

# Exploratory Data Analysis — VLO Next-Day Direction

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Dataset: Engineered features joined across VLO, PSX, MPC, ^GSPC, CL=F, GC=F, ^VIX.  
This report includes schema, missing values, numeric summaries, and univariate feature analyses.  
Also includes target comparisons for: y, vlo\_next\_dir, vlo\_next\_ret.  
NEW: Includes numeric stats + tests for vlo\_next\_dir (positive vs negative) on vlo\_next\_ret.

# Schema: dtypes, Non-Null Counts, Missing Ratios (page 1/2)

column	dtype	non_null	nulls	null_ratio
ret_VLO	float64	3160	0	0.0%
ret_PSX	float64	3160	0	0.0%
ret_MPC	float64	3160	0	0.0%
ret_^GSPC	float64	3160	0	0.0%
ret_CL=F	float64	3160	0	0.0%
ret_GC=F	float64	3160	0	0.0%
ret_^VIX	float64	3160	0	0.0%
ret2_VLO	float64	3160	0	0.0%
ret2_PSX	float64	3160	0	0.0%
ret2_MPC	float64	3160	0	0.0%
ret2_^GSPC	float64	3160	0	0.0%
ret2_CL=F	float64	3160	0	0.0%
ret2_GC=F	float64	3160	0	0.0%
ret2_^VIX	float64	3160	0	0.0%
PX_VLO	float64	3160	0	0.0%
PX_PSX	float64	3160	0	0.0%
PX_MPC	float64	3160	0	0.0%
PX_^GSPC	float64	3160	0	0.0%
PX_CL=F	float64	3160	0	0.0%
PX_GC=F	float64	3160	0	0.0%
PX_^VIX	float64	3160	0	0.0%
PXlag1_VLO	float64	3160	0	0.0%
PXlag1_PSX	float64	3160	0	0.0%
PXlag1_MPC	float64	3160	0	0.0%
PXlag1_^GSPC	float64	3160	0	0.0%
PXlag1_CL=F	float64	3160	0	0.0%
PXlag1_GC=F	float64	3160	0	0.0%
PXlag1_^VIX	float64	3160	0	0.0%
PXlag2_VLO	float64	3160	0	0.0%
PXlag2_PSX	float64	3160	0	0.0%
PXlag2_MPC	float64	3160	0	0.0%
PXlag2_^GSPC	float64	3160	0	0.0%
PXlag2_CL=F	float64	3160	0	0.0%
PXlag2_GC=F	float64	3160	0	0.0%
PXlag2_^VIX	float64	3160	0	0.0%
VOL_VLO	int64	3160	0	0.0%
VOL_PSX	int64	3160	0	0.0%
VOL_MPC	int64	3160	0	0.0%
VOL_^GSPC	int64	3160	0	0.0%
VOL_CL=F	int64	3160	0	0.0%
VOL_GC=F	int64	3160	0	0.0%
VOL_^VIX	int64	3160	0	0.0%
HL_VLO	float64	3160	0	0.0%
OC_VLO	float64	3160	0	0.0%
HL_PSX	float64	3160	0	0.0%

# Schema: dtypes, Non-Null Counts, Missing Ratios (page 2/2)

column	dtype	non_null	nulls	null_ratio
OC_PSX	float64	3160	0	0.0%
HL_MPC	float64	3160	0	0.0%
OC_MPC	float64	3160	0	0.0%
HL_^GSPC	float64	3160	0	0.0%
OC_^GSPC	float64	3160	0	0.0%
HL_CL=F	float64	3160	0	0.0%
OC_CL=F	float64	3160	0	0.0%
HL_GC=F	float64	3160	0	0.0%
OC_GC=F	float64	3160	0	0.0%
HL_^VIX	float64	3160	0	0.0%
OC_^VIX	float64	3160	0	0.0%
garch_var_1d	float64	3160	0	0.0%
garch_vol_1d	float64	3160	0	0.0%
garch_vol_z	float64	3160	0	0.0%
garch_vol_chg	float64	3160	0	0.0%
PR_has_release	int64	3160	0	0.0%
PR_has_oil	int64	3160	0	0.0%
PR_has_petroleum	int64	3160	0	0.0%
PR_has_market_stability	int64	3160	0	0.0%
vlo_next_ret	float64	3160	0	0.0%
vlo_next_dir	object	3160	0	0.0%
y	int64	3160	0	0.0%
EquityDown_OilDown	int64	3160	0	0.0%
RiskOff	int64	3160	0	0.0%
HighVIX	int64	3160	0	0.0%
VLO_vol5	float64	3160	0	0.0%
VLO_vol10	float64	3160	0	0.0%
VLO_vol20	float64	3160	0	0.0%
VLO_vol_ratio_5_20	float64	3160	0	0.0%
OilShock	int64	3160	0	0.0%
GoldShock	int64	3160	0	0.0%
VLO_minus_SPX	float64	3160	0	0.0%
RefinerPeerAvg	float64	3160	0	0.0%
VLO_minus_Peers	float64	3160	0	0.0%
Oil_minus_SPX	float64	3160	0	0.0%
Oil_minus_Refiners	float64	3160	0	0.0%
VLO_mom3	float64	3160	0	0.0%
VLO_mom5	float64	3160	0	0.0%
VLO_ret5_avg	float64	3160	0	0.0%
VLO_reversal_signal	float64	3160	0	0.0%
VLO_zscore20	float64	3160	0	0.0%
SPX_zscore20	float64	3160	0	0.0%
Oil_zscore20	float64	3160	0	0.0%

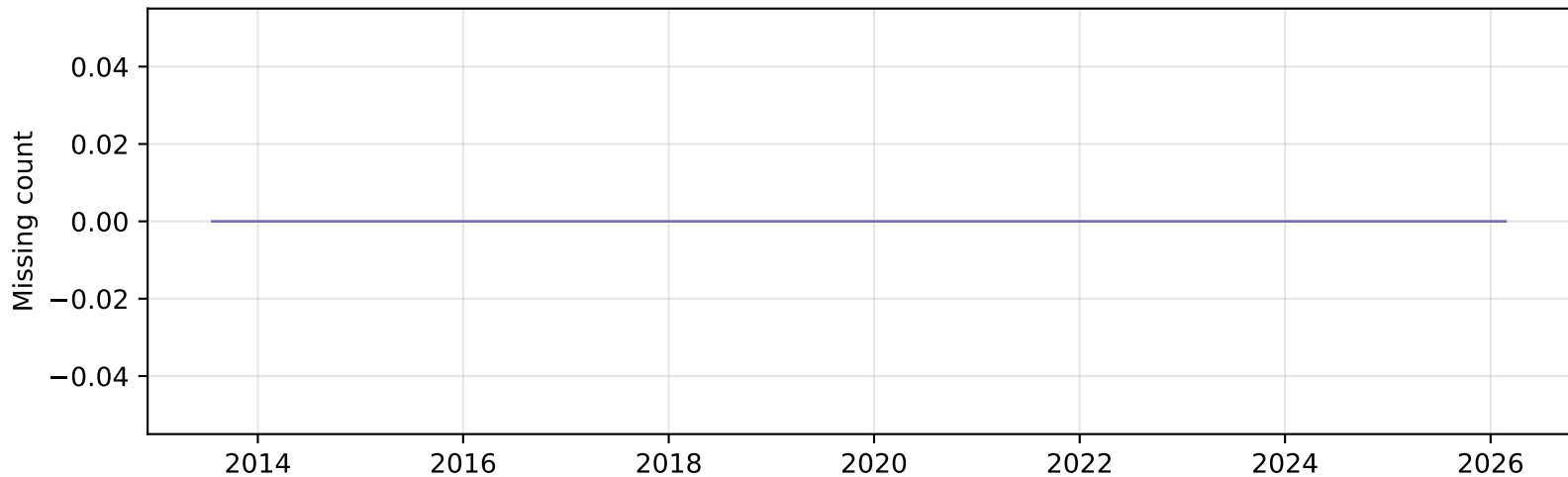
# Missing Values Summary (by Column) (page 1/2)

column	nulls	null_ratio_%
ret_VLO	0	0.0
ret_PSX	0	0.0
ret_MPC	0	0.0
ret_^GSPC	0	0.0
ret_CL=F	0	0.0
ret_GC=F	0	0.0
ret_^VIX	0	0.0
ret2_VLO	0	0.0
ret2_PSX	0	0.0
ret2_MPC	0	0.0
ret2_^GSPC	0	0.0
ret2_CL=F	0	0.0
ret2_GC=F	0	0.0
ret2_^VIX	0	0.0
PX_VLO	0	0.0
PX_PSX	0	0.0
PX_MPC	0	0.0
PX_^GSPC	0	0.0
PX_CL=F	0	0.0
PX_GC=F	0	0.0
PX_^VIX	0	0.0
PXlag1_VLO	0	0.0
PXlag1_PSX	0	0.0
PXlag1_MPC	0	0.0
PXlag1_^GSPC	0	0.0
PXlag1_CL=F	0	0.0
PXlag1_GC=F	0	0.0
PXlag1_^VIX	0	0.0
PXlag2_VLO	0	0.0
PXlag2_PSX	0	0.0
PXlag2_MPC	0	0.0
PXlag2_^GSPC	0	0.0
PXlag2_CL=F	0	0.0
PXlag2_GC=F	0	0.0
PXlag2_^VIX	0	0.0
VOL_VLO	0	0.0
VOL_PSX	0	0.0
VOL_MPC	0	0.0
VOL_^GSPC	0	0.0
VOL_CL=F	0	0.0
VOL_GC=F	0	0.0
VOL_^VIX	0	0.0
HL_VLO	0	0.0
OC_VLO	0	0.0
HL_PSX	0	0.0
OC_PSX	0	0.0
HL_MPC	0	0.0
OC_MPC	0	0.0
HL_^GSPC	0	0.0
OC_^GSPC	0	0.0

## Missing Values Summary (by Column) (page 2/2)

column	nulls	null_ratio_%
HL_CL=F	0	0.0
OC_CL=F	0	0.0
HL_GC=F	0	0.0
OC_GC=F	0	0.0
HL_^VIX	0	0.0
OC_^VIX	0	0.0
garch_var_1d	0	0.0
garch_vol_1d	0	0.0
garch_vol_z	0	0.0
garch_vol_chg	0	0.0
PR_has_release	0	0.0
PR_has_oil	0	0.0
PR_has_petroleum	0	0.0
PR_has_market_stability	0	0.0
vlo_next_ret	0	0.0
vlo_next_dir	0	0.0
y	0	0.0
EquityDown_OilDown	0	0.0
RiskOff	0	0.0
HighVIX	0	0.0
VLO_vol5	0	0.0
VLO_vol10	0	0.0
VLO_vol20	0	0.0
VLO_vol_ratio_5_20	0	0.0
OilShock	0	0.0
GoldShock	0	0.0
VLO_minus_SPX	0	0.0
RefinerPeerAvg	0	0.0
VLO_minus_Peers	0	0.0
Oil_minus_SPX	0	0.0
Oil_minus_Refiners	0	0.0
VLO_mom3	0	0.0
VLO_mom5	0	0.0
VLO_ret5_avg	0	0.0
VLO_reversal_signal	0	0.0
VLO_zscore20	0	0.0
SPX_zscore20	0	0.0
Oil_zscore20	0	0.0

Total Missing Values per Date



feature	count	mean	std	min	max
ret_VLO	3160.0	0.000707	0.024201	-0.213452	0.271572
ret_PSX	3160.0	0.000464	0.021164	-0.172757	0.200262
ret_MPC	3160.0	0.000669	0.024757	-0.314833	0.187546
ret_^GSPC	3160.0	0.000451	0.010837	-0.127652	0.090895
ret_CL=F	3160.0	-5.9e-05	0.026577	-0.282206	0.22394
ret_GC=F	3160.0	0.000421	0.010126	-0.120657	0.059054
ret_^VIX	3160.0	8.4e-05	0.079315	-0.442449	0.768245
ret2_VLO	3160.0	0.000667	0.024077	-0.213452	0.271572
ret2_PSX	3160.0	0.000427	0.021086	-0.172757	0.200262
ret2_MPC	3160.0	0.000642	0.024628	-0.314833	0.187546
ret2_^GSPC	3160.0	0.000449	0.010832	-0.127652	0.090895
ret2_CL=F	3160.0	6.6e-05	0.027137	-0.282206	0.319634
ret2_GC=F	3160.0	0.00044	0.010138	-0.120657	0.059054
ret2_^VIX	3160.0	8.4e-05	0.079397	-0.442449	0.768245
PX_VLO	3160.0	75.010944	40.770213	21.308798	203.919998
PX_PSX	3160.0	76.996818	28.233334	33.187241	162.348068
PX_MPC	3160.0	71.577753	50.61932	13.853654	210.061356
PX_^GSPC	3160.0	3451.528882	1409.524321	1630.47998	6978.600098
PX_CL=F	3160.0	66.147275	19.714935	12.34	123.699997
PX_GC=F	3160.0	1747.636391	720.541421	1050.800049	5318.399902
PX_^VIX	3160.0	17.823842	6.802863	9.14	82.690002
PXlag1_VLO	3160.0	74.954656	40.723158	21.308798	203.919998
PXlag1_PSX	3160.0	76.958778	28.208459	33.187241	162.348068
PXlag1_MPC	3160.0	71.523946	50.580555	13.853654	210.061356
PXlag1_^GSPC	3160.0	3449.873844	1408.592641	1630.47998	6978.600098
PXlag1_CL=F	3160.0	66.158551	19.731947	12.34	123.699997
PXlag1_GC=F	3160.0	1746.431137	717.955449	1050.800049	5318.399902
PXlag1_^VIX	3160.0	17.822956	6.806723	9.14	82.690002
PXlag2_VLO	3160.0	74.89954	40.671459	21.308798	203.919998
PXlag2_PSX	3160.0	76.922661	28.18151	33.187241	162.348068
PXlag2_MPC	3160.0	71.469806	50.538042	13.853654	210.061356
PXlag2_^GSPC	3160.0	3448.212578	1407.599571	1630.47998	6978.600098
PXlag2_CL=F	3160.0	66.168377	19.753986	10.01	123.699997
PXlag2_GC=F	3160.0	1745.223289	715.568699	1050.800049	5318.399902
PXlag2_^VIX	3160.0	17.822718	6.813435	9.14	82.690002

# Numeric Summary: count / mean / std / min / max (page 2/3)

feature	count	mean	std	min	max
VOL_VLO	3160.0	4654530.949367	2437751.840858	559800.0	44023700.0
VOL_PSX	3160.0	3120971.803797	1429978.904441	605700.0	16579800.0
VOL_MPC	3160.0	5357703.101266	3041689.158129	957900.0	39153800.0
VOL_^GSPC	3160.0	4030119797.468354	1018447699.572028	0.0	9976520000.0
VOL_CL=F	3160.0	419899.212975	210812.758627	0.0	1774383.0
VOL_GC=F	3160.0	5116.860127	27804.482047	0.0	386334.0
VOL_^VIX	3160.0	0.0	0.0	0.0	0.0
HL_VLO	3160.0	2.640693	1.712072	0.359997	15.729996
OC_VLO	3160.0	-0.00862	1.858977	-12.120003	12.120003
HL_PSX	3160.0	2.308592	1.267486	0.409996	14.799995
OC_PSX	3160.0	-0.011861	1.55163	-10.279999	11.529999
HL_MPC	3160.0	2.297778	1.69295	0.344997	17.680008
OC_MPC	3160.0	0.007199	1.68605	-12.770004	15.790001
HL_^GSPC	3160.0	37.471225	32.326241	3.699951	532.909668
OC_^GSPC	3160.0	0.583758	31.649378	-218.060059	491.620117
HL_CL=F	3160.0	2.111946	1.351719	0.48	23.209999
OC_CL=F	3160.0	-0.034291	1.452904	-15.960007	7.720001
HL_GC=F	3160.0	18.590887	26.585181	0.0	740.5
OC_GC=F	3160.0	0.298289	22.454498	-662.5	223.700195
HL_^VIX	3160.0	2.021025	2.24532	0.240001	42.340004
OC_^VIX	3160.0	-0.152139	1.697667	-17.360001	24.860001
garch_var_1d	3160.0	0.000605	0.000986	7.1e-05	0.014426
garch_vol_1d	3160.0	0.022266	0.01043	0.008437	0.120107
garch_vol_z	3160.0	-0.025854	1.391525	-2.833562	13.110841
garch_vol_chg	3160.0	-1e-06	0.002467	-0.030706	0.080193
PR_has_release	3160.0	0.1	0.300047	0.0	1.0
PR_has_oil	3160.0	0.032595	0.177602	0.0	1.0
PR_has_petroleum	3160.0	0.038924	0.193445	0.0	1.0
PR_has_market_stability	3160.0	0.006646	0.081262	0.0	1.0
vlo_next_ret	3160.0	0.000688	0.024201	-0.213452	0.271572
EquityDown_OilDown	3160.0	0.253165	0.434893	0.0	1.0
RiskOff	3160.0	0.186076	0.38923	0.0	1.0
HighVIX	3160.0	0.356329	0.47899	0.0	1.0
VLO_vol5	3160.0	0.020076	0.013597	0.001679	0.14472
VLO_vol10	3160.0	0.020858	0.012201	0.003353	0.131768



feature	count	mean	std	min	max
VLO_vol20	3160.0	0.02137	0.011209	0.005059	0.109765
VLO_vol_ratio_5_20	3160.0	0.940831	0.34507	0.118163	2.002188
OilShock	3160.0	0.056962	0.231807	0.0	1.0
GoldShock	3160.0	0.061392	0.240087	0.0	1.0
VLO_minus_SPX	3160.0	0.000256	0.020936	-0.140149	0.25994
RefinerPeerAvg	3160.0	0.000567	0.021819	-0.243795	0.172114
VLO_minus_Peers	3160.0	0.00014	0.011157	-0.058135	0.099458
Oil_minus_SPX	3160.0	-0.00051	0.026177	-0.296403	0.233195
Oil_minus_Refiners	3160.0	-0.000626	0.027626	-0.318885	0.240933
VLO_mom3	3160.0	0.002144	0.041515	-0.354101	0.334982
VLO_mom5	3160.0	0.003567	0.053694	-0.440812	0.369257
VLO_ret5_avg	3160.0	0.000713	0.010739	-0.088162	0.073851
VLO_reversal_signal	3160.0	-0.000713	0.010739	-0.073851	0.088162
VLO_zscore20	3160.0	-0.00983	0.981397	-3.910115	3.829064
SPX_zscore20	3160.0	-0.038898	0.990889	-3.779699	3.370961
Oil_zscore20	3160.0	-0.020401	0.981474	-3.749012	3.594037

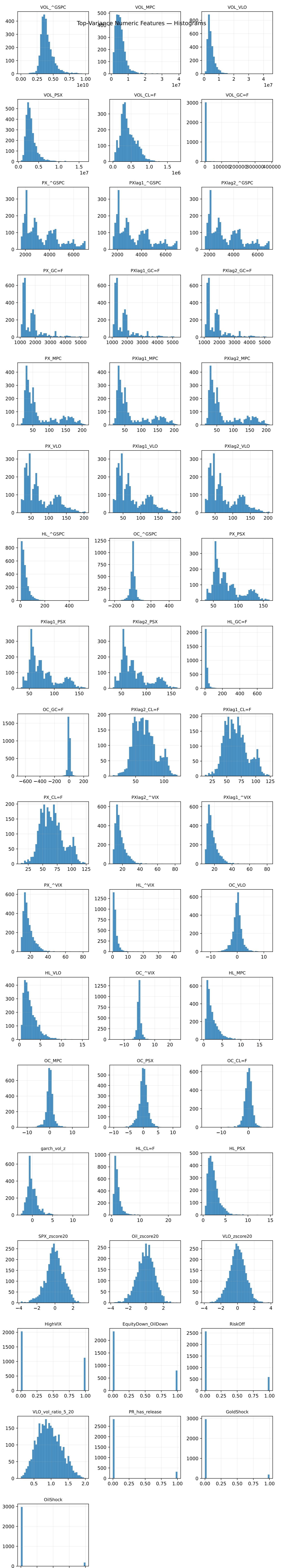
# Numeric Percentile Distribution: 1% / 5% / 25% / 50% / 75% / 95% / 99% (page 1/3)

feature	1%	5%	25%	50%	75%	95%	99%
ret_VLO	-0.065029	-0.035722	-0.010616	0.001061	0.012676	0.035546	0.059698
ret_PSX	-0.060259	-0.032251	-0.009138	0.000885	0.010744	0.030975	0.052566
ret_MPC	-0.064718	-0.036574	-0.011229	0.001722	0.012975	0.035655	0.061818
ret_^GSPC	-0.031768	-0.016147	-0.003703	0.00069	0.005572	0.01502	0.025142
ret_CL=F	-0.071358	-0.038526	-0.012538	0.000859	0.012774	0.034124	0.062496
ret_GC=F	-0.026624	-0.016005	-0.004404	0.000399	0.005649	0.015978	0.027099
ret_^VIX	-0.180907	-0.111718	-0.043497	-0.006587	0.035755	0.129136	0.243336
ret2_VLO	-0.065029	-0.035722	-0.010613	0.001061	0.012646	0.035336	0.059489
ret2_PSX	-0.060259	-0.032251	-0.009148	0.000885	0.010744	0.03093	0.051563
ret2_MPC	-0.064718	-0.036574	-0.011205	0.001733	0.012978	0.035655	0.059856
ret2_^GSPC	-0.031768	-0.016147	-0.003703	0.00069	0.005567	0.01502	0.024878
ret2_CL=F	-0.069992	-0.038493	-0.012459	0.000894	0.012824	0.034372	0.06428
ret2_GC=F	-0.026624	-0.015998	-0.004398	0.000401	0.005698	0.015994	0.027528
ret2_^VIX	-0.180907	-0.111718	-0.043488	-0.006679	0.035726	0.129354	0.243336
PX_VLO	22.454601	30.701901	42.313719	62.597126	108.836214	152.858454	179.493162
PX_PSX	37.516724	44.85585	55.43374	69.25106	90.600883	133.757323	148.357871
PX_MPC	22.092858	25.668025	33.833302	49.145002	105.251341	173.333144	194.493421
PX_^GSPC	1689.930188	1848.322485	2163.225037	2970.940063	4378.872559	6238.297266	6888.28314
PX_CL=F	25.2613	38.557001	51.147501	63.885	78.260002	103.091497	110.3956
PX_GC=F	1079.816039	1160.074976	1265.574982	1498.549988	1918.625	3348.044995	4482.446035
PX_^VIX	9.77	11.059	13.35	16.045	20.5	29.901	40.760501
PXlag1_VLO	22.426208	30.692615	42.284763	62.590118	108.787443	152.404225	179.454766
PXlag1_PSX	37.495378	44.838806	55.430504	69.212868	90.57691	133.721749	148.185602
PXlag1_MPC	22.092858	25.655894	33.824404	49.142748	105.20966	173.066349	194.493421
PXlag1_^GSPC	1689.930188	1847.546484	2163.225037	2968.435059	4378.387451	6230.38147	6888.28314
PXlag1_CL=F	25.2613	38.557001	51.147501	63.885	78.260002	103.120502	110.3956
PXlag1_GC=F	1079.816039	1160.074976	1265.574982	1498.049988	1918.425018	3347.714954	4481.256138
PXlag1_^VIX	9.77	11.059	13.35	16.040001	20.4925	29.901	40.810501
PXlag2_VLO	22.386469	30.684914	42.247398	62.555796	108.75754	151.700837	179.254892
PXlag2_PSX	37.479751	44.83749	55.42641	69.168186	90.533562	133.555183	147.928101
PXlag2_MPC	22.092858	25.638675	33.810719	49.140718	105.180676	172.92297	194.434514
PXlag2_^GSPC	1689.930188	1846.317468	2162.775085	2966.375	4377.307617	6227.547925	6884.343799
PXlag2_CL=F	25.2613	38.557001	51.147501	63.885	78.260002	103.129997	110.3956
PXlag2_GC=F	1079.816039	1160.074976	1265.574982	1497.699951	1918.400024	3340.265088	4462.369155
PXlag2_^VIX	9.77	11.059	13.35	16.040001	20.4925	29.901	40.975299

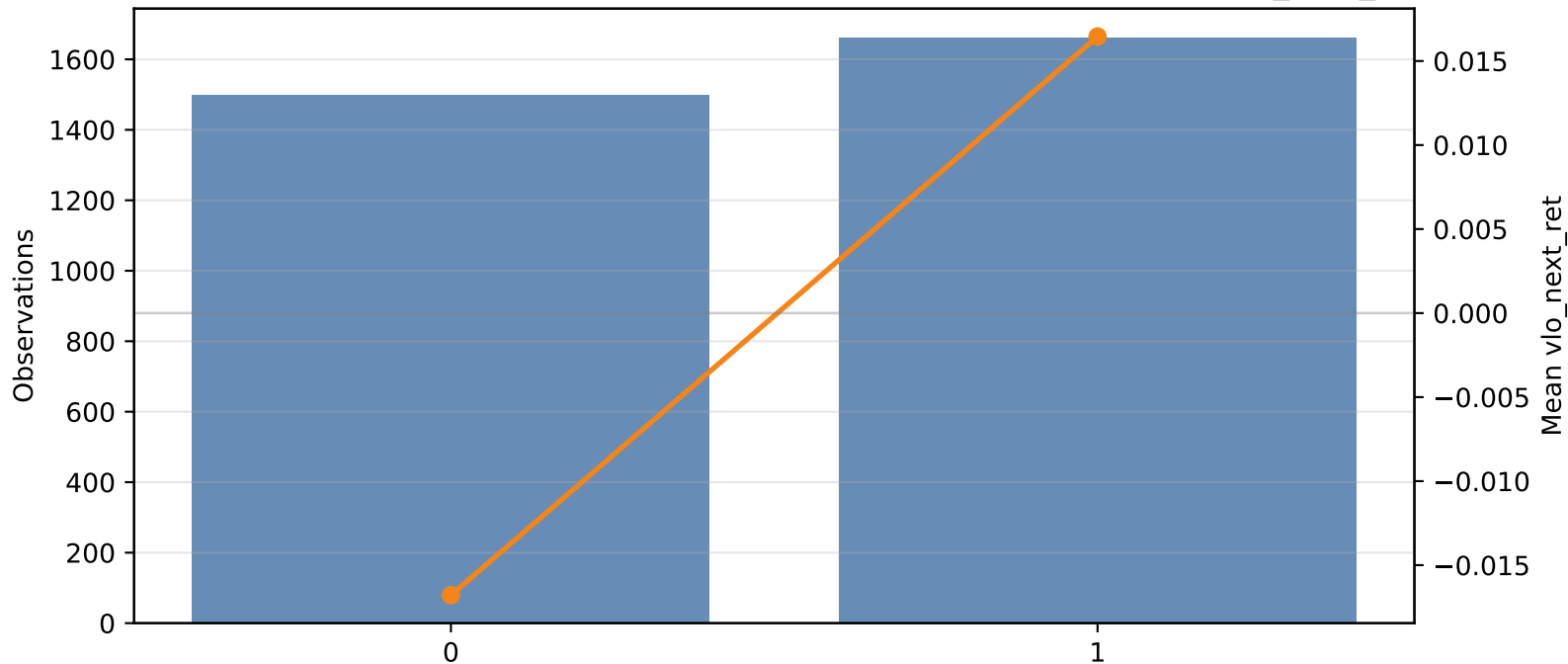
Numeric Percentile Distribution: 1% / 5% / 25% / 50% / 75% / 95% / 99% (page 2/3)							
Feature	1%	5%	25%	50%	75%	95%	99%
VOL_VLO	1618070.0	2084770.0	3024625.0	4011800.0	5631325.0	9446485.0	12871754.0
VOL_PSX	1232195.0	1599235.0	2229175.0	2801150.0	3601525.0	5733155.0	8472334.0
VOL_MPC	1352054.0	1852805.0	3259675.0	4843900.0	6670825.0	10531825.0	15721611.0
VOL_^GSPC	2248777500.0	2834140500.0	3377800000.0	3820405000.0	4465377500.0	5874722000.0	7830792099.999999
VOL_CL=F	77752.72	121064.65	272429.5	369073.0	550482.25	800597.1	1009447.28
VOL_GC=F	0.0	5.95	51.0	194.0	607.25	6030.35	180865.47
VOL_^VIX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HL_VLO	0.590004	0.82	1.420001	2.18	3.412502	5.990505	8.559998
OC_VLO	-5.434099	-3.119999	-0.870003	0.050003	0.869997	2.811501	5.230497
HL_PSX	0.650002	0.899998	1.439995	2.029999	2.860001	4.710499	6.479999
OC_PSX	-4.303302	-2.660503	-0.790001	0.020004	0.82	2.400002	3.932799
HL_MPC	0.555898	0.720001	1.150002	1.779999	2.940002	5.539994	8.199997
OC_MPC	-5.098198	-2.510494	-0.726248	0.025002	0.782503	2.509995	4.894102
HL_^GSPC	5.835912	8.140131	15.419922	28.319946	48.93512	97.298035	146.048892
OC_^GSPC	-95.185381	-49.691943	-10.630035	1.295166	14.459961	44.709686	80.544543
HL_CL=F	0.66	0.870003	1.32	1.769997	2.489998	4.469994	7.395603
OC_CL=F	-4.001	-2.279999	-0.790001	0.040001	0.77	2.030499	3.500498
HL_GC=F	0.0	0.0	7.099976	13.200073	22.400024	50.224951	101.664073
OC_GC=F	-52.587029	-24.21507	-5.800049	0.0	6.900024	25.505005	53.483999
HL_^VIX	0.360001	0.54	0.9175	1.42	2.33	5.0105	10.584899
OC_^VIX	-3.869999	-2.1	-0.809999	-0.23	0.34	2.219999	4.968199
garch_var_1d	9.7e-05	0.000138	0.000304	0.000404	0.000581	0.001295	0.005349
garch_vol_1d	0.009868	0.011748	0.017449	0.020088	0.024113	0.035984	0.073075
garch_vol_z	-2.215041	-1.792632	-0.822328	-0.317783	0.494691	2.569366	4.736489
garch_vol_chg	-0.005379	-0.001203	0.0	0.0	0.0	0.000689	0.004903
PR_has_release	0.0	0.0	0.0	0.0	0.0	1.0	1.0
PR_has_oil	0.0	0.0	0.0	0.0	0.0	0.0	1.0
PR_has_petroleum	0.0	0.0	0.0	0.0	0.0	0.0	1.0
PR_has_market_stability	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vlo_next_ret	-0.065029	-0.035722	-0.010618	0.001041	0.012646	0.035546	0.059699
EquityDown_OilDown	0.0	0.0	0.0	0.0	1.0	1.0	1.0
RiskOff	0.0	0.0	0.0	0.0	0.0	1.0	1.0
HighVIX	0.0	0.0	0.0	0.0	1.0	1.0	1.0
VLO_vol5	0.003745	0.006589	0.012223	0.01723	0.024192	0.041405	0.072789
VLO_vol10	0.006337	0.009476	0.013979	0.018234	0.024236	0.039365	0.074019

feature	1%	5%	25%	50%	75%	95%	99%
VLO_vol20	0.008024	0.011056	0.015341	0.019239	0.023621	0.038279	0.074038
VLO_vol_ratio_5_20	0.257996	0.406037	0.679639	0.91999	1.182415	1.545395	1.753911
OilShock	0.0	0.0	0.0	0.0	0.0	1.0	1.0
GoldShock	0.0	0.0	0.0	0.0	0.0	1.0	1.0
VLO_minus_SPX	-0.054953	-0.032602	-0.010269	0.000359	0.010954	0.032766	0.055536
RefinerPeerAvg	-0.058817	-0.032253	-0.009428	0.001199	0.011653	0.031253	0.052277
VLO_minus_Peers	-0.027569	-0.017822	-0.005902	0.000175	0.006085	0.017046	0.029173
Oil_minus_SPX	-0.070109	-0.038301	-0.0125	-8.3e-05	0.012644	0.035744	0.061341
Oil_minus_Refiners	-0.066344	-0.03834	-0.015098	-0.000357	0.013065	0.03846	0.069529
VLO_mom3	-0.108635	-0.063727	-0.018884	0.00301	0.024708	0.061255	0.095659
VLO_mom5	-0.147049	-0.080242	-0.023934	0.004393	0.033516	0.082003	0.128187
VLO_ret5_avg	-0.02941	-0.016048	-0.004787	0.000879	0.006703	0.016401	0.025637
VLO_reversal_signal	-0.025637	-0.016401	-0.006703	-0.000879	0.004787	0.016048	0.02941
VLO_zscore20	-2.429097	-1.649292	-0.627198	0.000594	0.626472	1.555444	2.281601
SPX_zscore20	-2.669097	-1.698126	-0.622322	-0.034625	0.595334	1.566725	2.09102
Oil_zscore20	-2.450365	-1.686059	-0.652991	0.027303	0.640076	1.531681	2.063642

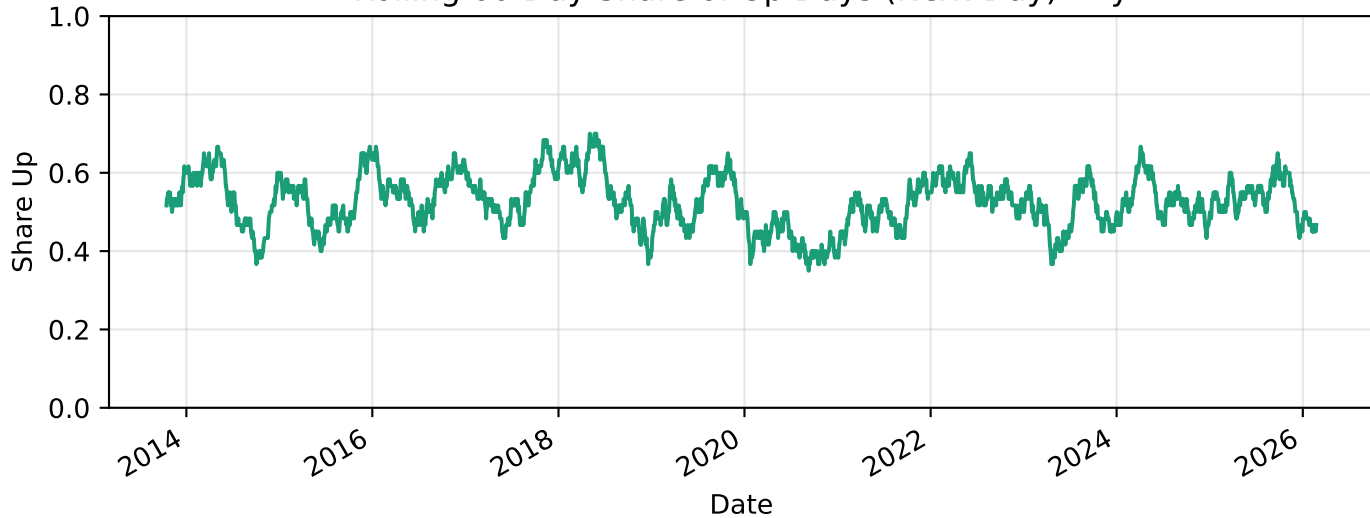
Top-Variance Numeric Features — Histograms



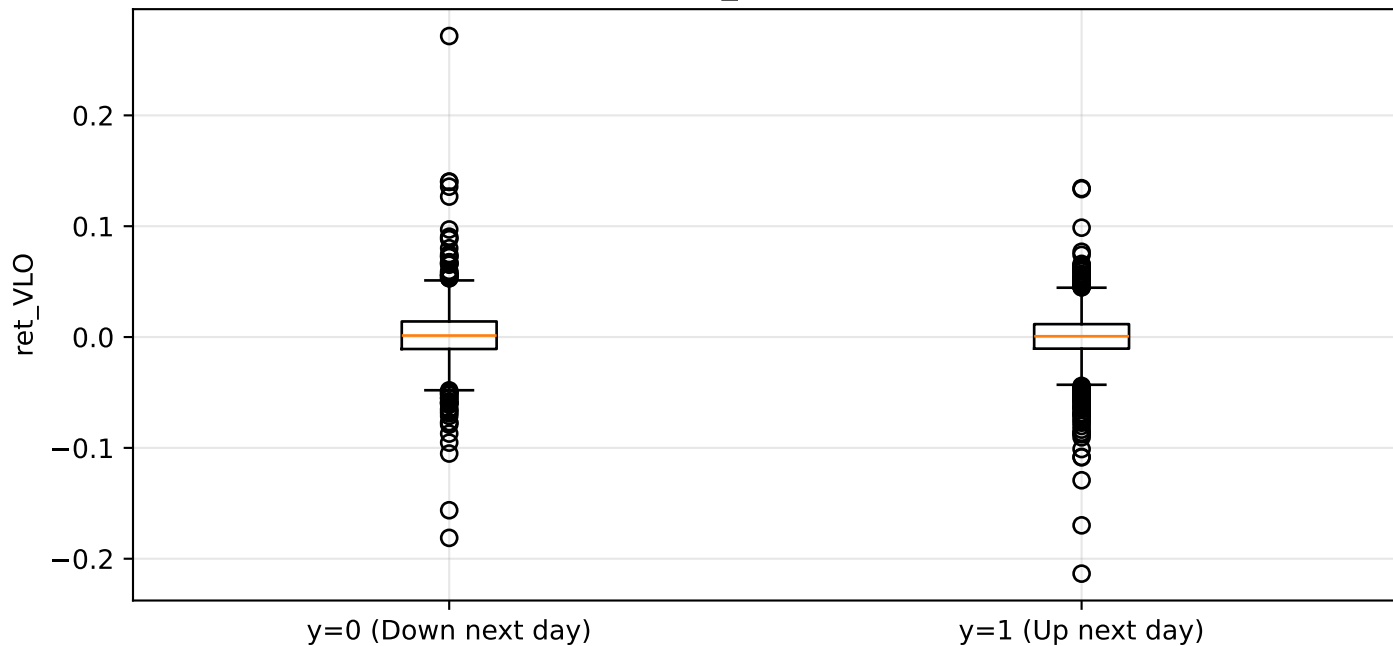
Class Counts — y (VLO Next-Day Direction) + Mean Next-Day Return (vlo\_next\_ret)



Rolling 60-Day Share of Up Days (Next-Day) — y

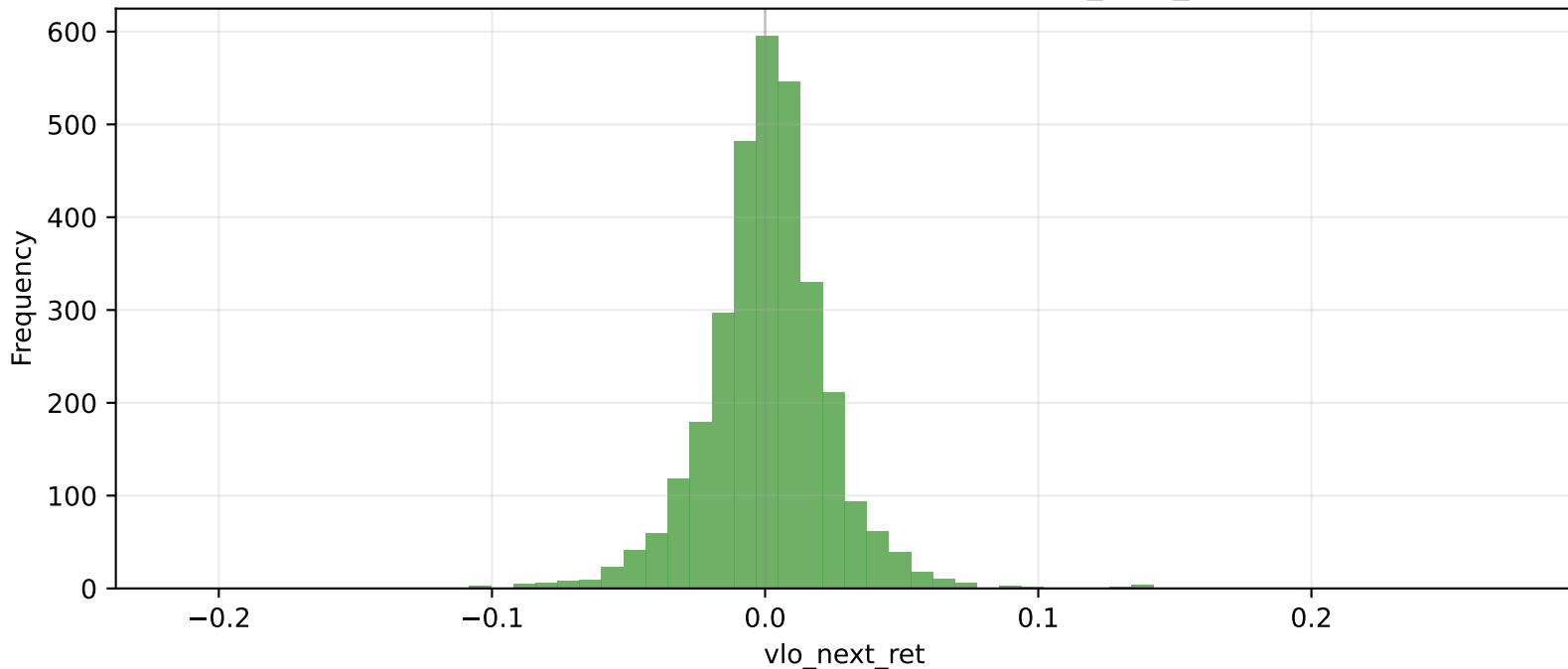


VLO Daily Log Returns (ret\_VLO) by Next-Day Direction (y)

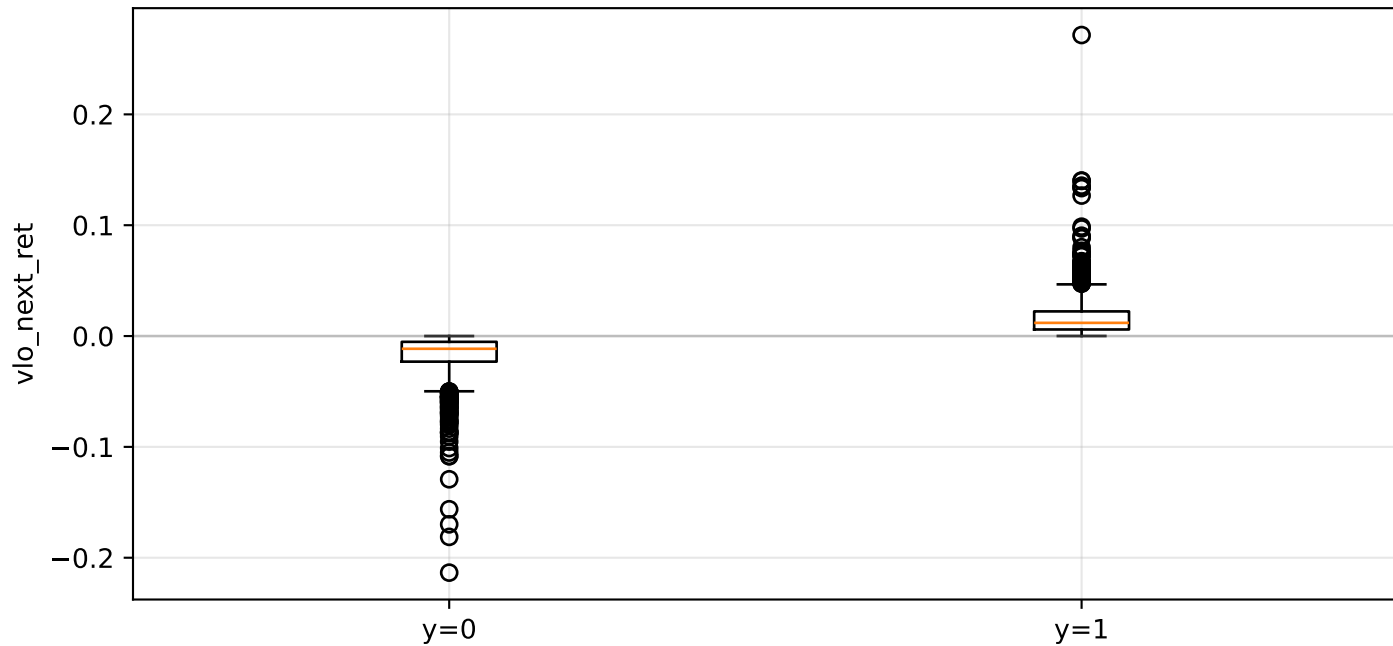




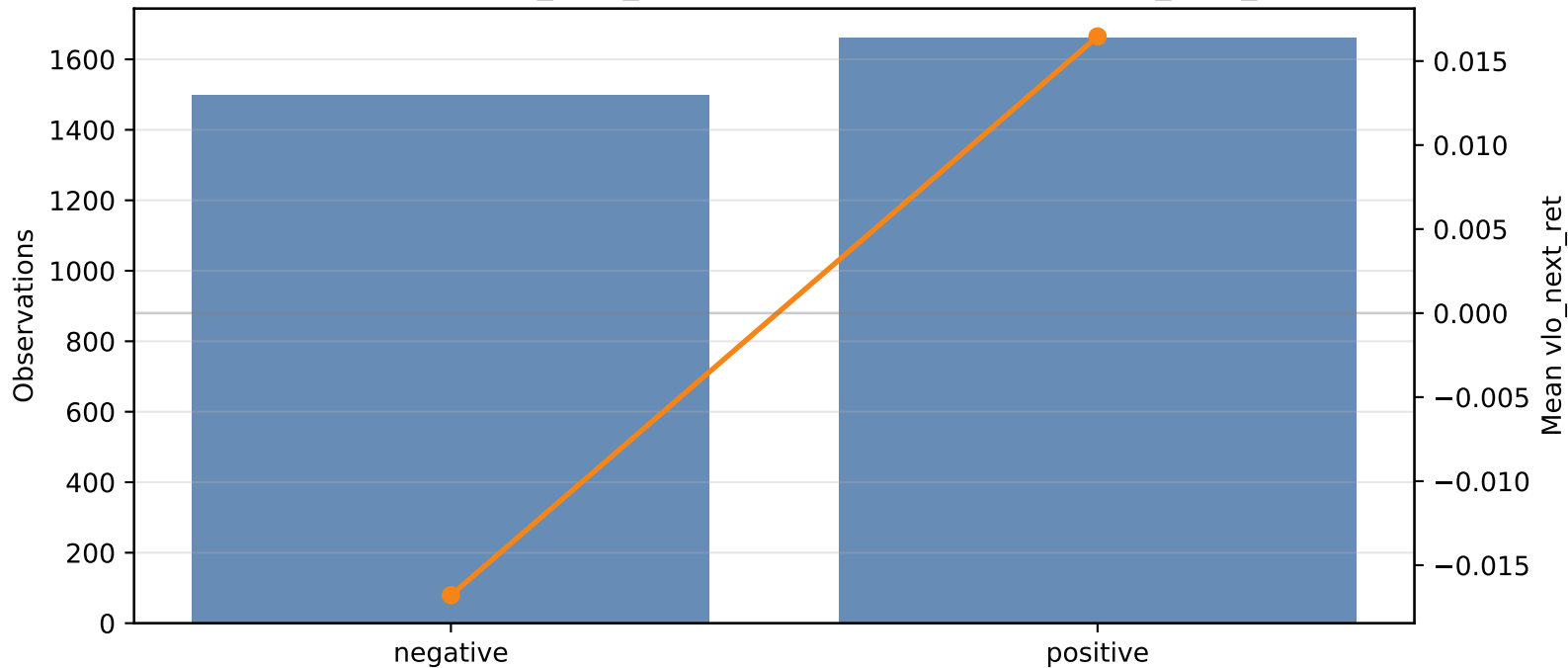
Distribution — Next-Day VLO Return (vlo\_next\_ret)



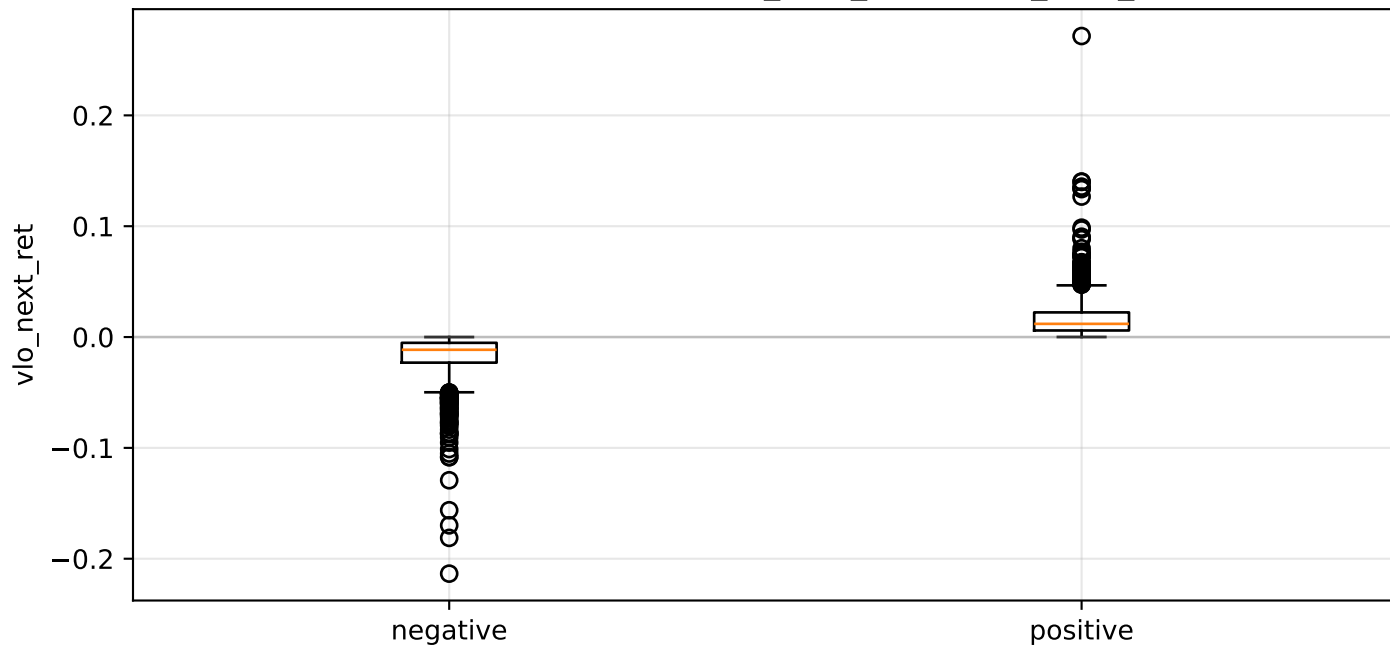
Next-Day VLO Return (vlo\_next\_ret) by y



Class Counts — vlo\_next\_dir + Mean Next-Day Return (vlo\_next\_ret)



Next-Day VLO Return (vlo\_next\_ret) by vlo\_next\_dir



## Next-Day Return Stats by vlo\_next\_dir (metrics as rows; groups as columns)

metric	negative	positive
n	1499.0	1661.0
mean	-0.01678777	0.01645961
median	-0.01148388	0.01189847
std	0.0182338	0.01702534
sem	0.00047095	0.00041774
min	-0.21345158	5.063e-05
p01	-0.08357939	0.00023545
p05	-0.04811727	0.00106755
p25	-0.02309842	0.00593053
p75	-0.00521766	0.02224586
p95	-0.00089779	0.04585641
p99	-0.00013798	0.07295152
max	0.0	0.27157182
skew	-3.39948442	4.1822801
kurtosis_excess	21.6775436	39.37702652
win_rate	0.0	1.0
mean_if_up	nan	0.01645961
mean_if_down	-0.01687784	nan
sharpe_ann	-14.61558223	15.34701765
t_mean_vs_0	-35.64648131	39.40111739
p_mean_vs_0	0.0	0.0

Between-Group Comparison (positive vs negative): metrics as rows

metric	value
pos_label	positive
neg_label	negative
n_pos	1661
n_neg	1499
mean_pos	0.01645961
mean_neg	-0.01678777
mean_diff_pos_minus_neg	0.03324738
median_pos	0.01189847
median_neg	-0.01148388
median_diff_pos_minus_neg	0.02338235
std_pos	0.01702534
std_neg	0.0182338
welch_t	52.81314432
welch_p	0.0
ks_stat	1.0
ks_p	0.0
cohens_d	1.88809914
cliffs_delta	1.0
win_rate_pos	1.0
win_rate_neg	0.0
win_rate_diff_pos_minus_neg	1.0

# All Features — Univariate Associations with y (page 1/3)

feature	corr_y	abs_corr_y	tstat_y	ks_y	auc_y	mi_y
vlo_next_ret	0.686109	0.686109	52.813144	1.0	1.0	0.691991
ret_MPC	-0.048059	0.048059	-2.703843	0.039163	0.485742	0.0
HL_VLO	-0.041917	0.041917	-2.344143	0.03319	0.48313	0.007253
ret2_CL=F	0.041655	0.041655	2.359831	0.041336	0.521676	0.00352
RefinerPeerAvg	-0.038334	0.038334	-2.153522	0.027364	0.49239	0.003603
garch_vol_1d	-0.034395	0.034395	-1.930058	0.037106	0.484372	0.008003
VLO_vol10	-0.033454	0.033454	-1.873222	0.037203	0.485285	0.0
ret_VLO	-0.032855	0.032855	-1.840534	0.044539	0.487488	0.007653
ret2_GC=F	-0.032725	0.032725	-1.845175	0.044984	0.477502	0.001625
ret2_^VIX	-0.032556	0.032556	-1.82358	0.042301	0.484209	0.0
HL_MPC	-0.029525	0.029525	-1.65297	0.037469	0.485015	0.0
HL_PSX	-0.0287	0.0287	-1.604038	0.031512	0.492059	0.008293
ret_CL=F	-0.028485	0.028485	-1.601915	0.054092	0.484678	0.0
VLO_zscore20	-0.027316	0.027316	-1.534127	0.041727	0.486235	0.006122
OC_MPC	-0.027136	0.027136	-1.516559	0.023341	0.494479	0.0
EquityDown_OilDown	0.026954	0.026954	1.517653	0.023471	0.511736	0.0
VLO_vol5	-0.026803	0.026803	-1.501371	0.041242	0.488493	0.022307
ret_^GSPC	-0.026216	0.026216	-1.470217	0.035602	0.485801	0.013282
ret2_^GSPC	0.025254	0.025254	1.416012	0.019597	0.502853	0.009626
VOL_MPC	-0.024714	0.024714	-1.388419	0.035472	0.488304	0.002435
VLO_vol20	-0.024578	0.024578	-1.377875	0.033202	0.488578	0.008045
VLO_minus_SPX	-0.024407	0.024407	-1.366061	0.031333	0.491902	0.0
PR_has_market_stability	-0.023699	0.023699	-1.312881	0.003856	0.498072	0.000956
ret_PSX	-0.022824	0.022824	-1.279952	0.029276	0.500207	0.0
PR_has_oil	-0.021914	0.021914	-1.224528	0.007793	0.496104	0.0
ret2_PSX	0.021126	0.021126	1.181743	0.027542	0.511608	0.0
RiskOff	0.021052	0.021052	1.185401	0.016407	0.508204	0.0
OC_^GSPC	-0.020779	0.020779	-1.164669	0.043103	0.489687	0.0
garch_var_1d	-0.020612	0.020612	-1.160903	0.037106	0.484372	0.002882
OC_GC=F	0.019092	0.019092	1.064005	0.038565	0.519057	0.0
OC_VLO	-0.018842	0.018842	-1.052052	0.038099	0.491221	0.0
OC_^VIX	0.01861	0.01861	1.045209	0.029286	0.507379	0.002081
PR_has_petroleum	-0.018522	0.018522	-1.036366	0.007174	0.496413	0.004903
Oil_minus_SPX	-0.018067	0.018067	-1.014845	0.046476	0.488454	0.006249
PR_has_release	-0.017111	0.017111	-0.959472	0.01028	0.49486	0.013286
HL_GC=F	-0.016457	0.016457	-0.913571	0.024512	0.493076	0.005448
PX_VLO	-0.015429	0.015429	-0.865927	0.021911	0.491464	0.0
PXlag2_VLO	-0.015012	0.015012	-0.842519	0.028842	0.492529	0.013114
PXlag1_VLO	-0.014233	0.014233	-0.798816	0.025116	0.492763	0.0
PXlag1_GC=F	-0.013974	0.013974	-0.784244	0.031549	0.495075	0.001034

# All Features — Univariate Associations with y (page 2/3)

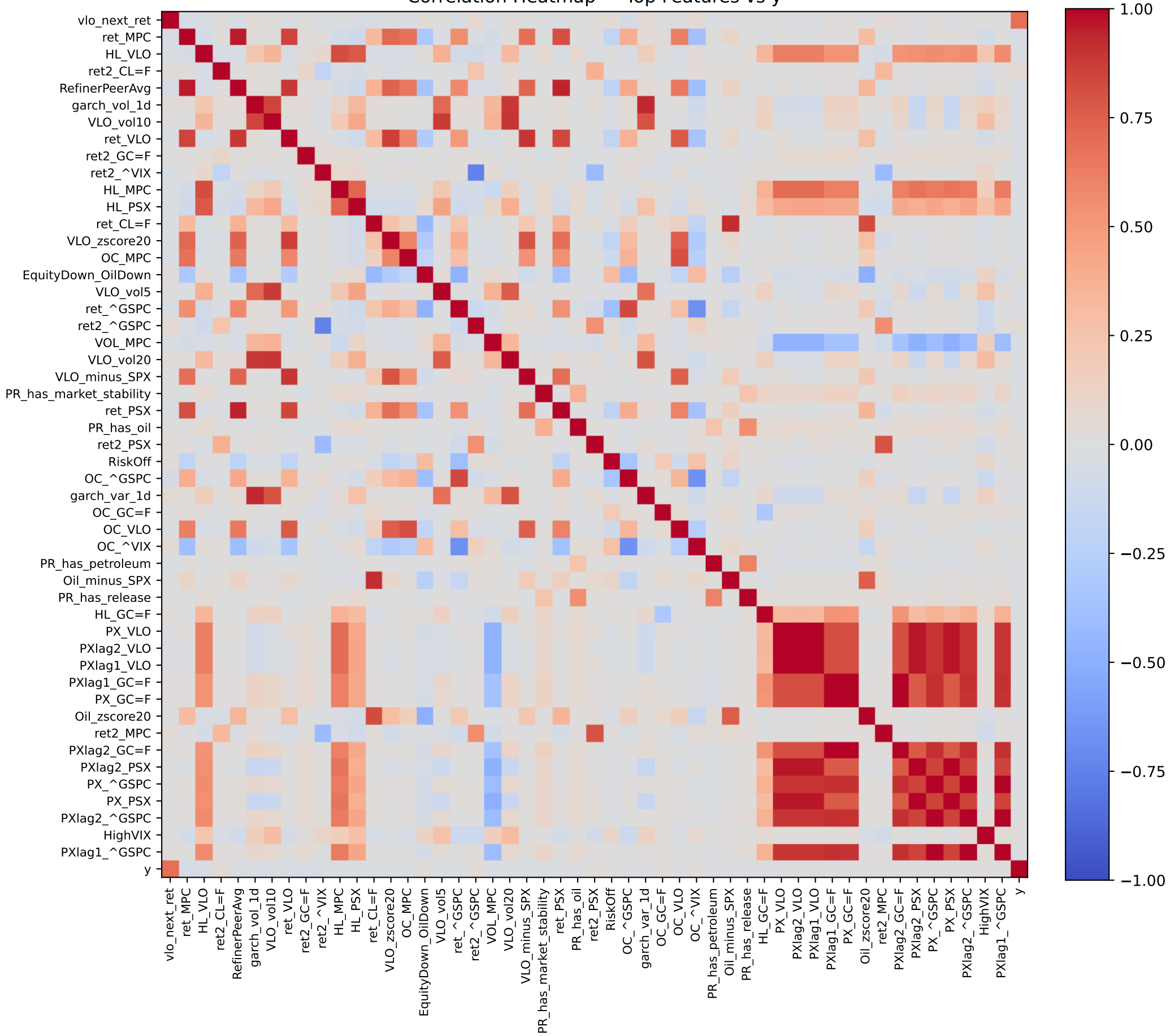
feature	corr_y	abs_corr_y	tstat_y	ks_y	auc_y	mi_y
PX_GC=F	-0.013927	0.013927	-0.781641	0.031112	0.494535	0.0
Oil_zscore20	-0.013552	0.013552	-0.760302	0.04851	0.488675	0.0
ret2_MPC	0.013245	0.013245	0.739817	0.033163	0.511524	0.009093
PXlag2_GC=F	-0.013013	0.013013	-0.730445	0.031876	0.495837	0.0
PXlag2_PSX	-0.012748	0.012748	-0.715838	0.030565	0.493921	0.01074
PX_^GSPC	-0.012277	0.012277	-0.690351	0.045899	0.489453	5e-06
PX_PSX	-0.01219	0.01219	-0.684571	0.025748	0.493147	0.009632
PXlag2_^GSPC	-0.012152	0.012152	-0.68333	0.045427	0.48941	0.0
HighVIX	0.012091	0.012091	0.679792	0.011597	0.505798	0.0
PXlag1_^GSPC	-0.011538	0.011538	-0.64877	0.044857	0.489681	0.0
PXlag1_PSX	-0.011216	0.011216	-0.62987	0.023942	0.494276	0.0
VOL_GC=F	-0.010583	0.010583	-0.593641	0.049115	0.4762	0.007753
SPX_zscore20	-0.010541	0.010541	-0.59105	0.0316	0.491653	0.0
OC_CL=F	-0.010319	0.010319	-0.579958	0.044672	0.488771	0.0
ret2_VLO	0.010274	0.010274	0.574041	0.02321	0.504078	0.020902
OilShock	-0.009882	0.009882	-0.554271	0.004587	0.497707	0.0
PXlag1_CL=F	0.009559	0.009559	0.537161	0.01853	0.505075	0.007245
garch_vol_chg	-0.009029	0.009029	-0.509414	0.010606	0.500305	0.0
VLO_mom3	-0.008903	0.008903	-0.499497	0.0256	0.501268	0.003825
PX_CL=F	0.008471	0.008471	0.476135	0.018595	0.504523	0.0
PX_MPC	-0.008164	0.008164	-0.458373	0.016101	0.497665	0.005078
PXlag2_MPC	-0.007539	0.007539	-0.423277	0.018233	0.498818	0.007072
PXlag1_MPC	-0.007046	0.007046	-0.395601	0.015938	0.49912	0.000699
VLO_vol_ratio_5_20	-0.007009	0.007009	-0.393526	0.027995	0.49589	0.000103
VOL_VLO	0.006992	0.006992	0.394779	0.020558	0.499211	0.00791
PXlag2_CL=F	0.006511	0.006511	0.365892	0.020775	0.503787	0.0
PXlag1_^VIX	-0.006261	0.006261	-0.350961	0.035334	0.502066	0.002119
HL_^VIX	0.005611	0.005611	0.315876	0.022724	0.500795	0.0
OC_PSX	-0.005551	0.005551	-0.310881	0.025874	0.503083	0.002337
VLO_mom5	-0.005407	0.005407	-0.303216	0.023084	0.503612	0.012069
VLO_reversal_signal	0.005407	0.005407	0.303216	0.023084	0.496388	0.011955
VLO_ret5_avg	-0.005407	0.005407	-0.303216	0.023084	0.503612	0.011968
PXlag2_^VIX	0.004568	0.004568	0.256809	0.027783	0.505057	0.0
VLO_minus_Peers	0.003702	0.003702	0.207531	0.032838	0.498966	0.0
VOL_PSX	-0.003105	0.003105	-0.174663	0.01902	0.494267	0.0
Oil_minus_Refiners	0.002873	0.002873	0.161565	0.028027	0.495635	0.003293
GoldShock	0.002712	0.002712	0.152477	0.001304	0.500652	0.011189
HL_^GSPC	-0.00265	0.00265	-0.148529	0.030751	0.493245	0.008305
VOL_^GSPC	-0.002257	0.002257	-0.12669	0.029318	0.493962	0.003591
garch_vol_z	-0.001457	0.001457	-0.082003	0.031108	0.495259	0.002191



## All Features — Univariate Associations with y (page 3/3)

feature	corr_y	abs_corr_y	tstat_y	ks_y	auc_y	mi_y
VOL_CL=F	-0.001191	0.001191	-0.066961	0.020378	0.498093	0.0
ret_GC=F	-0.000983	0.000983	-0.055229	0.024225	0.501918	0.0
PX_ <sup>VIX</sup>	-0.0009	0.0009	-0.050628	0.016739	0.498937	0.0
HL_CL=F	0.000815	0.000815	0.046098	0.03738	0.489067	0.0
ret_ <sup>VIX</sup>	0.000757	0.000757	0.042493	0.024588	0.49688	0.008313
VOL_ <sup>VIX</sup>	nan	nan	nan	0.0	nan	0.010205

Correlation Heatmap — Top Features vs y



vlo\_next\_ret by y



ret\_MPC by y



HL\_VLO by y



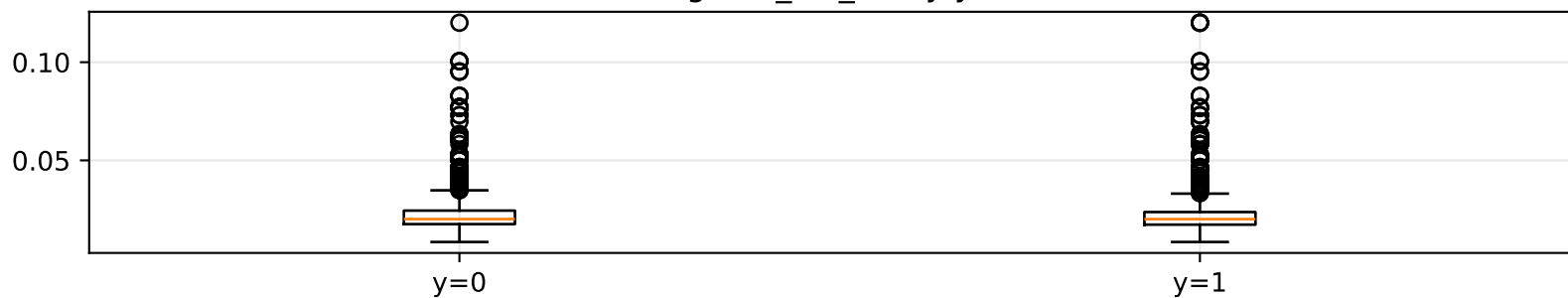
ret2\_CL=F by y



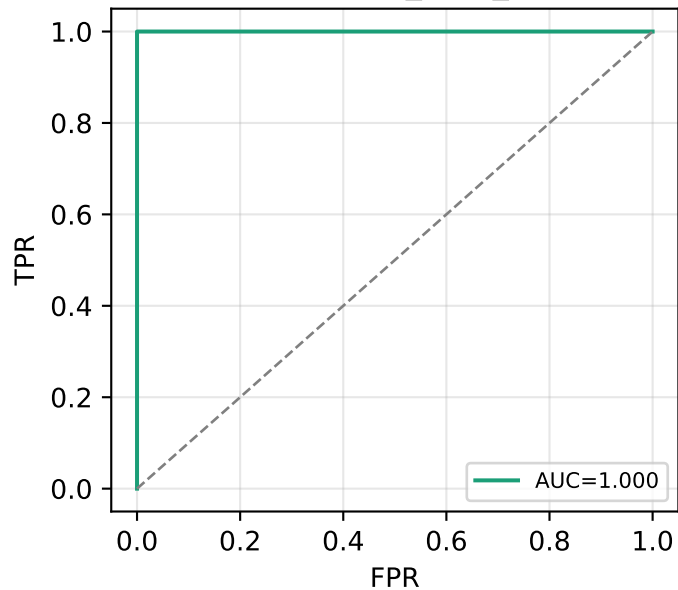
RefinerPeerAvg by y



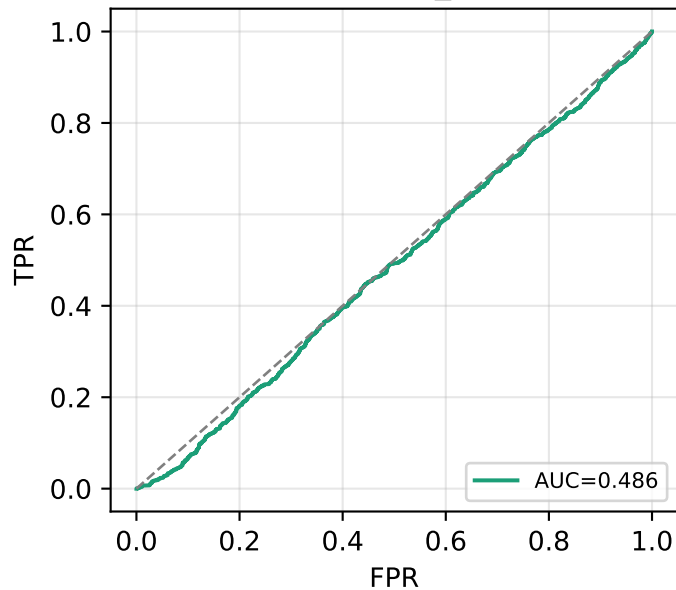
garch\_vol\_1d by y



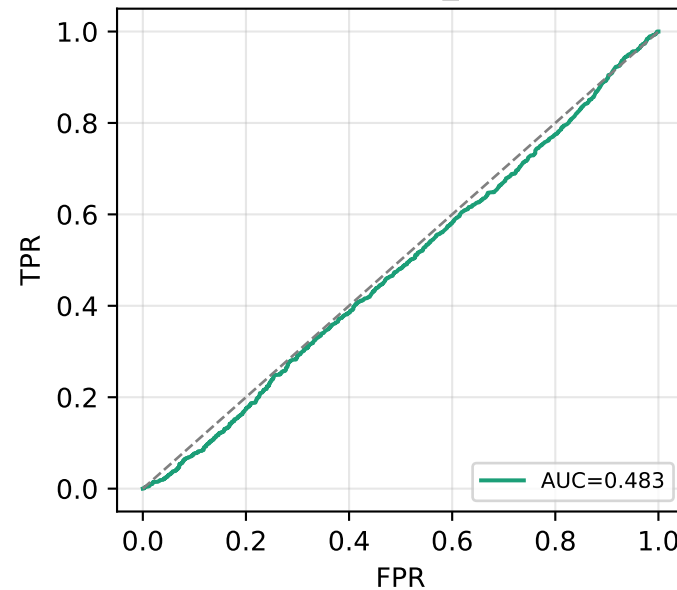
ROC — vlo\_next\_ret



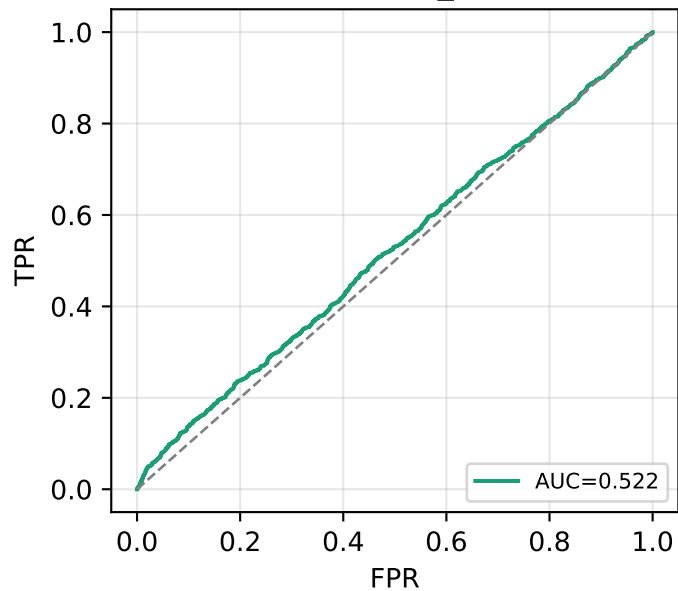
ROC — ret\_MPC



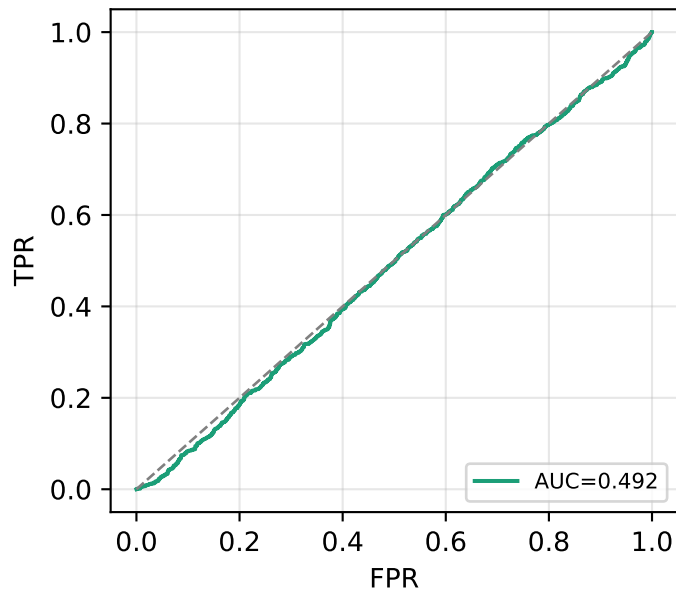
ROC — HL\_VLO



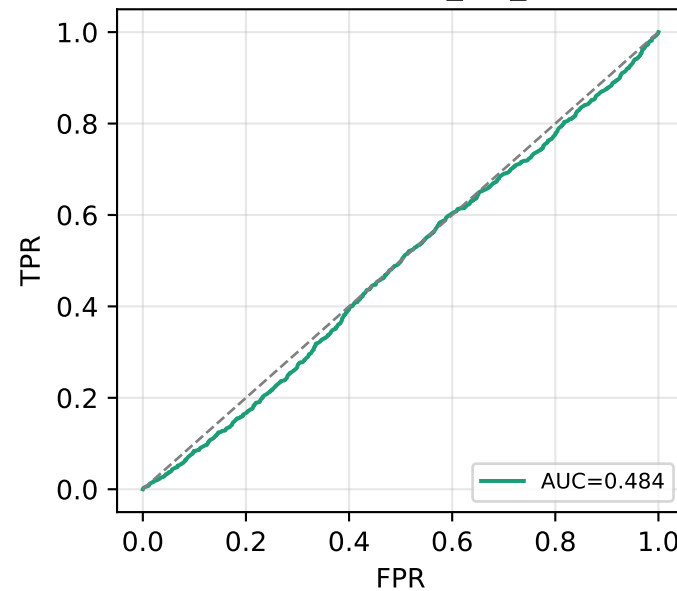
ROC — ret2\_CL=F



ROC — RefinerPeerAvg



ROC — garch\_vol\_1d



# Class-Wise Summary (Key Series)

ret_1^GSPC mean	ret_1^GSPC std	ret_1^GSPC min	ret_1^GSPC median	ret_1^GSPC max	ret_CL=F count	ret_CL=F mean	ret_CL=F std	ret_CL=F min
0.00075	0.0111	-0.127652	0.000898	0.090895	1499.0	0.000737	0.026485	-0.099945
0.000181	0.01059	-0.099945	0.000452	0.089683	1661.0	-0.000778	0.026647	-0.099945

## Report Metadata

Report path: /mnt/batch/tasks/shared/LS\_root/mounts/clusters/dvandyk1/code/Users/dvandyk1  
Rows in dataset: 3,160  
Features (numeric): 86  
sklearn available: True  
scipy available: True  
Generated: 2026-02-27 03:06:37