

# APPENDIX

## A1 Machine Learning Algorithms

### A1.1 Lasso

*Lasso* (*least absolute shrinkage and selection operator*) is a type of regularization that performs variable selection. This method aims to enhance predictive power of linear models and to highlight the most valuable predictors. As OLS models tend to exhibit low bias and high variance of forecasts, they may be overfitted. Lasso regularization helps to decrease the risk of overfitting.

In comparison with the Ordinary Least Squares method, there is an added penalty in Lasso:

$$\|Xw - y\|_2^2 - \lambda\|w\|_1 \rightarrow \min \tag{A1.1}$$

where  $\lambda$  is a hyperparameter of Lasso regularization that can be interpreted as the penalty rate.

### A1.2 Gradient Boosting

*Gradient Boosting* was firstly described by [Friedman \(2001\)](#), and its main idea is to create an ensemble of simple models by sequentially fitting and adding parameterized functions. The main goal of this algorithm is to find a function  $F^*(x)$  that maps  $x$  to  $y$  and specific (differentiable) loss function  $\Psi(y, F(x))$  is minimized:

$$F^*(x) =_{F(x)} \Psi(y, F(x)) \tag{A1.2}$$

$F(X)$  is represented as a linear combination of simple models (base learners):

$$F(x) = \sum_{m=0}^M \beta_m h(x; a_m) \implies F_m(x) = F_{m-1}(x) + \beta_m h(x; a_m) \quad (\text{A1.3})$$

where  $h(a; x)$  (base learner) is a simple function of  $x$  with parameters  $a = \{a_1, a_2, \dots\}$ ,  $\beta_m$  is the coefficient behind each base learner  $h_m$  to make a linear combination.

Suppose, we have a training sample  $\{y, x\}$  of size  $N$ . So, function  $F^*(x)$  could be fitted by repeating two steps  $m$  times. Firstly, function  $h(x; a)$  is fitted via least squares

$$a_m = \underset{a}{\text{argmin}} \sum_{i=1}^N [y_{im}^* - h(a; x_i)]^2 \quad (\text{A1.4})$$

to the current 'pseudo'-residuals

$$y_{im}^* = - \left[ \frac{\partial \Psi(y_{im}, F(x_{im}))}{\partial F(x_{im})} \right]_{F(x)=F_{m-1}(x)} \quad (\text{A1.5})$$

Then the optimal value of  $\beta_m$  is determined

$$\beta_m = \underset{\beta}{\text{argmin}} \sum_{i=0}^N (\Psi(y_i, F_{m-1}(x_i) + \beta h(a_m; x_i))) \quad (\text{A1.6})$$

This method replaces a potentially difficult function optimization problem with one based on least squares followed by a single parameter optimization based on general loss criterion  $\Psi$ .

The most commonly used base learners are binary decision trees (we use them in our study). Further, we use  $L1$  regularization on this algorithm to deal with overfitting. This type of regularization works on Gradient Boosting by constraining the leaf weights, rather than the feature weights.

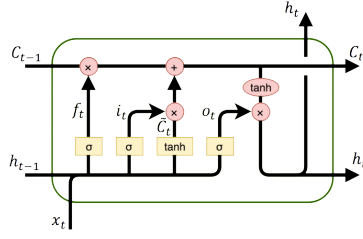


Figure 3: LSTM scheme

### A1.3 Random Forest

*Random forest* was firstly described by [Breiman \(2001\)](#). The algorithm consists of tree-structured algorithms  $\{h(\mathbf{x}, \Theta_k), k = 1, \dots\}$  where  $\{\Theta_k\}$  are i.i.d. random vectors. Each tree casts a unit vote at input  $\mathbf{x}$ . For the regression problem, RF extracts the mean vote of all the trees. The mechanism of tree-structured algorithms is the same as for GB, described above.

### A1.4 LSTM

*Long Short-Term Memory (LSTM)* was first described by [Hochreiter and Schmidhuber \(1997\)](#). LSTM is a kind of recurring neural network tahn can be represented as a sequence of blocks. The principal work of a block is described in Figure 3. This block can also be rewritten as:

$$\begin{aligned}
 f_t &= \sigma(x_t U^f + h_{t-1} W^f + b^f), \\
 i_t &= \sigma(x_t U^i + h_{t-1} W^i + b^i), \\
 o_t &= \sigma(x_t U^o + h_{t-1} W^o + b^o), \\
 \tilde{C}_t &= \tanh(x_t U^g + h_{t-1} W^g + b^g), \\
 C_t &= f_t * C_{t-1} + i_t * \tilde{C}_t, \\
 h_t &= \tanh(C_t) * o_t.
 \end{aligned}$$

where  $W$ ,  $U$  and  $b$  are the parameters of the block,  $x_t$  is an input vector,  $h_t$  is an output vector and  $C_t$  is a vector of conditions. The two functions  $\sigma$  and  $\tanh$  are  $\sigma(x) = \frac{1}{1+e^{-x}}$ , and  $\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$ . LSTM is typically trained with the use of *stochastic gradient descent* or one of its modifications. In our study, we use firstly *ADAM* optimizer, but we switch to alternatives in case it fails.

## A2 Exploratory Data Analysis

### A2.1 Dynamics of log-RV

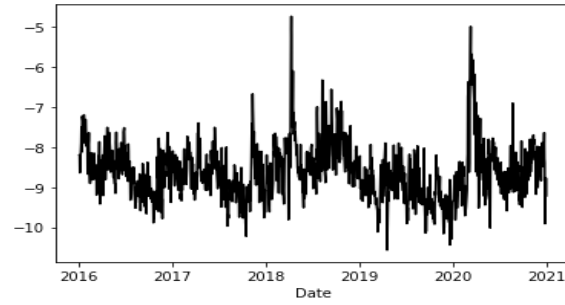


Figure 4: Dynamics of log-RV, SBERBANK

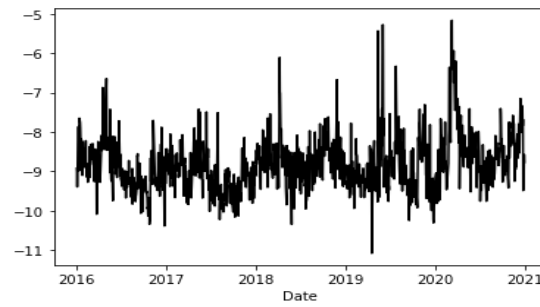


Figure 5: Dynamics of log-RV, GAZPROM

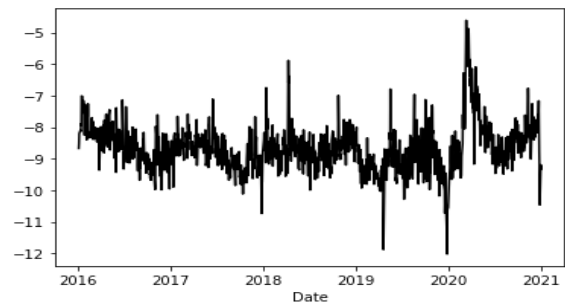


Figure 6: Dynamics of log-RV, LUKOIL

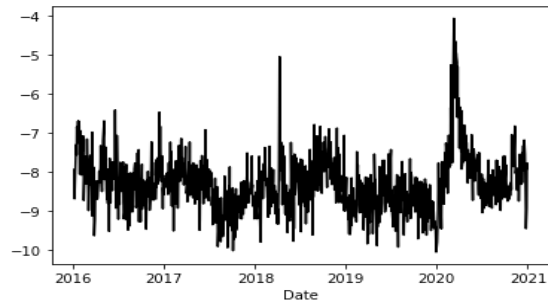


Figure 7: Dynamics of log-RV, NOVATEK

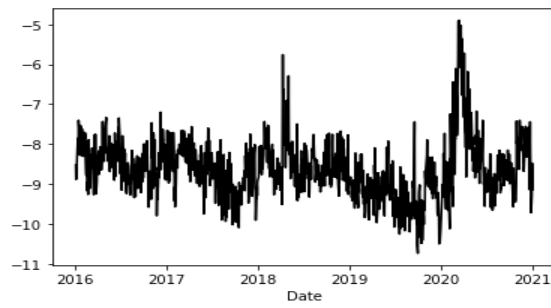


Figure 8: Dynamics of log-RV, ROSNEFT

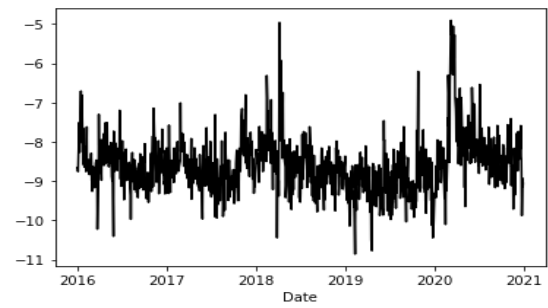


Figure 9: Dynamics of log-RV, NORNICKEL

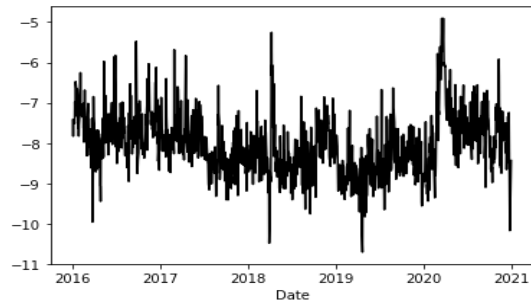


Figure 10: Dynamics of log-RV, POLYMETAL

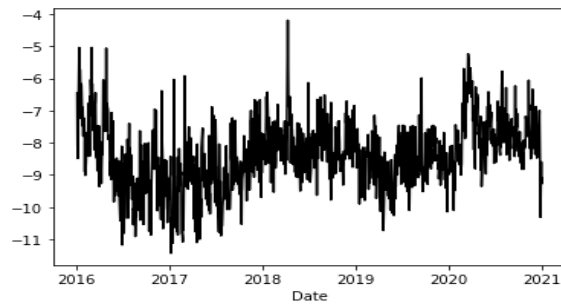


Figure 11: Dynamics of log-RV, POLYUS

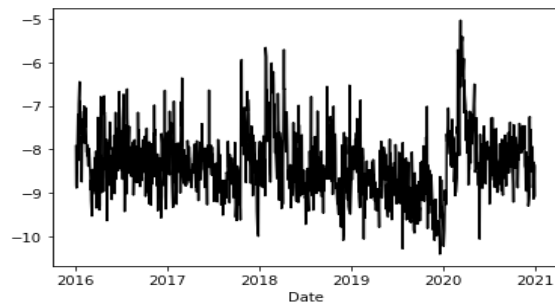


Figure 12: Dynamics of log-RV, MAGNIT

## A2.2 Distribution of Average log-RV across Weekdays

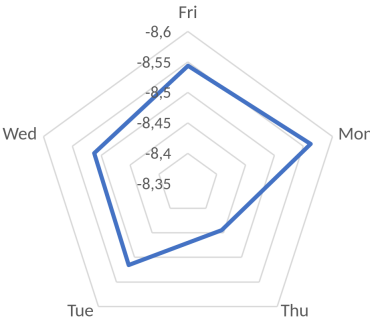


Figure 13: Average log-RV across weekdays, SBER

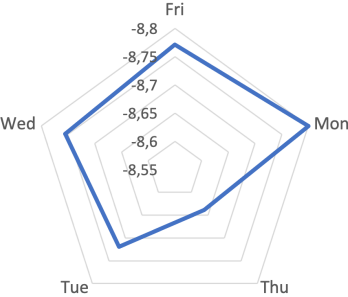


Figure 14: Average log-RV across weekdays, GAZPROM

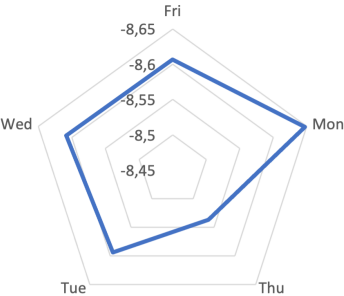


Figure 15: Average log-RV across weekdays, LUKOIL



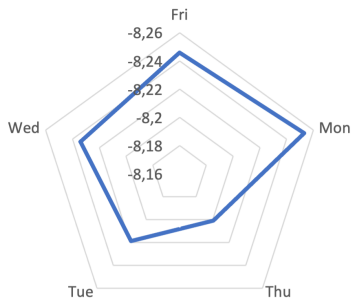


Figure 16: Average log-RV across weekdays, NOVATEK

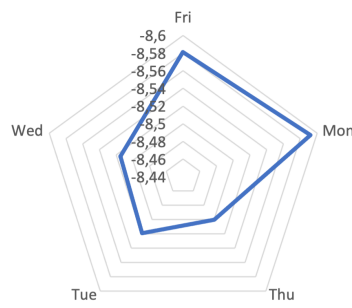


Figure 17: Average log-RV across weekdays, ROSNEFT

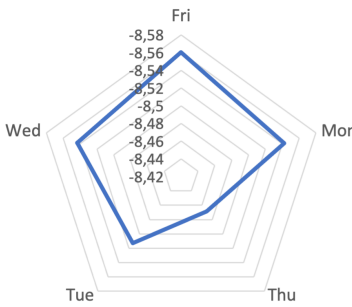


Figure 18: Average log-RV across weekdays, NORNICHEL

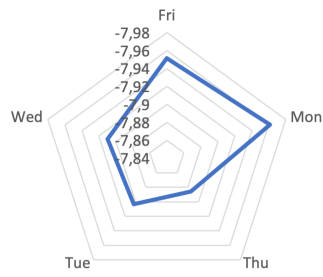


Figure 19: Average log-RV across weekdays, POLYMETAL

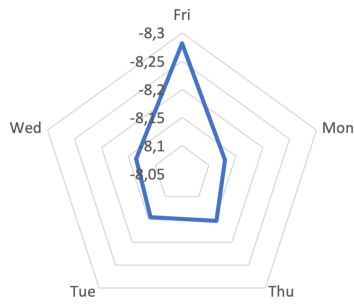


Figure 20: Average log-RV across weekdays, POLYUS

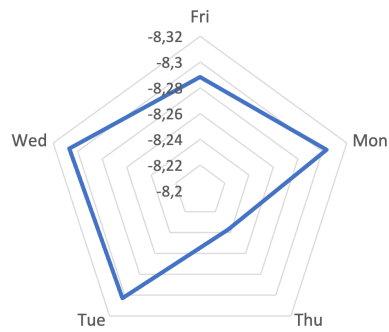


Figure 21: Average log-RV across weekdays, MAGNIT

## A2.3 Descriptive Statistics of Selected Variables<sup>4</sup>

Table 4: Descriptive statistics of selected variables, SBERBANK

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.61	0.03	-0.0	-0.35
<i>std</i>	0.69	0.13	0.1	0.07
$\rho_1$	0.73***	0.03	-0.1	0.5***
$\rho_2$	0.61***	-0.14	-0.12	0.35***
$\rho_3$	0.56***	-0.06	-0.12	0.3***
$\rho_4$	0.53***	0.03	0.03	0.28***
$\rho_5$	0.51***	-0.03	-0.09	0.27***
$\rho_6$	0.46***	-0.07	0.0	0.23***
$\rho_7$	0.44***	0.05	0.24*	0.24***
$\rho_8$	0.43***	0.31**	0.07	0.24***
$\rho_9$	0.41***	0.05	-0.09	0.25***
$\rho_{10}$	0.39***	-0.09	-0.15	0.19***

Table 5: Descriptive statistics of selected variables, GAZPROM

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.81	0.01	0.05	-0.33
<i>std</i>	0.69	0.11	0.24	0.07
$\rho_1$	0.66***	-0.12	0.25*	0.52***
$\rho_2$	0.55***	-0.22*	-0.11	0.34***
$\rho_3$	0.49***	0.02	-0.0	0.27***
$\rho_4$	0.45***	-0.11	0.16	0.25***
$\rho_5$	0.45***	-0.12	-0.18	0.24***
$\rho_6$	0.41***	-0.01	-0.06	0.24***
$\rho_7$	0.39***	0.11	0.08	0.25***
$\rho_8$	0.38***	-0.08	0.1	0.23***
$\rho_9$	0.37***	0.08	-0.0	0.24***
$\rho_{10}$	0.34***	-0.07	-0.06	0.19***

Table 6: Descriptive statistics of selected variables, LUKOIL

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.68	0.0	0.05	-0.34
<i>std</i>	0.74	0.14	0.19	0.07
$\rho_1$	0.73***	-0.09	0.13	0.54***
$\rho_2$	0.64***	-0.07	0.19	0.38***
$\rho_3$	0.59***	-0.22*	-0.11	0.35***
$\rho_4$	0.56***	0.14	0.16	0.33***
$\rho_5$	0.53***	0.11	0.31**	0.31***
$\rho_6$	0.51***	0.0	0.36***	0.3***
$\rho_7$	0.5***	-0.03	0.18	0.28***
$\rho_8$	0.5***	-0.03	0.09	0.3***
$\rho_9$	0.48***	-0.08	0.08	0.31***
$\rho_{10}$	0.48***	0.15	0.05	0.28***

<sup>4</sup>in all the tables in this section, \*, \*\*, \*\*\* denote  $ACF(j)$  value,  $\rho_j$  significance at 10, 5, and 1%

Table 7: Descriptive statistics of selected variables, NOVATEK

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.3	0.01	0.02	-0.35
<i>std</i>	0.71	0.12	0.15	0.07
$\rho_1$	0.64***	-0.02	0.13	0.57***
$\rho_2$	0.58***	-0.25*	-0.14	0.41***
$\rho_3$	0.52***	0.06	0.18	0.37***
$\rho_4$	0.49***	-0.01	0.29**	0.37***
$\rho_5$	0.49***	-0.08	0.06	0.33***
$\rho_6$	0.47***	0.01	-0.23*	0.31***
$\rho_7$	0.46***	-0.21	-0.07	0.33***
$\rho_8$	0.46***	-0.01	0.11	0.33***
$\rho_9$	0.45***	0.11	-0.09	0.31***
$\rho_{10}$	0.44***	0.03	-0.4***	0.29***

Table 8: Descriptive statistics of selected variables, ROSNEFT

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.63	0.0	0.06	-0.35
<i>std</i>	0.72	0.15	0.21	0.07
$\rho_1$	0.71***	0.05	0.2	0.56***
$\rho_2$	0.64***	-0.11	0.08	0.42***
$\rho_3$	0.61***	-0.02	0.04	0.39***
$\rho_4$	0.59***	-0.01	0.04	0.41***
$\rho_5$	0.57***	0.14	0.03	0.37***
$\rho_6$	0.53***	0.09	0.0	0.34***
$\rho_7$	0.53***	0.01	-0.05	0.31***
$\rho_8$	0.52***	0.12	-0.04	0.34***
$\rho_9$	0.5***	-0.1	-0.13	0.31***
$\rho_{10}$	0.46***	-0.17	-0.05	0.28***

Table 9: Descriptive statistics of selected variables, NORNICKEL

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.65	0.01	0.01	-0.34
<i>std</i>	0.66	0.15	0.17	0.07
$\rho_1$	0.71***	0.01	0.02	0.61***
$\rho_2$	0.61***	-0.17	-0.09	0.45***
$\rho_3$	0.55***	-0.12	-0.15	0.34***
$\rho_4$	0.47***	0.08	-0.12	0.26***
$\rho_5$	0.45***	-0.12	-0.04	0.24***
$\rho_6$	0.41***	-0.1	-0.16	0.24***
$\rho_7$	0.39***	-0.08	-0.04	0.16***
$\rho_8$	0.36***	0.13	0.1	0.15***
$\rho_9$	0.32***	-0.01	0.14	0.14***
$\rho_{10}$	0.33***	-0.19	0.1	0.1***

Table 10: Descriptive statistics of selected variables, POLYMETAL

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.03	0.02	0.01	-0.38
<i>std</i>	0.75	0.17	0.13	0.07
$\rho_1$	0.66***	-0.22*	-0.23*	0.53***
$\rho_2$	0.56***	-0.16	-0.12	0.36***
$\rho_3$	0.52***	0.0	0.01	0.31***
$\rho_4$	0.49***	-0.02	-0.02	0.25***
$\rho_5$	0.46***	-0.01	-0.08	0.25***
$\rho_6$	0.43***	-0.15	-0.25*	0.22***
$\rho_7$	0.43***	0.13	0.18	0.2***
$\rho_8$	0.4***	-0.09	-0.01	0.21***
$\rho_9$	0.39***	0.01	0.06	0.22***
$\rho_{10}$	0.39***	-0.04	-0.04	0.2***

Table 11: Descriptive statistics of selected variables, POLYUS

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.16	-0.01	0.02	-0.37
<i>std</i>	0.86	0.1	0.09	0.08
$\rho_1$	0.6***	0.19	-0.05	0.57***
$\rho_2$	0.51***	-0.27	-0.12	0.36***
$\rho_3$	0.46***	-0.04	-0.08	0.3***
$\rho_4$	0.43***	-0.06	-0.13	0.28***
$\rho_5$	0.39***	-0.23	-0.1	0.26***
$\rho_6$	0.39***	-0.27	-0.11	0.27***
$\rho_7$	0.39***	-0.16	0.17	0.26***
$\rho_8$	0.36***	0.11	-0.04	0.23***
$\rho_9$	0.38***	0.3	0.24	0.24***
$\rho_{10}$	0.36***	0.1	0.02	0.22***

Table 12: Descriptive statistics of selected variables, MAGNIT

<i>Statistics</i>	<i>log RV</i>	<i>Dividend price ratio</i>	<i>Earning price ratio</i>	<i>High – Low</i>
<i>Mean</i>	-8.35	0.03	0.0	-0.36
<i>std</i>	0.75	0.12	0.12	0.07
$\rho_1$	0.6***	-0.07	-0.21	0.54***
$\rho_2$	0.51***	-0.24*	-0.0	0.34***
$\rho_3$	0.45***	-0.09	-0.09	0.27***
$\rho_4$	0.4***	0.19	0.13	0.21***
$\rho_5$	0.37***	0.04	-0.14	0.21***
$\rho_6$	0.37***	-0.1	-0.05	0.21***
$\rho_7$	0.34***	-0.02	0.01	0.19***
$\rho_8$	0.35***	0.08	0.2	0.25***
$\rho_9$	0.34***	-0.04	-0.09	0.2***
$\rho_{10}$	0.31***	-0.16	-0.08	0.18***

## A2.4 Correlations Between Selected Variables<sup>5</sup>

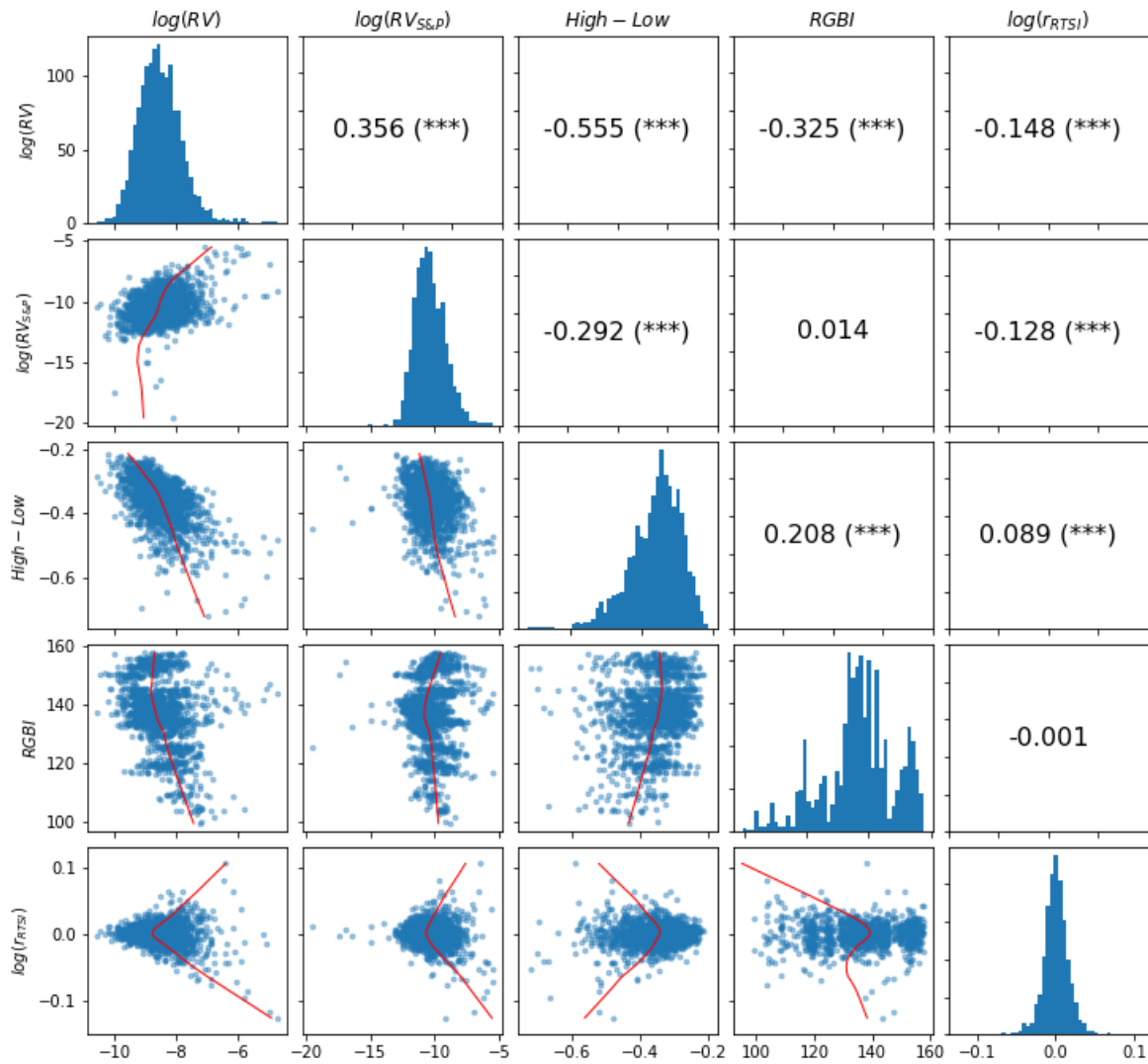


Figure 22: Correlations and dependencies between selected variables, SBERBANK

<sup>5</sup>in all the figures in this section, \*, \*\*, \*\*\* denote Pearson's correlation significance at 10, 5, and 1%

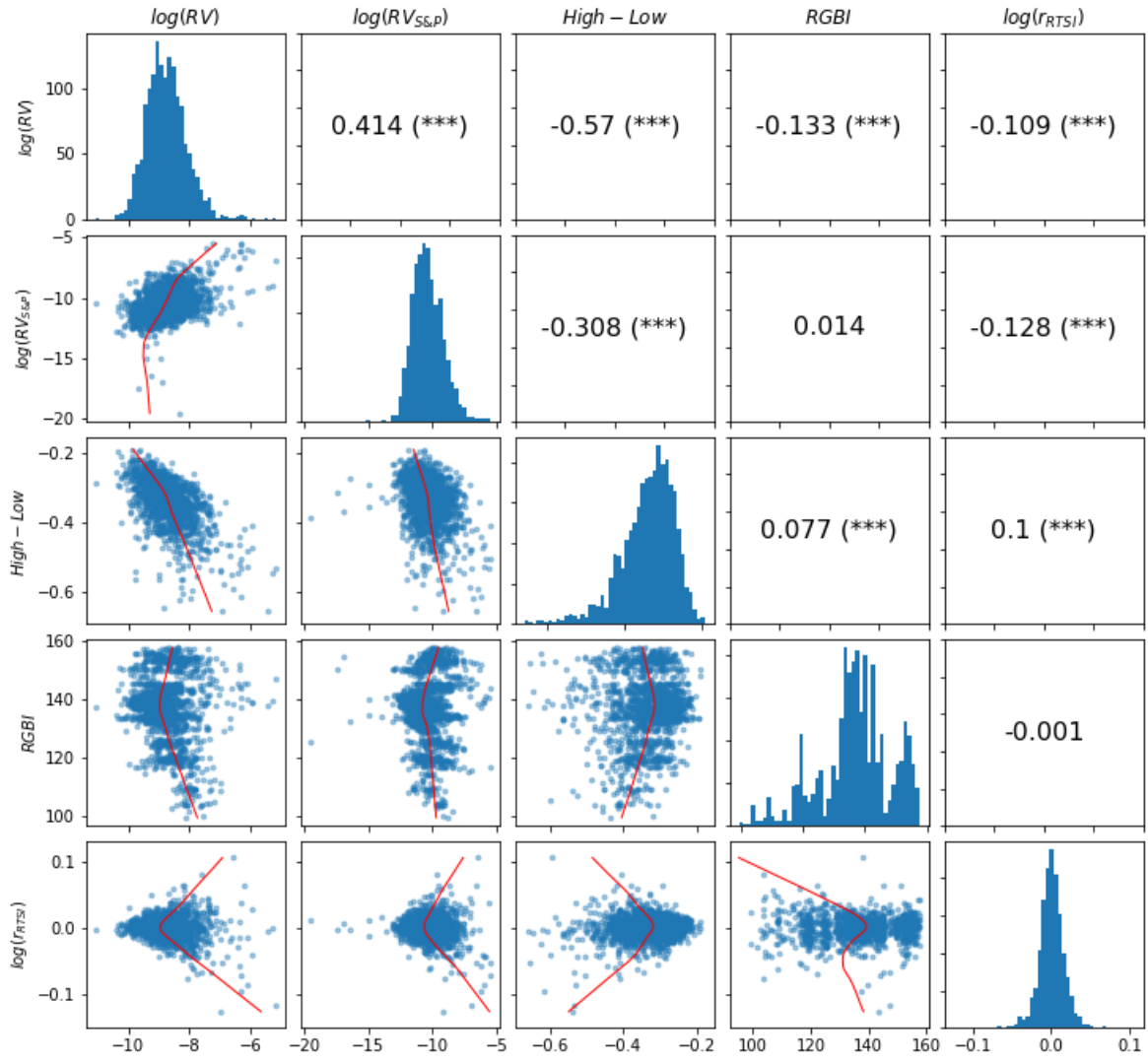


Figure 23: Correlations and dependencies between selected variables, GAZPROM

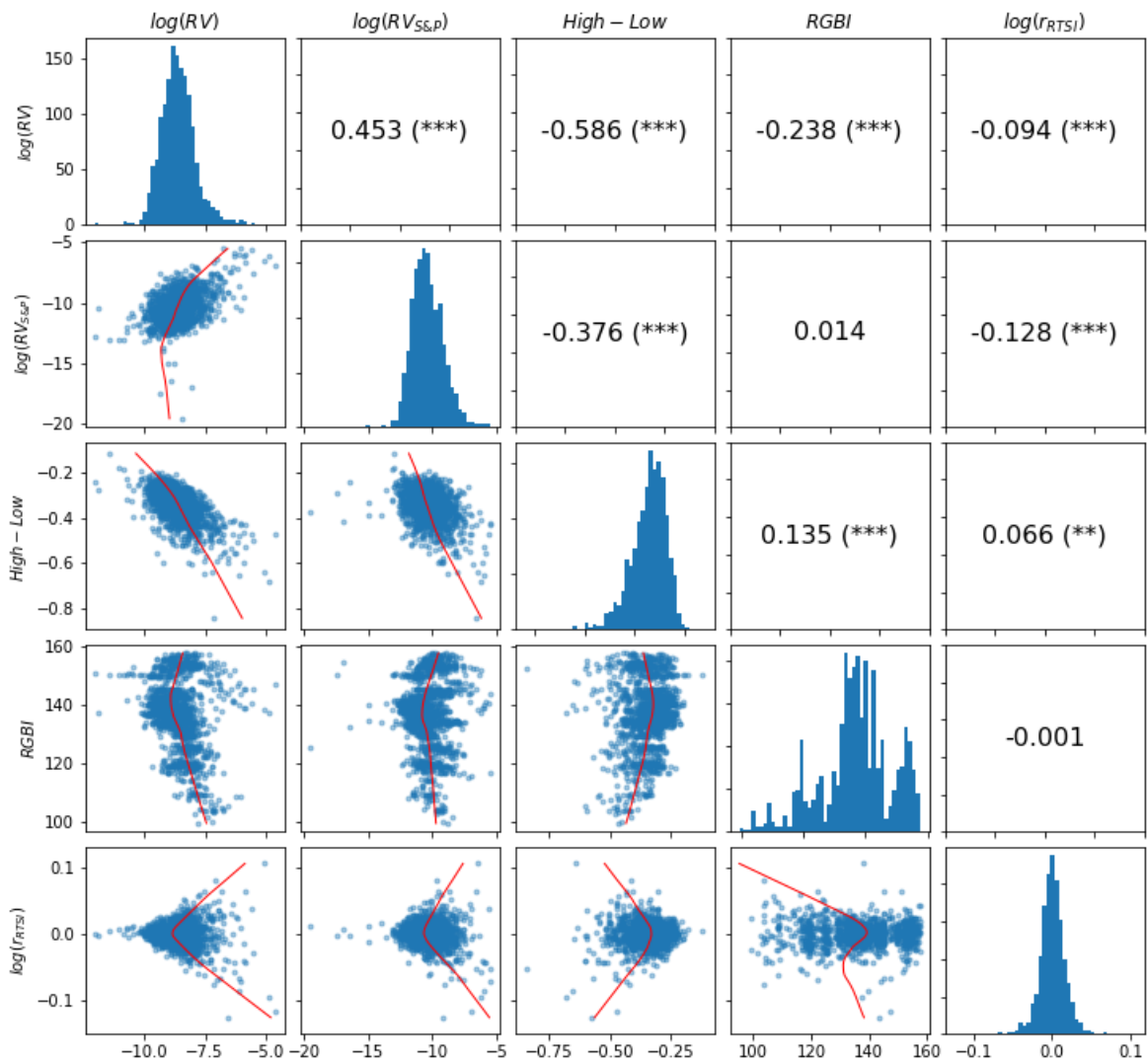


Figure 24: Correlations and dependencies between selected variables, LUKOIL



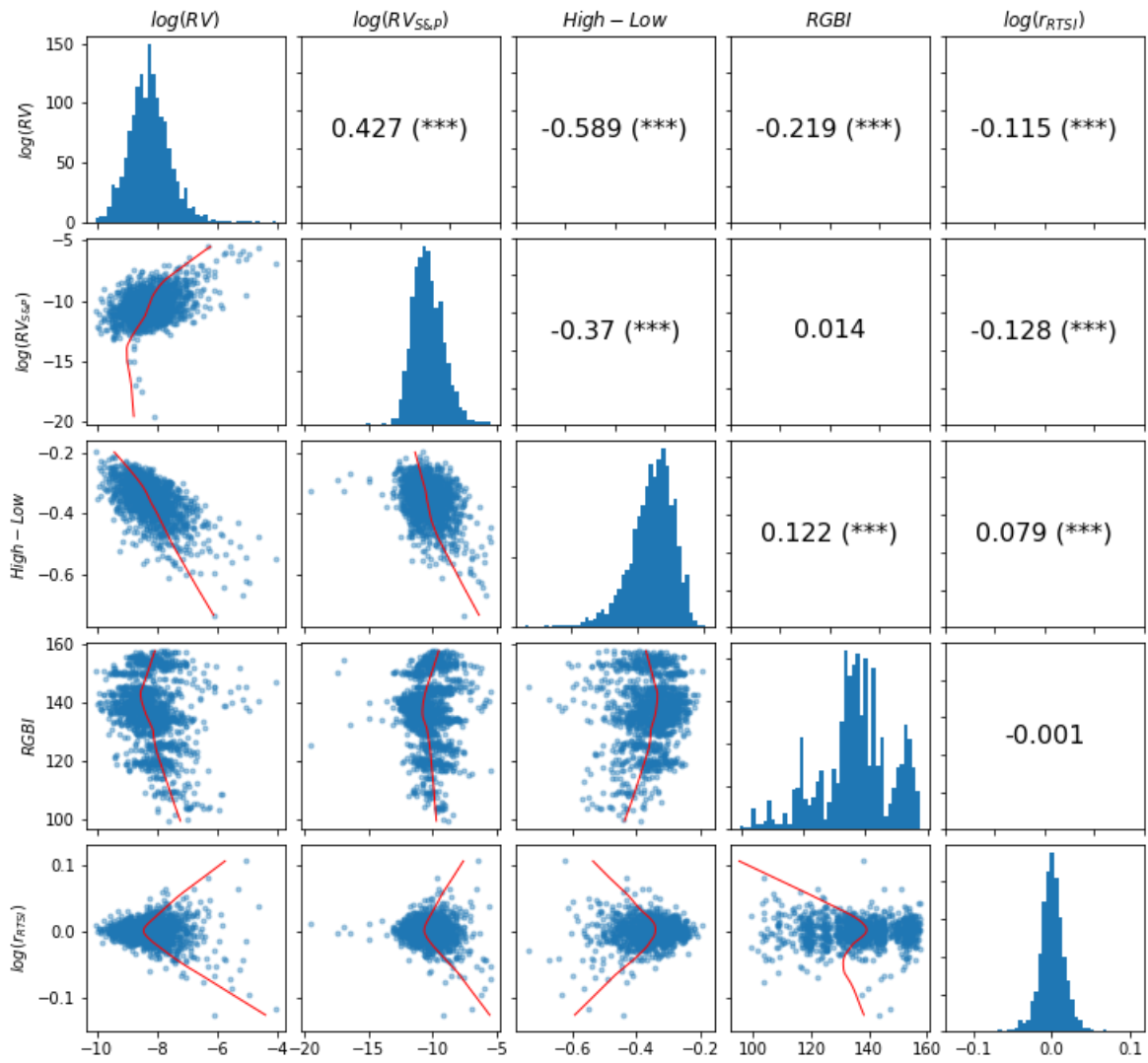


Figure 25: Correlations and dependencies between selected variables, NOVATEK

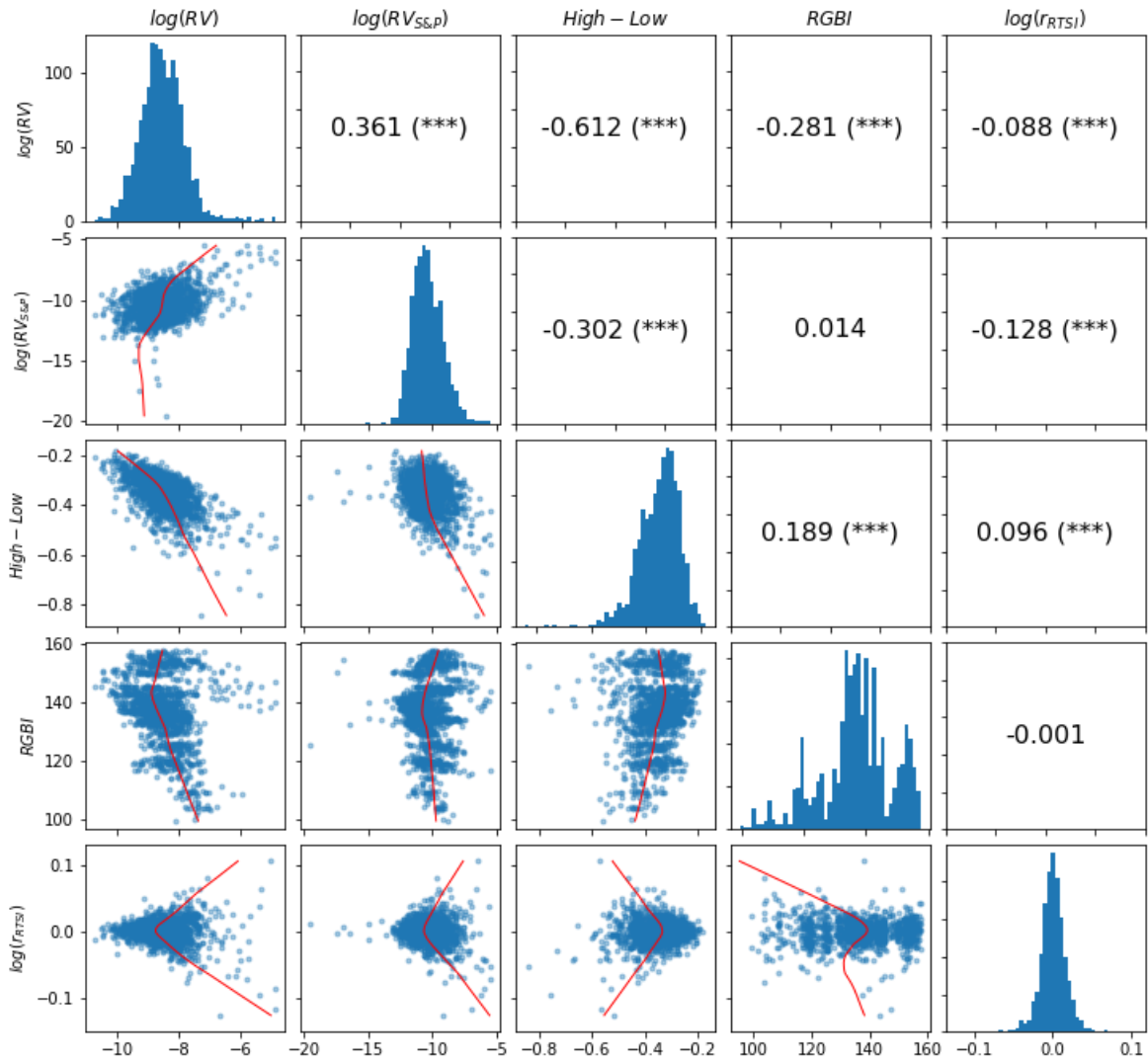


Figure 26: Correlations and dependencies between selected variables, ROSNEFT

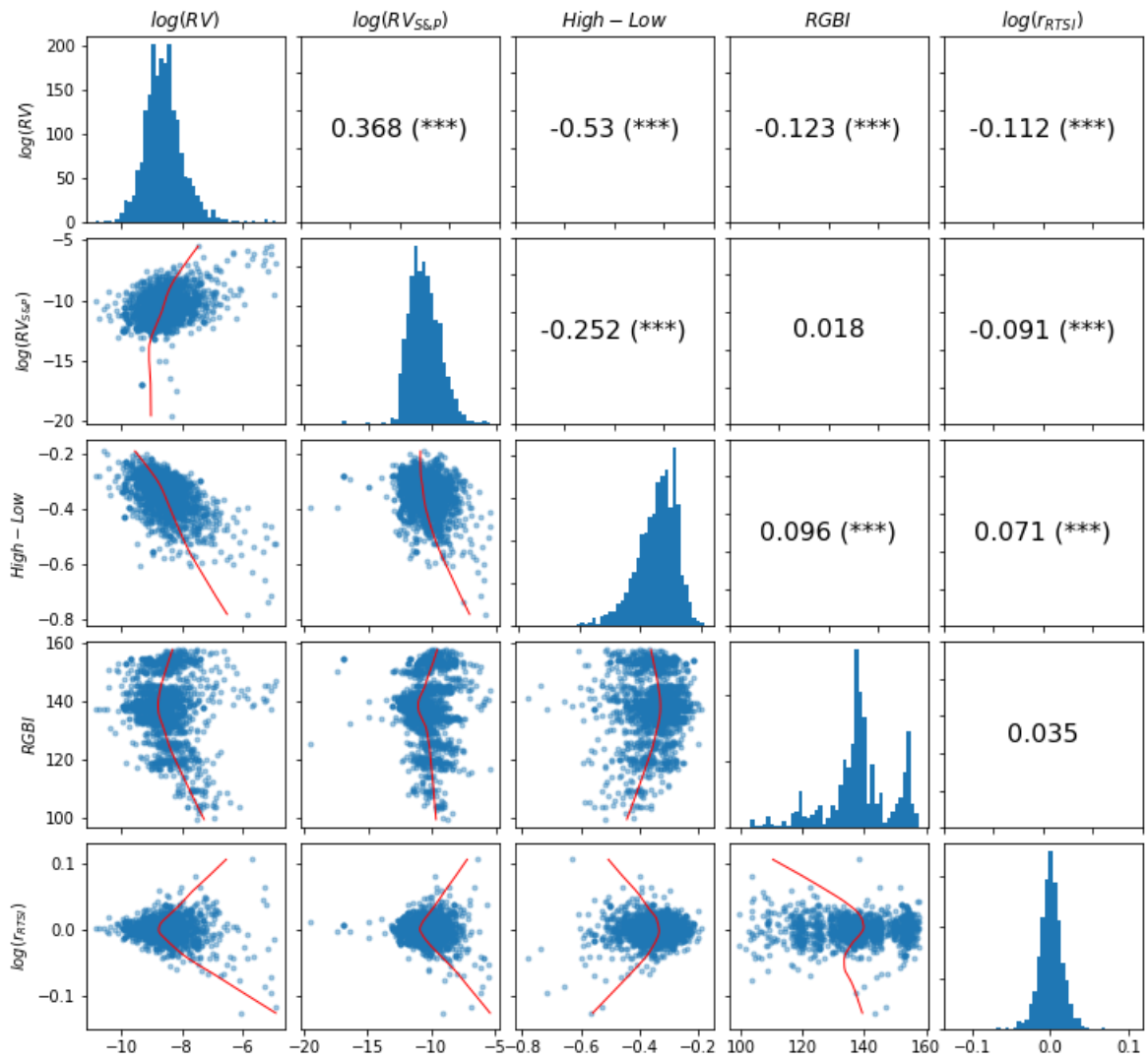


Figure 27: Correlations and dependencies between selected variables, NORNICKEL

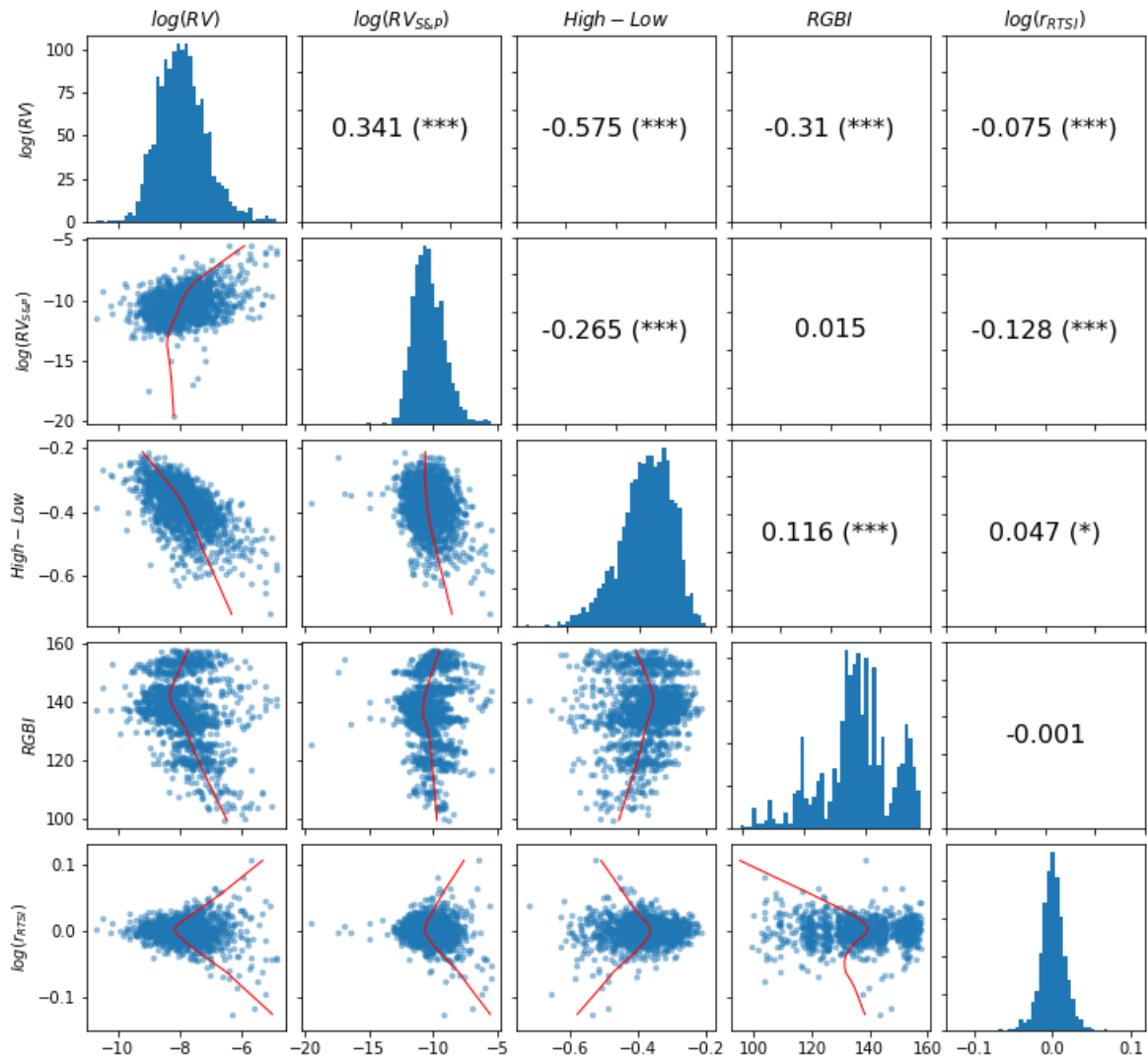


Figure 28: Correlations and dependencies between selected variables, POLYMETAL

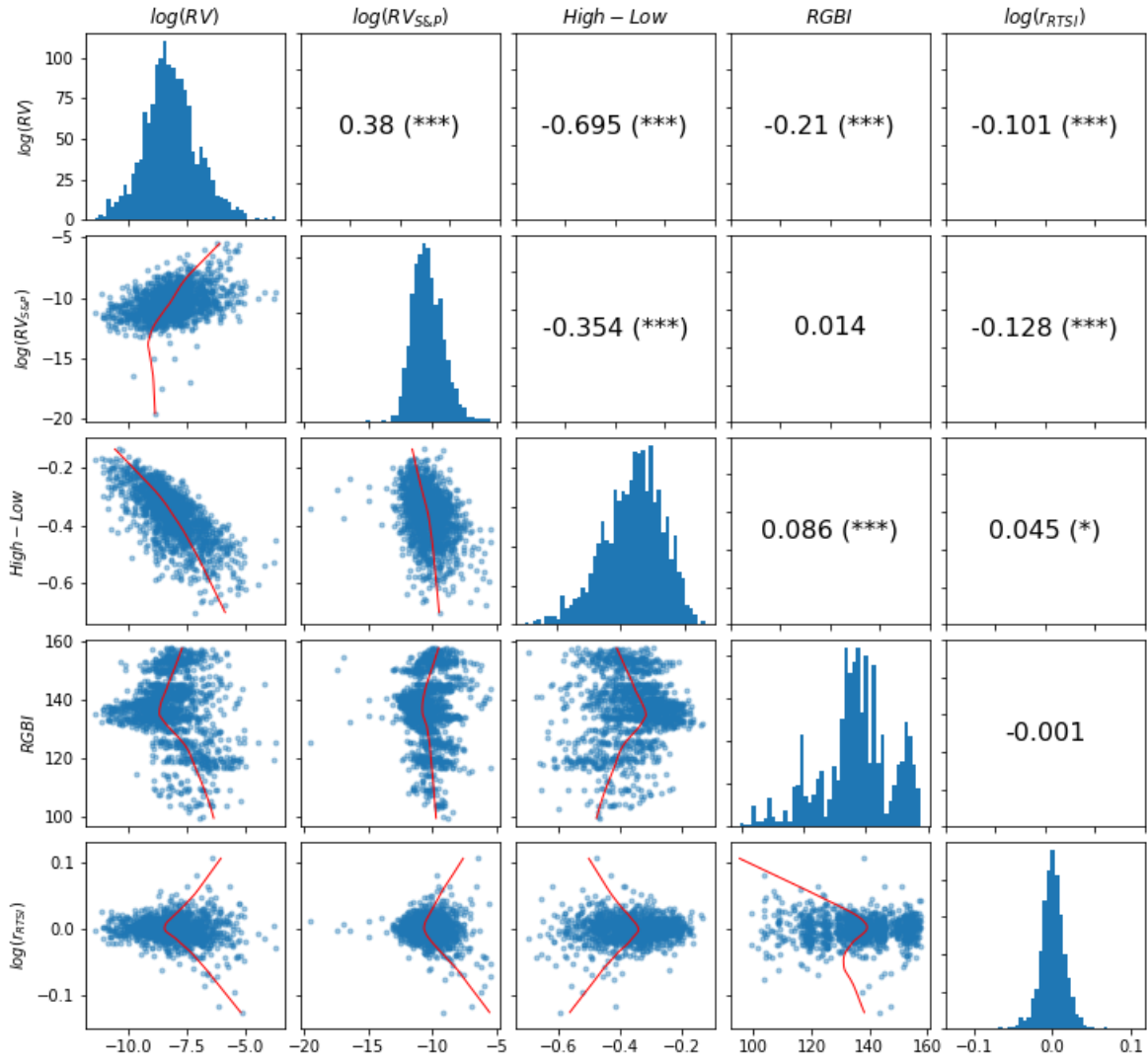


Figure 29: Correlations and dependencies between selected variables, POLYUS

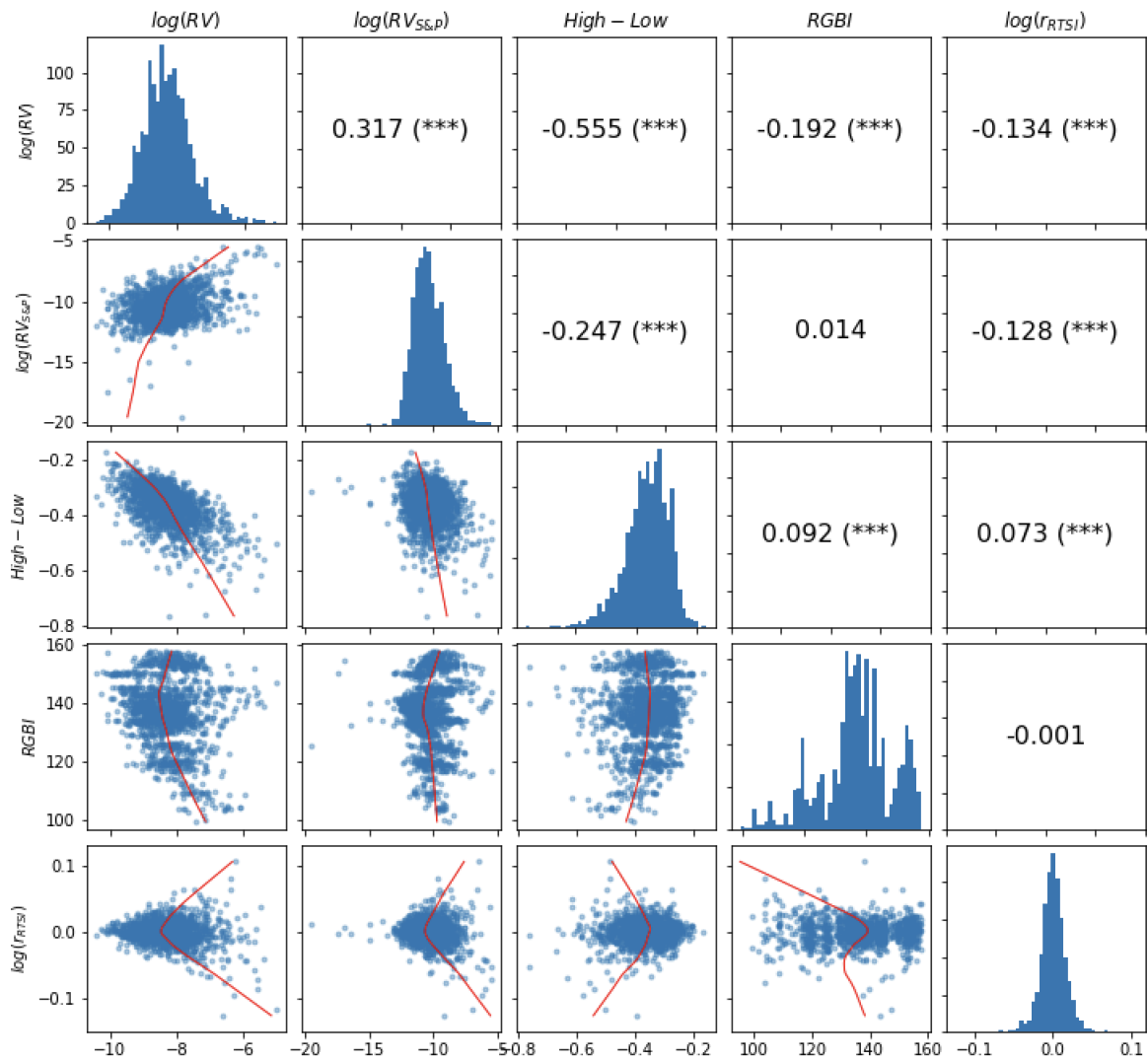


Figure 30: Correlations and dependencies between selected variables, MAGNIT

## A3 HAR-RV Estimation Results

Table 13: HAR-RV estimation results, SBERBANK

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.482*** (0.045)	0.462*** (0.045)	0.310*** (0.053)	0.310*** (0.052)	0.306*** (0.050)
log RV weekly	0.322*** (0.055)	0.320*** (0.055)	0.334*** (0.054)	0.317*** (0.053)	0.316*** (0.055)
log RV monthly	0.070 (0.046)	0.076* (0.044)	0.080* (0.043)	0.084* (0.046)	0.065 (0.049)
is after weekend		-0.010 (0.032)	-0.008 (0.032)	-0.002 (0.032)	-0.002 (0.032)
is friday		-0.052 (0.039)	-0.044 (0.045)	-0.047 (0.045)	-0.048 (0.044)
is after holiday		-0.025 (0.071)	-0.059 (0.069)	-0.061 (0.070)	-0.060 (0.070)
overnight returns		-6.979*** (2.409)	-2.253 (2.852)	-2.062 (2.825)	-2.269 (2.838)
RGBI			-0.000 (0.002)	-0.001 (0.002)	-0.001 (0.002)
log return RTSI			-0.905 (0.990)	-0.673 (0.983)	-0.685 (0.991)
high-low			-1.911*** (0.290)	-1.871*** (0.292)	-1.872*** (0.290)
growth rate of dividend price ratio			0.136 (0.165)	0.142 (0.169)	0.328 (0.232)
growth rate of earning price ratio			0.117 (0.242)	0.158 (0.239)	0.280 (0.299)
log RV S&P				0.040*** (0.015)	0.045*** (0.016)
log RV Brent				-0.036** (0.017)	-0.043** (0.019)
growth rate of imports from USA					-0.001 (0.045)
growth rate of exports to USA					-0.109 (0.068)
growth rate of CPI					4.401 (5.706)
growth rate of housing starts					-0.034 (0.032)
growth rate of quarterly GDP					0.142 (0.192)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.46	0.46	0.45	0.45	0.45
AIC	1641.59	1637.41	1600.68	1593.7	1598.42
LM test	0.97	0.97	0.87	0.95	0.95

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 14: HAR-RV estimation results, GAZPROM

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.400*** (0.040)	0.382*** (0.038)	0.267*** (0.040)	0.251*** (0.039)	0.251*** (0.039)
log RV weekly	0.371*** (0.057)	0.374*** (0.057)	0.364*** (0.055)	0.350*** (0.052)	0.349*** (0.052)
log RV monthly	0.079* (0.041)	0.077* (0.040)	0.085** (0.041)	0.029 (0.049)	0.022 (0.049)
is after weekend		0.008 (0.033)	-0.001 (0.033)	0.009 (0.034)	0.009 (0.034)
is friday		-0.065 (0.042)	-0.031 (0.049)	-0.030 (0.049)	-0.031 (0.048)
is after holiday		0.106 (0.126)	0.112 (0.126)	0.109 (0.123)	0.101 (0.125)
overnight returns		-6.795** (2.975)	-0.725 (3.320)	0.361 (3.171)	0.269 (3.162)
RGBI			0.003 (0.002)	0.002 (0.002)	0.003 (0.002)
log return RTSI			-1.669* (0.894)	-1.421 (0.881)	-1.478* (0.883)
high-low			-1.648*** (0.291)	-1.632*** (0.286)	-1.586*** (0.282)
growth rate of dividend price ratio			0.062 (0.151)	0.022 (0.152)	-0.020 (0.158)
growth rate of earning price ratio			-0.003 (0.069)	-0.030 (0.071)	-0.023 (0.071)
log RV S&P				0.048*** (0.017)	0.047*** (0.017)
log RV Brent				0.009 (0.020)	0.005 (0.021)
growth rate of imports from USA					-0.034 (0.052)
growth rate of exports to USA					-0.017 (0.062)
growth rate of CPI					4.497 (5.634)
growth rate of housing starts					-0.051* (0.028)
growth rate of quarterly GDP					-0.020 (0.166)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.51	0.5	0.5	0.49	0.49
AIC	1863.85	1858.09	1835.48	1825.0	1830.11
LM test	0.1	0.04	0.07	0.15	0.14

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01



Table 15: HAR-RV estimation results, LUKOIL

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.432*** (0.042)	0.418*** (0.040)	0.302*** (0.042)	0.293*** (0.042)	0.286*** (0.041)
log RV weekly	0.348*** (0.068)	0.342*** (0.068)	0.235*** (0.058)	0.207*** (0.057)	0.188*** (0.059)
log RV monthly	0.115** (0.054)	0.118** (0.050)	0.218*** (0.043)	0.209*** (0.046)	0.225*** (0.046)
is after weekend		-0.008 (0.034)	-0.009 (0.034)	0.001 (0.033)	-0.000 (0.033)
is friday		-0.073* (0.041)	-0.064 (0.045)	-0.064 (0.044)	-0.065 (0.044)
is after holiday		-0.071 (0.064)	-0.090 (0.062)	-0.090 (0.061)	-0.096 (0.060)
overnight returns		-8.096** (3.203)	-0.537 (3.397)	0.754 (3.335)	0.685 (3.271)
RGBI			-0.002 (0.002)	-0.003 (0.002)	-0.002 (0.002)
log return RTSI			-2.167** (1.090)	-1.990* (1.075)	-1.987* (1.075)
high-low			-1.735*** (0.282)	-1.669*** (0.278)	-1.678*** (0.275)
growth rate of dividend price ratio			0.605*** (0.174)	0.577*** (0.167)	0.635*** (0.178)
growth rate of earning price ratio			0.041 (0.060)	0.021 (0.061)	0.015 (0.062)
log RV S&P				0.043*** (0.015)	0.041*** (0.016)
log RV Brent				0.008 (0.020)	0.003 (0.021)
growth rate of imports from USA					0.015 (0.047)
growth rate of exports to USA					-0.113* (0.066)
growth rate of CPI					0.660 (6.302)
growth rate of housing starts					-0.067* (0.035)
growth rate of quarterly GDP					-0.115 (0.155)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.49	0.49	0.48	0.47	0.47
AIC	1789.72	1784.22	1730.78	1721.86	1720.8
LM test	0.06	0.03	0.38	0.68	0.75

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 16: HAR-RV estimation results, NOVATEK

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.297*** (0.044)	0.290*** (0.044)	0.196*** (0.044)	0.188*** (0.043)	0.188*** (0.043)
log RV weekly	0.410*** (0.073)	0.400*** (0.073)	0.362*** (0.069)	0.341*** (0.066)	0.337*** (0.065)
log RV monthly	0.182*** (0.044)	0.184*** (0.043)	0.214*** (0.045)	0.173*** (0.047)	0.170*** (0.050)
is after weekend		-0.019 (0.036)	-0.024 (0.035)	-0.012 (0.035)	-0.014 (0.035)
is friday		-0.025 (0.040)	-0.003 (0.046)	-0.003 (0.046)	-0.004 (0.045)
is after holiday		-0.120 (0.093)	-0.099 (0.093)	-0.101 (0.092)	-0.104 (0.090)
overnight returns		-7.322* (4.248)	-2.991 (4.534)	-1.124 (4.309)	-1.142 (4.313)
RGBI			-0.000 (0.002)	-0.001 (0.002)	-0.001 (0.002)
log return RTSI			-3.059** (1.205)	-2.819** (1.168)	-2.809** (1.178)
high-low			-1.543*** (0.297)	-1.486*** (0.291)	-1.427*** (0.297)
growth rate of dividend price ratio			0.143 (0.112)	0.082 (0.117)	0.087 (0.124)
growth rate of earning price ratio			-0.047 (0.100)	-0.035 (0.100)	-0.030 (0.097)
log RV S&P				0.053*** (0.016)	0.051*** (0.017)
log RV Brent				0.004 (0.017)	0.001 (0.018)
growth rate of imports from USA					0.001 (0.052)
growth rate of exports to USA					-0.116* (0.065)
growth rate of CPI					-1.007 (6.963)
growth rate of housing starts					-0.002 (0.036)
growth rate of quarterly GDP					-0.220 (0.168)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.51	0.51	0.5	0.5	0.5
AIC	1896.76	1898.79	1873.42	1861.16	1866.26
LM test	0.0	0.0	0.0	0.11	0.14

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 17: HAR-RV estimation results, ROSNEFT

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.353*** (0.037)	0.331*** (0.035)	0.224*** (0.039)	0.222*** (0.038)	0.222*** (0.038)
log RV weekly	0.454*** (0.060)	0.448*** (0.059)	0.429*** (0.059)	0.418*** (0.056)	0.414*** (0.056)
log RV monthly	0.089* (0.051)	0.094** (0.047)	0.109** (0.049)	0.106** (0.051)	0.096* (0.051)
is after weekend		0.030 (0.035)	0.035 (0.036)	0.040 (0.036)	0.039 (0.035)
is friday		-0.037 (0.038)	-0.008 (0.042)	-0.009 (0.042)	-0.009 (0.042)
is after holiday		-0.049 (0.078)	-0.072 (0.076)	-0.072 (0.076)	-0.079 (0.075)
overnight returns		-10.928*** (2.648)	-5.891* (3.324)	-4.948 (3.407)	-4.956 (3.409)
RGBI			-0.000 (0.002)	-0.001 (0.002)	-0.001 (0.002)
log return RTSI			-1.347 (1.201)	-1.262 (1.194)	-1.325 (1.200)
high-low			-1.592*** (0.270)	-1.561*** (0.268)	-1.534*** (0.270)
growth rate of dividend price ratio			0.019 (0.123)	0.004 (0.124)	-0.019 (0.121)
growth rate of earning price ratio			-0.019 (0.090)	-0.018 (0.088)	-0.006 (0.091)
log RV S&P				0.027** (0.013)	0.024* (0.014)
log RV Brent				-0.007 (0.016)	-0.009 (0.017)
growth rate of imports from USA					-0.014 (0.045)
growth rate of exports to USA					-0.029 (0.059)
growth rate of CPI					2.731 (5.554)
growth rate of housing starts					-0.011 (0.032)
growth rate of quarterly GDP					-0.183 (0.168)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.48	0.47	0.47	0.47	0.47
AIC	1714.29	1702.82	1679.21	1678.46	1685.35
LM test	0.01	0.0	0.01	0.03	0.04

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 18: HAR-RV estimation results, NORNICKEL

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.316*** (0.050)	0.312*** (0.049)	0.183*** (0.051)	0.166*** (0.050)	0.166*** (0.050)
log RV weekly	0.398*** (0.066)	0.397*** (0.065)	0.370*** (0.063)	0.349*** (0.059)	0.347*** (0.059)
log RV monthly	0.138*** (0.053)	0.140*** (0.052)	0.154*** (0.052)	0.126** (0.054)	0.129** (0.053)
is after weekend		-0.046 (0.035)	-0.058* (0.034)	-0.046 (0.034)	-0.046 (0.034)
is friday		-0.037 (0.044)	-0.036 (0.046)	-0.034 (0.045)	-0.034 (0.045)
is after holiday		-0.036 (0.076)	-0.032 (0.072)	-0.039 (0.074)	-0.039 (0.074)
overnight returns		-3.807 (3.463)	2.378 (3.353)	2.665 (3.169)	2.476 (3.158)
RGBI			0.002 (0.002)	0.001 (0.002)	0.001 (0.002)
log return RTSI			-1.007 (1.327)	-0.701 (1.289)	-0.677 (1.281)
high-low			-2.110*** (0.323)	-2.119*** (0.319)	-2.096*** (0.320)
growth rate of dividend price ratio			0.141 (0.143)	0.135 (0.140)	0.144 (0.143)
growth rate of earning price ratio			0.103 (0.099)	0.124 (0.099)	0.113 (0.099)
log RV S&P				0.066*** (0.015)	0.064*** (0.016)
log RV Brent				-0.020 (0.018)	-0.020 (0.020)
growth rate of imports from USA					0.019 (0.055)
growth rate of exports to USA					-0.045 (0.071)
growth rate of CPI					-1.961 (6.680)
growth rate of housing starts					-0.026 (0.035)
growth rate of quarterly GDP					-0.124 (0.189)
Observations	1,785	1,785	1,785	1,785	1,785
RMSE	0.51	0.51	0.49	0.49	0.49
AIC	2643.13	2645.91	2580.13	2548.1	2555.23
LM test	0.0	0.0	0.0	0.0	0.0

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 19: HAR-RV estimation results, POLYMETAL

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.367*** (0.038)	0.360*** (0.039)	0.264*** (0.047)	0.249*** (0.047)	0.248*** (0.046)
log RV weekly	0.340*** (0.067)	0.338*** (0.066)	0.285*** (0.061)	0.269*** (0.060)	0.252*** (0.061)
log RV monthly	0.179*** (0.055)	0.181*** (0.053)	0.240*** (0.051)	0.226*** (0.053)	0.252*** (0.055)
is after weekend		-0.007 (0.040)	-0.003 (0.041)	0.009 (0.041)	0.008 (0.040)
is friday		-0.054 (0.042)	-0.023 (0.046)	-0.023 (0.045)	-0.023 (0.045)
is after holiday		-0.001 (0.101)	-0.017 (0.099)	-0.029 (0.101)	-0.016 (0.100)
overnight returns		-8.337 (6.014)	-6.258 (5.688)	-5.105 (5.622)	-4.660 (5.690)
RGBI			-0.002 (0.002)	-0.003* (0.002)	-0.004** (0.002)
log return RTSI			-2.086** (1.044)	-1.727* (1.014)	-1.583 (1.005)
high-low			-1.380*** (0.338)	-1.398*** (0.339)	-1.379*** (0.339)
growth rate of dividend price ratio			0.234 (0.226)	0.164 (0.223)	0.238 (0.221)
growth rate of earning price ratio			0.001 (0.222)	-0.003 (0.226)	0.006 (0.240)
log RV S&P				0.049*** (0.017)	0.054*** (0.017)
log RV Brent				0.007 (0.024)	0.003 (0.024)
growth rate of imports from USA					0.072 (0.055)
growth rate of exports to USA					-0.130* (0.075)
growth rate of CPI					-5.176 (6.975)
growth rate of housing starts					0.002 (0.031)
growth rate of quarterly GDP					0.095 (0.181)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.54	0.54	0.53	0.53	0.53
AIC	2026.9	2030.03	2004.52	1992.57	1996.41
LM test	0.65	0.72	0.9	0.94	0.93

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

Table 20: HAR-RV estimation results, POLYUS

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.356*** (0.038)	0.369*** (0.039)	0.208*** (0.059)	0.200*** (0.058)	0.199*** (0.058)
log RV weekly	0.333*** (0.058)	0.327*** (0.057)	0.299*** (0.065)	0.286*** (0.062)	0.262*** (0.061)
log RV monthly	0.205*** (0.044)	0.203*** (0.045)	0.171*** (0.059)	0.122** (0.062)	0.156** (0.070)
is after weekend		-0.019 (0.054)	-0.106** (0.054)	-0.088* (0.053)	-0.089* (0.053)
is friday		0.055 (0.056)	0.014 (0.074)	0.008 (0.073)	0.007 (0.073)
is after holiday		-0.057 (0.138)	-0.168* (0.096)	-0.202** (0.099)	-0.200** (0.097)
overnight returns		9.454* (5.649)	7.686 (5.124)	7.529 (5.150)	7.739 (5.235)
RGBI			0.005 (0.003)	0.006* (0.003)	0.006 (0.004)
log return RTSI			-0.161 (1.575)	0.632 (1.481)	0.743 (1.469)
high-low			-2.292*** (0.479)	-2.190*** (0.470)	-2.227*** (0.475)
growth rate of dividend price ratio			-0.709* (0.424)	-0.728* (0.420)	-0.799* (0.484)
growth rate of earning price ratio			-1.005** (0.508)	-0.946* (0.499)	-1.103* (0.574)
log RV S&P				0.082*** (0.021)	0.078*** (0.023)
log RV Brent				-0.024 (0.030)	-0.027 (0.034)
growth rate of imports from USA					0.117 (0.106)
growth rate of exports to USA					-0.149 (0.109)
growth rate of CPI					-5.719 (11.094)
growth rate of housing starts					0.035 (0.049)
growth rate of quarterly GDP					-0.167 (0.302)
Observations	1,256	1,256	838	838	838
RMSE	0.74	0.73	0.64	0.64	0.64
AIC	2800.92	2804.32	1668.02	1655.67	1661.63
LM test	0.01	0.01	0.05	0.07	0.1

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 21: HAR-RV estimation results, MAGNIT

	<i>Dependent variable: log RV<sub>t+1</sub></i>				
	Basic	Overnight and calendar	Financial	Spillover	Macroeconomic
log RV	0.369*** (0.043)	0.356*** (0.044)	0.196*** (0.044)	0.192*** (0.045)	0.190*** (0.045)
log RV weekly	0.336*** (0.059)	0.341*** (0.059)	0.310*** (0.055)	0.294*** (0.056)	0.276*** (0.055)
log RV monthly	0.129** (0.054)	0.130** (0.055)	0.148*** (0.054)	0.131** (0.057)	0.131** (0.054)
is after weekend		-0.044 (0.039)	-0.038 (0.039)	-0.029 (0.039)	-0.030 (0.039)
is friday		-0.024 (0.043)	-0.028 (0.048)	-0.029 (0.047)	-0.029 (0.047)
is after holiday		0.011 (0.106)	0.023 (0.107)	0.024 (0.107)	0.007 (0.104)
overnight returns		-5.472* (2.818)	-0.051 (3.150)	1.250 (3.074)	0.892 (2.962)
RGBI			0.001 (0.002)	0.000 (0.002)	0.001 (0.002)
log return RTSI			-0.124 (1.181)	0.048 (1.162)	-0.044 (1.166)
high-low			-2.395*** (0.314)	-2.395*** (0.312)	-2.344*** (0.311)
growth rate of dividend price ratio			-0.119 (0.205)	-0.085 (0.207)	-0.073 (0.200)
growth rate of earning price ratio			-0.260 (0.233)	-0.191 (0.225)	-0.177 (0.231)
log RV S&P				0.038** (0.016)	0.033** (0.017)
log RV Brent				0.001 (0.019)	0.001 (0.021)
growth rate of imports from USA					-0.008 (0.054)
growth rate of exports to USA					-0.030 (0.072)
growth rate of CPI					-0.269 (6.573)
growth rate of housing starts					-0.068 (0.043)
growth rate of quarterly GDP					-0.298 (0.190)
Observations	1,255	1,255	1,255	1,255	1,255
RMSE	0.58	0.58	0.57	0.57	0.57
AIC	2209.2	2212.91	2174.45	2171.07	2171.79
LM test	0.0	0.0	0.01	0.05	0.08

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

# A4 Machine Learning Results

## A4.1 Graphs with Top-1 Models

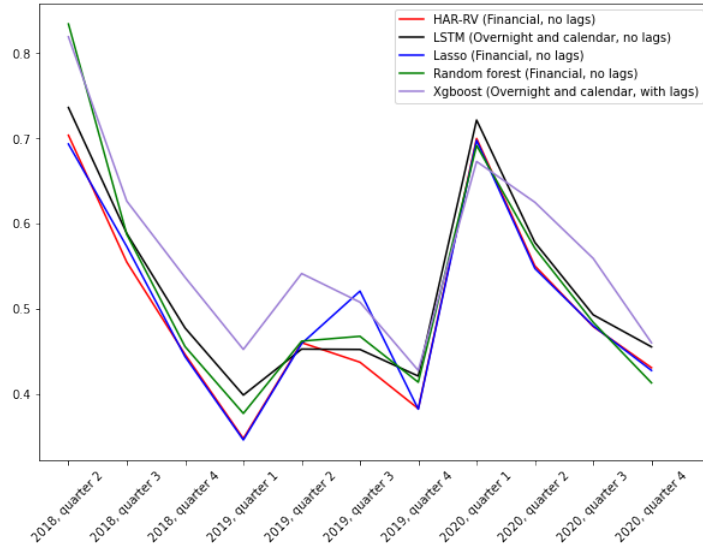


Figure 31: Results for top-1 ML models, SBERBANK

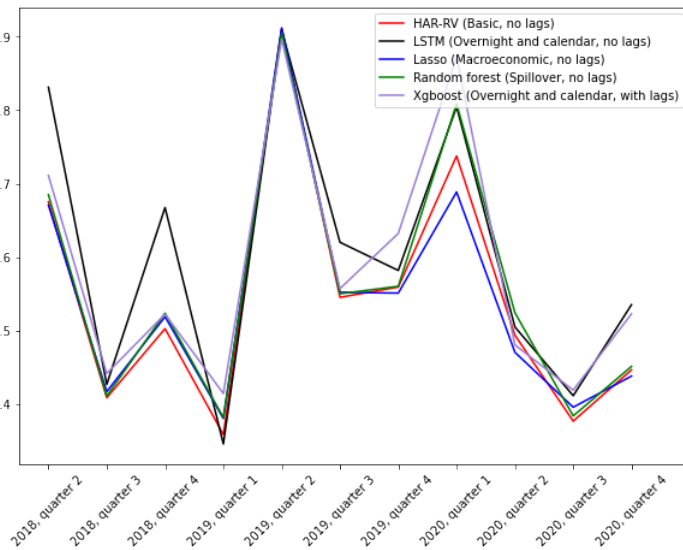


Figure 32: Results for top-1 ML models, GAZPROM



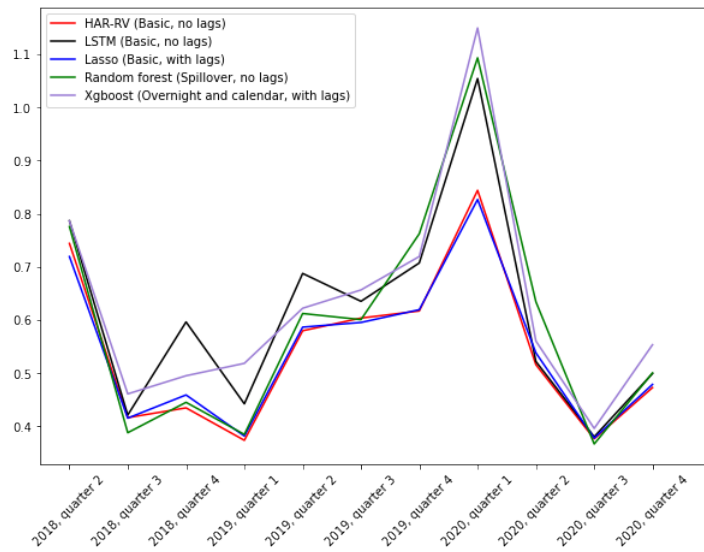


Figure 33: Results for top-1 ML models, LUKOIL

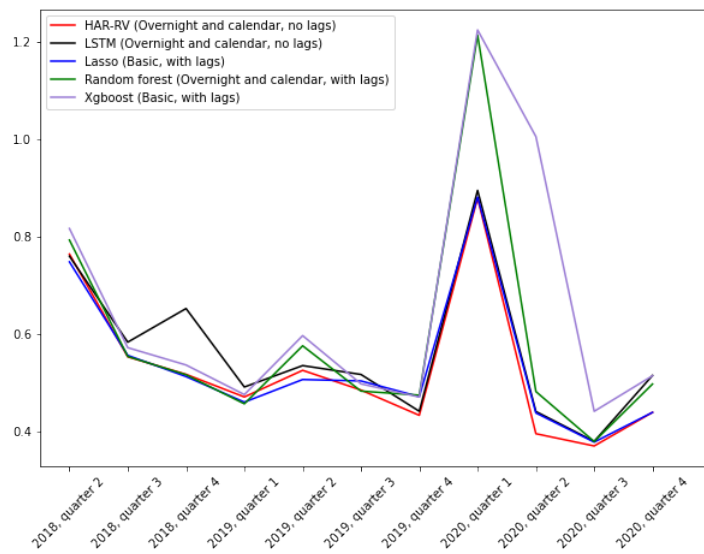


Figure 34: Results for top-1 ML models, NOVATEK

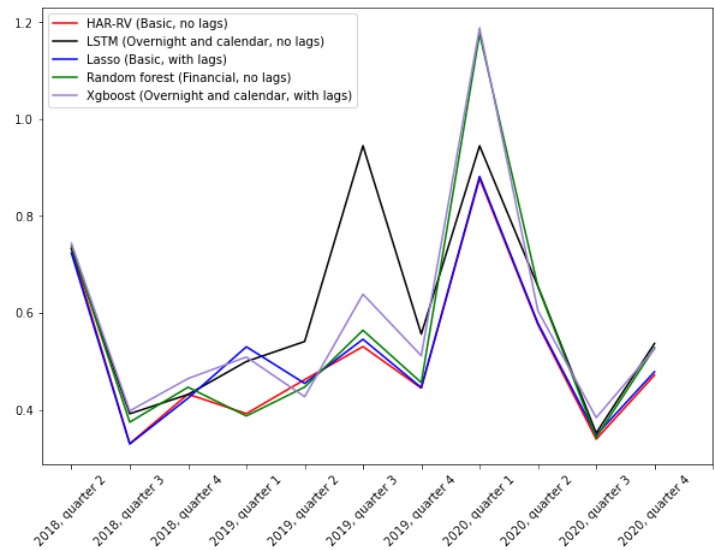


Figure 35: Results for top-1 ML models, ROSNEFT

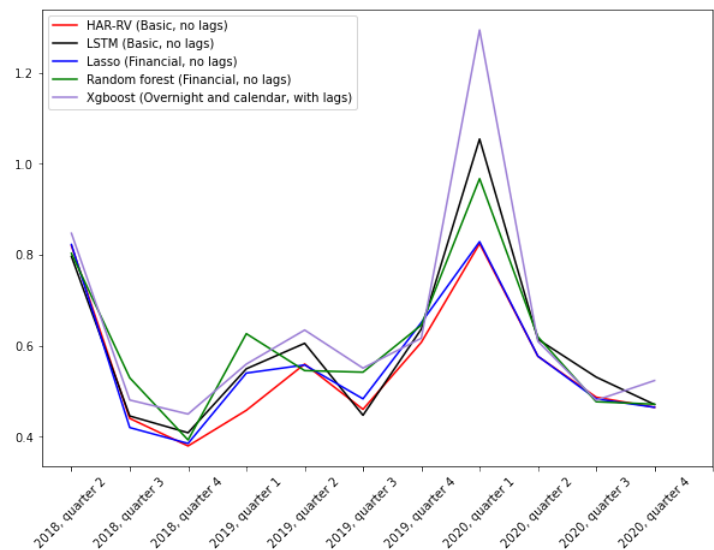


Figure 36: Results for top-1 ML models, NORNICHEL

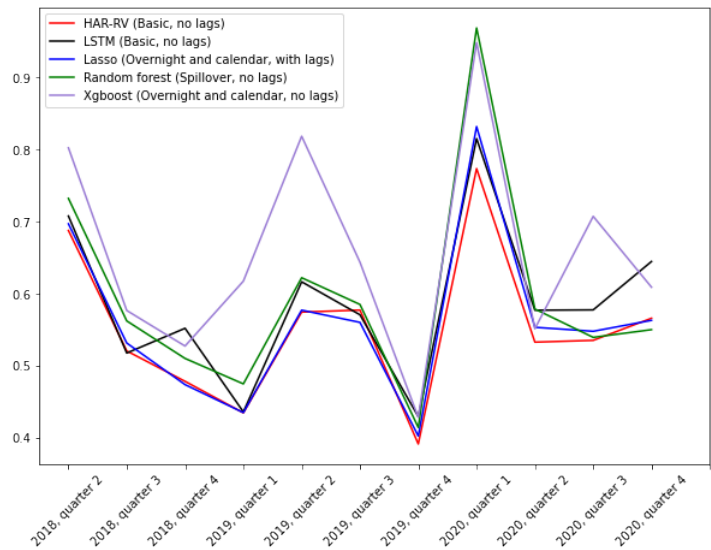


Figure 37: Results for top-1 ML models, POLYMETAL

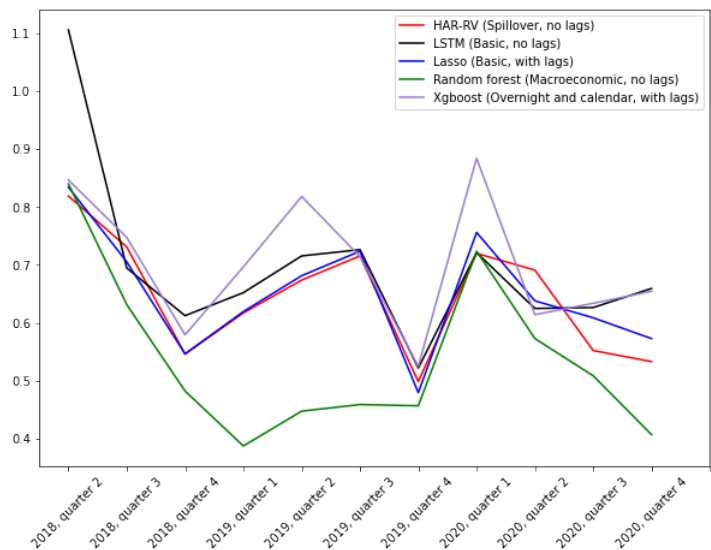


Figure 38: Results for top-1 ML models, POLYUS

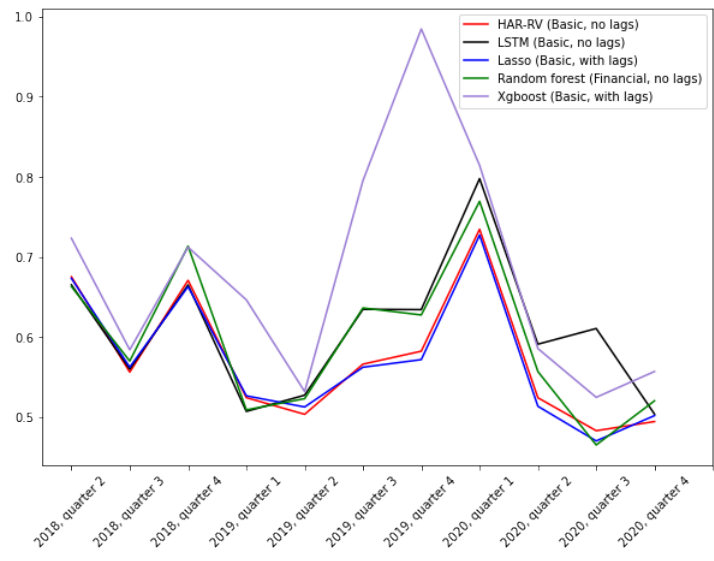


Figure 39: Results for top-1 ML models, MAGNIT

## A4.2 Tables with Top-3 Models

Table 22: Results of models for SBERBANK with 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
	Financial no lags	Financial no lags	Spillover no lags	Basic with lags	Overnight and calendar with lags	Basic with lags	Basic no lags	Financial no lags	Spillover no lags	Basic with lags	Overnight and calendar no lags	Basic no lags	Spillover no lags
2018 Q2	0.7	0.69	0.68	0.7	0.82	0.82	0.81	0.83	0.83	0.8	0.74	0.79	0.76
2018 Q3	0.55	0.57	0.58	0.58	0.63	0.62	0.62	0.59	0.6	0.67	0.59	0.63	0.6
2018 Q4	0.45	0.44	0.45	0.45	0.54	0.54	0.51	0.46	0.5	0.51	0.48	0.49	0.59
2019 Q1	0.35	0.35	0.36	0.35	0.45	0.47	0.43	0.38	0.39	0.35	0.4	0.43	0.41
2019 Q2	0.46	0.46	0.48	0.48	0.54	0.53	0.5	0.46	0.46	0.48	0.45	0.46	9.19
2019 Q3	0.44	0.52	0.52	0.51	0.51	0.56	0.5	0.47	0.46	0.48	0.45	0.61	0.6
2019 Q4	0.38	0.38	0.38	0.39	0.43	0.41	0.5	0.41	0.42	0.39	0.42	0.39	0.83
2020 Q1	0.7	0.7	0.7	0.69	0.67	0.68	0.84	0.69	0.72	0.71	0.72	0.69	1.35
2020 Q2	0.55	0.55	0.54	0.54	0.62	0.61	0.56	0.57	0.55	0.55	0.58	0.55	0.58
2020 Q3	0.48	0.48	0.48	0.48	0.56	0.56	0.55	0.48	0.49	0.54	0.49	0.48	0.57
2020 Q4	0.43	0.43	0.43	0.41	0.46	0.43	0.44	0.41	0.42	0.42	0.46	0.47	0.59
Mean RMSE	0.5	0.51	0.51	0.51	0.57	0.57	0.57	0.52	0.53	0.54	0.52	0.54	1.46

Table 23: Results of models for GAZPROM with 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM			
	Basic no lags	Macroeconomic no lags	Financial no lags	Financial with lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Spillover no lags	Financial no lags	Spillover with lags	Overnight and calendar no lags	Basic no lags	Financial no lags	
2018 Q2	0.68	0.67	0.67	0.67	0.71	0.71	0.74	0.72	0.68	0.69	0.7	0.83	0.72	0.75
2018 Q3	0.41	0.42	0.4	0.42	0.44	0.44	0.43	0.41	0.42	0.39	0.43	0.41	0.43	0.43
2018 Q4	0.5	0.52	0.49	0.51	0.52	0.53	0.56	0.52	0.52	0.51	0.67	0.67	0.67	0.67
2019 Q1	0.36	0.38	0.37	0.35	0.41	0.43	0.4	0.38	0.38	0.37	0.35	0.43	0.43	0.43
2019 Q2	0.91	0.91	0.92	0.91	0.9	0.88	0.89	0.91	0.92	0.93	0.91	0.91	0.96	0.96
2019 Q3	0.55	0.55	0.55	0.55	0.56	0.57	0.64	0.55	0.53	0.55	0.62	0.55	0.62	0.62
2019 Q4	0.56	0.55	0.55	0.55	0.63	0.65	0.63	0.56	0.55	0.59	0.58	0.76	0.58	0.58
2020 Q1	0.74	0.69	0.72	0.74	0.87	0.9	0.98	0.81	0.81	0.81	0.8	0.86	0.76	0.76
2020 Q2	0.49	0.47	0.52	0.49	0.48	0.49	0.56	0.52	0.54	0.51	0.51	0.54	0.86	0.86
2020 Q3	0.38	0.4	0.38	0.4	0.42	0.41	0.46	0.38	0.4	0.38	0.41	0.46	0.74	0.74
2020 Q4	0.45	0.44	0.45	0.45	0.52	0.51	0.51	0.45	0.45	0.47	0.54	0.46	0.74	0.74
Mean RMSE	0.55	0.55	0.55	0.55	0.59	0.6	0.62	0.56	0.56	0.56	0.6	0.61	0.68	0.68

Table 24: Results of models for LUKOIL with 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
	Basic no lags	Basic with lags	Overnight and calendar with lags	Financial no lags	Overnight and calendar with lags	Basic with lags	Spillover with lags	Spillover no lags	Overnight and calendar no lags	Overnight and calendar with lags	Basic no lags	Overnight and calendar no lags	Spillover no lags
2018 Q2	0.74	0.72	0.72	0.74	0.79	0.83	0.75	0.78	0.78	0.77	0.79	0.76	0.77
2018 Q3	0.42	0.42	0.42	0.4	0.46	0.47	0.44	0.39	0.41	0.42	0.42	0.5	0.4
2018 Q4	0.43	0.46	0.46	0.44	0.5	0.49	0.48	0.45	0.46	0.44	0.6	0.44	0.45
2019 Q1	0.37	0.38	0.38	0.38	0.52	0.5	0.66	0.38	0.39	0.38	0.44	0.46	0.66
2019 Q2	0.58	0.59	0.59	0.56	0.62	0.63	0.63	0.61	0.57	0.57	0.69	0.61	0.64
2019 Q3	0.6	0.6	0.6	0.59	0.66	0.65	0.72	0.6	0.61	0.62	0.64	0.63	0.65
2019 Q4	0.62	0.62	0.62	0.63	0.72	0.7	0.85	0.76	0.71	0.7	0.71	0.82	0.74
2020 Q1	0.84	0.83	0.84	0.9	1.15	1.16	1.11	1.09	1.04	1.16	1.05	1.02	1.35
2020 Q2	0.52	0.54	0.54	0.59	0.56	0.56	0.7	0.63	0.78	0.7	0.52	0.54	0.57
2020 Q3	0.38	0.38	0.38	0.37	0.4	0.4	0.37	0.37	0.39	0.38	0.38	0.61	0.38
2020 Q4	0.47	0.48	0.48	0.46	0.55	0.57	0.57	0.5	0.54	0.55	0.5	0.54	0.61
Mean RMSE	0.54	0.55	0.55	0.55	0.63	0.63	0.66	0.6	0.61	0.61	0.61	0.63	0.66

Table 25: Results of models for NOVATEK with 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
	Overnight and calendar no lags	Basic with lags	Overnight and calendar with lags	Overnight and calendar no lags	Basic with lags	Overnight and calendar with lags	Overnight and calendar no lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Overnight and calendar no lags	Basic no lags	Macroeconomic no lags
2018 Q2	0.76	0.75	0.75	0.77	0.82	0.83	0.85	0.79	0.79	0.76	0.76	0.78	0.8
2018 Q3	0.55	0.56	0.56	0.58	0.57	0.57	0.53	0.55	0.56	0.55	0.58	0.56	0.59
2018 Q4	0.52	0.51	0.51	0.53	0.54	0.53	0.58	0.52	0.52	0.53	0.65	0.64	0.57
2019 Q1	0.47	0.46	0.46	0.47	0.47	0.45	0.6	0.46	0.46	0.51	0.49	0.48	1.07
2019 Q2	0.52	0.51	0.51	0.53	0.6	0.6	0.64	0.58	0.57	0.55	0.53	0.53	0.54
2019 Q3	0.48	0.5	0.5	0.5	0.5	0.56	0.54	0.48	0.48	0.51	0.52	0.5	0.63
2019 Q4	0.43	0.47	0.47	0.47	0.47	0.5	0.6	0.47	0.47	0.48	0.44	0.98	0.82
2020 Q1	0.88	0.88	0.88	0.9	1.22	1.14	1.37	1.21	1.23	1.22	0.89	0.9	1.92
2020 Q2	0.39	0.44	0.44	0.44	1.0	1.01	0.92	0.48	0.48	0.49	0.44	0.5	0.52
2020 Q3	0.37	0.38	0.38	0.37	0.44	0.44	0.49	0.38	0.38	0.4	0.38	0.43	0.45
2020 Q4	0.44	0.44	0.44	0.44	0.51	0.54	0.48	0.48	0.5	0.46	0.51	0.47	0.51
Mean RMSE	0.53	0.54	0.54	0.54	0.65	0.65	0.69	0.58	0.59	0.59	0.56	0.62	0.76

Table 26: Results of models for ROSNEFT with 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Basic no lags	Basic with lags	Overnight and calendar with lags	Financial no lags	Overnight and calendar with lags	Basic with lags	Financial no lags	Financial no lags	Financial with lags	Spillover with lags	Overnight and calendar no lags	Basic no lags	Overnight and calendar no lags	Macroeconomic no lags
2018 Q2	0.73	0.72	0.72	0.72	0.74	0.75	0.74	0.74	0.74	0.73	0.73	0.73	0.73	0.82	
2018 Q3	0.33	0.33	0.33	0.34	0.4	0.39	0.37	0.37	0.34	0.34	0.39	0.34	0.34	0.36	
2018 Q4	0.43	0.42	0.42	0.42	0.46	0.49	0.48	0.45	0.45	0.45	0.43	0.44	0.42	0.42	
2019 Q1	0.39	0.53	0.53	0.56	0.51	0.52	0.43	0.39	0.41	0.45	0.5	0.75	0.81	0.81	
2019 Q2	0.46	0.45	0.45	0.44	0.43	0.44	0.46	0.45	0.44	0.45	0.54	0.64	8.43	8.43	
2019 Q3	0.53	0.55	0.55	0.53	0.64	0.63	0.74	0.56	0.6	0.59	0.94	0.76	0.72	0.72	
2019 Q4	0.44	0.45	0.45	0.45	0.51	0.52	0.53	0.46	0.45	0.45	0.56	0.73	0.64	0.64	
2020 Q1	0.88	0.88	0.88	0.91	1.19	1.12	0.96	1.18	1.22	1.24	0.94	1.02	1.34	1.34	
2020 Q2	0.58	0.58	0.58	0.64	0.6	0.64	0.92	0.65	0.62	0.59	0.66	0.66	1.15	1.15	
2020 Q3	0.34	0.35	0.35	0.34	0.38	0.4	0.4	0.34	0.34	0.34	0.35	0.39	0.53	0.53	
2020 Q4	0.47	0.48	0.48	0.48	0.53	0.51	0.53	0.53	0.51	0.51	0.54	0.48	0.59	0.59	
Mean RMSE	0.51	0.52	0.52	0.53	0.58	0.58	0.6	0.56	0.56	0.56	0.6	0.63	1.44	1.44	

Table 27: Results of models for NORNICKEL with 2020

Period	HAR-RV	Lasso				Random Forest			Gradient Boosting			LSTM		
		Financial no lags	Basic with lags	Overnight and calendar with lags	Financial no lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Financial no lags	Spillover no lags	Basic with lags	Basic no lags	Overnight and calendar no lags	Financial no lags
2018 Q2	0.82	0.82	0.85	0.86	0.85	0.84	0.77	0.8	0.79	0.84	0.8	0.81	0.95	0.95
2018 Q3	0.44	0.42	0.45	0.45	0.48	0.48	0.54	0.53	0.51	0.48	0.45	0.43	0.44	0.44
2018 Q4	0.38	0.39	0.38	0.39	0.45	0.44	0.48	0.39	0.43	0.41	0.41	0.45	0.4	0.4
2019 Q1	0.46	0.54	0.54	0.54	0.56	0.57	0.82	0.63	0.64	0.53	0.55	0.56	0.58	0.58
2019 Q2	0.56	0.56	0.57	0.59	0.63	0.64	0.57	0.55	0.55	0.59	0.61	0.61	0.63	0.63
2019 Q3	0.46	0.48	0.46	0.46	0.55	0.54	0.55	0.54	0.55	0.47	0.45	0.61	0.46	0.46
2019 Q4	0.61	0.65	0.6	0.61	0.62	0.64	0.71	0.65	0.65	0.62	0.64	0.62	0.77	0.77
2020 Q1	0.82	0.83	0.82	0.84	1.29	1.28	0.95	0.97	0.98	1.11	1.05	0.9	1.4	1.4
2020 Q2	0.58	0.58	0.58	0.59	0.61	0.64	0.91	0.62	0.63	0.62	0.61	0.61	0.81	0.81
2020 Q3	0.49	0.48	0.49	0.48	0.48	0.48	0.57	0.48	0.48	0.53	0.53	0.78	0.45	0.45
2020 Q4	0.47	0.47	0.47	0.47	0.52	0.53	0.54	0.47	0.47	0.49	0.47	0.53	0.54	0.54
Mean RMSE	0.55	0.57	0.57	0.57	0.64	0.64	0.68	0.6	0.61	0.61	0.6	0.63	0.67	0.67

Table 28: Results of models for POLYMETAL with 2020

Period	HAR-RV	Lasso				Random Forest			Gradient Boosting			LSTM		
		Basic no lags	Overnight and calendar with lags	Basic no lags	Basic with lags	Overnight and calendar no lags	Basic with lags	Overnight and calendar with lags	Spillover no lags	Macroeconomic no lags	Financial no lags	Basic no lags	Overnight and calendar no lags	Financial no lags
2018 Q2	0.69	0.7	0.69	0.69	0.8	0.74	0.74	0.73	0.72	0.73	0.71	0.71	0.87	0.87
2018 Q3	0.52	0.53	0.52	0.52	0.58	0.63	0.62	0.56	0.52	0.57	0.52	0.54	0.56	0.56
2018 Q4	0.48	0.47	0.61	0.48	0.53	0.53	0.52	0.51	0.5	0.5	0.55	0.48	0.57	0.57
2019 Q1	0.43	0.44	0.39	0.46	0.62	0.68	0.68	0.47	0.48	0.49	0.44	0.48	0.64	0.64
2019 Q2	0.57	0.58	0.57	0.58	0.82	0.84	0.86	0.62	0.66	0.62	0.62	0.97	7.81	7.81
2019 Q3	0.58	0.56	0.58	0.57	0.64	0.6	0.6	0.59	0.59	0.58	0.57	0.56	0.57	0.57
2019 Q4	0.39	0.4	0.4	0.4	0.43	0.44	0.44	0.41	0.42	0.43	0.43	0.44	0.46	0.46
2020 Q1	0.77	0.83	0.78	0.85	0.95	0.94	1.02	0.97	0.99	1.01	0.82	0.9	0.94	0.94
2020 Q2	0.53	0.55	0.55	0.55	0.55	0.61	0.61	0.58	0.62	0.62	0.58	0.55	0.69	0.69
2020 Q3	0.54	0.55	0.53	0.53	0.71	0.62	0.63	0.54	0.56	0.52	0.58	0.54	0.54	0.54
2020 Q4	0.57	0.56	0.57	0.56	0.61	0.63	0.58	0.55	0.54	0.56	0.64	0.65	0.62	0.62
Mean RMSE	0.55	0.56	0.56	0.56	0.66	0.66	0.66	0.59	0.6	0.6	0.59	0.62	1.3	1.3

Table 29: Results of models for POLYUS with 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM			
		Spillover no lags	Basic with lags	Financial no lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Macroeconomic no lags	Overnight and calendar no lags	Basic no lags	Basic no lags	Overnight and calendar no lags	Financial no lags	
2018 Q2	0.82	0.83	0.82	0.84	0.85	0.85	0.9	0.84	0.82	0.83	1.11	1.08	0.96	0.96
2018 Q3	0.73	0.71	0.71	0.7	0.75	0.76	0.72	0.63	0.68	0.68	0.69	0.77	0.71	0.71
2018 Q4	0.55	0.55	0.54	0.61	0.58	0.59	0.56	0.48	0.48	0.47	0.61	0.6	0.56	0.56
2019 Q1	0.62	0.62	0.63	0.61	0.7	0.74	0.71	0.39	0.38	0.37	0.65	0.74	0.68	0.68
2019 Q2	0.67	0.68	0.67	0.68	0.82	0.78	0.78	0.45	0.48	0.48	0.48	0.84	0.98	0.98
2019 Q3	0.72	0.72	0.72	0.73	0.71	0.75	0.83	0.46	0.47	0.47	0.73	0.71	0.73	0.73
2019 Q4	0.5	0.48	0.48	0.5	0.52	0.54	0.62	0.46	0.41	0.41	0.52	0.62	0.54	0.54
2020 Q1	0.72	0.76	0.77	0.77	0.88	0.89	0.71	0.72	0.68	0.72	0.72	0.84	1.36	1.36
2020 Q2	0.69	0.64	0.63	0.62	0.61	0.62	0.78	0.57	0.58	0.58	0.62	0.67	0.67	0.67
2020 Q3	0.55	0.61	0.61	0.57	0.63	0.6	0.66	0.51	0.52	0.53	0.63	0.8	0.6	0.6
2020 Q4	0.53	0.57	0.58	0.55	0.65	0.68	0.65	0.41	0.42	0.42	0.66	0.64	0.62	0.62
Mean RMSE	0.65	0.65	0.65	0.65	0.7	0.71	0.72	0.54	0.54	0.54	0.7	0.76	0.76	0.76

Table 30: Results of models for MAGNIT with 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Basic no lags	Basic with lags	Overnight and calendar with lags	Financial no lags	Basic with lags	Overnight and calendar with lags	Financial with lags	Financial no lags	Spillover no lags	Financial with lags	Basic no lags	Overnight and calendar no lags	Macroeconomic no lags	
2018 Q2	0.68	0.67	0.68	0.67	0.72	0.75	0.76	0.66	0.68	0.66	0.67	0.68	0.68		
2018 Q3	0.56	0.56	0.56	0.55	0.58	0.61	0.58	0.57	0.57	0.55	0.56	0.57	0.7		
2018 Q4	0.67	0.66	0.68	0.69	0.71	0.73	0.82	0.71	0.75	0.72	0.67	0.76	0.77		
2019 Q1	0.52	0.53	0.52	0.52	0.65	0.64	0.56	0.51	0.51	0.51	0.51	0.63	0.54		
2019 Q2	0.5	0.51	0.51	0.53	0.53	0.61	0.64	0.52	0.52	0.57	0.53	0.49	0.49		
2019 Q3	0.57	0.56	0.56	0.64	0.8	0.87	0.8	0.64	0.65	0.62	0.63	0.65	0.62		
2019 Q4	0.58	0.57	0.57	0.58	0.98	0.92	0.74	0.63	0.62	0.62	0.63	0.63	9.07		
2020 Q1	0.73	0.73	0.73	0.74	0.81	0.8	0.91	0.77	0.8	0.83	0.8	0.85	1.78		
2020 Q2	0.52	0.51	0.52	0.53	0.59	0.57	0.68	0.56	0.54	0.55	0.59	0.62	0.54		
2020 Q3	0.48	0.47	0.47	0.46	0.53	0.47	0.51	0.47	0.47	0.48	0.61	0.48	0.48		
2020 Q4	0.49	0.5	0.5	0.51	0.56	0.52	0.52	0.52	0.5	0.5	0.5	0.57	0.63		
Mean RMSE	0.57	0.57	0.57	0.58	0.68	0.68	0.68	0.6	0.6	0.6	0.61	0.63	1.48		

Table 31: Results of models for SBERBANK with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Financial no lags	Financial no lags	Spillover no lags	Basic with lags	Basic no lags	Overnight and calendar no lags	Overnight and calendar with lags	Financial with lags	Financial no lags	Spillover with lags	Overnight and calendar no lags	Basic no lags	Spillover no lags	
2018 Q2	0.7	0.69	0.68	0.7	0.81	0.81	0.82	0.82	0.82	0.83	0.83	0.74	0.79	0.76	
2018 Q3	0.55	0.57	0.58	0.58	0.62	0.62	0.63	0.6	0.59	0.6	0.59	0.63	0.6		
2018 Q4	0.45	0.44	0.45	0.45	0.51	0.51	0.54	0.48	0.46	0.49	0.48	0.49	0.59		
2019 Q1	0.35	0.35	0.36	0.35	0.43	0.43	0.45	0.35	0.38	0.36	0.4	0.43	0.41		
2019 Q2	0.46	0.46	0.48	0.48	0.5	0.51	0.54	0.46	0.46	0.46	0.45	0.46	9.19		
2019 Q3	0.44	0.52	0.52	0.51	0.5	0.52	0.51	0.47	0.47	0.47	0.45	0.61	0.6		
2019 Q4	0.38	0.38	0.38	0.39	0.5	0.5	0.43	0.41	0.41	0.41	0.42	0.39	0.83		
2020 Q3	0.48	0.48	0.48	0.48	0.55	0.56	0.56	0.5	0.48	0.49	0.49	0.48	0.57		
2020 Q4	0.43	0.43	0.43	0.41	0.44	0.43	0.46	0.41	0.41	0.41	0.46	0.47	0.59		
Mean RMSE	0.47	0.48	0.48	0.49	0.54	0.54	0.55	0.5	0.5	0.5	0.5	0.53	1.57		

Table 32: Results of models for GAZPROM with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Basic no lags	Financial no lags	Basic with lags	Financial no lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Financial no lags	Spillover no lags	Spillover with lags	Overnight and calendar no lags	Basic no lags	Financial no lags	
2018 Q2	0.68	0.67	0.67	0.68	0.71	0.74	0.72	0.69	0.68	0.7	0.83	0.72	0.75		
2018 Q3	0.41	0.4	0.42	0.41	0.44	0.44	0.43	0.42	0.41	0.39	0.43	0.41	0.43		
2018 Q4	0.5	0.49	0.51	0.53	0.52	0.53	0.56	0.52	0.52	0.51	0.67	0.67	0.67		
2019 Q1	0.36	0.37	0.35	0.37	0.41	0.43	0.4	0.38	0.38	0.37	0.35	0.43	0.43		
2019 Q2	0.91	0.92	0.91	0.91	0.9	0.88	0.89	0.92	0.91	0.93	0.91	0.91	0.96		
2019 Q3	0.55	0.55	0.55	0.55	0.56	0.57	0.64	0.53	0.55	0.55	0.62	0.55	0.62		
2019 Q4	0.56	0.55	0.55	0.56	0.63	0.65	0.63	0.55	0.56	0.59	0.58	0.76	0.58		
2020 Q3	0.38	0.38	0.4	0.39	0.42	0.41	0.46	0.4	0.38	0.38	0.41	0.46	0.74		
2020 Q4	0.45	0.45	0.45	0.44	0.52	0.51	0.51	0.45	0.45	0.47	0.54	0.46	0.74		
Mean RMSE	0.53	0.53	0.53	0.54	0.57	0.57	0.58	0.54	0.54	0.54	0.59	0.6	0.66		

Table 33: Results of models for LUKOIL with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Financial no lags	Financial no lags	Basic with lags	Financial with lags	Overnight and calendar with lags	Basic with lags	Overnight and calendar no lags	Overnight and calendar with lags	Financial no lags	Basic with lags	Basic no lags	Spillover no lags	Overnight and calendar no lags	
2018 Q2	0.74	0.74	0.72	0.74	0.79	0.83	0.76	0.77	0.77	0.77	0.79	0.77	0.76		
2018 Q3	0.39	0.4	0.42	0.41	0.46	0.47	0.43	0.42	0.39	0.42	0.42	0.4	0.5		
2018 Q4	0.44	0.44	0.46	0.45	0.5	0.49	0.51	0.44	0.44	0.44	0.6	0.45	0.44		
2019 Q1	0.37	0.38	0.38	0.39	0.52	0.5	0.55	0.38	0.39	0.38	0.44	0.66	0.46		
2019 Q2	0.56	0.56	0.59	0.58	0.62	0.63	0.68	0.57	0.59	0.56	0.69	0.64	0.61		
2019 Q3	0.59	0.59	0.6	0.59	0.66	0.65	0.64	0.62	0.64	0.62	0.64	0.65	0.63		
2019 Q4	0.63	0.63	0.62	0.61	0.72	0.7	0.75	0.7	0.79	0.7	0.71	0.74	0.82		
2020 Q3	0.39	0.37	0.38	0.38	0.4	0.4	0.39	0.38	0.36	0.39	0.38	0.38	0.61		
2020 Q4	0.47	0.46	0.48	0.47	0.55	0.57	0.54	0.55	0.51	0.54	0.5	0.61	0.54		
Mean RMSE	0.51	0.51	0.51	0.51	0.58	0.58	0.58	0.54	0.54	0.54	0.57	0.59	0.6		

Table 34: Results of models for NOVATEK with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso				Random Forest				Gradient Boosting			LSTM		
		Financial no lags	Financial no lags	Basic with lags	Overnight and calendar with lags	Basic with lags	Overnight and calendar with lags	Financial no lags	Overnight and calendar with lags	Financial no lags	Spillover no lags	Overnight and calendar no lags	Basic no lags	Financial no lags	
2018 Q2	0.76	0.77	0.75	0.75	0.82	0.83	0.82	0.79	0.79	0.76	0.76	0.78	0.81		
2018 Q3	0.55	0.55	0.56	0.56	0.57	0.57	0.56	0.55	0.56	0.55	0.58	0.56	0.63		
2018 Q4	0.51	0.52	0.51	0.51	0.54	0.53	0.54	0.52	0.51	0.53	0.65	0.64	0.58		
2019 Q1	0.47	0.47	0.46	0.46	0.47	0.45	0.56	0.46	0.46	0.51	0.49	0.48	1.1		
2019 Q2	0.51	0.51	0.51	0.51	0.6	0.6	0.57	0.58	0.57	0.55	0.53	0.53	0.62		
2019 Q3	0.5	0.5	0.5	0.5	0.5	0.56	0.71	0.48	0.48	0.51	0.52	0.5	0.51		
2019 Q4	0.4	0.45	0.47	0.47	0.47	0.5	0.64	0.47	0.47	0.48	0.44	0.98	0.58		
2020 Q3	0.37	0.38	0.38	0.38	0.44	0.44	0.42	0.38	0.38	0.4	0.38	0.43	0.47		
2020 Q4	0.43	0.43	0.44	0.44	0.51	0.54	0.45	0.5	0.5	0.46	0.51	0.47	0.49		
Mean RMSE	0.5	0.51	0.51	0.51	0.55	0.56	0.59	0.52	0.53	0.53	0.54	0.6	0.64		

Table 35: Results of models for ROSNEFT with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
		Basic no lags	Basic no lags	Overnight and calendar no lags	Macroeconomic no lags	Overnight and calendar with lags	Basic with lags	Financial no lags	Financial with lags	Financial no lags	Spillover with lags	Overnight and calendar no lags	Basic no lags
2018 Q2	0.73	0.75	0.75	0.71	0.74	0.75	0.73	0.74	0.74	0.73	0.73	0.74	0.82
2018 Q3	0.33	0.33	0.34	0.35	0.4	0.39	0.39	0.34	0.37	0.34	0.39	0.34	0.36
2018 Q4	0.43	0.42	0.42	0.43	0.46	0.49	0.47	0.45	0.45	0.45	0.43	0.44	0.42
2019 Q1	0.39	0.44	0.44	0.44	0.51	0.52	0.38	0.41	0.39	0.45	0.5	0.75	0.81
2019 Q2	0.46	0.47	0.46	0.47	0.43	0.44	0.46	0.44	0.45	0.45	0.54	0.64	8.43
2019 Q3	0.53	0.53	0.53	0.56	0.64	0.63	0.74	0.6	0.56	0.59	0.94	0.76	0.72
2019 Q4	0.44	0.44	0.45	0.45	0.51	0.52	0.59	0.45	0.46	0.45	0.56	0.73	0.64
2020 Q3	0.34	0.34	0.34	0.33	0.38	0.4	0.39	0.34	0.34	0.34	0.35	0.39	0.53
2020 Q4	0.47	0.47	0.47	0.47	0.53	0.51	0.51	0.51	0.53	0.51	0.54	0.48	0.59
Mean RMSE	0.46	0.47	0.47	0.47	0.51	0.52	0.52	0.48	0.48	0.48	0.55	0.58	1.48

Table 36: Results of models for NORNICKEL with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
		Basic no lags	Basic no lags	Financial with lags	Basic with lags	Overnight and calendar with lags	Basic with lags	Spillover no lags	Basic with lags	Overnight and calendar with lags	Financial with lags	Basic no lags	Financial no lags
2018 Q2	0.82	0.91	0.82	0.85	0.85	0.84	0.77	0.84	0.84	0.81	0.8	0.95	0.93
2018 Q3	0.44	0.46	0.42	0.45	0.48	0.48	0.54	0.48	0.47	0.47	0.45	0.44	0.48
2018 Q4	0.38	0.37	0.39	0.38	0.45	0.44	0.48	0.41	0.41	0.39	0.41	0.4	0.46
2019 Q1	0.46	0.48	0.54	0.54	0.56	0.57	0.82	0.53	0.53	0.59	0.55	0.58	0.61
2019 Q2	0.56	0.56	0.56	0.57	0.63	0.64	0.57	0.59	0.6	0.58	0.61	0.63	0.54
2019 Q3	0.46	0.44	0.48	0.46	0.55	0.54	0.55	0.47	0.47	0.52	0.45	0.46	0.48
2019 Q4	0.61	0.62	0.65	0.6	0.62	0.64	0.71	0.62	0.62	0.68	0.64	0.77	0.73
2020 Q3	0.49	0.48	0.48	0.49	0.48	0.48	0.57	0.53	0.54	0.5	0.53	0.45	0.61
2020 Q4	0.47	0.48	0.47	0.47	0.52	0.53	0.54	0.49	0.49	0.51	0.47	0.54	0.5
Mean RMSE	0.52	0.53	0.53	0.54	0.57	0.57	0.62	0.55	0.55	0.56	0.54	0.58	0.59

Table 37: Results of models for POLYMETAL with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
		Basic no lags	Overnight and calendar with lags	Basic with lags	Basic no lags	Overnight and calendar with lags	Basic with lags	Macroeconomic no lags	Macroeconomic no lags	Spillover no lags	Financial no lags	Basic no lags	Overnight and calendar no lags
2018 Q2	0.69	0.7	0.69	0.69	0.74	0.74	0.75	0.72	0.73	0.73	0.71	0.71	0.87
2018 Q3	0.52	0.53	0.52	0.52	0.62	0.63	0.64	0.52	0.56	0.57	0.52	0.54	0.56
2018 Q4	0.48	0.47	0.48	0.61	0.52	0.53	0.58	0.5	0.51	0.5	0.55	0.48	0.57
2019 Q1	0.43	0.44	0.46	0.39	0.68	0.68	0.71	0.48	0.47	0.49	0.44	0.48	0.64
2019 Q2	0.57	0.58	0.58	0.57	0.86	0.84	0.73	0.66	0.62	0.62	0.62	0.97	7.81
2019 Q3	0.58	0.56	0.57	0.58	0.6	0.6	0.65	0.59	0.59	0.58	0.57	0.56	0.57
2019 Q4	0.39	0.4	0.4	0.4	0.44	0.44	0.43	0.42	0.41	0.43	0.43	0.44	0.46
2020 Q3	0.54	0.55	0.55	0.53	0.63	0.62	0.61	0.56	0.54	0.52	0.58	0.54	0.54
2020 Q4	0.57	0.56	0.56	0.57	0.58	0.63	0.6	0.54	0.55	0.56	0.64	0.65	0.62
Mean RMSE	0.53	0.53	0.53	0.54	0.63	0.63	0.63	0.55	0.55	0.56	0.56	0.6	1.41

Table 38: Results of models for POLYUS with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
		Spillover no lags	Spillover no lags	Financial no lags	Overnight and calendar with lags	Overnight and calendar with lags	Basic with lags	Financial no lags	Macroeconomic no lags	Basic no lags	Overnight and calendar no lags	Basic no lags	Financial no lags
2018 Q2	0.82	0.81	0.82	0.84	0.85	0.85	0.88	0.84	0.83	0.82	1.11	0.96	1.27
2018 Q3	0.73	0.73	0.72	0.71	0.75	0.76	0.74	0.63	0.68	0.68	0.69	0.71	0.77
2018 Q4	0.55	0.55	0.57	0.55	0.58	0.59	0.56	0.48	0.47	0.48	0.61	0.56	0.56
2019 Q1	0.62	0.62	0.62	0.62	0.7	0.74	0.67	0.39	0.37	0.38	0.65	0.68	0.6
2019 Q2	0.67	0.7	0.67	0.68	0.82	0.78	0.76	0.45	0.48	0.48	0.72	0.98	0.91
2019 Q3	0.72	0.72	0.72	0.72	0.71	0.75	0.84	0.46	0.47	0.47	0.73	0.73	0.71
2019 Q4	0.5	0.48	0.49	0.48	0.52	0.54	0.67	0.46	0.41	0.41	0.52	0.54	0.52
2020 Q3	0.55	0.61	0.6	0.61	0.63	0.6	0.57	0.51	0.53	0.52	0.63	0.6	0.68
2020 Q4	0.53	0.54	0.55	0.57	0.65	0.68	0.65	0.41	0.42	0.42	0.66	0.62	0.66
Mean RMSE	0.63	0.64	0.64	0.64	0.69	0.7	0.71	0.51	0.52	0.52	0.7	0.71	0.74

Table 39: Results of models for MAGNIT with NO Q1 and Q2 of 2020

Period	HAR-RV	Lasso			Random Forest			Gradient Boosting			LSTM		
		Basic no lags	Basic no lags	Overnight and calendar no lags	Basic with lags	Financial with lags	Basic with lags	Financial no lags	Financial with lags	Financial no lags	Spillover no lags	Basic no lags	Overnight and calendar no lags
2018 Q2	0.68	0.68	0.68	0.67	0.76	0.72	0.78	0.66	0.66	0.68	0.67	0.68	0.68
2018 Q3	0.56	0.56	0.56	0.56	0.58	0.58	0.64	0.55	0.57	0.57	0.56	0.57	0.7
2018 Q4	0.67	0.67	0.67	0.66	0.82	0.71	0.79	0.72	0.71	0.75	0.67	0.76	0.77
2019 Q1	0.52	0.52	0.52	0.53	0.56	0.65	0.56	0.51	0.51	0.51	0.51	0.63	0.54
2019 Q2	0.5	0.5	0.5	0.51	0.64	0.53	0.6	0.57	0.52	0.52	0.53	0.49	0.49
2019 Q3	0.57	0.55	0.55	0.56	0.8	0.8	0.86	0.62	0.64	0.65	0.63	0.65	0.62
2019 Q4	0.58	0.56	0.56	0.57	0.74	0.98	0.75	0.62	0.63	0.62	0.63	0.63	9.07
2020 Q3	0.48	0.48	0.48	0.47	0.51	0.53	0.48	0.48	0.47	0.47	0.61	0.48	0.48
2020 Q4	0.49	0.49	0.49	0.5	0.52	0.56	0.61	0.5	0.52	0.5	0.5	0.57	0.63
Mean RMSE	0.56	0.56	0.56	0.56	0.66	0.67	0.67	0.58	0.58	0.59	0.59	0.61	1.55



### A4.3 Prediction-Based Importance of Variables

Table 40: Best variables, chosen by Lasso, SBERBANK

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is Friday, is after weekend
Frequently chosen	log RV S&P, log RV Brent, growth rate of export, growth rate of housing starts, RGBI

Table 41: Best variables, chosen by Lasso, GAZPROM

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is Friday, is after weekend
Frequently chosen	log RV S&P, log RV Brent, growth rate of import, growth rate of CPI, growth rate of housing starts, overnight returns

Table 42: Best variables, chosen by Lasso, LUKOIL

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is Friday, is after weekend
Frequently chosen	log RV S&P, log RV Brent, growth rate of import, growth rate of export, growth rate of housing starts, RGBI

Table 43: Best variables, chosen by Lasso, NOVATEK

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is Friday, is after weekend
Frequently chosen	Log RV S&P, log RV Brent, growth rate of import, growth rate of export, growth rate of CPI, overnight returns, RGBI

Table 44: Best variables, chosen by Lasso, ROSNEFT

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is after weekend
Frequently chosen	Log RV S&P, log RV Brent, growth rate of import, growth rate of CPI, is Friday, overnight returns, RGBI, earning price ratio

Table 45: Best variables, chosen by Lasso, NORNICKEL

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is after weekend
Frequently chosen	Log RV S&P, log RV Brent, growth rate of export, growth rate of CPI, growth rate of GDP, is Friday, overnight returns, RGBI, growth rate of earning price ratio, growth rate of housing starts

Table 46: Best variables, chosen by Lasso, POLYMETAL

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV
Frequently chosen	Log RV S&P, log RV Brent, growth rate of export, growth rate of CPI, is after weekend, is after holiday, is Friday, overnight returns, RGBI, growth rate of earning price ratio, growth rate of housing starts

Table 47: Best variables, chosen by Lasso, POLYUS

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV
Frequently chosen	Log RV S&P, log RV Brent, growth rate of export, is after holiday, is after weekend, is Friday, overnight returns, RGBI, High-Low, growth rate of housing starts

Table 48: Best variables, chosen by Lasso, MAGNIT

	Group of variables
Sustainably chosen	Log RV, log weekly RV, log monthly RV, is after weekend, is Friday
Frequently chosen	Log RV S&P, log RV Brent, growth rate of import, growth rate of GDP, overnight returns, RGBI, growth rate of earning price ratio, growth rate of dividend price ratio, growth rate of housing starts