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Liquidity Pricing Risk and Crude Oil Market: Analyzing the Liquidity as a Priced Factor in Yields during the Pandemic Uncertainty

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Abstract: The liquidity risk can impact the transaction execution with the significant losses. In the crude oil market, this work examines the market liquidity as a priced risk factor in yields. This area may considerably matter to be investigated, while an unprecedented slump is observed in the crude oil price during the pandemic period. The analysis is derived through the time series and multivariate algorithm methods. Pre-pandemic uncertainty and in the era of easing coronavirus-related restrictions, the liquidity was not priced in returns of the same trading session. In the period of economic restrictions, the crude oil trading was exposed to the liquidity risk for the same trading session. This risk was compensated by a premium return in environments of price uncertainty. In this debate, the liquidity risk was a priced risk factor in yields. Evidence from the VAR findings reports, that the past time series of the liquidity was priced in returns before the pandemic crisis takes place. Post-easing economic restrictions and in the era of pandemic-related restrictions, the past times series of the liquidity was not priced in returns. This quantification of the market liquidity may be more applicable for the liquidity risk management in the crude oil market.
Keywords: *Asset pricing, COVID-19, Crude oil market, Liquidity cost, Returns.*
JEL Classification: *G10; G14.*

1. Introduction

The crude oil market is exposed to the considerable fluctuations over the past decade (Perifanis & Dagoumas, 2019). The stream in the field also explores the historical events to understand the pattern of price variations. This debate can link to the financial crisis of 2007-2009, as well as the Gulf War. Nevertheless, the COVID-19 crisis leads to an unprecedented slump in the crude oil market (Gharib, Mefteh-Wali, & Jabeur, 2021). Figure 1 depicts the price fluctuations in the crude oil market, where it is noted to be traded negative on April 20, 2020. The sudden plunge in the crude oil price may have changed the economic realities more than the earlier economic downfalls.

The pandemic outbreak is not only linked to the exceptional number of fatalities, but it has impacted the global lifestyles (Ahundjanov, Akhundjanov, & Okhunjanov, 2021). Following the health restrictions in wake of the COVID-19, the global market was turned into the economic blockade (Vidya & Prabheesh, 2020). A sudden halt in the economic activities has impacted the economic development (Goodell, 2020) , supply chain (Vidya & Prabheesh, 2020) and global stock indices (David, Inácio Jr, & Machado, 2021).

The crude oil market was highly impacted by the pandemic crisis (Gerlagh, Heijmans, & Rosendahl, 2020) and it was dropped to negative value for the first time in the history. The global market economy was affected by the observed plunge in the crude oil price (Gharib et al., 2021). Despite the energy transition, the oil is a key input of energy in many global markets. As the crude oil market was collapsed to -$37.63 per barrel during the COVID-19, the price plunge can raise concerns on the future market economy.

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The external environment, as the epidemic and severe events, can impact the efficiency of the energy market (Ichev & Marinč, 2018). The market liquidity undoubtedly determines the price efficiency of the financial assets (Guijarro, Moya-Clemente, & Saleemi, 2019) and its uncertainty should be priced in the asset returns (Amihud, Hameed, Kang, & Zhang, 2015). In this debate, the liquidity matters for the policymakers, academic, and investors.

The market liquidity can shrink in environments of the financial uncertainty (Guijarro, Moya-Clemente, & Saleemi, 2021). This phenomenon is linked to the recent pandemic uncertainty, where the liquidity is analyzed as a priced risk factor in the crude oil returns. Post-pandemic era, the literature devotes much attention on the relationship between the crude oil supply and its demand. In the crude oil market, this study broadly contributes by disclosing the authoritative role of the liquidity and its associated cost on yields.

Figure 1.
Closing prices of the crude oil.

2. Review of Literature

The price efficiency in the energy market is directly associated with the sustainable economic development (Eyden, Difeto, Gupta, & Wohar, 2019; Wen, Zhao, & Chang, 2021). The uncertainty to the oil market has short-lived in the era of pandemic, but it may have long-lasting consequences on the market economy (Gil-Alana & Monge, 2021; Le, Le, & Le, 2021). The price of the crude oil was severely plummeted in environments of the pandemic uncertainty (Gerlagh et al., 2020; Gharib et al., 2021). In this case, the crude oil was traded with severe significant losses.

The pandemic crisis has not only impacted the trade process in the financial markets (Saleemi, 2021), but it may have changed the economic realities more than the historical crises. Post-pandemic era, the price efficiency of distinct financial assets can be a crucial subject to the academics, regulators, and investors. The economic collapse in environments of the epidemic and grievous events reflects the efficiency in the energy prices (Ichev & Marinč, 2018). In the market microstructure, the liquidity measurement reflects the efficiency in the asset prices (Guijarro et al., 2021), and the specialist is likely compensated by a premium return in environments of the liquidity risk (Amihud et al., 2015; Amihud &

Mendelson, 2012). The liquidity is a priced risk element in the transaction execution against the uncertainty of future prices and returns (Amihud et al., 2015; Saleemi, 2020).

The market liquidity facilitates the functioning of the financial markets more effectively (Ma, Anderson, & Marshall, 2016; Zhang, Yang, Su, & Zhang, 2014), and it is priced in yields on the assets (Acharya & Pedersen, 2005; Amihud et al., 2015; Chikore, Gachira, Nkomo, & Chiwanza, 2014; Hasbrouck, 2009; Korajczyk & Sadka, 2008; Marozva, 2019; Pástor & Stambaugh, 2003; Saleemi, 2021; Vu, Chai, & Do, 2015). In this context, the specialist should price the liquidity to reduce the significant losses against the future price uncertainty (Saleemi, 2020).

The liquidity is a key aspect of the capital assets (Amihud & Mendelson, 1991). The liquidity has an authoritative role to the transparency, as well as the issuance of the firm's shares (Lang, Lins, & Maffett, 2012). The liquidity management can reduce the capital cost (Acharya & Pedersen, 2005) strengthen the investment decision-making (Norli, Ostergaard, & Schindele, 2015) and ease the trade process (Saleemi, 2020). The liquidity is not a constant risk factor, but varies over time in the financial markets (Guijarro et al., 2021; Hasbrouck & Seppi, 2001). There is no unified approach to estimate the market liquidity in the asset pricing literature (Goyenko, Holden, & Trzcinka, 2009). However, the execution of the financial asset with bearing limited costs is often referred to the market liquidity (Liu, 2006). The trading cost can denote to the market frictions, which are not constant and directly involved to estimate the liquidity (DeGennaro & Robotti, 2007). The bid-ask spread, also known as liquidity-cost measure, has gained tremendous attention for the quantification of trading costs (Abdi & Ranaldo, 2017; Corwin & Schultz, 2012; Saleemi., 2022; Sarr & Lybek, 2002).The bid-ask spread estimates all the market frictions, that can impact the execution of the financial transaction (Huang & Stoll, 1997; Sarr & Lybek, 2002). The stream in the field is multidimensional (Fong, Holden, & Trzcinka, 2017; Goyenko et al., 2009) but structures the spread in the context of asymmetric information cost (Glosten & Milgrom, 1985) inventory control cost (Ho & Stoll, 1981; Ho & Stoll, 1983), and order processing cost (Roll, 1984). The specialist enables continues trading by accepting the risk of price uncertainty, informed counterparty, and future transaction processing cost. In this debate, the liquidity providers would reduce their risk exposure by imposing costs on the counterparty, i.e., a spread. The size of the spread is higher in uncertainty of the future returns, transaction processing cost, and asset transparency value (Saleemi, 2020). In the market microstructure, the asset is considered illiquid with a wider spread (Corwin & Schultz, 2012; Liu, 2006; Sarr & Lybek, 2002).

3. Data Sampling and Methods

In environments of the liquidity risk, a liquidity provider injects the liquidity on some conditional costs. The bid-ask spread is often applied for quantification of the liquidity-providing cost. The work investigates whether the market liquidity is a priced risk factor in the crude oil returns. This research covers the period January 03, 2006 – August 16, 2022, where the analysis is performed in three dimensions: pre-pandemic uncertainty, coronavirus-related restrictions, and lifting lockdown.

The coronavirus was perceived as a global threat on March 11, 2020. In the late March and early April 2020, a patchwork of restrictions was implemented. The common issue for officials to halt the virus speed, as well as select the appropriate period for easing social and economic restrictions. Such restrictions were slowly lifted in May 2020, but the time varies across the globe. In this context, an era of the coronavirus-related restrictions is investigated between March 11, 2020, and May 29, 2020. The impact of easing restrictions covers the period June 01, 2020 – August 16, 2022.

The liquidity-providing cost is measured through the informed realized spread. The low-frequency data is used in the construction of the spread model. The low-frequency data is illustrated in daily components of a financial security. Such components of an asset are denoted to opening, closing, high, and low price (OCHL), as well as its trading volume. Pricing the risk of informed trading in the spread size, another version of the realized spread is proposed by Saleemi (2022). The Informed Realized Spread (IRS) may be a meaningful estimation of the liquidity-providing cost, as a wider set of the financial data is required in its analytical modeling. The IRS methodology is depicted in Equation 1.

$$IRS_t = \frac{2|[E(ask_{t+1}+bid_{t+1})0.5]-Closing_t|}{QuotedS_t * \left(\frac{1}{2}\right)} \tag{1}$$

Where $QuotedS_t$ is the sum of high quote, $high_t$, and low quote, low_t, on day t. $E(ask_{t+1})$ is the expected highest ask price of the following trading session $t+1$, and estimated through Equation 2.

$$E(ask_{t+1}) = (high_{t+1})\pi + \left[(QuotedS_{t+1}) * \frac{1}{2}\right]\pi \tag{2}$$

Where π indicates the probability of the informed optimistic buyer; $high_{t+1}$ depicts the highest quoted price of the next trading day $t+1$; and $QuotedS_{t+1}$ is the sum of quoted prices on day $t+1$. Modeling the probability of the informed pessimistic seller, $E(bid_{t+1})$ illustrates the expected lowest bid price of the next trading session $t+1$. The expected lowest price is computed in Equation 3.

$$E(bid_{t+1}) = (low_{t+1})p + \left[(QuotedS_{t+1}) * \frac{1}{2}\right]p \tag{3}$$

Where p refers to the probability of the informed pessimistic seller, and low_{t+1} denotes to the lowest quoted price of day $t+1$. The closing prices of the transaction execution are utilized to estimate the crude oil yields. The estimation of returns is based on a daily basis, and depicted in Equation 4.

$$r_t = \left(\frac{closing_t}{closing_{t-1}}\right) - 1 \tag{4}$$

Where r_t is the return of day t; $closing_t$ indicates the executing price of the transaction on same trading session; and $closing_{t-1}$ refers to the executing price of the transaction on previous trading day. For quantification of the relationship between variables, the regression model is constructed through Equation 5.

$$cy_t = \alpha + \beta lc_t + \epsilon_t \tag{5}$$

where cy_t denotes to the crude oil yield of day t; lc_t indicates the liquidity cost against accepting the position of crude oil on day t; and ϵ_t depicts the error term.

The variables are further checked as a linear combination of their corresponding lags and other variables' lags. Based on the multivariate algorithm technique, the Vector Autoregression (VAR) is conducted to understand the linear interdependence between the multivariate variables. In this case, the selection of the optimal lags is derived through the schwarz criterion approach, and depicted in Equations 6 and 7.

$$coy_t = \alpha_{coy} + \gamma_{11} coy_{t-1} + \gamma_{12} coy_{t-2} + \emptyset_{11} lpc_{t-1} + \emptyset_{12} lpc_{t-2} + \epsilon_{coy,t} \tag{6}$$

Where, coy_t is the return on the crude oil of day t; coy_{t-1} (coy_{t-2}) shows the yield of day $t-1$ ($t-2$); lpc_{t-1} (lpc_{t-2}) demonstrates the liquidity-providing cost of day $t-1$ ($t-2$); and $\epsilon_{coy,t}$ indicates the white-noise variable.

$$lpc_t = \alpha_{lpc} + \gamma_{21} coy_{t-1} + \gamma_{22} coy_{t-2} + \emptyset_{21} lpc_{t-1} + \emptyset_{22} lpc_{t-2} + \epsilon_{lpc,t} \tag{7}$$

Where, lpc_t illustrates the liquidity-providing cost of day t; and $\epsilon_{lpc,t}$ is another white-noise variable. Equations 6 and 7 are depicted in a matrix notation as:

$$\begin{bmatrix} coy_t \\ lpc_t \end{bmatrix} = \begin{bmatrix} \alpha_{coy} \\ \alpha_{lpc} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} coy_{t-1} \\ coy_{t-2} \end{bmatrix} + \begin{bmatrix} \emptyset_{11} & \emptyset_{12} \\ \emptyset_{21} & \emptyset_{22} \end{bmatrix} \begin{bmatrix} lpc_{t-1} \\ lpc_{t-2} \end{bmatrix} + \begin{bmatrix} \epsilon_{coy,t} \\ \epsilon_{lpc,t} \end{bmatrix} \tag{8}$$

Equation 8 can be reviewed in the following components as:

$$CRL_t = \begin{bmatrix} coy_t \\ lpc_t \end{bmatrix}, A = \begin{bmatrix} \alpha_{coy} \\ \alpha_{lpc} \end{bmatrix}, \gamma = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}, R_t = \begin{bmatrix} coy_{t-1} \\ coy_{t-2} \end{bmatrix}, \emptyset = \begin{bmatrix} \emptyset_{11} & \emptyset_{12} \\ \emptyset_{21} & \emptyset_{22} \end{bmatrix},$$

$$L_t = \begin{bmatrix} lpc_{t-1} \\ lpc_{t-2} \end{bmatrix}, \epsilon_t = \begin{bmatrix} \epsilon_{coy,t} \\ \epsilon_{lpc,t} \end{bmatrix} \quad (9)$$

Finally, Equation 9 is rearranged to construct the VAR model as Equation 10:

$$CRL_t = A + \gamma R_t + \emptyset L_t + \epsilon_t \quad (10)$$

4. Analysis and Discussion

The statistical attributes of the variables are depicted in Table 1, where the negative skewness is noted for the dataset. Table 2 reports that the unit root is not present in the time series. The linearity between variables for the same trading session is quantified in Table 3. Pre-pandemic era, the liquidity-providing cost is negatively associated with the yield. The significant relationship depicts, that a decline in the spread is linked to a higher yield on the crude oil. In this case, the specialist may seem to consider the crude oil less riskier investment, and impose a lower cost on the counterparty. Pre-pandemic uncertainty, the liquidity is not thereby priced in returns for the same trading session.

Table 1.
Descriptive statistics (daily basis).

Variables	Min	Median	Mean	Max	Standard Deviation	Skewness
IRS	-6.44	0.01	0.02	3.14	0.13	-33.4
r	-3.05	0.0009	-0.0004	0.37	0.05	-37.8

Note: Informed Realized Spread: IRS; Return: r.

In the wake of global pandemic-related restrictions, the regression results are changed. The liquidity-providing cost is reported to be positive and significantly linked to yields on the crude oil. The positive association between variables indicates that an incline in the spread significantly leads to an increase in yields. In this case, a liquidity supplier would accept the position of the crude oil by imposing a higher cost on the counterparty. This implies that the specialist considers the crude oil more riskier investment, and asks a higher compensation in environments of the economic uncertainty. Therefore, the liquidity is a priced risk factor in returns on the same trading session.

Table 2.
Augmented dickey-fuller (ADF) test for unit roots.

Variables	Test statistic	P-value	1% Critical value	5% Critical value	1% Critical value
IRS	-53.1	0.000	-2.58	-1.95	-1.62
R	-47.7	0.000	-2.58	-1.95	-1.62

Table 3.
Regression analysis results.

Variables		Estimate	p-value
	Pre-pandemic uncertainty		
cy_t (i)	Intercept IRS_t	0.001 -0.04	0.04 * 0.01 **
	Era of restrictions		
cy_t (ii)	Intercept IRS_t	-0.04 0.34	0.15 0.000 ***
	Easing restrictions		
cy_t (iii)	Intercept IRS_t	0.002 -0.01	0.17 0.86

Note: (i) Adjusted R-squared: 0.0016; F-statistic: 7.176; p-value: 0.007; (ii) Adjusted R-squared: 0.753; F-statistic: 175.6; p-value: 0.000; (iii) Adjusted R-squared: -0.001; F-statistic: 0.029; p-value: 0.864. Significance level: *** < 0.001; ** < 0.01; * < 0.05.

If the impact of easing restrictions is investigated, the liquidity-providing cost is not significantly associated with the yield. As the economic activity takes place, the liquidity is not priced in the crude oil returns for the same trading session.

The following experiment checks the linear interdependence between the multivariate time series through the VAR methodology. Pre-pandemic period, Table 4 estimates the return and liquidity-providing cost for the next trading session by applying the past times series. The yield is reported to be positive and significantly explained by the past time series of the liquidity-providing cost. The linear interdependence indicates, that a past wider spread is associated with the higher yield on the following trading session. In this context, the holding of the crude oil seems a riskier investment for the specialist. Thereby, a higher cost against holding the position of the crude oil compensates the specialist in terms of higher returns. Meanwhile, the return is noted to be negative and significantly explained by its corresponding past time series.

A negative relationship is reported between spread and lag_{t-2} of the yield. This implies, that a lower return on previous trading session leads to an incline in the spread of day t. Therefore, the liquidity provider imposes a higher cost on the next trading day against a lower yield of the previous trading session. Meanwhile, the liquidity-providing cost is noted to be negative and significantly associated with its own past time series.

The VAR results are further supported through the study of residual distribution, heteroscedasticity, impulse response, and forecast error variance decomposition. The distribution of residuals is checked using the Jarque-Bera (JB) technique. The JB test depicts, that residuals in the VAR model are not normally distributed. Whether the time series in the VAR model suffers from the heteroscedasticity effects, the autoregressive conditional heteroscedastic (ARCH) approach is applied. The ARCH test reports that the time series is heteroscedastic.

Table 4.
Estimation of VAR coefficients and significance test values, pre-pandemic era.

Variables		Estimate	p-value
coy_t (i)	$\gamma_{11,coy}$	-0.71	0.000 ***
	$\emptyset_{11,IRS}$	0.04	0.02 *
	$\gamma_{12,coy}$	-0.38	0.000 ***
	$\emptyset_{12,IRS}$	0.04	0.01 *
	α_{coy}	-0.00003	0.93
IRS_t (ii)	$\gamma_{21,coy}$	0.001	0.90
	$\emptyset_{21,IRS}$	-0.60	0.000 ***
	$\gamma_{22,coy}$	-0.04	0.000 ***
	$\emptyset_{22,IRS}$	-0.35	0.000 ***
	α_{IRS}	0.00005	0.88

Note: i) ARCH test: 0.000; JB test: 0.000; (ii) ARCH test: 0.000; JB test: 0.000. Significance level: *** < 0.001; * < 0.05.

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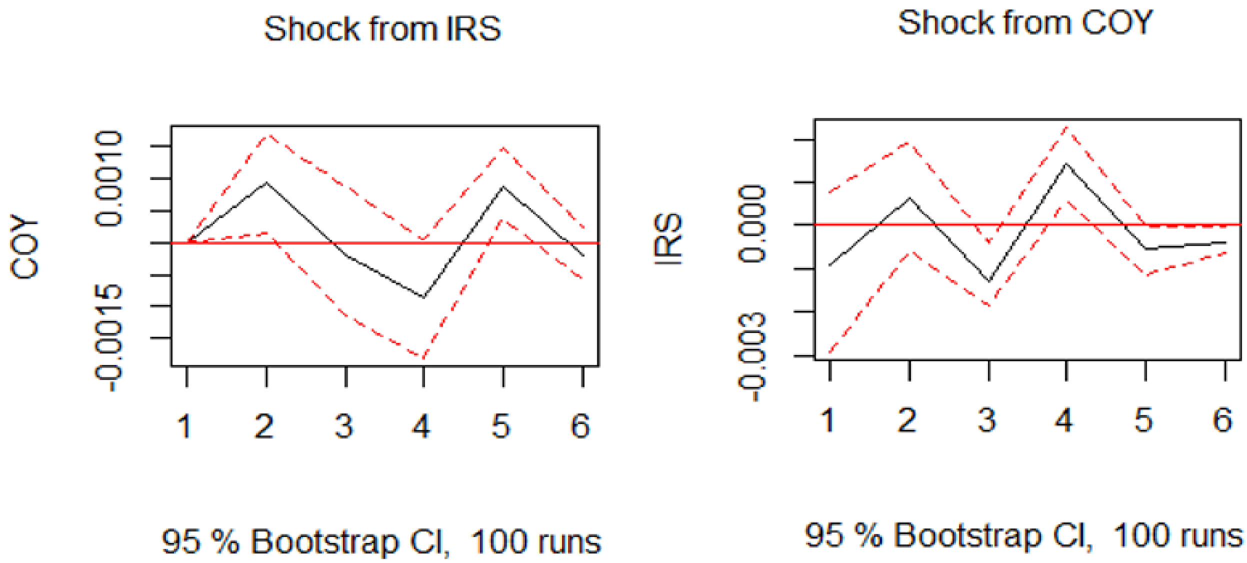

Figure 2.
Pre-pandemic era, the impulse response analysis.

The impulse response findings are plotted in Figure 2, where the standard deviation shock of the variable explains the changes to another variable. It is noticed, that the standard deviation shock in the liquidity-providing cost affects the return at each responsive session. Therefore, the yield on the crude oil varies around the line zero. Meanwhile, the standard deviation shock in the return impacts the liquidity-providing cost at each responsive period. In this context, the liquidity-providing cost is reported to be fluctuated around the line zero. The forecast error variance decomposition test is depicted in Figure 3, where the exogenous shocks are linked to the corresponding variable and the value of another variable. The variables are reported to be influenced by their own variance shocks.

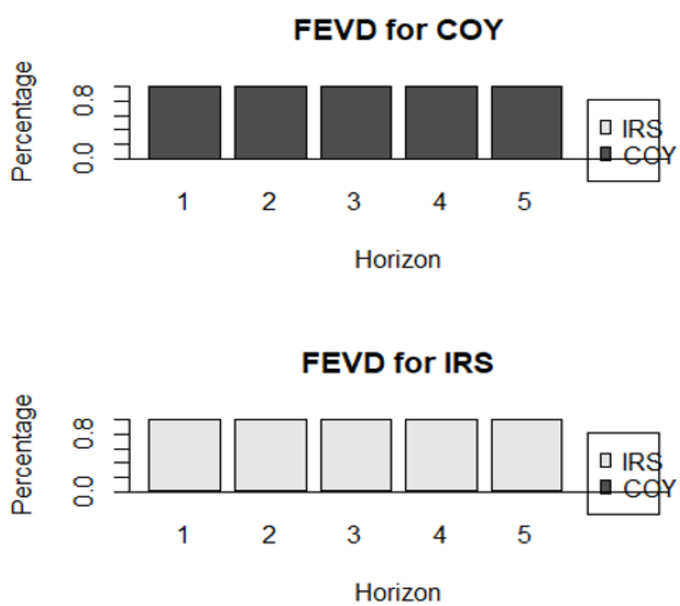

Figure 3.
Pre-pandemic era, FEVD analysis.

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Table 5.
Estimation of VAR coefficients and significance test values, during the pandemic-related restrictions.

Variables		Estimate	p-value
coy_t (i)	$\gamma_{11,coy}$	0.91	0.000 ***
	$\emptyset_{11,IRS}$	-0.58	0.000 ***
	$\gamma_{12,coy}$	0.76	0.002 **
	$\emptyset_{12,IRS}$	-0.34	0.000 ***
	α_{coy}	-0.0008	0.98
IRS_t (ii)	$\gamma_{21,coy}$	3.68	0.000 ***
	$\emptyset_{21,IRS}$	-1.79	0.000 ***
	$\gamma_{22,coy}$	2.45	0.001 **
	$\emptyset_{22,IRS}$	-0.95	0.000 ***
	α_{IRS}	-0.006	0.95

Note: i) ARCH test: 0.248; JB test: 0.000; (ii) ARCH test: 0.241; JB test: 0.000. Significance level: *** < 0.001; ** < 0.01.

If the era of economic restrictions is examined, the VAR findings are changed. Table 5 depicts the VAR coefficients for the past times series of liquidity-providing cost and return. A significantly negative association is found between yield and lagged coefficients of the spread. This implies, that a lower spread of previous trading session is linked to the higher yield on the next trading period. In this case, the specialist imposes a lower liquidity-providing cost on the counterparty against holding the position for the next trading session. Therefore, the past time series of the liquidity is not priced in returns. Meanwhile, the return is noted to be significantly associated with its own past time series.

The spread is reported to be positive and significantly explained by the lagged coefficients of the return. Meanwhile, the liquidity-providing cost is significantly correlated with its own past time series. In the VAR model, the time series is heteroscedastic and the residuals are not normally distributed. The impact of the standard deviation shocks is depicted in Figure 4. The standard deviation shock in the liquidity-providing cost influences the return at each responsive session. The standard deviation shock in the return affects the liquidity-providing cost and therefore, it varies around the line zero. Figure 5 depicts the variance shocks using the forecast error variance decomposition test. The yield is noted to be impacted by its corresponding variance, as well as the exogenous shocks of the spread. The liquidity-providing cost is influenced by its own exogenous shocks and the variance shocks of the return.

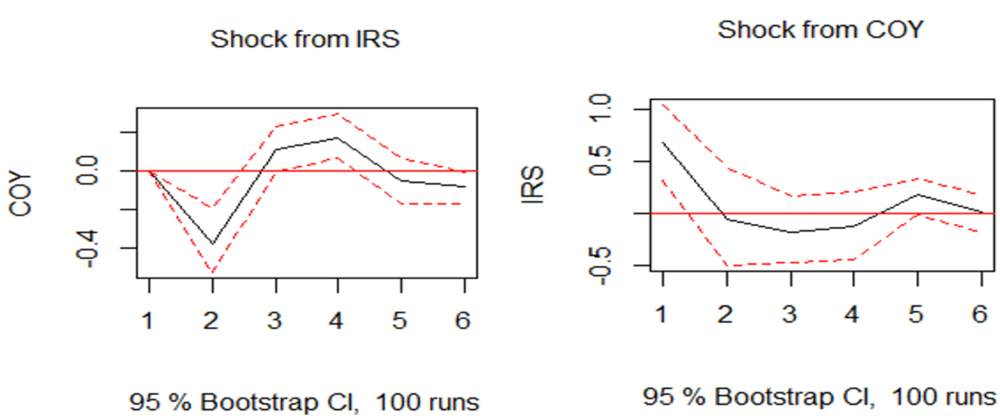

Figure 4.
The Impulse Response analysis during the pandemic-related restrictions.

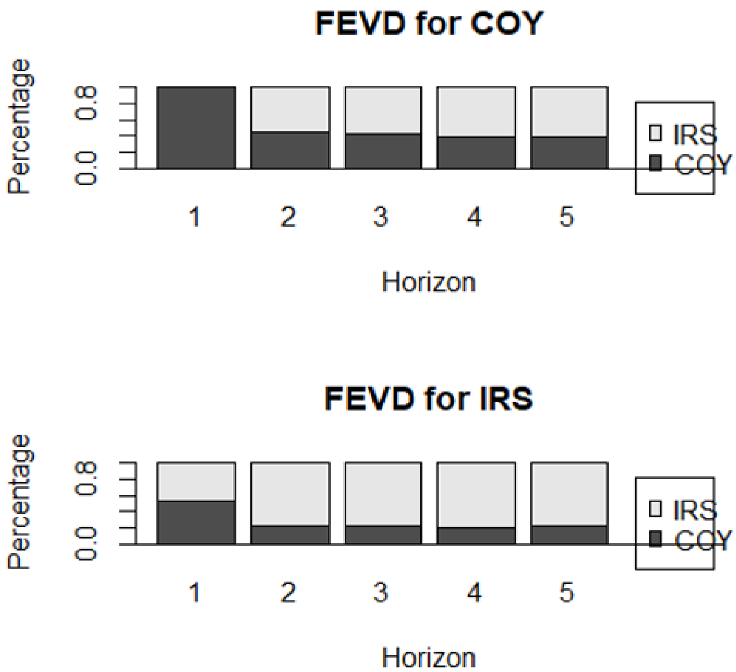

Figure 5.
FEVD analysis during the pandemic-related restrictions.

The following experiment checks the authoritative role of easing restrictions on the relationship dynamics between variables. In this context, Table 6 reports the VAR coefficients for the past times series of liquidity-providing cost and return. The yield is negative and significantly explained by the past time series of the spread. The linear interdependence illustrates, that the past lower spread is linked to a higher yield of the following trading session. In this case, the specialist imposes a lower liquidity-providing cost on the counterparty against holding the position for the next trading day. Thereby, the past time series of the liquidity is not priced in returns. The return is significantly explained by its corresponding past time series.

Table 5.
After easing pandemic-related restrictions, estimation of VAR coefficients and significance test values.

Variables		Estimate	P-Value
coy_t (i)	$\gamma_{11,coy}$	-0.64	0.000 ***
	$\emptyset_{11,IRS}$	-0.25	0.000 ***
	$\gamma_{12,coy}$	-0.34	0.000 ***
	$\emptyset_{12,IRS}$	-0.11	0.02 **
	α_{coy}	-0.0001	0.89
IRS_t (ii)	$\gamma_{21,coy}$	0.005	0.86
	$\emptyset_{21,IRS}$	-0.66	0.000 ***
	$\gamma_{22,coy}$	0.01	0.82
	$\emptyset_{22,IRS}$	-0.28	0.000 ***
	α_{IRS}	0.000008	0.99

Note: i) ARCH test: 0.000; JB test: 0.000; (ii) ARCH test: 0.000; JB test: 0.000. Significance level: *** < 0.001; ** < 0.01.

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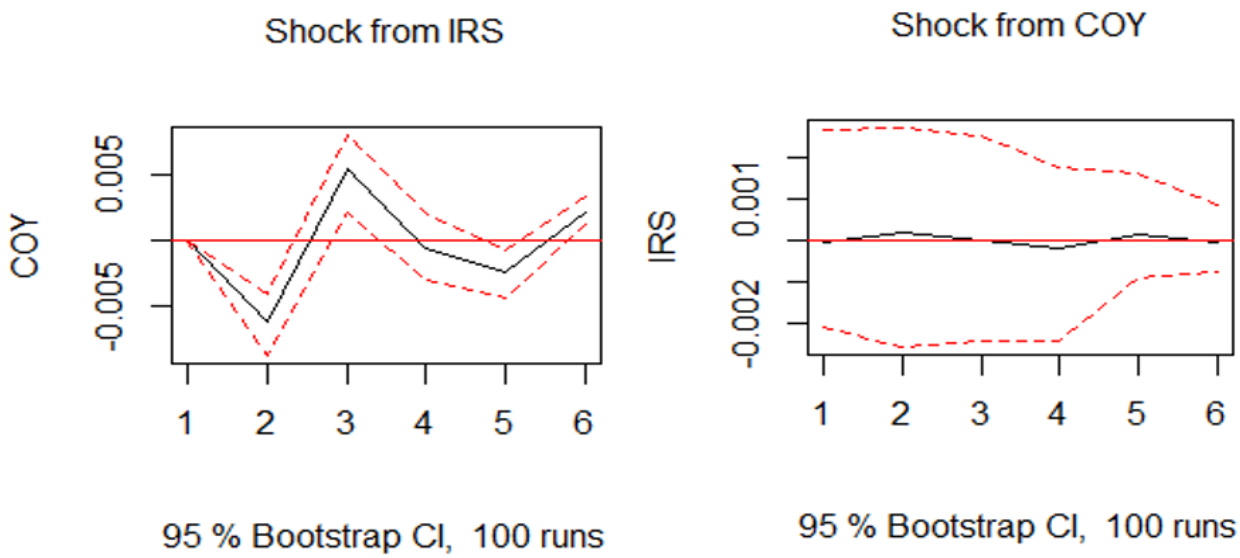

Figure 6.
After easing pandemic-related restrictions, the impulse response analysis.

The liquidity-providing cost is not significantly correlated with the past time series of the return. A significantly negative correlation is reported between the liquidity-providing cost and its own past time series. In the VAR model, the residuals are not normally distributed. The time series is reported to be heteroscedastic. The impulse response function is examined in Figure 6, where the standard deviation shock in one variable impacts the value of another variable at each responsive period. In Figure 7, the variables are noted to be highly influenced by their own exogenous shocks.

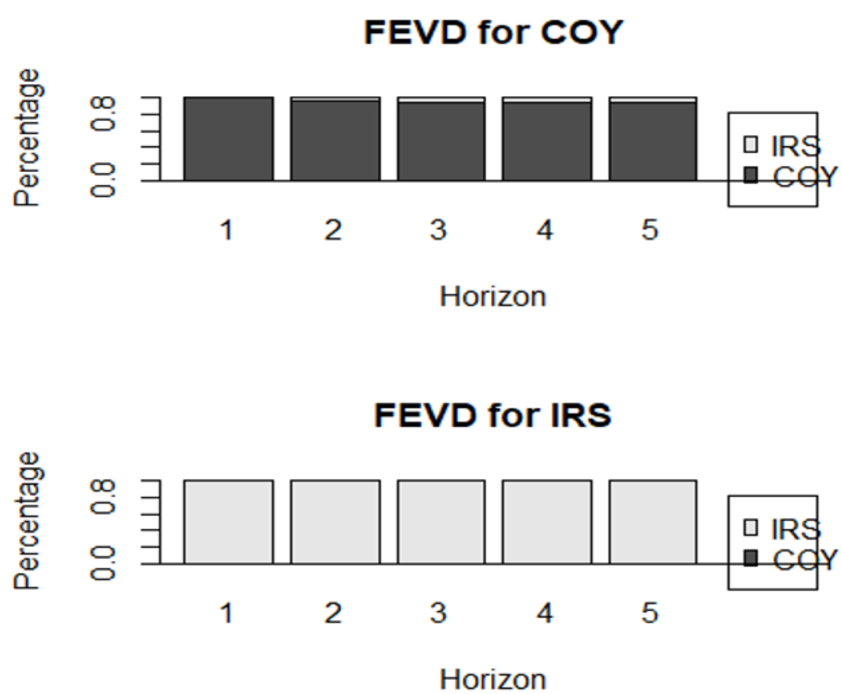

Figure 7.
After easing pandemic-related restrictions, FEVD analysis.

5. Conclusion

In the commodity market, this work studies the relationship dynamics between liquidity-providing cost and yield. Using the multivariate statistical techniques, the focus lies on the crude oil market. Pre-pandemic crisis, the spread was negative and significantly associated with the return of the same trading session. In this case, the liquidity was not priced in returns. In the period of coronavirus-related restrictions, the results were changed. On the same trading day, the liquidity-providing cost was positive and significantly correlated with the yield. This implies that the crude oil was a riskier investment for the specialist, and a wider spread acted as acompensation in environments of uncertainty. Therefore, the liquidity was priced in returns of the same trading session. In the era of easing COVID-19 restrictions, the spread was not significantly associated with the return of the same trading day. In this debate, the liquidity was not priced.

Pre-pandemic era, the return was positive and significantly explained by the past time series of the liquidity-providing cost. This implies that a past wider spread leads to an incline in the yield of the next trading session. Therefore, the past time series of the liquidity was priced in returns. In the period of COVID-19 lockdown, the yield was negative and significantly associated with the past time series of the spread. Evidence from the coronavirus-related restrictions reports, that the past time series of the liquidity was not priced in returns. Post-easing economic restrictions, a significantly negative association was found between return and lags of the spread. In this case, the past time series of the liquidity was not priced in returns.

In the crude oil market, this study has important implications in terms of quantifying the authoritative role of the liquidity-providing cost on yields that earlier studies have ignored. As this research covers the crude oil market, the outcomes may not be generalizable to other commodities. The study encourages other researchers to disclose the influential role of the liquidity-providing cost on yields of different commodities.

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