The crude oil market and the role of speculative trading

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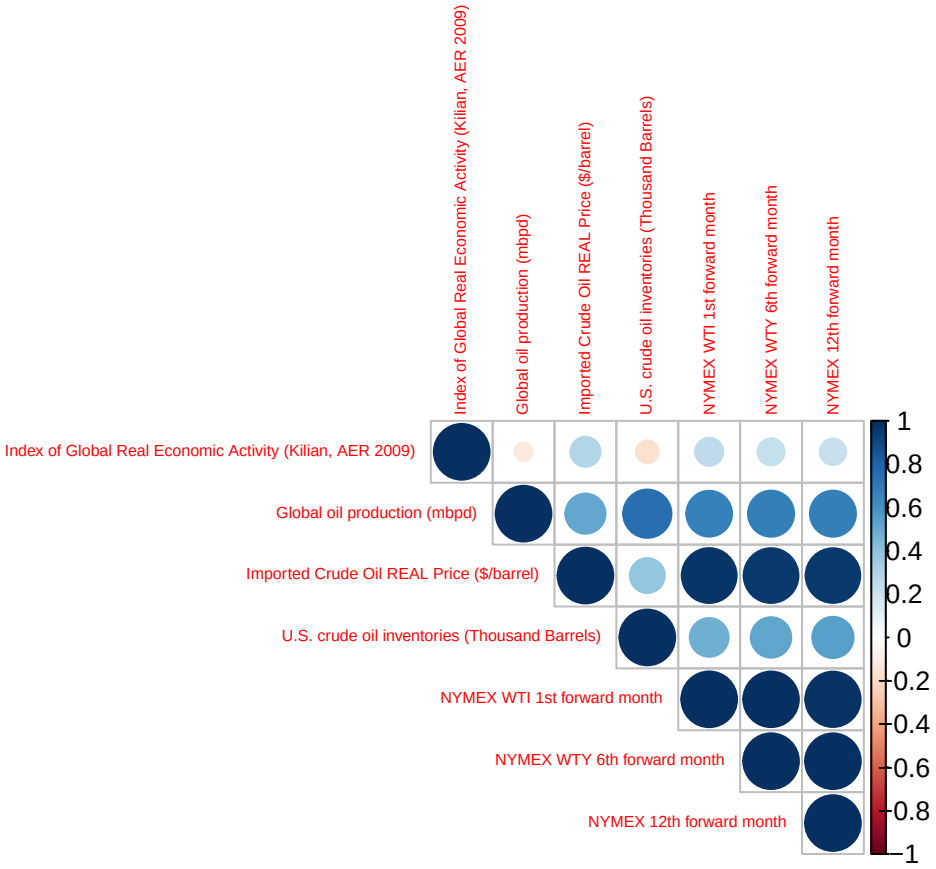
1 Introduction

The goal of this project is to analyze the crude oil market based on different factors. We know that supply and demand can impact the oil price as it was already demonstrated in the literature. (Kilian, 2009a, Lippi and Nobili, 2012). However, speculative trading also has an important impact on the crude oil market. (Juvenal and Petrella, 2015, Knittel and Pindyck, 2016, Li et al., 2022, Zhao et al., 2022). We will present to you the methods we've implemented and discuss the results obtained. To do so, we've been working with the following dataset from 01/1990 to 01/2023 and which contained several columns such as the level of crude oil inventories for US or The real price of crude oil.

2 Question 1



First of all we've computed the correlation matrix to have a first glimpse. We are focused on the "Imported Crude Oil REAL Price ($/barrel)" and we can see that it is highly correlated with the NYMEX WTI 1st forward month , NYMEX WTY 6th forward month , NYMEX 12th forward month but not that much with the Index of Global Real Economic Activity (Kilian, AER 2009).

```
##
## Call:
## lm(formula = logoil_price_return ~ economic_activityreturn +
##     global_oil_productionreturn + us_crude_inventoryreturn +
##     logfirst_forward_return + logsix_forward_return + logtwelve_forward_return,
##     data = data)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.105594 -0.016061 -0.000428  0.015421  0.171589
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 -2.333e-03  1.488e-03  -1.568  0.11780
## economic_activityreturn      2.316e-04  8.092e-05   2.862  0.00444 **
## global_oil_productionreturn  4.136e-03  1.709e-03   2.420  0.01598 *
## us_crude_inventoryreturn     9.155e-08  1.249e-07   0.733  0.46418
## logfirst_forward_return      7.627e-01  4.139e-02  18.430  < 2e-16 ***
## logsix_forward_return        3.785e-01  1.475e-01   2.565  0.01068 *
## logtwelve_forward_return    -1.561e-01  1.443e-01  -1.082  0.28002
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0294 on 389 degrees of freedom
## Multiple R-squared:  0.9056, Adjusted R-squared:  0.9042
## F-statistic: 622.2 on 6 and 389 DF,  p-value: < 2.2e-16
```

Then we've implemented a linear model with logoil_price_return as the dependent variable, and economic_activityreturn, global_oil_productionreturn, us_crude_inventoryreturn, logfirst_forward_return, logsix_forward_return, and logtwelve_forward_return as the independent variables. We've calculated all the returns and log returns and the Index of Global Real Economic Activity column is the only one for which we kept the return and not the log return. The multiple linear regression model analyzes the impact of independent variables on the dependent variable. The model gives us estimates of the regression coefficients for each of the independent variables, which is the impact of each independent variable on the dependent variable. Results of the model demonstrated that economic variables like global oil production (global_oil_productionreturn) have a positive impact on the price of oil, and that the change in U.S. crude inventories (us_crude_inventoryreturn) doesn't have a significant impact on the price of oil. Also, changes in future oil prices at different horizons (logfirst_forward_return, logsix_forward_return) have a significant and positive impact on the current oil price. The goodness of fit of the model is linked to the residual statistics, which is the differences between the observed values and the predicted values of the model. Results indicate that the model fits the data fairly well, with a standard error residual of 0.0294, which means that the model predictions are on average within 3 cents of the actual oil price. Finally, the multiple R-squared of 0.9036 indicates that independent variables explain at 90.36% the variation in the price of oil which is a good indication that our model can accurately predict future variations in oil prices. The estimated coefficient shows the contribution of each explanatory variable to the dependent variable. For example, the estimated coefficient for "logfirst_forward_return" is 0.7517, and it means that a one-unit increase in "logfirst_forward_return" is associated with a 0.7517-unit increase in the dependent variable. The variable "economic_activityreturn" has a t-value of 2.89 and a p-value of 0.004, which means that this variable has a significant effect on the dependent

variable. The variable "logfirst_forward_return" has a t-value of 18.38 and a very low p-value of 9.53e-55, which means that this variable has a very significant effect on the dependent variable. The variable "logsix_forward_return" has a t-value of 2.69 and a p-value of 0.007, which means that this variable has a significant effect on the dependent variable. The other variables do not have a high t-value and/or have a high p-value, and it means that they are not significant in explaining the dependent variable.

```
##
##  studentized Breusch-Pagan test
##
## data:  model
## BP = 17.092, df = 6, p-value = 0.008949
```

```
##
##  Durbin-Watson test
##
## data:  model
## DW = 2.1871, p-value = 0.9663
## alternative hypothesis: true autocorrelation is greater than 0
```

```
##
##  Jarque-Bera Normality Test
##
## data:  model$residuals
## JB = 411.43, p-value < 2.2e-16
## alternative hypothesis: greater
```

We've computed several tests and here are the results obtained : Breusch-Pagan test: This heteroscedasticity test , evaluates whether the variance of our residuals is constant or not based on the explanatory variables. The BP statistic is equal to 18.493, meaning that the null hypothesis (no heteroskedasticity) is rejected at the 0.05 level of significance. Durbin-Watson test: This autocorrelation test checks whether the residuals are correlated with each other. The DW statistic is 2.1875, meaning that there is no autocorrelation of the residuals because it is close to 2. The p-value is greater than 0.05, which validates this conclusion. Jarque-Bera normality test: This test checks if the residuals follow or not a normal distribution. The JB statistic of 418.95 with a p-value less than 0.05, meaning that the null hypothesis (residuals follow a normal distribution) is rejected.

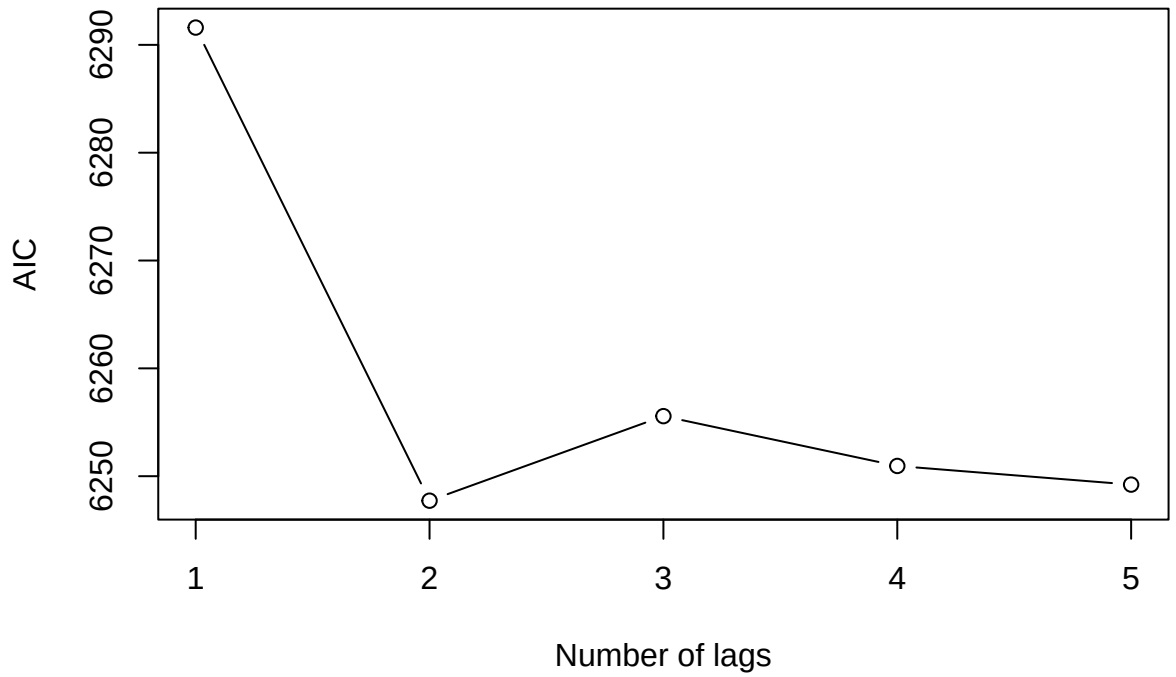
```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: oil_pricereturn, global_oil_productionreturn, us_crude_inventoryr
## Deterministic variables: const
## Sample size: 394
## Log Likelihood: -3045.865
## Roots of the characteristic polynomial:
## 0.5436 0.5436 0.4782 0.4782 0.3595 0.3586 0.3586 0.3317 0.3317 0.1908  0.18  0.18
## Call:
## VAR(y = vardata, p = 2)
##
##
## Estimation results for equation oil_pricereturn:
## ================================================
## oil_pricereturn = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_crude_invent
##
##                                  Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1               6.714e-01  1.031e-01   6.512 2.35e-10 ***
## global_oil_productionreturn.l1 -5.185e-01  3.343e-01  -1.551   0.1218
## us_crude_inventoryreturn.l1    -1.556e-05  2.461e-05  -0.632   0.5277
## logfirst_forward_return.l1     -1.719e+01  8.021e+00  -2.144   0.0327 *
## logsix_forward_return.l1        3.549e+01  2.673e+01   1.328   0.1850
## logtwelve_forward_return.l1    -3.509e+01  2.647e+01  -1.326   0.1857
## oil_pricereturn.l2               7.092e-02  1.035e-01   0.685   0.4937
## global_oil_productionreturn.l2 -6.453e-01  3.235e-01  -1.995   0.0468 *
## us_crude_inventoryreturn.l2     1.741e-05  2.399e-05   0.726   0.4684
## logfirst_forward_return.l2     -2.114e+01  8.446e+00  -2.503   0.0127 *
## logsix_forward_return.l2        1.027e+01  2.839e+01   0.362   0.7177
## logtwelve_forward_return.l2     2.647e+00  2.736e+01   0.097   0.9230
## const                           1.917e-01  2.664e-01   0.720   0.4723
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 5.193 on 381 degrees of freedom
## Multiple R-Squared: 0.2917,  Adjusted R-squared: 0.2694
## F-statistic: 13.08 on 12 and 381 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation global_oil_productionreturn:
## ============================================================
## global_oil_productionreturn = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_
##
##                                  Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1             -7.945e-03  1.584e-02  -0.502 0.616172
## global_oil_productionreturn.l1 -6.312e-02  5.135e-02  -1.229 0.219752
## us_crude_inventoryreturn.l1    -7.741e-06  3.780e-06  -2.048 0.041279 *
## logfirst_forward_return.l1      9.244e+00  1.232e+00   7.504 4.42e-13 ***
## logsix_forward_return.l1       -2.372e+01  4.105e+00  -5.778 1.57e-08 ***
```

```
## logtwelve_forward_return.l1     1.764e+01  4.065e+00   4.340 1.83e-05 ***
## oil_pricereturn.l2             -3.552e-02  1.590e-02  -2.234 0.026086 *
## global_oil_productionreturn.l2  9.233e-05  4.969e-02   0.002 0.998518
## us_crude_inventoryreturn.l2    -5.931e-06  3.684e-06  -1.610 0.108276
## logfirst_forward_return.l2      4.972e+00  1.297e+00   3.833 0.000148 ***
## logsix_forward_return.l2       -7.267e-01  4.360e+00  -0.167 0.867724
## logtwelve_forward_return.l2    -5.475e-01  4.203e+00  -0.130 0.896431
## const                           6.416e-02  4.091e-02   1.568 0.117661
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.7976 on 381 degrees of freedom
## Multiple R-Squared: 0.2922,  Adjusted R-squared:  0.27
## F-statistic: 13.11 on 12 and 381 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation us_crude_inventoryreturn:
## ========================================================
## us_crude_inventoryreturn = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_cru
##
##                                  Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1              5.584e+01  2.194e+02   0.255 0.799214
## global_oil_productionreturn.l1 -2.571e+03  7.114e+02  -3.614 0.000342 ***
## us_crude_inventoryreturn.l1     3.259e-01  5.236e-02   6.224 1.28e-09 ***
## logfirst_forward_return.l1     -2.683e+04  1.706e+04  -1.572 0.116722
## logsix_forward_return.l1        5.170e+04  5.686e+04   0.909 0.363829
## logtwelve_forward_return.l1    -3.653e+04  5.631e+04  -0.649 0.516877
## oil_pricereturn.l2             -4.893e+02  2.203e+02  -2.222 0.026902 *
## global_oil_productionreturn.l2 -5.939e+02  6.883e+02  -0.863 0.388803
## us_crude_inventoryreturn.l2    -4.522e-02  5.104e-02  -0.886 0.376104
## logfirst_forward_return.l2     -1.690e+04  1.797e+04  -0.940 0.347630
## logsix_forward_return.l2        2.773e+04  6.040e+04   0.459 0.646461
## logtwelve_forward_return.l2     2.528e+04  5.822e+04   0.434 0.664411
## const                           6.177e+01  5.668e+02   0.109 0.913272
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 11050 on 381 degrees of freedom
## Multiple R-Squared: 0.1961,  Adjusted R-squared: 0.1708
## F-statistic: 7.746 on 12 and 381 DF,  p-value: 6.367e-13
##
##
## Estimation results for equation logfirst_forward_return:
## ========================================================
## logfirst_forward_return = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_crud
##
##                                  Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1             5.778e-03  1.725e-03   3.350 0.000888 ***
```

```
## global_oil_productionreturn.l1 -1.187e-02  5.592e-03  -2.122 0.034449 *
## us_crude_inventoryreturn.l1    -6.808e-07  4.117e-07  -1.654 0.098994 .
## logfirst_forward_return.l1     -5.626e-01  1.342e-01  -4.194 3.42e-05 ***
## logsix_forward_return.l1        2.049e+00  4.470e-01   4.584 6.19e-06 ***
## logtwelve_forward_return.l1    -1.613e+00  4.427e-01  -3.645 0.000305 ***
## oil_pricereturn.l2              3.414e-03  1.732e-03   1.971 0.049406 *
## global_oil_productionreturn.l2 -1.096e-02  5.411e-03  -2.026 0.043452 *
## us_crude_inventoryreturn.l2     5.316e-07  4.012e-07   1.325 0.185980
## logfirst_forward_return.l2     -4.363e-01  1.413e-01  -3.089 0.002159 **
## logsix_forward_return.l2        2.652e-01  4.748e-01   0.559 0.576759
## logtwelve_forward_return.l2    -1.117e-01  4.577e-01  -0.244 0.807330
## const                           5.626e-03  4.456e-03   1.263 0.207499
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.08686 on 381 degrees of freedom
## Multiple R-Squared: 0.226,   Adjusted R-squared: 0.2016
## F-statistic: 9.268 on 12 and 381 DF,  p-value: 9.426e-16
##
##
## Estimation results for equation logsix_forward_return:
## ======================================================
## logsix_forward_return = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_crude_
##
##                                 Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1              4.339e-03  1.269e-03   3.419 0.000697 ***
## global_oil_productionreturn.l1 -5.418e-03  4.116e-03  -1.316 0.188820
## us_crude_inventoryreturn.l1    -1.123e-07  3.030e-07  -0.371 0.711192
## logfirst_forward_return.l1     -1.012e-01  9.873e-02  -1.025 0.305902
## logsix_forward_return.l1        4.997e-01  3.290e-01   1.519 0.129597
## logtwelve_forward_return.l1    -4.403e-01  3.258e-01  -1.352 0.177286
## oil_pricereturn.l2              1.336e-03  1.274e-03   1.049 0.294990
## global_oil_productionreturn.l2 -5.391e-03  3.982e-03  -1.354 0.176589
## us_crude_inventoryreturn.l2     1.236e-07  2.953e-07   0.419 0.675787
## logfirst_forward_return.l2     -1.521e-01  1.040e-01  -1.463 0.144285
## logsix_forward_return.l2       -7.546e-02  3.494e-01  -0.216 0.829137
## logtwelve_forward_return.l2     1.357e-01  3.368e-01   0.403 0.687358
## const                           4.176e-03  3.279e-03   1.274 0.203584
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.06392 on 381 degrees of freedom
## Multiple R-Squared: 0.1764,  Adjusted R-squared: 0.1505
## F-statistic: 6.802 on 12 and 381 DF,  p-value: 3.825e-11
##
##
## Estimation results for equation logtwelve_forward_return:
## =========================================================
```

```
## logtwelve_forward_return = oil_pricereturn.l1 + global_oil_productionreturn.l1 + us_cru
##
##                                 Estimate Std. Error t value Pr(>|t|)
## oil_pricereturn.l1              3.501e-03  1.060e-03   3.302  0.00105 **
## global_oil_productionreturn.l1 -4.051e-03  3.438e-03  -1.178  0.23939
## us_crude_inventoryreturn.l1    -1.215e-09  2.531e-07  -0.005  0.99617
## logfirst_forward_return.l1     -7.286e-02  8.247e-02  -0.884  0.37752
## logsix_forward_return.l1        3.114e-01  2.748e-01   1.133  0.25784
## logtwelve_forward_return.l1    -2.382e-01  2.721e-01  -0.875  0.38192
## oil_pricereturn.l2              1.243e-03  1.064e-03   1.168  0.24367
## global_oil_productionreturn.l2 -3.138e-03  3.326e-03  -0.943  0.34614
## us_crude_inventoryreturn.l2    -7.252e-09  2.466e-07  -0.029  0.97656
## logfirst_forward_return.l2     -1.169e-01  8.684e-02  -1.346  0.17923
## logsix_forward_return.l2       -2.557e-03  2.919e-01  -0.009  0.99301
## logtwelve_forward_return.l2     3.928e-02  2.814e-01   0.140  0.88904
## const                           3.725e-03  2.739e-03   1.360  0.17466
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.0534 on 381 degrees of freedom
## Multiple R-Squared: 0.1765,  Adjusted R-squared: 0.1506
## F-statistic: 6.807 on 12 and 381 DF,  p-value: 3.74e-11
##
##
##
## Covariance matrix of residuals:
##                             oil_pricereturn global_oil_productionreturn
## oil_pricereturn                     26.9676                   -0.396435
## global_oil_productionreturn         -0.3964                    0.636182
## us_crude_inventoryreturn         -3987.1983                  576.851277
## logfirst_forward_return              0.3650                   -0.013796
## logsix_forward_return                0.2866                   -0.005312
## logtwelve_forward_return             0.2379                   -0.004030
##                             us_crude_inventoryreturn logfirst_forward_return
## oil_pricereturn                         -3.987e+03               3.650e-01
## global_oil_productionreturn              5.769e+02              -1.380e-02
## us_crude_inventoryreturn                 1.221e+08              -1.458e+02
## logfirst_forward_return                 -1.458e+02               7.545e-03
## logsix_forward_return                   -3.974e+01               5.003e-03
## logtwelve_forward_return                -2.265e+01               3.946e-03
##                             logsix_forward_return logtwelve_forward_return
## oil_pricereturn                          0.286628                 0.237861
## global_oil_productionreturn             -0.005312                -0.004030
## us_crude_inventoryreturn               -39.743370               -22.652677
## logfirst_forward_return                  0.005003                 0.003946
## logsix_forward_return                    0.004086                 0.003343
## logtwelve_forward_return                 0.003343                 0.002851
##
## Correlation matrix of residuals:
```

```
##                              oil_pricereturn global_oil_productionreturn
## oil_pricereturn                      1.00000                    -0.09571
## global_oil_productionreturn         -0.09571                     1.00000
## us_crude_inventoryreturn            -0.06949                     0.06546
## logfirst_forward_return              0.80926                    -0.19912
## logsix_forward_return                0.86346                    -0.10419
## logtwelve_forward_return             0.85782                    -0.09462
##                              us_crude_inventoryreturn logfirst_forward_return
## oil_pricereturn                           -0.06949                  0.8093
## global_oil_productionreturn                0.06546                 -0.1991
## us_crude_inventoryreturn                   1.00000                 -0.1520
## logfirst_forward_return                   -0.15196                  1.0000
## logsix_forward_return                     -0.05627                  0.9011
## logtwelve_forward_return                  -0.03840                  0.8508
##                              logsix_forward_return logtwelve_forward_return
## oil_pricereturn                            0.86346                  0.85782
## global_oil_productionreturn               -0.10419                 -0.09462
## us_crude_inventoryreturn                  -0.05627                 -0.03840
## logfirst_forward_return                    0.90111                  0.85084
## logsix_forward_return                      1.00000                  0.97953
## logtwelve_forward_return                   0.97953                  1.00000
```




```
## The optimal number of lags is 2
```

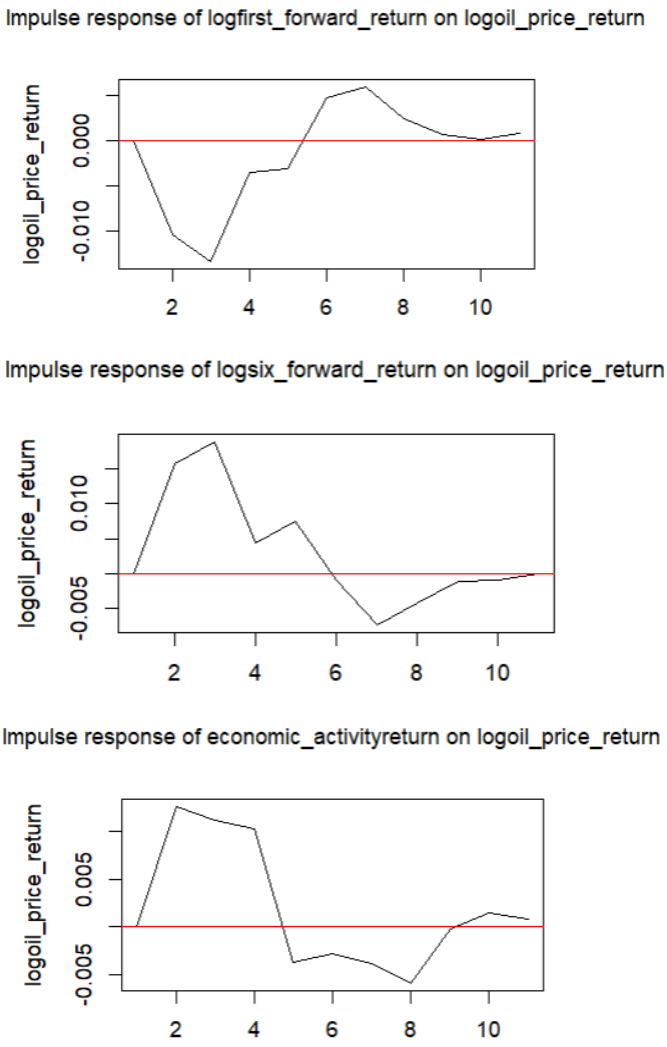
We applied a VAR (Vector Autoregression) model with the same variables that on our LM model. Results show the estimated coefficients for eachexplanatory variable and for the two lags. Results also show the p-value for each coefficient. Positive or negative coefficients show the direction and strength of our relationship between explanatory variables and the dependent variable . We can see that the variation in economic activity (economic_activityreturn) has a significant impact on the variation in oil prices for the first lag period.Then, the variation of world oil production (logglobal_oil_production_return) has a significant impact on the variation of oil prices for the first lag period. On the other hand, the change in U.S. crude inventory (logus_crude_inventory_return) has no significant impact on the change in oil prices.

We obtained a reasonable adjusted R^2 of about 0.276 meaning that the explanatory variables can explain about 28% of the variation in the change in oil prices. Our F-test is also significant, meaning that our model is useful in explaining the variation in oil prices.

In our case, the covariance matrix shows that the variance of the residuals for logoil_price_return is 0.006558. The off-diagonal values proved that there is a positive covariance between the residuals of economic_activityreturn and logoil_price_return, and that there is a negative covariance between the residuals of logglobal_oil_production_return and logoil_price_return. Covariance between the residuals of the other variables and logoil_price_return is close to zero. For the correlation matrix of residuals, for example, the correlation coefficient between the residuals of logoil_price_return and economic_activityreturn is 0.09876, which means that there is a weak positive correlation between these two variable residuals. Also, the correlation coefficient between the residuals of logoil_price_return and logglobal_oil_production_return is equal to -0.20495, which means that there is a weak negative correlation between these two variables' residuals.

We've seen that the determinants of crude oil price fluctuations were the variables Index of Global Real Economic Activity (Kilian, AER 2009), NYMEX WTI 1st forward month, NYMEX WTY 6th forward month as they were significant in our model.

3 Question 2



To analyze how shocks of these determinants affect the crude oil price, we've computed the impulse response of the 3 variables and here are our results obtained.

For the impulse response of logglobal_oil_production_return on logoilprice_return, the for first 3 periods, a shock on the global oil production will lead to a decrease of -0.008 but then for the next 3 period the shock will lead to an increase of the oil price going from -0.008 to 0.002. Then for the last periods, there is a slow decreasing trend.

For the impulse response of logfirst_forward_return on logoilprice_return, the observations are similar to the previous impulse response. A shock on the on logoilprice_return NYMEX WTI 1st forward month will first lead to a negative variation on the price going to 0.012, then the variation will go up until 0.002 and finally we observe a slow decreasing trend.

For the impulse response of logsix_forward_return on logoilprice_return, for the first 3 period a shock on the NYMEX WTY 6th forward month will lead to a increasing trend to 0.013 on our oil price and then until the 7 period, we will observe a decreasing trend on our price. Finally for the final period the stock will lead to a slow increasing trend. By computing the impulse responses, we've been able to analyze how a shock on these 3 determinants will impact positively or negatively the oil price.

4 Question 3

To evaluate the extent to which the role of these determinants changes over time, we've implemented our VAR model with a rolling window spaced of 60 months to check if the 3 determinants are still significant or not over time. We obtained 397 iterations so we've decided to pick some random element of our lists on which we stored our results which will be a sample of our rolling window results. Let's summarize the results of the following table :

Rolling window	1	50	100	200	300
Index of Global Real Economic Activity (Kilian, AER 2009)	significant for the first lag	significant for the first lag	significant for the first lag	significant for the first lag	significant for the first lag
NYMEX WTI 1st forward month,	significant for both lags	significant for both lags	significant for both lags	significant for both lags	Non significant for both lags
NYMEX WTY 6th forward	significant for the first lag	significant for the first lag	significant for the first lag	significant for the first lag	Non significant for both lags
Adjusted R-squared	0.2313	0.2761	0.2761	0.2761	0.2761

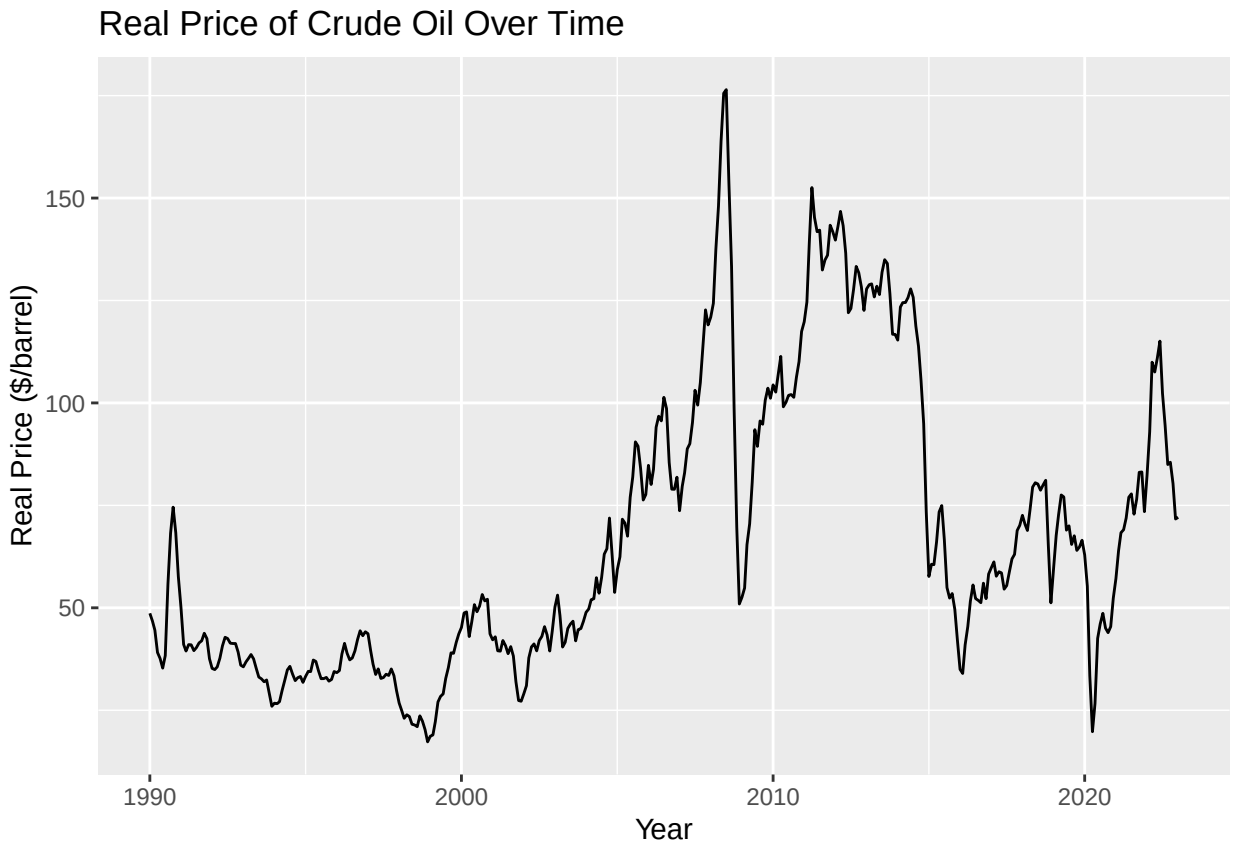
Significances of our determinants depending on different lags and rolling window period

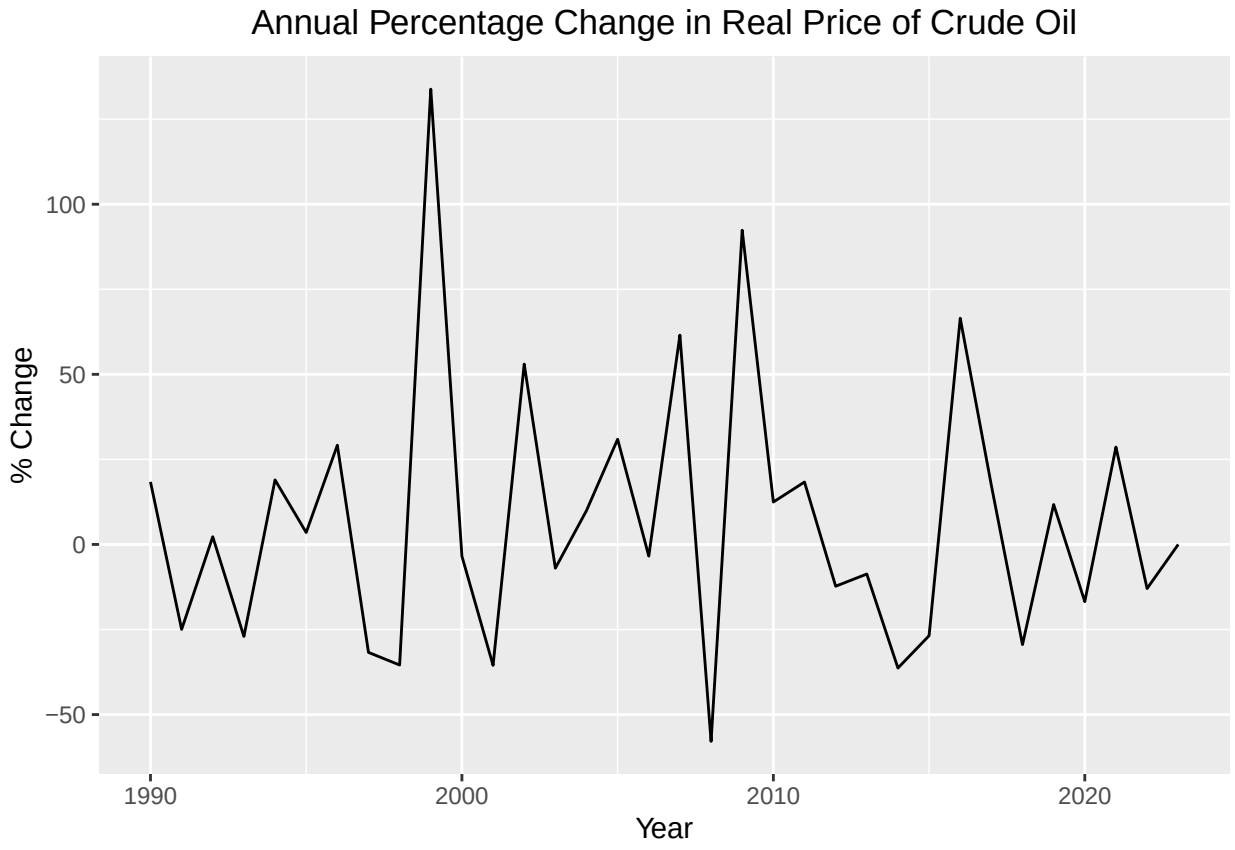
Rolling window	1	50	100	200	300
Index of Global Real Economic Activity (Kilian, AER 2009)	positive for the first lag	positive for the first lag	positive for the first lag	positive for the first lag	Positive for the first lags
NYMEX WTI 1st forward month,	negatives for both lags	negatives for both lags	negatives for both lags	negatives for both lags	Non significant for both lags
NYMEX WTY 6th forward	positive for the first lag	positive for the first lag	positive for the first lag	positive for the first lag	Non significant for both lags
Adjusted R-squared	0.2313	0.2761	0.2761	0.2761	0.2761

Values of the coefficients of our determinants depending on different lags and rolling window period

We can see that the results remain the same for the first 4 rolling windows that we picked randomly. The Index of Global Real Economic Activity (Kilian, AER 2009) is significant for the first lag and its coefficient is positive. The NYMEX WTI 1st forward month is significant for both lags with negative coefficient for both lags. The NYMEX WTY 6th forward is significant for the first lag with a positive coefficient for the first lag. However, for the last rolling window picked, we can see that The NYMEX WTI 1st forward month and The NYMEX WTI 6st forward month became Non significant for both lags. It means that over time these determinants can become non significant or not depending on the lags. However, it's possible that with a more important sample, we could have more easily identify the variation of the coefficient and the significance of the variables.

5 Question 4


Real Price of Crude Oil Over Time
Real Price ($/barrel)
150
100
50
1990
2000
2010
2020
Year


Annual Percentage Change in Real Price of Crude Oil
% Change
100
50
0
−50
1990
2000
2010
2020
Year

We've plotted the real price of crude oil. We can see 3 important shock periods which are the years 2000, 2008 and 2020. For the shock of 2000, it was caused by the Gulf War of 1990/01 which was driven by a shift in speculative demand. Byt Hamilton(2009a) considered that after the invasion of Kuwait the oil inventories didn't change that much so this result is puzzling for him. He considered that the variation is linked to a flow supply shock. For the next period of 2008, it was caused by the crash of Wall Street which had a significant impact on the oil price shocks. It led to a huge economic downturn, and many investors were forced to sell off their assets, such as oil to cover their losses or margin calls. Because of that, the demand for oil decreased, leading to a sharp decline in oil prices. Also it led to a decrease in economic activity globally, which decreased the demand for oil. To finish with , this Global Financial Crisis impacted the commodity markets, including the oil market. regulatory changes a lot so it increased margin requirements and the limits on speculative trading.

For the last shock of 2020, we know that The COVID-19 pandemic had a huge impact on the global oil market and prices. It led to worldwide lockdowns, leading to a significant drop in demand for oil. It causes a surplus of supply, which decreases oil prices. Also, the breakdown of the Organization of the Petroleum Exporting Countries agreement in March 2020, which limited oil production, caused a war between Saudi Arabia and Russia and as a result, the price of oil fell to historic lows in April 2020. On the graph with the annual percentage change, the shocks of these 3 different periods are more visible.

6 Conclusion

To conclude, we've implemented a method based on the different references. With the LM and VAR model we've been able to first analyze which variables were the most determinant for our oil price prediction. Then by checking the impulse response, we've analyzed how our oil price will be impacted by a shock of the determinants. On a third time,we've used a rolling window like mentioned on the (Extreme risk spillover between crude oil price and financial factors, Zhao, Zhao, W.-L., Fan, Y., and Ji, Q. (2022)) to see how these determinants changed over the time. Finally, we've seen that historical and geopolitical events such as Covid-19 can hugely impact the oil price.