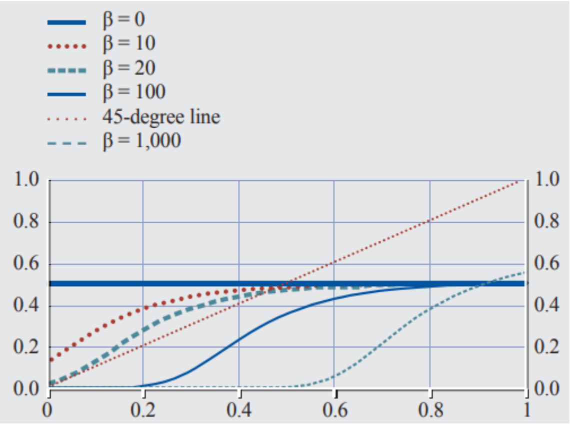
$$C(d)=\overline{p_{t+1}}\tau+\varepsilon_t^d$$

While ε_t^d and ε_t^e, consider a wide range of sub costs related to transportation and delivery, thus:

$$p_t = pr\left\{\left(1-\overline{p}_{t+1}\right)\left[\tau+i\left(p_t\right)\right]+\overline{p}_{t+1}i\left(p_t\right)\varepsilon_t^e\langle\overline{p}_{t+1}\tau+\varepsilon_t^d\right\}$$

$$= pr\left\{\varepsilon_t^e-\varepsilon_t^d\langle 2\overline{p}_{t+1}\tau-\tau-i\left(p_t\right)\right\}$$

Fig.3. Sensitivity dynamics for various crude weighted price β



Source: Bloomberg (2021)

Note: τ = 0.0004; i(pt) = 0.20 exp(-7 pt)

In overnight crude oil markets, some brokers prohibited traders to deal with 3 months futures contract to avoid similar market risks. With no buyers in oil markets, exchange trading funds moved to forward their holding contracts to 6 months delivery, to avoid failure if prices go negative. As a result, global crude markets shifted to another trading level, WTI 3 months delivery contracts dropped by 70% to 5.70$, London Intercontinental Exchange wasn't an exception as Brent futures dropped to 19.39$ per barrel leading other references to subzero level as well as Dubai-Oman for Persian Gulf oil delivered to the Asian markets and West African and Russian crude.

7. REFINERS ACTIVITIES INTERRUPTION

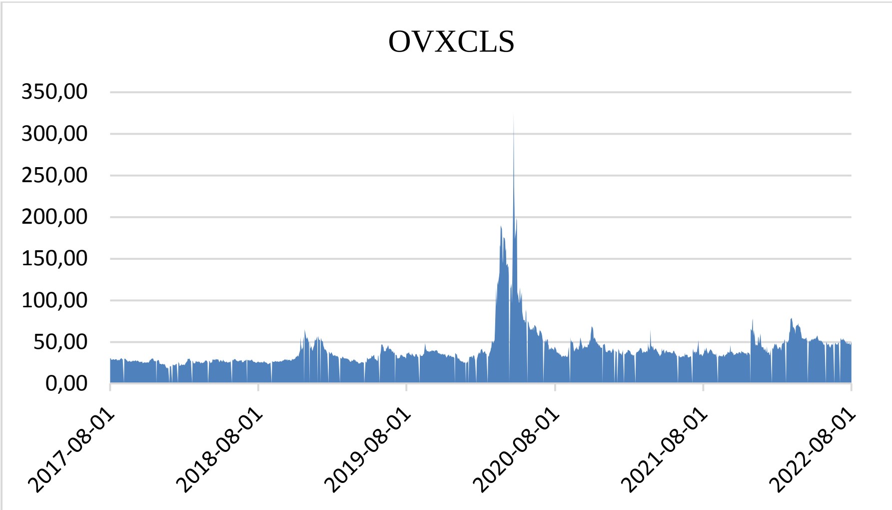
Along with global demand plunging, refiners have experienced a significant halt around the world. In U.S. oil market Royal Dutch Shell announced it would turn down some refining activities 3 months ahead, the same were happening through Asian and European oil markets. From March to June U.S. refineries operated approximately 13.70 million barrels each day, instead of average amount 18.76 million barrels a day in 2019 (U.S. Energy Information Administration, 2020). Oil market analysts expect much more 35% refineries activities shut are ahead during 2020 of total capacity, since global demand still shrinking.

8. CRUDE EXCHANGE TRADED FUNDS VOLATILITY

Most crude oil trading markets had been affected with under zero prices of West Texas Intermediate for May delivery, causing global oil prices to record 30 years down. Exchange trading funds in crude in Asia jointly lost around 94 million dollar overnight due to crude futures contracts.

Investment statistics from Chinese crude oil funds 24 hours before WTI futures contract went negative, illustrated more than 1.7 billion dollar of market position for one month physical oil delivery. But as prices reached minus 37.36$ per barrel now investors' assets became liabilities (Yilin Wu, Shiyu M, 2021).

Fig.4. Crude Oil ETF Volatility Index



Source: St Louis fed, collected oil market data, July 2022.

Transactions of crude oil exchange funds with negative prices were part of some markets expectations. CME Group of Chicago the operator of commodity futures exchange had sent signal to investors to be prepared for below zero futures contract energy prices, and offered a stress testing system in order to evaluate their ability to meet futures oil contract commitments.

Table 4. Correlations between oil futures and financial instruments

	2016				2017				2018				2019				2020				2021				2022			
S&P 500																												
US dollar																												
Brent implied volatility																												
Inflation expectation																												
Bonds																												

< -0.65	-0.65 to -0.4	-0.4 to -0.25	-0.25 to 0.25	0.25 to 0.4	0.4 to 0.65	> 0.65
Negative correlation				Positive correlation		

Source: US energy information administration, 2022 data.

On the other hands, OPEC Plus arrived to an agreement to reduce global supplies by start cutting roughly 9.7 million barrels from 1 May 2020, with potential to raise it to 10 million of total outcome (Sharif A, Aloui C, Yarovaya L, 2020). Although, with no buyers in spot markets for 30 days contracts that cause refineries shut down, it was not enough to stop negative prices in exchange crude oil trading funds. (See table.4).

9. STRATEGIC OIL RESERVES AND FLOATING STORAGES VLCCs-FPSOs

Many market analysts in net importers countries suggest that surplus oil in the system might be transferred to corporate strategic reserves of IEA members, which have a total capacity of 1.5 billion barrels. For instance the U.S. has one of the biggest strategic oil reserves in the world with 730 million barrel of capacity, data delivered from U.S. energy information administration show 20% of the total capacity still empty or around 650 million barrels.

Although, accurate information about total countries oil reserves levels are not available. But if we assume 20% of their reserves are still empty, it refers to 300 million barrels capacity not filled up yet. Many industrialized economies attempted to take advantage of sub-zero oil prices to fill up their reserves. India for example has a total capacity of 67 million barrels of petroleum reserve, and intending to purchase 50 million barrels in May, June and July after expanding more spaces to store extra barrels (Tahir M, Khan S, Inzamam K, 2021).

Even offshore crude storage looks a good option in time of negative prices, but it might not be an easy task in oil industry as not all petroleum grades have the same storage features. There are around 802 of very large crude carriers in the world, some are publicly owned companies and the rest are joint ventures. In addition to more than 175 floating production storage and offloading (FPSO) that can receive around 1 million barrel of crude, often cartel oil firms owned these FPSOs and operating them far overseas in order to maintain competition and control oil markets (Golombek, R., A. A. Irarrazabal, and L. Ma, 2018). If prices go down than firms can use FPSOs and VLCCs to store up to 350 million barrels for 3-4 months before price reboots.

In addition, both refineries and commercial crude stockpiles could play a major role during negative prices. For instance the U.S. has 793 million barrels of storage capacity including crude in transit, refined products and pipeline fills and still 350 million of spare capacity not yet filled up.

10. RESULTS AND DISCUSSION

10.1. Hypotheses test:

1- The function of global supply does not include existing storage capacity nor spare stockpiles costs, because since marginal production cost is an amounting function, crude storage would replace price-cost divergences for futures crude in both oligopoly and perfect market condition all the time.

2- Crude production would keep pumping since marginal operational costs are set under market rates for Stackelberg market leaders, which refers to linear supply chart. While the rest of OPEC-Plus members are scatter plot depending on marginal production costs.

10.2. Results & discussion:

The evaluation of OPEC-Plus impacts on futures oil price illustrate that non-OPEC producers could act as Stackelberg perfect competitors by adjusting production quotas in oligopolistic conditions, at such time futures crude prices might roughly fluctuate below zero assuming no spare storage readily available to absorb the oversupply:

$$\left(\left(\frac{OPEC^{Plus.\mathrm{Pr}od}}{OPEC^{Cap}} \times OP^{Quo}\right) \div \left(\frac{OPEC_t^{prod}}{Aggregate}\right)\right)$$

Parallel with OPEC-Plus perfect market competition of supply, negative futures crude could not be driven by prices power in the short run, since existing storage facilities have major impact upon traders' on hold contracts for physical delivery. In contract to the long run where market forces neglect stockpiles rooms effects to prices power leverage on futures crude contract $\left(\sum_n \beta_n^{OPPlus\,\mathrm{Pr}ice} = Futures_{price}^{SypplyOPEC-Plus}\right)$.

Empirical results illustrated that global storage spaces could bear up to 1.5 billion barrel of oil so far, without considering additional stockpiles facilities and equipment that are expected to be operational before the end of 2022. Although, in worst scenario of global over supply which may be caused by economies lockdowns and 930 million barrels of oil glut, there will be still 35% of commercial storage capacity spare which may be used in order to stabilize crude oil crude market in the short and medium terms. Even though, these data do not explore commercial derivatives oil prospective held by refineries that can offer more storage rooms.

11. CONCLUSION

Negative crude oil crisis might turn away financial investors in stock markets from investing in oil derivatives, since market non-stabilizer factors still alarmed due to OPEC-Plus prices war, corona virus impacts on oil demand and potential of long recession of global economy. By money market outflow and Contango market conditions, crude market vulnerability would be settle in new higher level that certainly reflects upon future prices in medium terms.

Global crude oil market seemly arrived to the break point, where negative prices compelling OPEC-Plus members and net exporting countries to make a significant reduce in outputs in order to eliminate the oversupply. Although, empirical results show zero interconnection between futures crude contract prices and market forces in Contango conditions. Otherwise, it is familiar with two principal factors of Stackelberg structure of crude market dynamics and storage facility system.

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