



Volatility Clustering & Cross Correlation, which one is more informative?

--- An evidence from return of SP500 & Crude Oil

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- Data source : Bloomberg

- Sample:

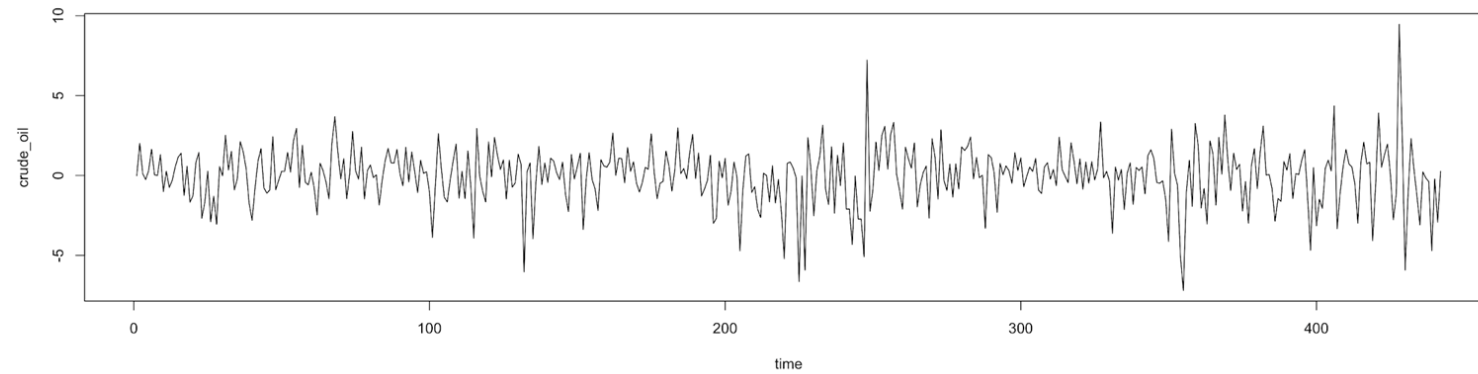
Price of oil and S&P 500 from 2 Jan 2018 to 4 Oct 2019

- Return computation:

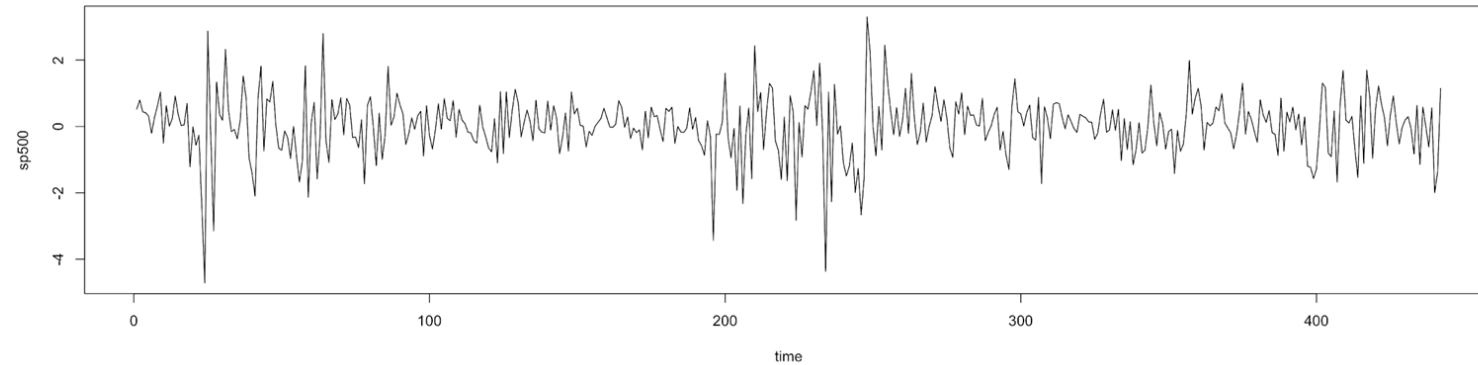
$$r_t = 100 * \ln(p_t / P_{t-1})$$

SP500 & Crude Oil

crude oil



sp500



Descriptive statistics

	Oil price	S&P 500
Mean	-0.0323	0.0190
Median	0.1532	0.0780
Min	-7.1974	-4.7165
Max	9.4633	3.3039
Standard deviation	1.8387	0.9252

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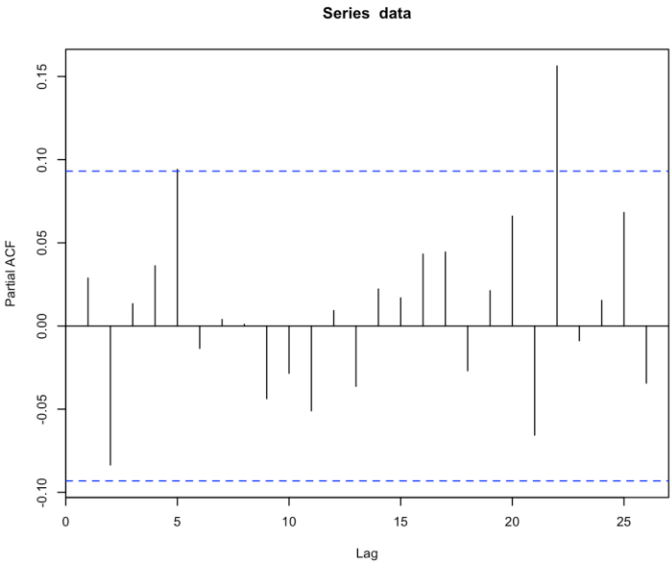
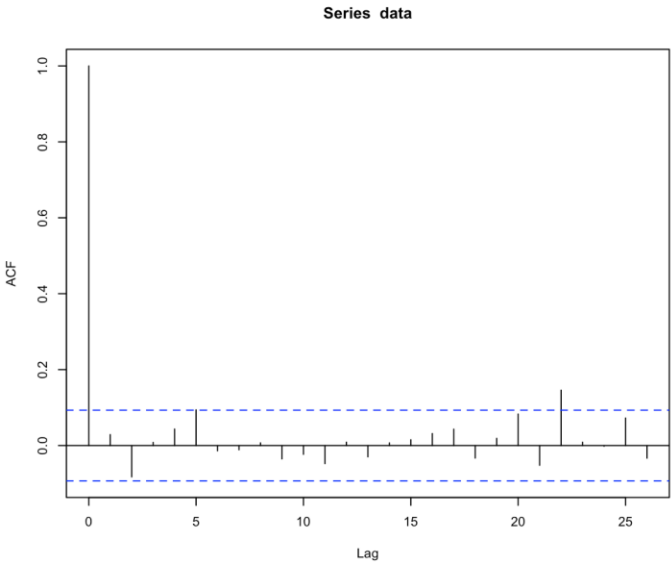
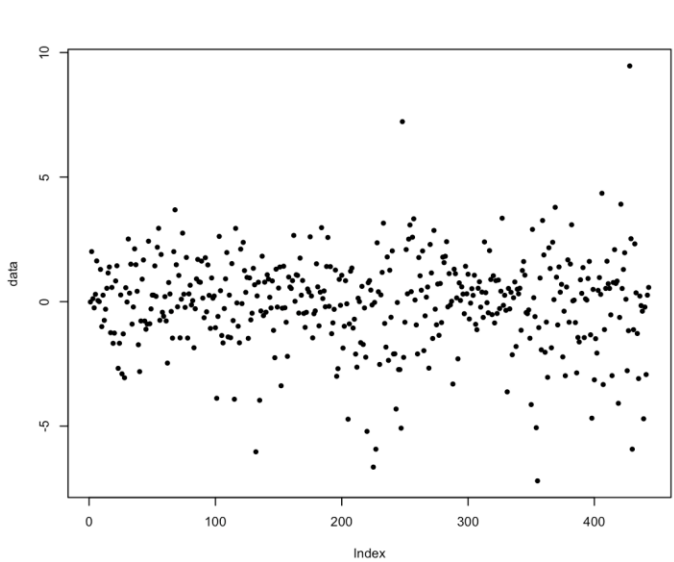
Out-of-Sample Performance



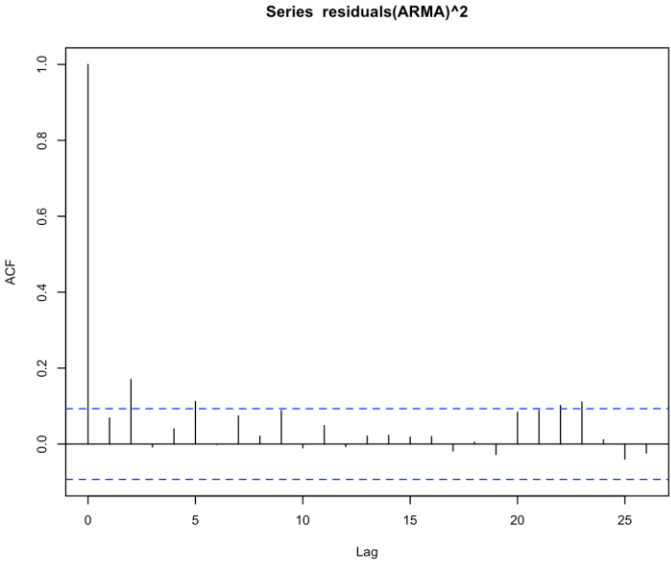
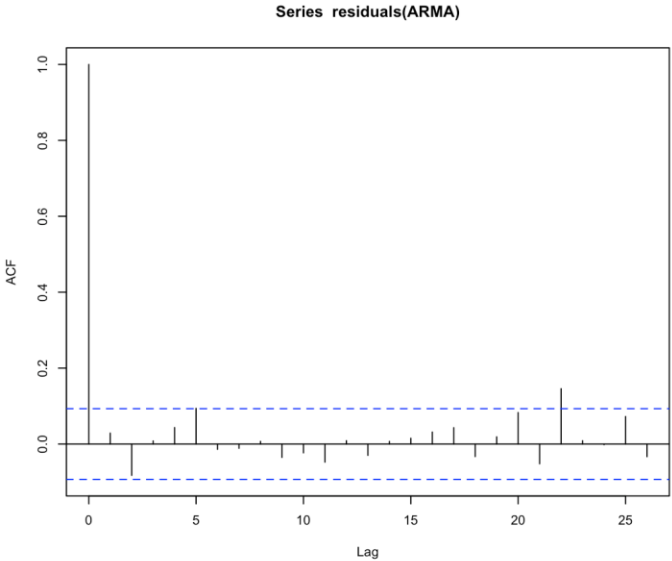
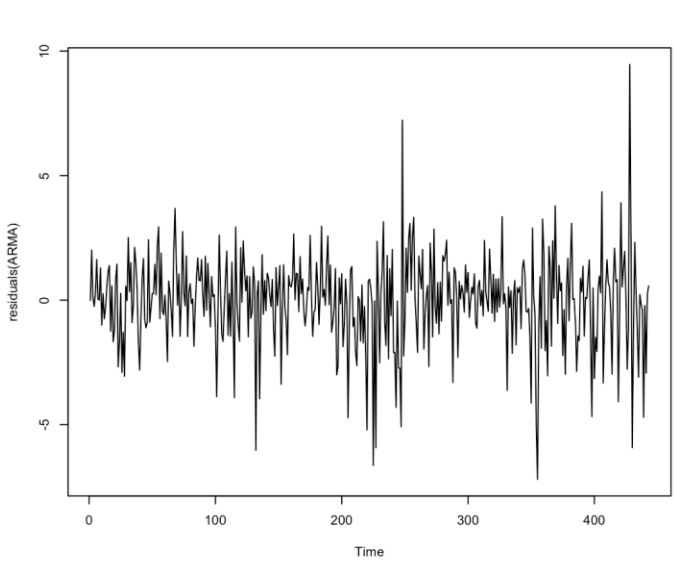
Conclusion

Crude Oil

Return



Residual
Of ARMA



Crude Oil: ARMA(0,0)/GARCH(1,1)

	Coefficient(s):			
	mu	omega	alpha1	beta1
	0.039074	0.154823	0.067359	0.890560

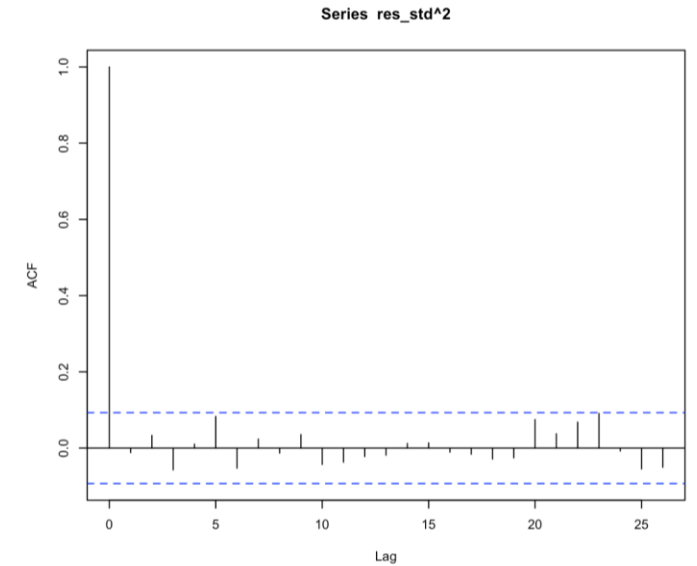
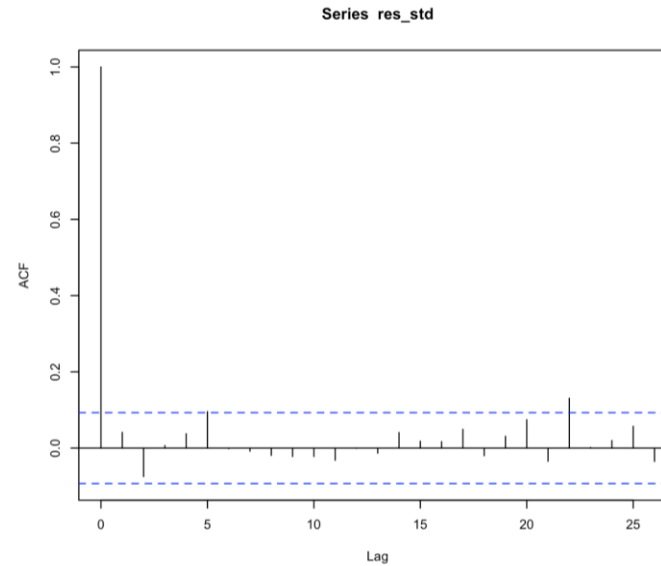
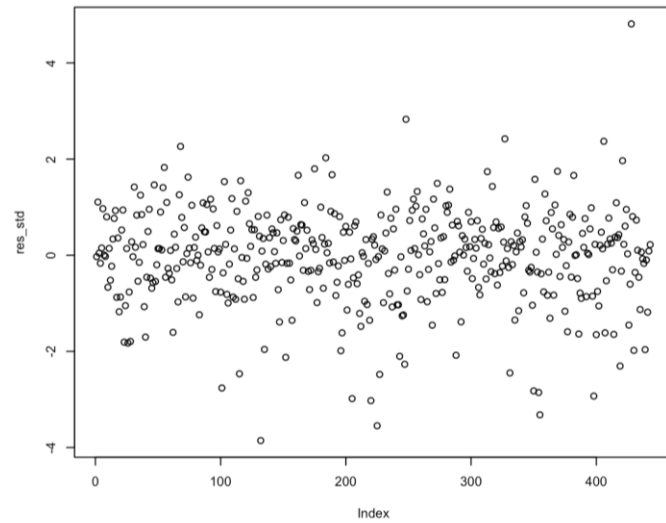
$$r_t = 0.039074 + \varepsilon_t$$

$$\varepsilon_t = \sqrt{h_t} z_t$$

$$h_t = 0.1548 + 0.0674\varepsilon_{t-1}^2 + 0.8906h_{t-1}$$

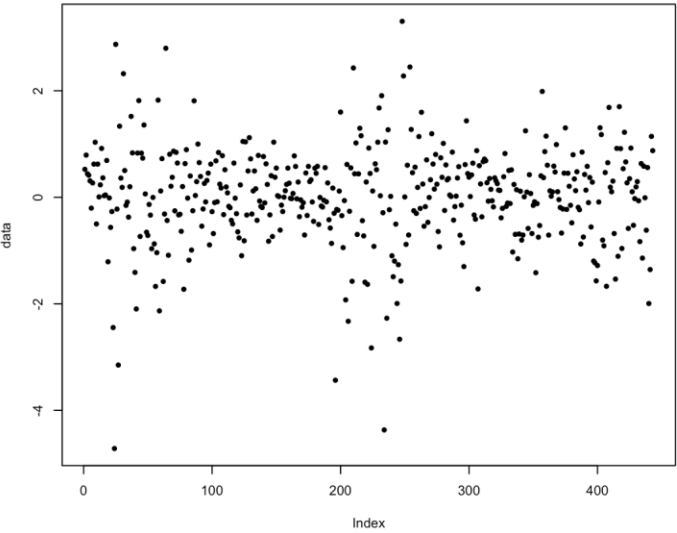
Crude Oil: ARMA(0,0)/GARCH(1,1)

Std of
ARMA/GARCH

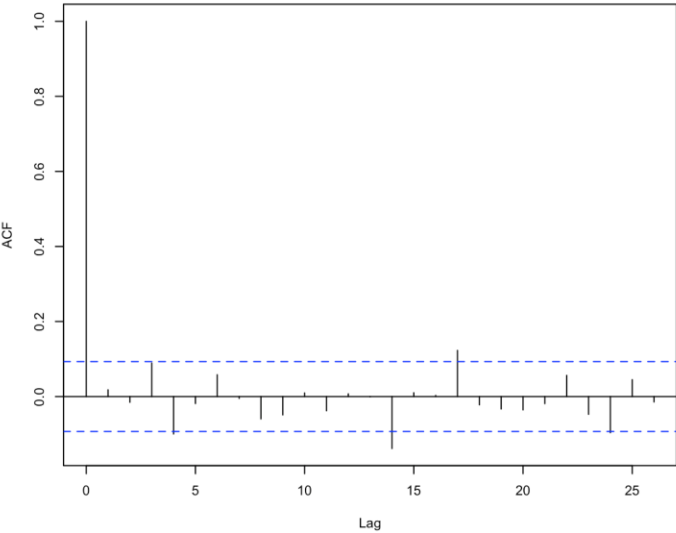


SP500

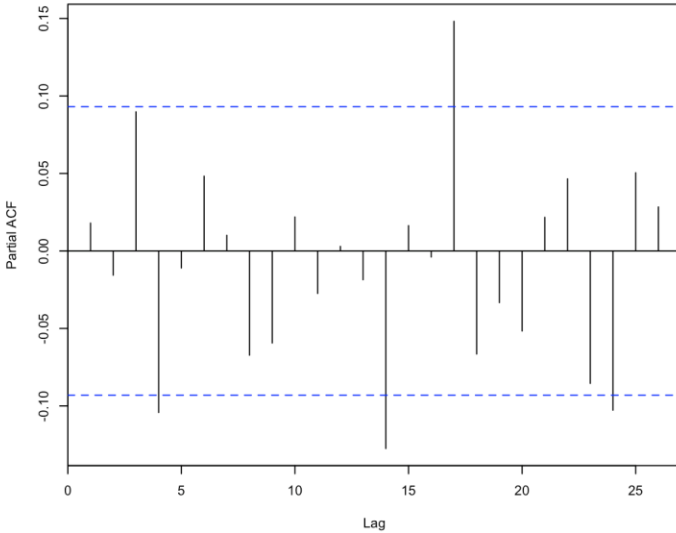
Return



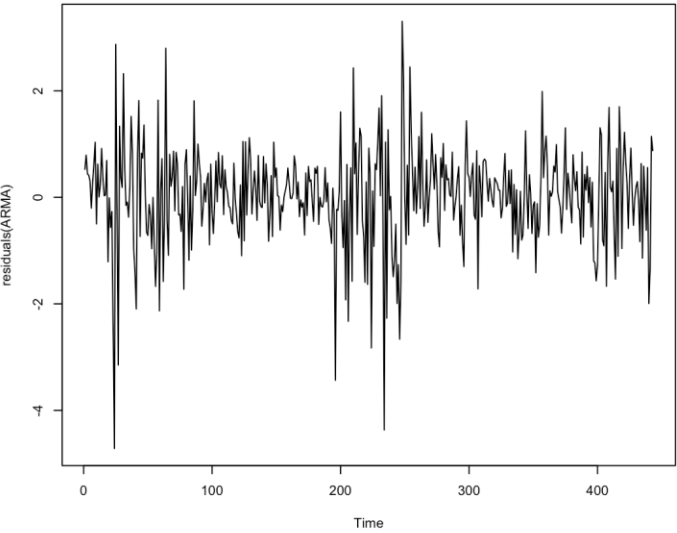
Series data



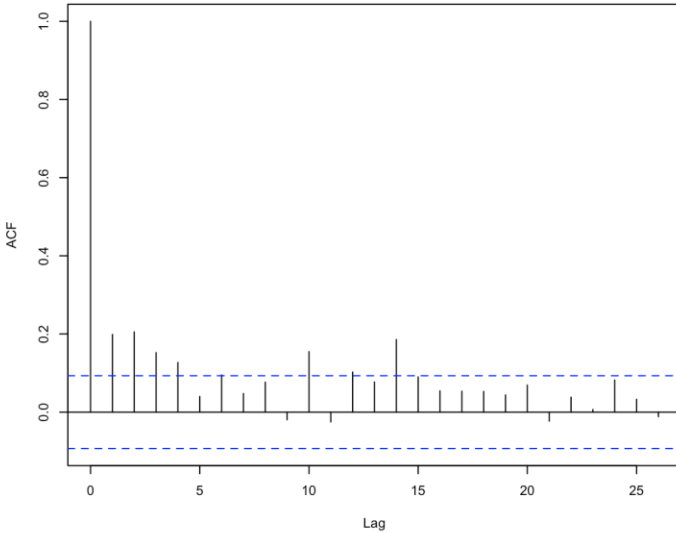
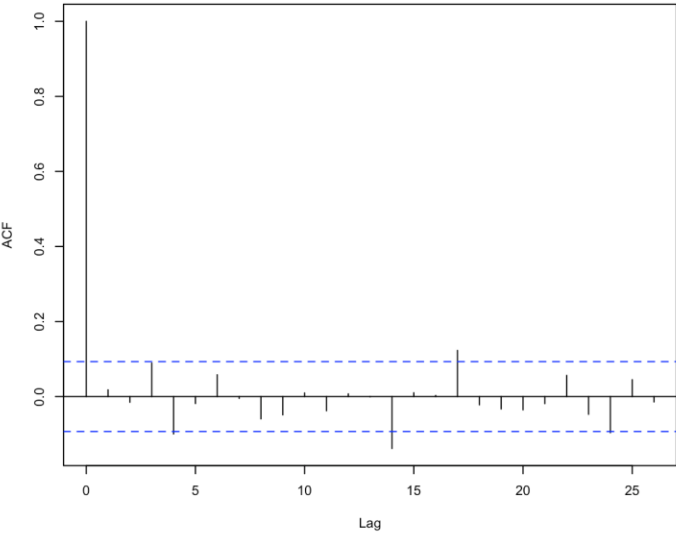
Series data



Series residuals(ARMA)



Series residuals(ARMA)^2



Residual
Of ARMA

SP500: ARMA(0,0)/GARCH(1,1)

	Coefficient(s):			
	mu	omega	alpha1	beta1
	0.091636	0.046968	0.243410	0.729714

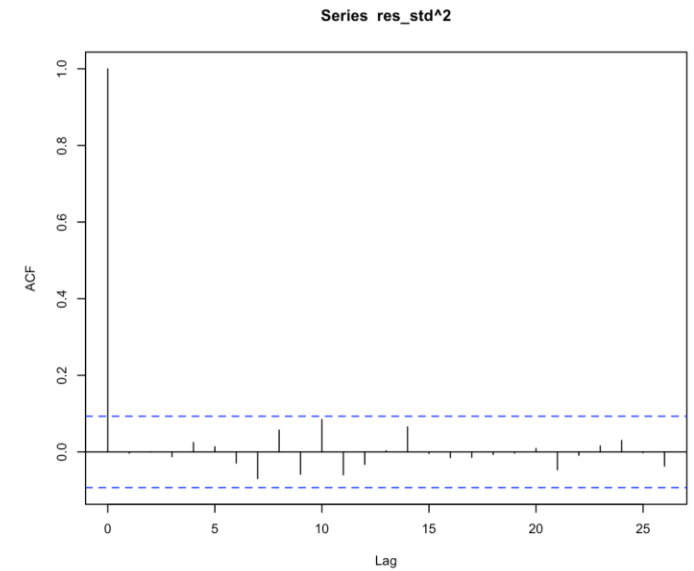
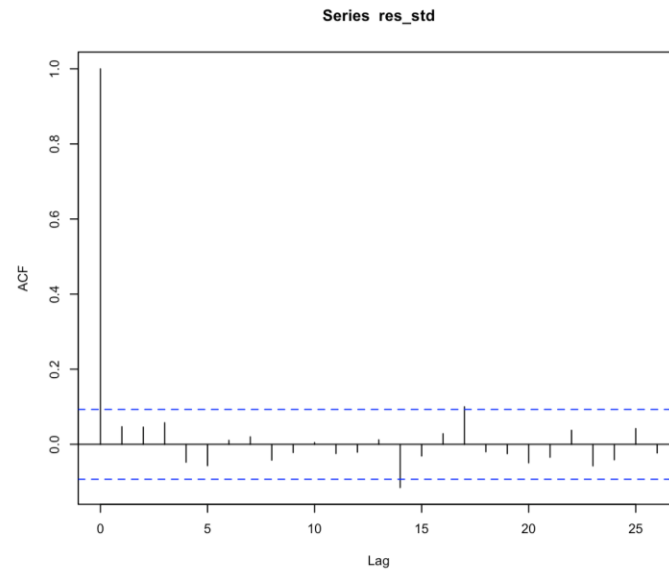
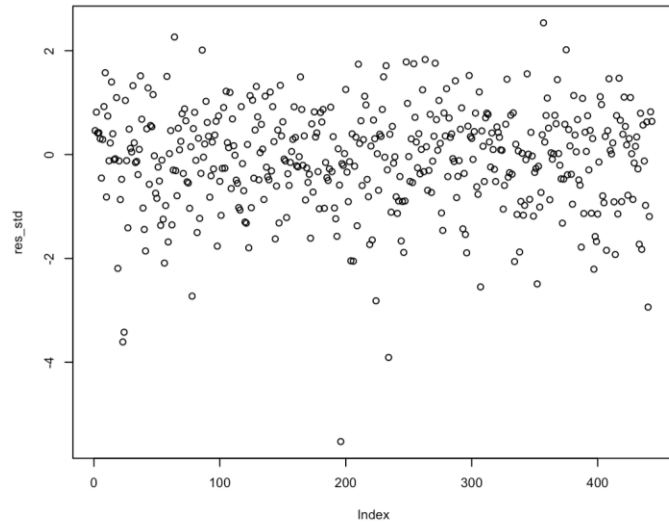
$$r_t = 0.0916 + \varepsilon_t$$

$$\varepsilon_t = \sqrt{h_t} z_t$$

$$h_t = 0.0470 + 0.2434\varepsilon_{t-1}^2 + 0.7297h_{t-1}$$

SP500: ARMA(0,0)/GARCH(1,1)

Std of
ARMA/GARCH



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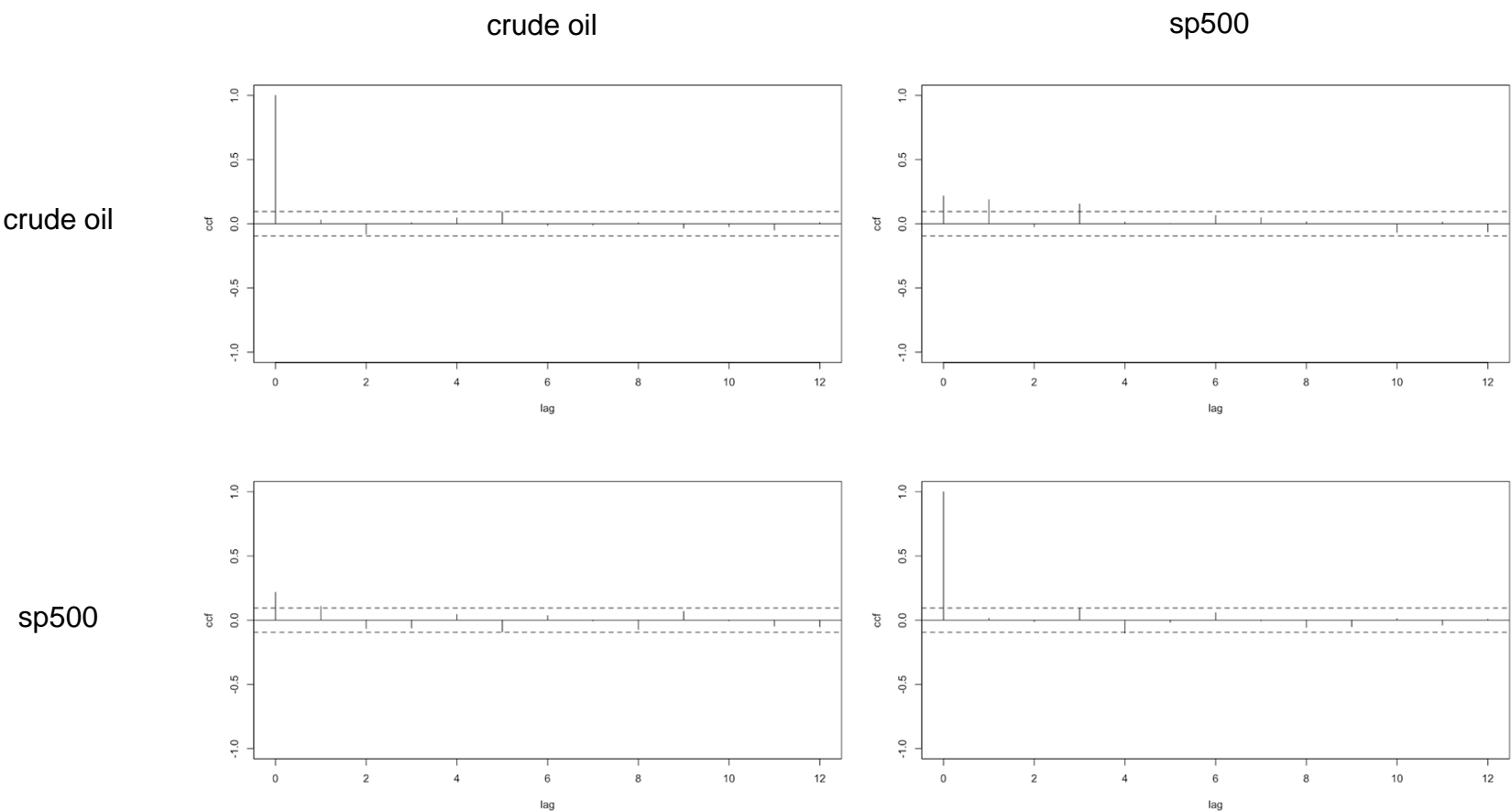


Out-of-Sample Performance



Conclusion

Cross-correlation Matrix



Cross-correlation Matrix

Lag 1			Lag 2			Lag 3			Lag 4			Lag 5	
.	+		.	.		.	+	
+	-		.	.

Choose order 3 for VAR

selected order: aic = 5

selected order: bic = 0

selected order: hq = 1

Summary table:

	p	AIC	BIC	HQ	M(p)	p-value
[1,]	0	1.0542	1.0542	1.0542	0.0000	0.0000
[2,]	1	1.0220	1.0591	1.0366	21.3799	0.0003
[3,]	2	1.0257	1.0997	1.0549	6.1223	0.1902
[4,]	3	0.9966	1.1077	1.0404	19.8817	0.0005
[5,]	4	0.9971	1.1452	1.0555	7.4039	0.1160
[6,]	5	0.9904	1.1755	1.0634	10.3508	0.0349
[7,]	6	1.0017	1.2239	1.0893	2.8030	0.5913
[8,]	7	1.0147	1.2739	1.1169	2.1309	0.7117
[9,]	8	1.0272	1.3234	1.1441	2.2824	0.6840
[10,]	9	1.0329	1.3662	1.1644	5.0755	0.2796
[11,]	10	1.0473	1.4175	1.1933	1.5369	0.8201
[12,]	11	1.0613	1.4685	1.2219	1.6591	0.7981
[13,]	12	1.0701	1.5144	1.2453	3.7396	0.4424
[14,]	13	1.0774	1.5587	1.2672	4.3495	0.3608

Fitted Model

The unconstrained fitted VAR(3)

$$y_t = \begin{bmatrix} -0.06 \\ 0.01 \end{bmatrix} + \begin{bmatrix} -0.01 & 0.41 \\ 0.05 & -0.00 \end{bmatrix} y_{t-1} - \begin{bmatrix} -0.14 & 0 \\ -0.04 & -0.01 \end{bmatrix} y_{t-2} + \begin{bmatrix} -0.02 & 0.37 \\ -0.04 & 0.13 \end{bmatrix} y_{t-3}$$

The simplified VAR(3)

$$y_t = \begin{bmatrix} 0.00 & 0.41 \\ 0.06 & 0.00 \end{bmatrix} y_{t-1} - \begin{bmatrix} -0.14 & 0 \\ 0 & 0 \end{bmatrix} y_{t-2} + \begin{bmatrix} 0 & 0.37 \\ 0 & 0.10 \end{bmatrix} y_{t-3}$$

Fitted Model

$$Oil_t = 0.41 * SP500_{t-1} - 0.14 * Oil_{t-2} + 0.37 * SP500_{t-3}$$

$$SP500_t = 0.06 * Oil_{t-1} + 0.10 * SP500_{t-3}$$

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Out-of-Sample Performance: Crude Oil

Period	1	2	3	4	5	6	7	8	RMSE
Real Value	0.570	0.773	-0.773	0.034	2.535	1.930	-2.317	-0.677	----
ARMA Prediction	1.835	1.835	1.835	1.835	1.835	1.835	1.835	1.835	2.1454
ARMA/GARCH Prediction	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	1.4726
VAR Prediction	-0.173	0.298	0.382	-0.036	-0.013	0.043	0.010	-0.002	1.5017

Out-of-Sample Performance: SP500

Period	1	2	3	4	5	6	7	8	RMSE
Real Value	0.876	-0.813	-0.319	0.256	1.514	0.092	0.263	0.539	----
ARMA Prediction	0.924	0.924	0.924	0.924	0.924	0.924	0.924	0.924	0.9108
ARMA/GARCH Prediction	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.6965
VAR Prediction	-0.095	0.097	0.098	0.012	0.007	0.008	0.004	0.001	0.7615

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Conclusion

- In our case, volatility clustering is more informative than cross correlation
- There is no theoretical guarantee for our findings
- Volatility clustering and cross correlation do NOT conflict with each other

Can we combine VAR & GARCH effect together?

Thank you!