

Exploratory Data Analysis — VLO Next-Day Directional

Generated: 2026-02-10 23:28:20

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 | 3448 | 0 | 0.0% |
| ret_PSX | float64 | 3448 | 0 | 0.0% |
| ret_MPC | float64 | 3448 | 0 | 0.0% |
| ret_^GSPC | float64 | 3448 | 0 | 0.0% |
| ret_CL=F | float64 | 3448 | 0 | 0.0% |
| ret_GC=F | float64 | 3448 | 0 | 0.0% |
| ret_~VIX | float64 | 3448 | 0 | 0.0% |
| ret2_VLO | float64 | 3448 | 0 | 0.0% |
| ret2_PSX | float64 | 3448 | 0 | 0.0% |
| ret2_MPC | float64 | 3448 | 0 | 0.0% |
| ret2_~GSPC | float64 | 3448 | 0 | 0.0% |
| ret2_CL=F | float64 | 3448 | 0 | 0.0% |
| ret2_GC=F | float64 | 3448 | 0 | 0.0% |
| ret2_~VIX | float64 | 3448 | 0 | 0.0% |
| PX_VLO | float64 | 3448 | 0 | 0.0% |
| PX_PSX | float64 | 3448 | 0 | 0.0% |
| PX_MPC | float64 | 3448 | 0 | 0.0% |
| PX_~GSPC | float64 | 3448 | 0 | 0.0% |
| PX_CL=F | float64 | 3448 | 0 | 0.0% |
| PX_GC=F | float64 | 3448 | 0 | 0.0% |
| PX_~VIX | float64 | 3448 | 0 | 0.0% |
| PXlag1_VLO | float64 | 3448 | 0 | 0.0% |
| PXlag1_PSX | float64 | 3448 | 0 | 0.0% |
| PXlag1_MPC | float64 | 3448 | 0 | 0.0% |
| PXlag1_~GSPC | float64 | 3448 | 0 | 0.0% |
| PXlag1_CL=F | float64 | 3448 | 0 | 0.0% |
| PXlag1_GC=F | float64 | 3448 | 0 | 0.0% |
| PXlag1_~VIX | float64 | 3448 | 0 | 0.0% |
| PXlag2_VLO | float64 | 3448 | 0 | 0.0% |
| PXlag2_PSX | float64 | 3448 | 0 | 0.0% |
| PXlag2_MPC | float64 | 3448 | 0 | 0.0% |
| PXlag2_~GSPC | float64 | 3448 | 0 | 0.0% |
| PXlag2_CL=F | float64 | 3448 | 0 | 0.0% |
| PXlag2_GC=F | float64 | 3448 | 0 | 0.0% |
| PXlag2_~VIX | float64 | 3448 | 0 | 0.0% |
| VOL_VLO | int64 | 3448 | 0 | 0.0% |
| VOL_PSX | int64 | 3448 | 0 | 0.0% |
| VOL_MPC | int64 | 3448 | 0 | 0.0% |
| VOL_~GSPC | int64 | 3448 | 0 | 0.0% |
| VOL_CL=F | int64 | 3448 | 0 | 0.0% |
| VOL_GC=F | int64 | 3448 | 0 | 0.0% |
| VOL_~VIX | int64 | 3448 | 0 | 0.0% |
| HL_VLO | float64 | 3448 | 0 | 0.0% |
| OC_VLO | float64 | 3448 | 0 | 0.0% |
| HL_PSX | float64 | 3448 | 0 | 0.0% |

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

| column | dtype | non_null | nulls | null_ratio |
|---------------------|---------|----------|-------|------------|
| OC_PSX | float64 | 3448 | 0 | 0.0% |
| HL_MPC | float64 | 3448 | 0 | 0.0% |
| OC_MPC | float64 | 3448 | 0 | 0.0% |
| HL_~GSPC | float64 | 3448 | 0 | 0.0% |
| OC_~GSPC | float64 | 3448 | 0 | 0.0% |
| HL_CL=F | float64 | 3448 | 0 | 0.0% |
| OC_CL=F | float64 | 3448 | 0 | 0.0% |
| HL_GC=F | float64 | 3448 | 0 | 0.0% |
| OC_GC=F | float64 | 3448 | 0 | 0.0% |
| HL_~VIX | float64 | 3448 | 0 | 0.0% |
| OC_~VIX | float64 | 3448 | 0 | 0.0% |
| vlo_next_ret | float64 | 3448 | 0 | 0.0% |
| vlo_next_dir | object | 3448 | 0 | 0.0% |
| y | int64 | 3448 | 0 | 0.0% |
| EquityDown_OilDown | int64 | 3448 | 0 | 0.0% |
| RiskOff | int64 | 3448 | 0 | 0.0% |
| HighVIX | int64 | 3448 | 0 | 0.0% |
| VLO_vol5 | float64 | 3448 | 0 | 0.0% |
| VLO_vol10 | float64 | 3448 | 0 | 0.0% |
| VLO_vol20 | float64 | 3448 | 0 | 0.0% |
| VLO_vol_ratio_5_20 | float64 | 3448 | 0 | 0.0% |
| OilShock | int64 | 3448 | 0 | 0.0% |
| GoldShock | int64 | 3448 | 0 | 0.0% |
| VLO_minus_SPX | float64 | 3448 | 0 | 0.0% |
| RefinerPeerAvg | float64 | 3448 | 0 | 0.0% |
| VLO_minus_Peers | float64 | 3448 | 0 | 0.0% |
| Oil_minus_SPX | float64 | 3448 | 0 | 0.0% |
| Oil_minus_Refiners | float64 | 3448 | 0 | 0.0% |
| VLO_mom3 | float64 | 3448 | 0 | 0.0% |
| VLO_mom5 | float64 | 3448 | 0 | 0.0% |
| VLO_ret5_avg | float64 | 3448 | 0 | 0.0% |
| VLO_reversal_signal | float64 | 3448 | 0 | 0.0% |
| VLO_zscore20 | float64 | 3448 | 0 | 0.0% |
| SPX_zscore20 | float64 | 3448 | 0 | 0.0% |
| Oil_zscore20 | float64 | 3448 | 0 | 0.0% |

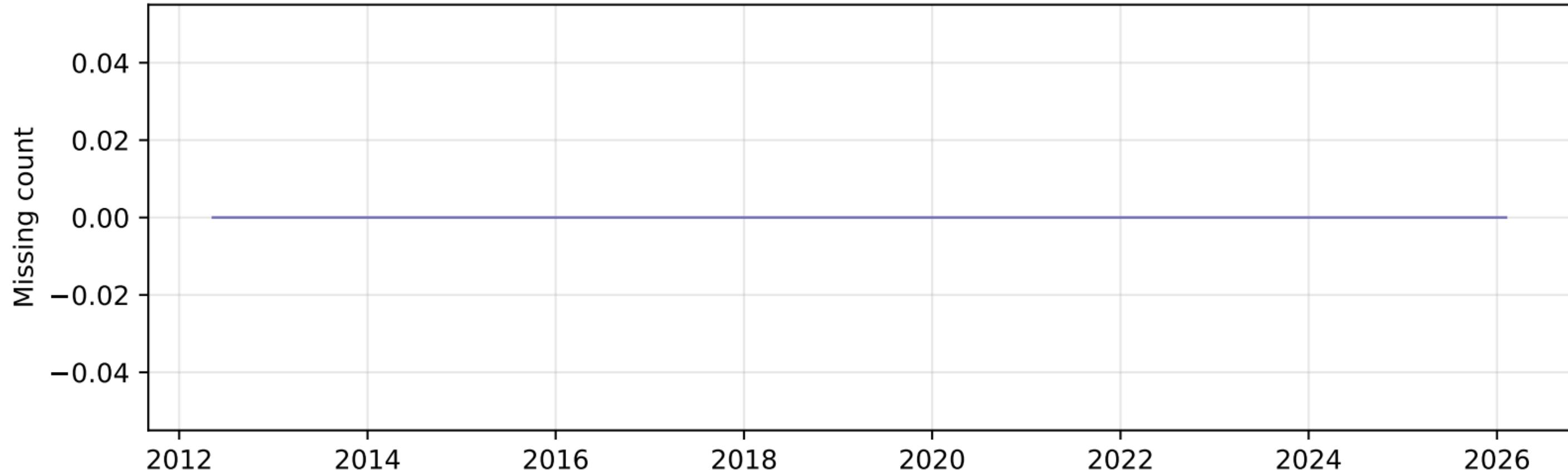
Missing Values Summary (by Column) (page 1/2)

| 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 |
| 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



Numeric Summary: count / mean / std / min / max (page 1/3)

| feature | count | mean | std | min | max |
|--------------|--------|-------------|-------------|-------------|-------------|
| ret_VLO | 3448.0 | 0.000807 | 0.023973 | -0.213452 | 0.271572 |
| ret_PSX | 3448.0 | 0.000598 | 0.021071 | -0.172757 | 0.200262 |
| ret_MPC | 3448.0 | 0.0008 | 0.024398 | -0.314833 | 0.187546 |
| ret_~GSPC | 3448.0 | 0.000476 | 0.010633 | -0.127652 | 0.090895 |
| ret_CL=F | 3448.0 | -4e-05 | 0.025813 | -0.282206 | 0.22394 |
| ret_GC=F | 3448.0 | 0.000314 | 0.010327 | -0.120657 | 0.059054 |
| ret_~VIX | 3448.0 | -3.7e-05 | 0.07856 | -0.442449 | 0.768245 |
| ret2_VLO | 3448.0 | 0.000765 | 0.023859 | -0.213452 | 0.271572 |
| ret2_PSX | 3448.0 | 0.000561 | 0.020999 | -0.172757 | 0.200262 |
| ret2_MPC | 3448.0 | 0.000768 | 0.024281 | -0.314833 | 0.187546 |
| ret2_~GSPC | 3448.0 | 0.000475 | 0.010628 | -0.127652 | 0.090895 |
| ret2_CL=F | 3448.0 | 8.7e-05 | 0.026337 | -0.282206 | 0.319634 |
| ret2_GC=F | 3448.0 | 0.000335 | 0.010332 | -0.120657 | 0.059054 |
| ret2_~VIX | 3448.0 | -6.6e-05 | 0.078615 | -0.442449 | 0.768245 |
| PX_VLO | 3448.0 | 69.806336 | 41.408681 | 11.44617 | 196.210007 |
| PX_PSX | 3448.0 | 72.890858 | 29.47688 | 18.661123 | 162.348053 |
| PX_MPC | 3448.0 | 67.159122 | 50.183053 | 11.591083 | 211.11409 |
| PX_~GSPC | 3448.0 | 3269.216591 | 1445.490423 | 1278.040039 | 6978.600098 |
| PX_CL=F | 3448.0 | 68.407839 | 20.299975 | 12.34 | 123.699997 |
| PX_GC=F | 3448.0 | 1723.069778 | 667.210608 | 1050.800049 | 5318.399902 |
| PX_~VIX | 3448.0 | 17.663251 | 6.58695 | 9.14 | 82.690002 |
| PXlag1_VLO | 3448.0 | 69.752921 | 41.36612 | 11.44617 | 196.210007 |
| PXlag1_PSX | 3448.0 | 72.851226 | 29.457818 | 18.661123 | 162.348053 |
| PXlag1_MPC | 3448.0 | 67.105687 | 50.143812 | 11.591083 | 211.11409 |
| PXlag1_~GSPC | 3448.0 | 3267.613311 | 1444.612524 | 1278.040039 | 6978.600098 |
| PXlag1_CL=F | 3448.0 | 68.416198 | 20.309098 | 12.34 | 123.699997 |
| PXlag1_GC=F | 3448.0 | 1722.13979 | 665.077249 | 1050.800049 | 5318.399902 |
| PXlag1_~VIX | 3448.0 | 17.664115 | 6.589853 | 9.14 | 82.690002 |
| PXlag2_VLO | 3448.0 | 69.701045 | 41.320649 | 11.44617 | 191.101242 |
| PXlag2_PSX | 3448.0 | 72.813631 | 29.437593 | 18.661123 | 162.348053 |
| PXlag2_MPC | 3448.0 | 67.053093 | 50.103898 | 11.591083 | 211.11409 |
| PXlag2_~GSPC | 3448.0 | 3266.000689 | 1443.670702 | 1278.040039 | 6978.600098 |
| PXlag2_CL=F | 3448.0 | 68.422306 | 20.322219 | 10.01 | 123.699997 |
| PXlag2_GC=F | 3448.0 | 1721.160236 | 662.837474 | 1050.800049 | 5318.399902 |
| PXlag2_~VIX | 3448.0 | 17.666215 | 6.595777 | 9.14 | 82.690002 |

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

| feature | count | mean | std | min | max |
|--------------------|--------|-------------------|------------------|-------------|--------------|
| VOL_VLO | 3448.0 | 5099375.732019 | 2922242.476911 | 559800.0 | 44023700.0 |
| VOL_PSX | 3448.0 | 3233042.024362 | 1485206.416509 | 605700.0 | 16579800.0 |
| VOL_MPC | 3448.0 | 5480148.607889 | 3015020.926321 | 957900.0 | 39153800.0 |
| VOL_~GSPC | 3448.0 | 3978971600.928074 | 994887969.326019 | 0.0 | 9976520000.0 |
| VOL_CL=F | 3448.0 | 405261.074536 | 208295.861002 | 0.0 | 1774383.0 |
| VOL_GC=F | 3448.0 | 5177.583527 | 28053.519114 | 0.0 | 386334.0 |
| VOL_~VIX | 3448.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HL_VLO | 3448.0 | 2.482309 | 1.695443 | 0.292505 | 15.729996 |
| OC_VLO | 3448.0 | -0.00526 | 1.777322 | -12.120003 | 12.120003 |
| HL_PSX | 3448.0 | 2.226932 | 1.244532 | 0.409996 | 14.799995 |
| OC_PSX | 3448.0 | -0.005316 | 1.504075 | -10.279999 | 11.529999 |
| HL_MPC | 3448.0 | 2.161997 | 1.646007 | 0.275 | 17.680008 |
| OC_MPC | 3448.0 | 0.012539 | 1.600088 | -12.770004 | 15.790001 |
| HL_~GSPC | 3448.0 | 35.3598 | 31.485094 | 3.699951 | 532.909668 |
| OC_~GSPC | 3448.0 | 0.622177 | 30.280579 | -218.060059 | 491.620117 |
| HL_CL=F | 3448.0 | 2.107944 | 1.317756 | 0.48 | 23.209999 |
| OC_CL=F | 3448.0 | -0.028068 | 1.444238 | -15.960007 | 7.720001 |
| HL_GC=F | 3448.0 | 18.268446 | 24.884374 | 0.0 | 740.5 |
| OC_GC=F | 3448.0 | 0.112817 | 21.359635 | -662.5 | 223.700195 |
| HL_~VIX | 3448.0 | 1.951853 | 2.173019 | 0.240001 | 42.340004 |
| OC_~VIX | 3448.0 | -0.144658 | 1.64976 | -17.360001 | 24.860001 |
| vlo_next_ret | 3448.0 | 0.000803 | 0.023984 | -0.213452 | 0.271572 |
| EquityDown_OilDown | 3448.0 | 0.257251 | 0.437182 | 0.0 | 1.0 |
| RiskOff | 3448.0 | 0.183005 | 0.386726 | 0.0 | 1.0 |
| HighVIX | 3448.0 | 0.351218 | 0.47742 | 0.0 | 1.0 |
| VLO_vol5 | 3448.0 | 0.020014 | 0.01326 | 0.001679 | 0.14472 |
| VLO_vol10 | 3448.0 | 0.020801 | 0.011809 | 0.003353 | 0.131768 |
| VLO_vol20 | 3448.0 | 0.0213 | 0.010802 | 0.005059 | 0.109765 |
| VLO_vol_ratio_5_20 | 3448.0 | 0.940344 | 0.344439 | 0.118164 | 2.002188 |
| OilShock | 3448.0 | 0.057425 | 0.232686 | 0.0 | 1.0 |
| GoldShock | 3448.0 | 0.060035 | 0.237586 | 0.0 | 1.0 |
| VLO_minus_SPX | 3448.0 | 0.000331 | 0.020752 | -0.140148 | 0.25994 |
| RefinerPeerAvg | 3448.0 | 0.000699 | 0.021565 | -0.243795 | 0.172114 |
| VLO_minus_Peers | 3448.0 | 0.000108 | 0.011436 | -0.058135 | 0.099458 |
| Oil_minus_SPX | 3448.0 | -0.000516 | 0.025324 | -0.296403 | 0.233195 |

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

| feature | count | mean | std | min | max |
|---------------------|--------|-----------|----------|-----------|----------|
| Oil_minus_Refiners | 3448.0 | -0.000739 | 0.027067 | -0.318885 | 0.240933 |
| VLO_mom3 | 3448.0 | 0.00242 | 0.041127 | -0.354102 | 0.334982 |
| VLO_mom5 | 3448.0 | 0.00398 | 0.053133 | -0.440812 | 0.369256 |
| VLO_ret5_avg | 3448.0 | 0.000796 | 0.010627 | -0.088162 | 0.073851 |
| VLO_reversal_signal | 3448.0 | -0.000796 | 0.010627 | -0.073851 | 0.088162 |
| VLO_zscore20 | 3448.0 | -0.008158 | 0.979284 | -3.910114 | 3.829063 |
| SPX_zscore20 | 3448.0 | -0.03648 | 0.990842 | -3.779699 | 3.370961 |
| Oil_zscore20 | 3448.0 | -0.018075 | 0.982353 | -3.749012 | 3.594037 |

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

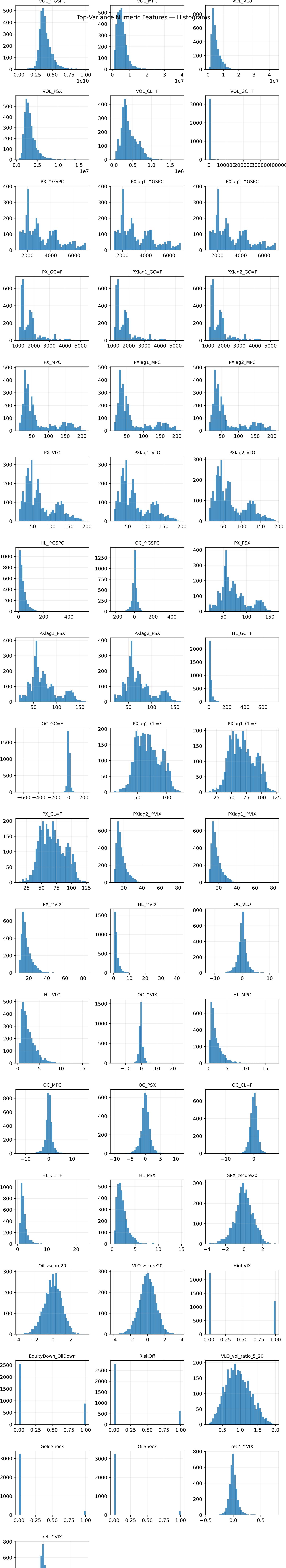
| feature | 1% | 5% | 25% | 50% | 75% | 95% | 99% |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ret_VLO | -0.063444 | -0.035806 | -0.010663 | 0.001103 | 0.013092 | 0.035242 | 0.058894 |
| ret_PSX | -0.059754 | -0.032229 | -0.009231 | 0.000965 | 0.011061 | 0.031491 | 0.052653 |
| ret_MPC | -0.063416 | -0.035569 | -0.011236 | 0.001734 | 0.013241 | 0.035131 | 0.058943 |
| ret_^GSPC | -0.030335 | -0.015883 | -0.003664 | 0.000687 | 0.005572 | 0.014839 | 0.024791 |
| ret_CL=F | -0.069101 | -0.037693 | -0.011911 | 0.000953 | 0.012259 | 0.033466 | 0.060761 |
| ret_GC=F | -0.026939 | -0.016034 | -0.004446 | 0.000351 | 0.005579 | 0.01597 | 0.026764 |
| ret_^VIX | -0.181225 | -0.11188 | -0.04279 | -0.006317 | 0.035626 | 0.126865 | 0.238451 |
| ret2_VLO | -0.063444 | -0.035806 | -0.010663 | 0.001103 | 0.013056 | 0.035175 | 0.058245 |
| ret2_PSX | -0.059754 | -0.032229 | -0.009242 | 0.000948 | 0.011061 | 0.031368 | 0.051687 |
| ret2_MPC | -0.063416 | -0.035569 | -0.011236 | 0.001734 | 0.013271 | 0.035131 | 0.058673 |
| ret2_^GSPC | -0.030335 | -0.015883 | -0.003664 | 0.000687 | 0.005567 | 0.014839 | 0.024699 |
| ret2_CL=F | -0.068502 | -0.037599 | -0.011878 | 0.000965 | 0.012264 | 0.033622 | 0.061207 |
| ret2_GC=F | -0.026939 | -0.016014 | -0.004433 | 0.000362 | 0.005591 | 0.015988 | 0.02716 |
| ret2_^VIX | -0.181225 | -0.11188 | -0.04279 | -0.006374 | 0.035517 | 0.126865 | 0.238451 |
| PX_VLO | 13.410843 | 20.981887 | 37.872153 | 58.335638 | 102.473793 | 147.976697 | 174.612492 |
| PX_PSX | 21.269063 | 34.99322 | 53.665302 | 65.678215 | 87.997719 | 132.019801 | 144.096944 |
| PX_MPC | 14.427143 | 21.146675 | 31.392739 | 45.767733 | 93.120556 | 171.637595 | 193.671339 |
| PX_^GSPC | 1343.751796 | 1486.634479 | 2075.112427 | 2840.290039 | 4277.909912 | 6068.220068 | 6854.699663 |
| PX_CL=F | 25.921 | 39.4335 | 52.34 | 66.990002 | 83.365 | 103.029999 | 109.949599 |
| PX_GC=F | 1082.74599 | 1166.670001 | 1272.775024 | 1564.400024 | 1887.75 | 3317.399902 | 4310.78104 |
| PX_^VIX | 9.7847 | 11.2135 | 13.41 | 15.97 | 20.022501 | 29.35 | 40.2001 |
| PXlag1_VLO | 13.328524 | 20.928538 | 37.852917 | 58.29747 | 102.419022 | 147.915677 | 174.081437 |
| PXlag1_PSX | 21.175475 | 34.852981 | 53.662681 | 65.642578 | 87.978289 | 132.007819 | 143.9531 |
| PXlag1_MPC | 14.382035 | 21.089094 | 31.392739 | 45.679808 | 93.053066 | 171.354291 | 193.40309 |
| PXlag1_^GSPC | 1343.751796 | 1482.703955 | 2074.83252 | 2839.60498 | 4275.352295 | 6067.259106 | 6854.699663 |
| PXlag1_CL=F | 25.921 | 39.4335 | 52.34 | 67.0 | 83.402498 | 103.029999 | 109.949599 |
| PXlag1_GC=F | 1082.74599 | 1166.670001 | 1272.775024 | 1564.400024 | 1887.350037 | 3317.294971 | 4305.666104 |
| PXlag1_^VIX | 9.7847 | 11.22 | 13.41 | 15.97 | 20.02 | 29.35 | 40.5132 |
| PXlag2_VLO | 13.277671 | 20.911479 | 37.852917 | 58.268829 | 102.363024 | 147.74051 | 173.866469 |
| PXlag2_PSX | 21.160243 | 34.44249 | 53.65227 | 65.615635 | 87.958441 | 131.990005 | 143.692498 |
| PXlag2_MPC | 14.246449 | 21.063217 | 31.381767 | 45.673971 | 92.610865 | 171.341048 | 193.02124 |
| PXlag2_^GSPC | 1343.751796 | 1475.538483 | 2074.317566 | 2839.544922 | 4274.157471 | 6064.703955 | 6851.476577 |
| PXlag2_CL=F | 25.921 | 39.4335 | 52.34 | 67.009998 | 83.475 | 103.029999 | 109.949599 |
| PXlag2_GC=F | 1082.74599 | 1166.670001 | 1272.775024 | 1564.400024 | 1887.224976 | 3315.805029 | 4302.432046 |
| PXlag2_^VIX | 9.7847 | 11.2135 | 13.4175 | 15.97 | 20.022501 | 29.35 | 40.730601 |

Numeric Percentile Distribution: 1% / 5% / 25% / 50% / 75% / 95% / 99% (page 2/3)

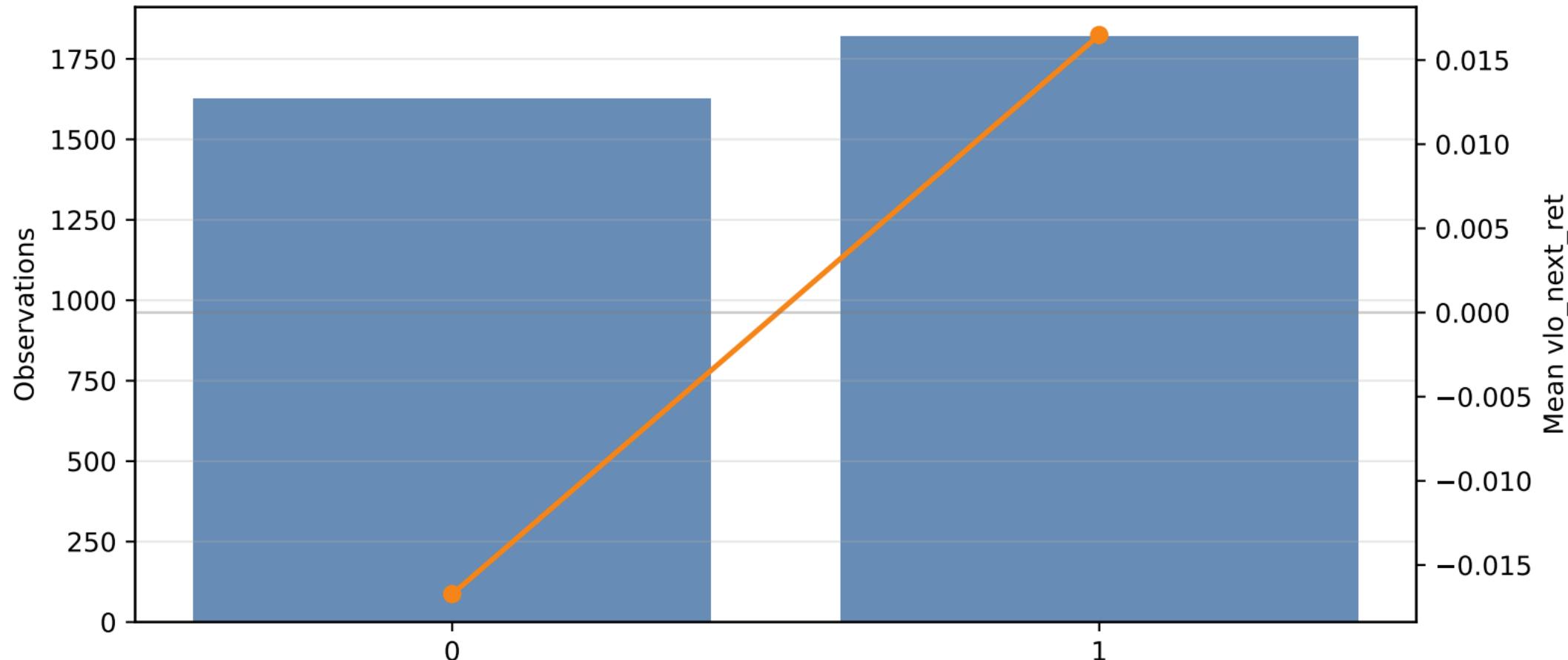
| ture | 1% | 5% | 25% | 50% | 75% | 95% | 9 |
|------------------|--------------|--------------|--------------|--------------|--------------|-------------------|------------------|
| L_VLO | 1647676.0 | 2129610.0 | 3103375.0 | 4283900.0 | 6322675.0 | 10597915.0 | 14593296 |
| L_PX | 1243494.0 | 1617615.0 | 2285550.0 | 2898200.0 | 3779300.0 | 5991580.0 | 847682 |
| L_MPC | 1372523.0 | 1917580.0 | 3411525.0 | 5021050.0 | 6821600.0 | 10612620.0 | 1579587 |
| L_^GSPC | 2217460600.0 | 2812792500.0 | 3359732500.0 | 3776045000.0 | 4392155000.0 | 5773011999.999999 | 7755657499.99999 |
| L_CL=F | 78269.72 | 121202.95 | 259122.5 | 351401.5 | 531567.25 | 791684.3 | 1005475 |
| L_GC=F | 0.0 | 6.0 | 48.0 | 186.0 | 597.75 | 6064.15 | 181005 |
| L_^VIX | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| _VLO | 0.501289 | 0.68 | 1.260002 | 2.029625 | 3.24 | 5.742503 | 8.2505 |
| _VLO | -5.335895 | -2.9165 | -0.789998 | 0.059998 | 0.80579 | 2.696499 | 5.12 |
| _PSX | 0.614698 | 0.8335 | 1.360001 | 1.950001 | 2.769998 | 4.589996 | 6.3611 |
| _PSX | -4.1806 | -2.526506 | -0.75 | 0.029999 | 0.802502 | 2.310005 | 3.8559 |
| _MPC | 0.42735 | 0.630001 | 1.06 | 1.630001 | 2.75 | 5.330002 | 7.8752 |
| _MPC | -4.897104 | -2.346499 | -0.68 | 0.029999 | 0.739999 | 2.323 | 4.6705 |
| _^GSPC | 5.638806 | 7.833582 | 14.430115 | 26.135132 | 46.359985 | 93.692957 | 142.1341 |
| _^GSPC | -92.634072 | -47.520563 | -9.61261 | 1.25 | 13.262512 | 42.806982 | 74.4412 |
| _CL=F | 0.66 | 0.880001 | 1.330002 | 1.780001 | 2.480003 | 4.386001 | 7.09 |
| _CL=F | -3.945296 | -2.279999 | -0.779999 | 0.044998 | 0.779999 | 2.026501 | 3.5671 |
| _GC=F | 0.0 | 0.299927 | 7.300049 | 13.300049 | 22.400024 | 47.595013 | 96.1768 |
| _GC=F | -51.412086 | -24.165002 | -6.0 | 0.0 | 6.900024 | 24.900104 | 50.305 |
| _^VIX | 0.360001 | 0.53 | 0.8875 | 1.38 | 2.27 | 4.8695 | 10.1971 |
| _^VIX | -3.8077 | -2.003 | -0.78 | -0.22 | 0.349999 | 2.136501 | 4.8571 |
| _next_ret | -0.063444 | -0.035806 | -0.010672 | 0.001103 | 0.013092 | 0.035293 | 0.0588 |
| uityDown_OilDown | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | |
| kOff | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | |
| hVIX | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | |
| O_vol5 | 0.003873 | 0.00664 | 0.012261 | 0.017264 | 0.024268 | 0.040894 | 0.0713 |
| O_vol10 | 0.006518 | 0.009607 | 0.014105 | 0.018381 | 0.02425 | 0.038342 | 0.0719 |
| O_vol20 | 0.00805 | 0.011203 | 0.015607 | 0.019288 | 0.02356 | 0.037803 | 0.0736 |
| O_vol_ratio_5_20 | 0.257825 | 0.405771 | 0.684987 | 0.919242 | 1.1814 | 1.545331 | 1.7559 |
| Shock | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | |
| ldShock | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | |
| O_minus_SPX | -0.054642 | -0.032412 | -0.010242 | 0.000543 | 0.011071 | 0.032438 | 0.0552 |
| innerPeerAvg | -0.057464 | -0.032202 | -0.009396 | 0.001258 | 0.011878 | 0.031246 | 0.0507 |
| O_minus_Peers | -0.027845 | -0.018087 | -0.006282 | 0.000141 | 0.006255 | 0.017666 | 0.0300 |
| _minus_SPX | -0.066179 | -0.037248 | -0.011978 | -0.000265 | 0.011921 | 0.034377 | 0.0609 |

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

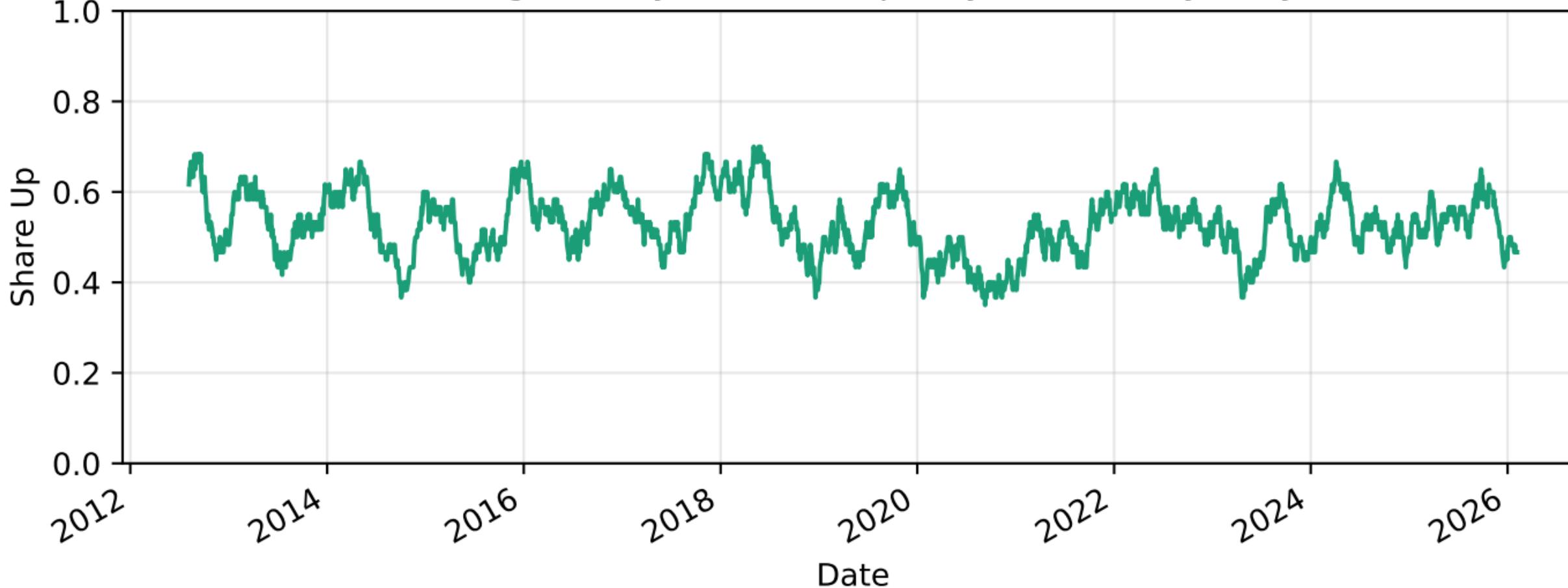
| feature | 1% | 5% | 25% | 50% | 75% | 95% | 99% |
|---------------------|-----------|-----------|-----------|-----------|----------|----------|----------|
| Oil_minus_Refiners | -0.063243 | -0.038046 | -0.014945 | -0.000738 | 0.012774 | 0.03787 | 0.067054 |
| VLO_mom3 | -0.107465 | -0.06365 | -0.018708 | 0.00324 | 0.025139 | 0.060549 | 0.095956 |
| VLO_mom5 | -0.143995 | -0.080197 | -0.023564 | 0.005388 | 0.033955 | 0.080828 | 0.133778 |
| VLO_ret5_avg | -0.028799 | -0.016039 | -0.004713 | 0.001078 | 0.006791 | 0.016166 | 0.026756 |
| VLO_reversal_signal | -0.026756 | -0.016166 | -0.006791 | -0.001078 | 0.004713 | 0.016039 | 0.028799 |
| VLO_zscore20 | -2.429621 | -1.641285 | -0.624753 | -0.000463 | 0.632667 | 1.554669 | 2.272825 |
| SPX_zscore20 | -2.642379 | -1.698661 | -0.611246 | -0.034625 | 0.595334 | 1.575401 | 2.113883 |
| Oil_zscore20 | -2.450554 | -1.685601 | -0.64713 | 0.029539 | 0.643936 | 1.532993 | 2.075681 |



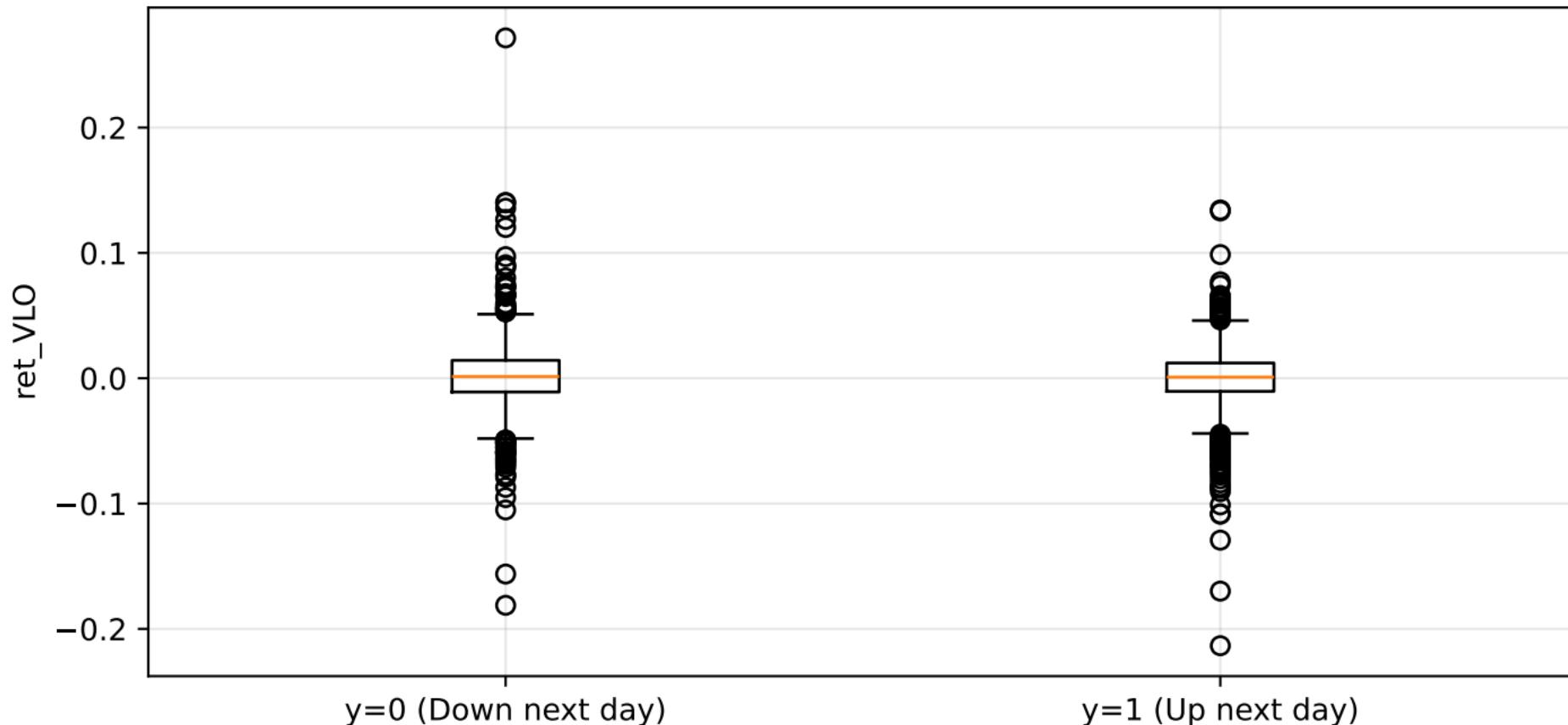
Class Counts — y (VLO Next-Day Direction) + Mean Next-Day Return (vlo_next_ret)



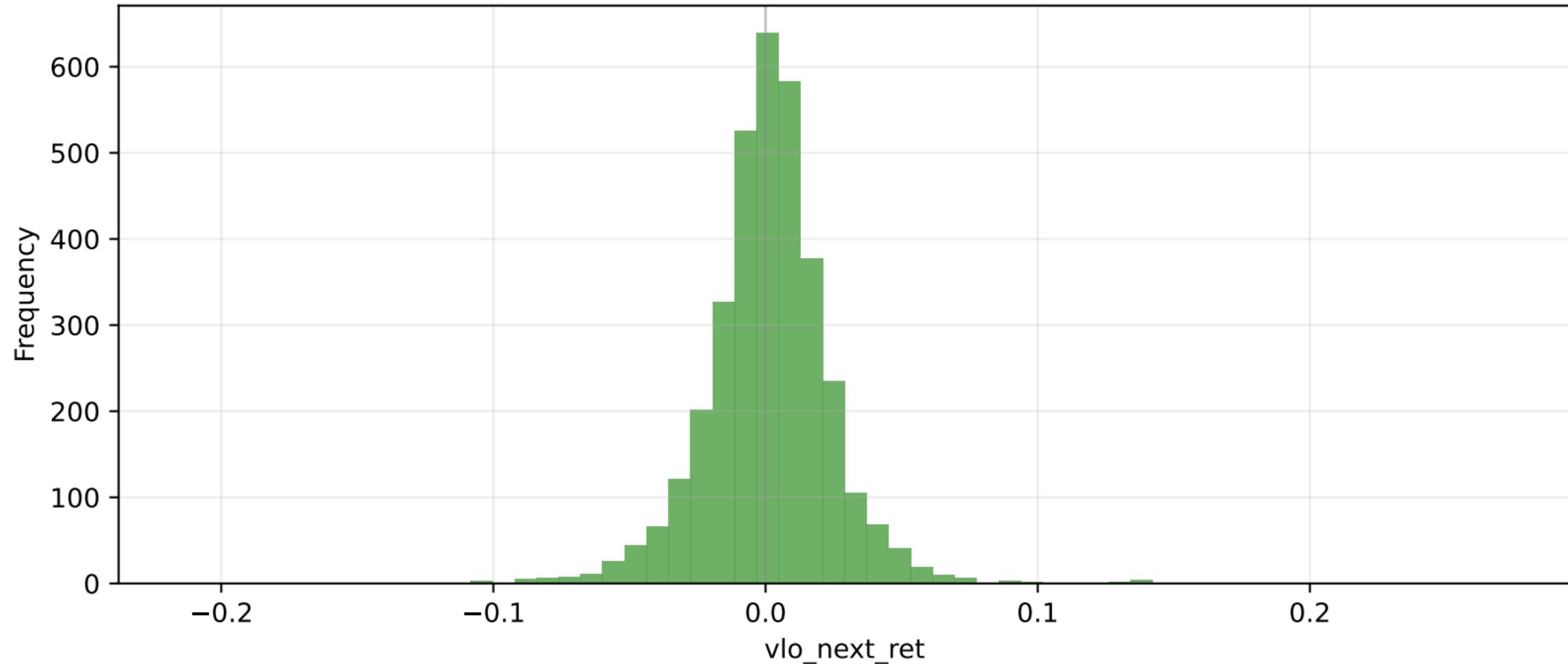
Rolling 60-Day Share of Up Days (Next-Day) — y



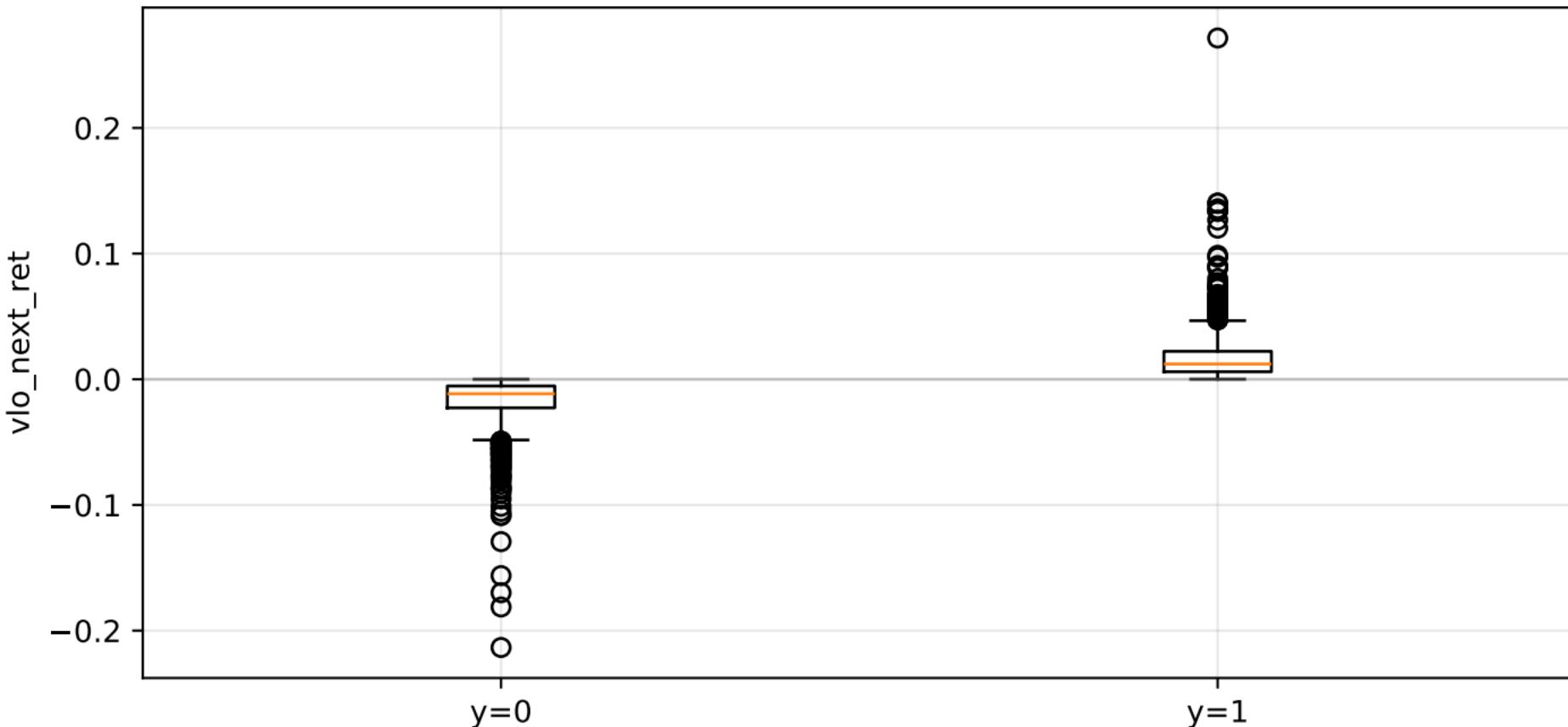
VLO Daily Log Returns (ret_VLO) by Next-Day Direction (y)



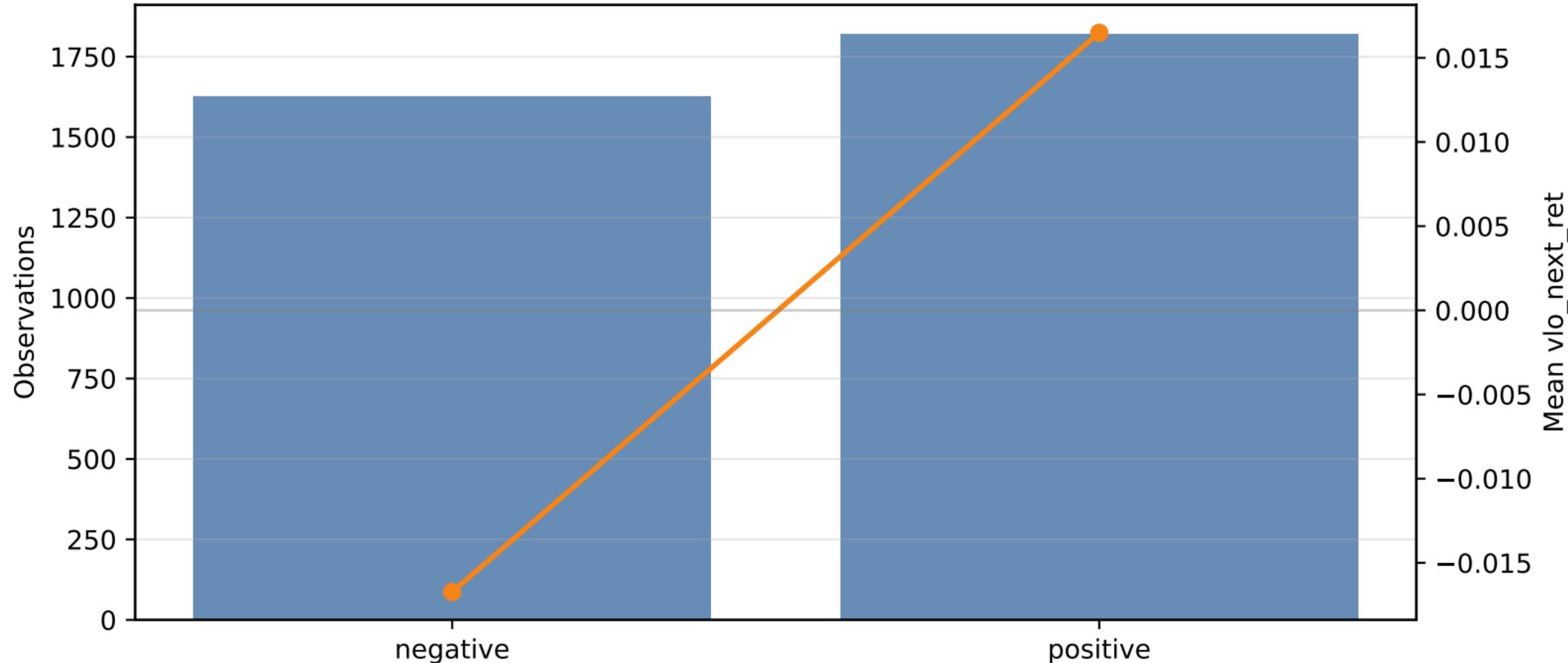
Distribution — Next-Day VLO Return (vlo_next_ret)



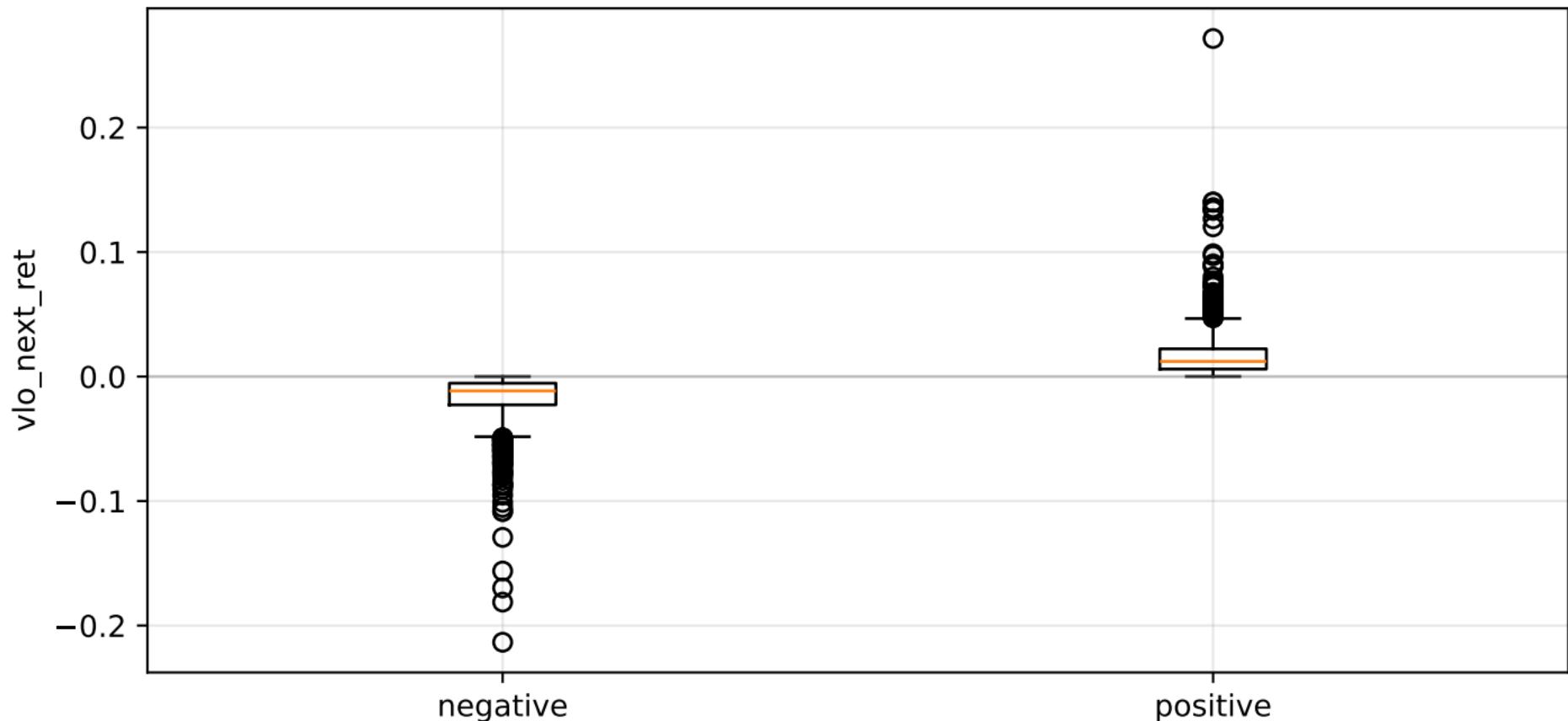
Next-Day VLO Return (vlo_next_ret) by y



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 | 1628.0 | 1820.0 |
| mean | -0.01673035 | 0.01648653 |
| median | -0.01155576 | 0.01214965 |
| std | 0.017924 | 0.01677679 |
| sem | 0.00044423 | 0.00039325 |
| min | -0.21345156 | 6.443e-05 |
| p01 | -0.07992257 | 0.00026205 |
| p05 | -0.04809042 | 0.0010695 |
| p25 | -0.02272456 | 0.00602375 |
| p75 | -0.0053461 | 0.02227642 |
| p95 | -0.00087915 | 0.04504588 |
| p99 | -0.00013109 | 0.07259571 |
| max | 0.0 | 0.27157194 |
| skew | -3.35141102 | 4.13662082 |
| kurtosis_excess | 21.49592595 | 38.85318897 |
| win_rate | 0.0 | 1.0 |
| mean_if_up | nan | 0.01648653 |
| mean_if_down | -0.01683376 | nan |
| sharpe_ann | -14.81734408 | 15.59986187 |
| t_mean_vs_0 | -37.66147246 | 41.92336907 |
| 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 | 1820 |
| n_neg | 1628 |
| mean_pos | 0.01648653 |
| mean_neg | -0.01673035 |
| mean_diff_pos_minus_neg | 0.03321689 |
| median_pos | 0.01214965 |
| median_neg | -0.01155576 |
| median_diff_pos_minus_neg | 0.02370541 |
| std_pos | 0.01677679 |
| std_neg | 0.017924 |
| welch_t | 55.98792907 |
| welch_p | 0.0 |
| ks_stat | 1.0 |
| ks_p | 0.0 |
| cohens_d | 1.91695927 |
| cliffs_delta | 1.0 |
| win_rate_pos | 1.0 |
| win_rate_neg | 0.0 |
| win_rate_diff_pos_minus_neg | 1.0 |

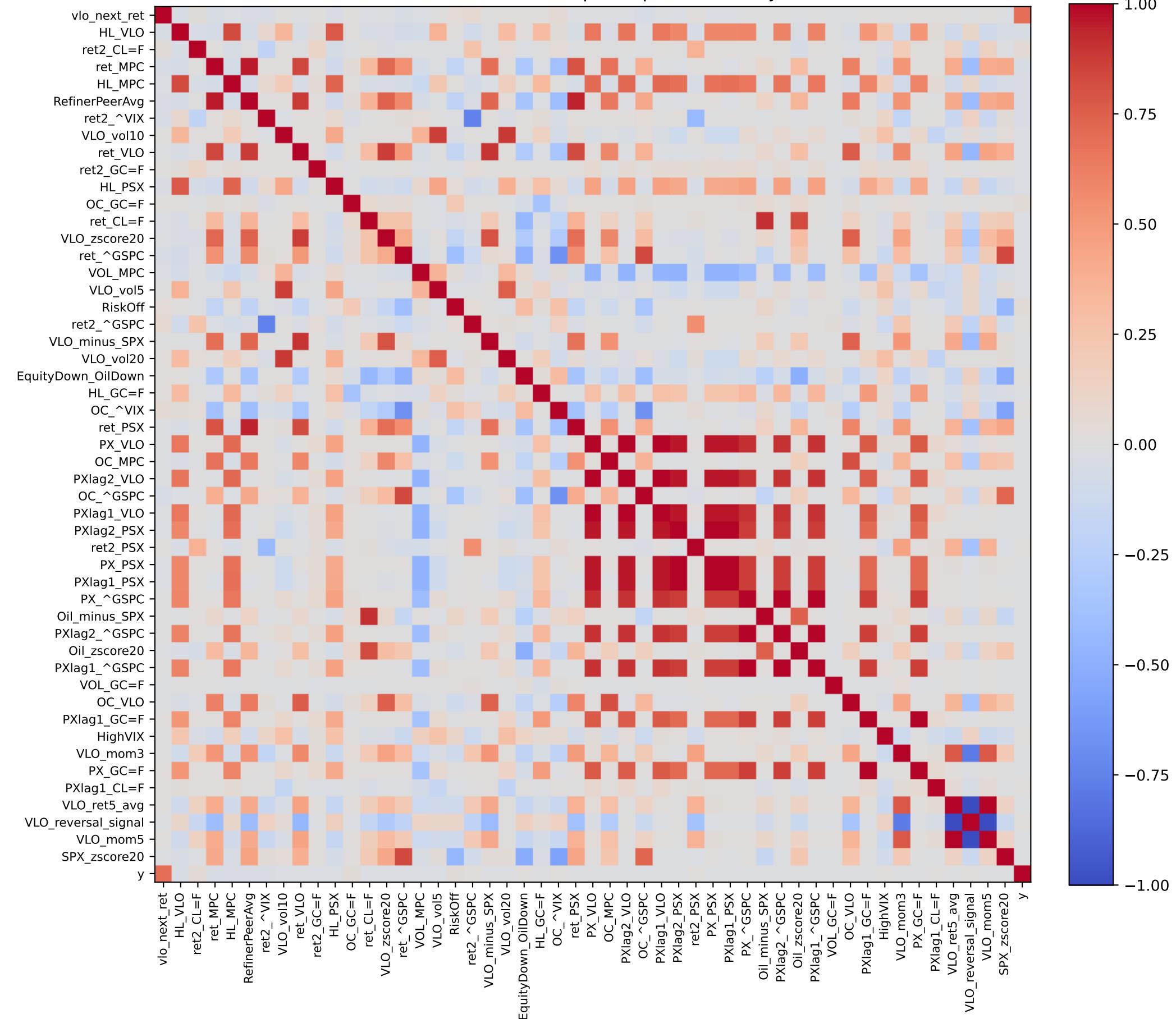
All Features — Univariate Associations with y (page 1/2)

| feature | corr_y | abs_corr_y | tstat_y | ks_y | auc_y | mi_y |
|--------------------|-----------|------------|-----------|----------|----------|----------|
| vlo_next_ret | 0.691505 | 0.691505 | 55.987929 | 1.0 | 1.0 | 0.691741 |
| HL_VLO | -0.046045 | 0.046045 | -2.688072 | 0.038474 | 0.480136 | 0.0 |
| ret2_CL=F | 0.041076 | 0.041076 | 2.431799 | 0.03974 | 0.520831 | 0.000194 |
| ret_MPC | -0.040133 | 0.040133 | -2.358049 | 0.035606 | 0.490424 | 0.0 |
| HL_MPC | -0.03244 | 0.03244 | -1.894876 | 0.039294 | 0.4842 | 0.0 |
| RefinerPeerAvg | -0.031592 | 0.031592 | -1.85431 | 0.023803 | 0.496759 | 0.006697 |
| ret2_^VIX | -0.031387 | 0.031387 | -1.836539 | 0.044836 | 0.484461 | 0.003393 |
| VLO_vol10 | -0.031058 | 0.031058 | -1.815622 | 0.03114 | 0.487767 | 0.0 |
| ret_VLO | -0.029653 | 0.029653 | -1.734045 | 0.038749 | 0.490558 | 0.00678 |
| ret2_GC=F | -0.028534 | 0.028534 | -1.677799 | 0.049113 | 0.4759 | 0.0 |
| HL_PSX | -0.026983 | 0.026983 | -1.573757 | 0.029387 | 0.494262 | 0.010954 |
| OC_GC=F | 0.026437 | 0.026437 | 1.538385 | 0.038386 | 0.519364 | 0.0 |
| ret_CL=F | -0.025338 | 0.025338 | -1.488233 | 0.050185 | 0.485804 | 0.0 |
| VLO_zscore20 | -0.025066 | 0.025066 | -1.469879 | 0.03978 | 0.487339 | 0.011347 |
| ret_^GSPC | -0.024854 | 0.024854 | -1.455634 | 0.035942 | 0.485628 | 0.009192 |
| VOL_MPC | -0.024309 | 0.024309 | -1.426265 | 0.028077 | 0.488932 | 0.0 |
| VLO_vol5 | -0.024115 | 0.024115 | -1.410738 | 0.035546 | 0.48958 | 0.016554 |
| RiskOff | 0.023936 | 0.023936 | 1.40861 | 0.01854 | 0.50927 | 0.011565 |
| ret2_^GSPC | 0.022097 | 0.022097 | 1.293884 | 0.018124 | 0.500832 | 0.001433 |
| VLO_minus_SPX | -0.02152 | 0.02152 | -1.256988 | 0.027358 | 0.494203 | 0.0 |
| VLO_vol20 | -0.021356 | 0.021356 | -1.250123 | 0.028107 | 0.49171 | 0.003947 |
| EquityDown_OilDown | 0.021004 | 0.021004 | 1.234876 | 0.018391 | 0.509196 | 0.0 |
| HL_GC=F | -0.019178 | 0.019178 | -1.111587 | 0.025508 | 0.489386 | 0.021829 |
| OC_^VIX | 0.018429 | 0.018429 | 1.081582 | 0.023634 | 0.506621 | 0.0 |
| ret_PSX | -0.018196 | 0.018196 | -1.066811 | 0.027899 | 0.50323 | 0.0 |
| PX_VLO | -0.017936 | 0.017936 | -1.05193 | 0.02568 | 0.489112 | 0.0 |
| OC_MPC | -0.017884 | 0.017884 | -1.042651 | 0.019983 | 0.498778 | 0.0 |
| PXlag2_VLO | -0.017558 | 0.017558 | -1.029688 | 0.027135 | 0.49015 | 0.009596 |
| OC_^GSPC | -0.017203 | 0.017203 | -1.006782 | 0.040273 | 0.489487 | 0.007856 |
| PXlag1_VLO | -0.01707 | 0.01707 | -1.001113 | 0.023675 | 0.490226 | 0.0 |
| PXlag2_PSX | -0.01705 | 0.01705 | -1.000735 | 0.029352 | 0.491132 | 0.008608 |
| ret2_PSX | 0.016883 | 0.016883 | 0.986173 | 0.028031 | 0.510244 | 0.0 |
| PX_PSX | -0.016551 | 0.016551 | -0.971599 | 0.026838 | 0.490286 | 0.009906 |
| PXlag1_PSX | -0.015889 | 0.015889 | -0.932685 | 0.023308 | 0.491358 | 0.0 |
| PX_^GSPC | -0.015407 | 0.015407 | -0.905195 | 0.045877 | 0.487471 | 0.002178 |
| Oil_minus_SPX | -0.015391 | 0.015391 | -0.902953 | 0.043558 | 0.490448 | 0.002935 |
| PXlag2_^GSPC | -0.015309 | 0.015309 | -0.899436 | 0.045457 | 0.487447 | 0.0 |
| Oil_zscore20 | -0.015002 | 0.015002 | -0.879259 | 0.050545 | 0.487688 | 0.0 |
| PXlag1_^GSPC | -0.014813 | 0.014813 | -0.870264 | 0.04504 | 0.487653 | 0.0 |
| VOL_GC=F | -0.014499 | 0.014499 | -0.848358 | 0.047932 | 0.475643 | 0.005982 |

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

| feature | corr_y | abs_corr_y | tstat_y | ks_y | auc_y | mi_y |
|---------------------|-----------|------------|-----------|----------|----------|----------|
| OC_VLO | -0.013544 | 0.013544 | -0.789147 | 0.034333 | 0.493486 | 0.0 |
| PXlag1_GC=F | -0.011931 | 0.011931 | -0.699399 | 0.033633 | 0.494957 | 0.001601 |
| HighVIX | 0.011906 | 0.011906 | 0.699265 | 0.011385 | 0.505692 | 0.0 |
| VLO_mom3 | -0.011636 | 0.011636 | -0.681614 | 0.018055 | 0.499941 | 0.0 |
| PX_GC=F | -0.011526 | 0.011526 | -0.675751 | 0.032272 | 0.494708 | 0.0 |
| PXlag1_CL=F | 0.011439 | 0.011439 | 0.671402 | 0.019505 | 0.506672 | 0.011191 |
| VLO_ret5_avg | -0.011399 | 0.011399 | -0.667883 | 0.019181 | 0.499446 | 0.012324 |
| VLO_reversal_signal | 0.011399 | 0.011399 | 0.667883 | 0.019181 | 0.500554 | 0.01261 |
| VLO_mom5 | -0.011399 | 0.011399 | -0.667883 | 0.019181 | 0.499446 | 0.012407 |
| SPX_zscore20 | -0.011239 | 0.011239 | -0.658457 | 0.034125 | 0.490646 | 0.0 |
| PXlag2_GC=F | -0.010728 | 0.010728 | -0.629102 | 0.033404 | 0.495475 | 0.0 |
| PX_CL=F | 0.010601 | 0.010601 | 0.622352 | 0.018567 | 0.50638 | 0.0 |
| PX_MPC | -0.010523 | 0.010523 | -0.61723 | 0.02179 | 0.493902 | 0.0 |
| PXlag2_MPC | -0.010012 | 0.010012 | -0.58725 | 0.017572 | 0.495094 | 0.002548 |
| OC_CL=F | -0.009911 | 0.009911 | -0.581858 | 0.046313 | 0.488169 | 0.0 |
| PXlag1_MPC | -0.009728 | 0.009728 | -0.57059 | 0.017882 | 0.49525 | 0.00455 |
| OilShock | -0.008772 | 0.008772 | -0.513979 | 0.004088 | 0.497956 | 0.018487 |
| VLO_vol_ratio_5_20 | -0.008744 | 0.008744 | -0.512671 | 0.028386 | 0.494839 | 0.003344 |
| PXlag2_CL=F | 0.008461 | 0.008461 | 0.496608 | 0.019984 | 0.505344 | 0.00071 |
| HL_~VIX | 0.00828 | 0.00828 | 0.486896 | 0.022419 | 0.505396 | 0.0 |
| ret2_MPC | 0.006995 | 0.006995 | 0.408026 | 0.028654 | 0.50802 | 0.011492 |
| VOL_VLO | 0.006372 | 0.006372 | 0.374493 | 0.02268 | 0.502929 | 0.009458 |
| VOL_~GSPC | -0.006298 | 0.006298 | -0.369157 | 0.034453 | 0.490794 | 0.0 |
| PXlag1_~VIX | -0.005568 | 0.005568 | -0.325914 | 0.029828 | 0.502587 | 0.0 |
| ret_GC=F | 0.005329 | 0.005329 | 0.312486 | 0.023779 | 0.504586 | 0.0 |
| PXlag2_~VIX | 0.004721 | 0.004721 | 0.277173 | 0.027117 | 0.506014 | 0.003327 |
| VOL_CL=F | -0.004695 | 0.004695 | -0.275775 | 0.025037 | 0.495171 | 0.0 |
| HL_~GSPC | -0.004262 | 0.004262 | -0.249408 | 0.029191 | 0.492165 | 0.00745 |
| VOL_PSX | -0.002749 | 0.002749 | -0.16135 | 0.016006 | 0.499199 | 0.0 |
| VLO_minus_Peers | -0.002587 | 0.002587 | -0.151301 | 0.034718 | 0.496443 | 0.00647 |
| OC_PSX | -0.002366 | 0.002366 | -0.138405 | 0.026872 | 0.504938 | 0.007885 |
| GoldShock | 0.001802 | 0.001802 | 0.105795 | 0.000857 | 0.500429 | 0.0 |
| HL_CL=F | -0.001141 | 0.001141 | -0.067467 | 0.035487 | 0.488422 | 0.008737 |
| Oil_minus_Refiners | 0.001007 | 0.001007 | 0.05914 | 0.030179 | 0.493306 | 0.004601 |
| PX_~VIX | -0.000871 | 0.000871 | -0.051179 | 0.01846 | 0.500112 | 0.0 |
| ret2_VLO | 5.9e-05 | 5.9e-05 | 0.003424 | 0.026158 | 0.498461 | 0.020757 |
| ret_~VIX | 3.8e-05 | 3.8e-05 | 0.002239 | 0.0243 | 0.495705 | 0.000442 |
| VOL_~VIX | nan | nan | nan | 0.0 | nan | 0.0 |

Correlation Heatmap — Top Features vs y



vlo_next_ret by y



HL_VLO by y



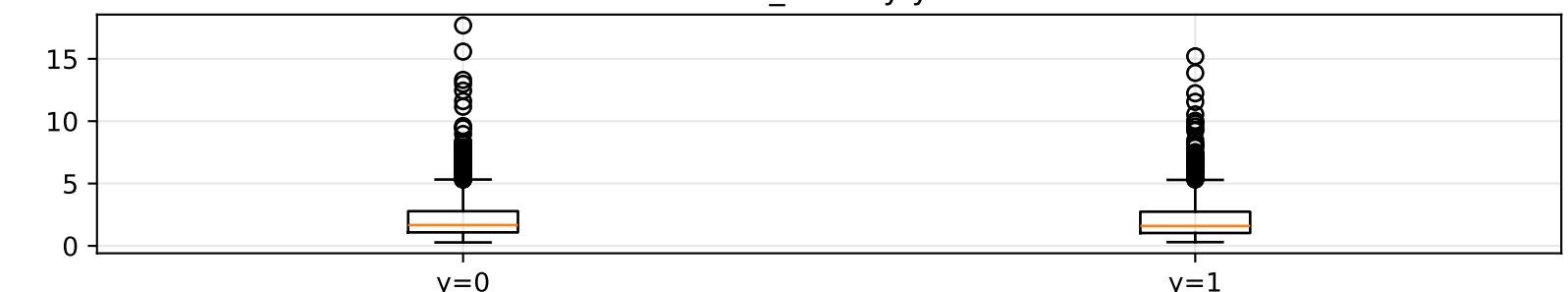
ret2_CL=F by y



ret_MPC by y



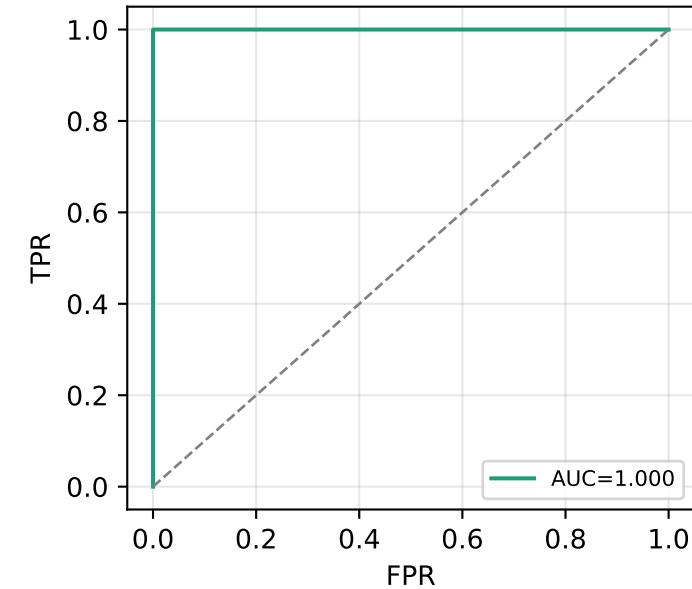
HL_MPC by y



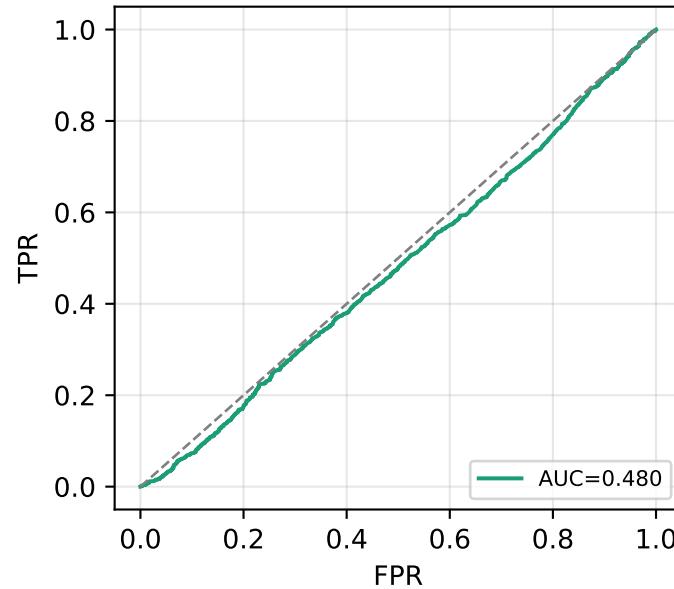
RefinerPeerAvg by y



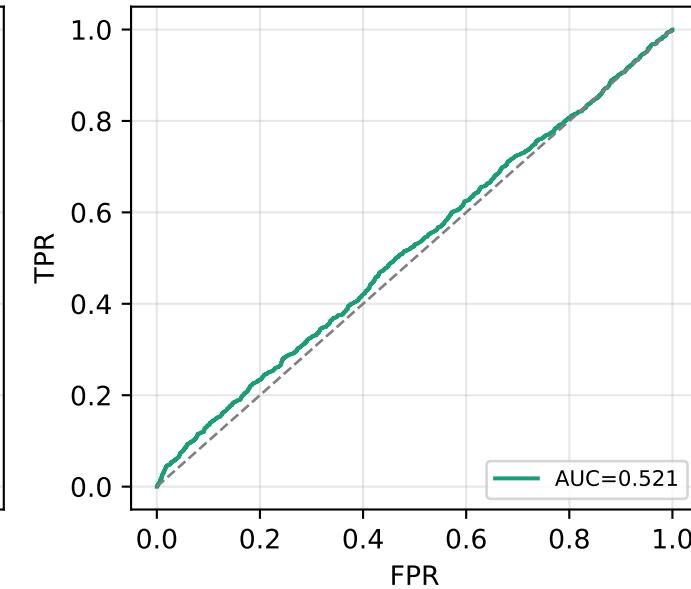
ROC — vlo_next_ret



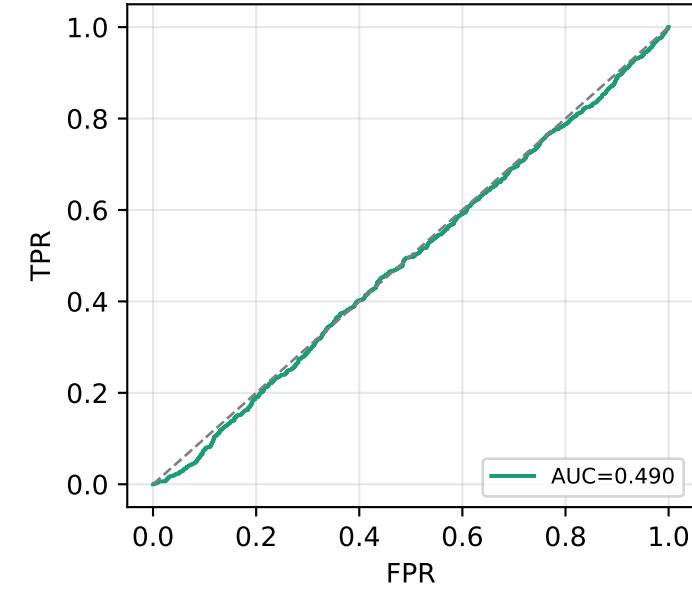
ROC — HL_VLO



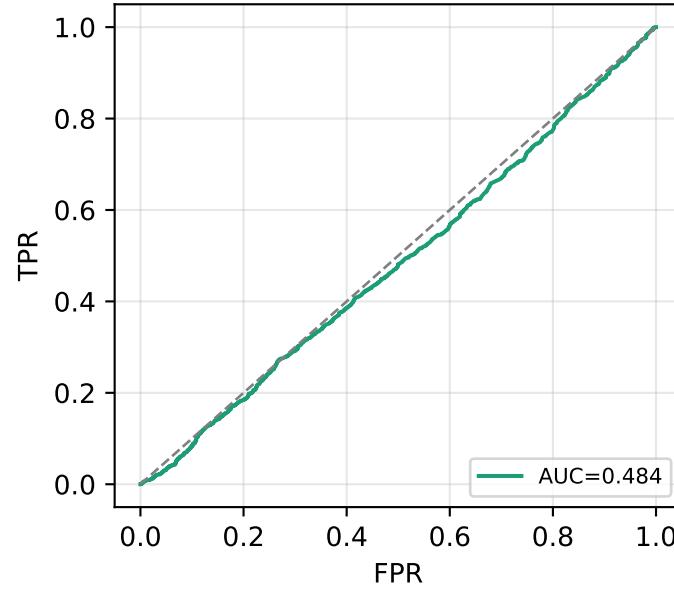
ROC — ret2_CL=F



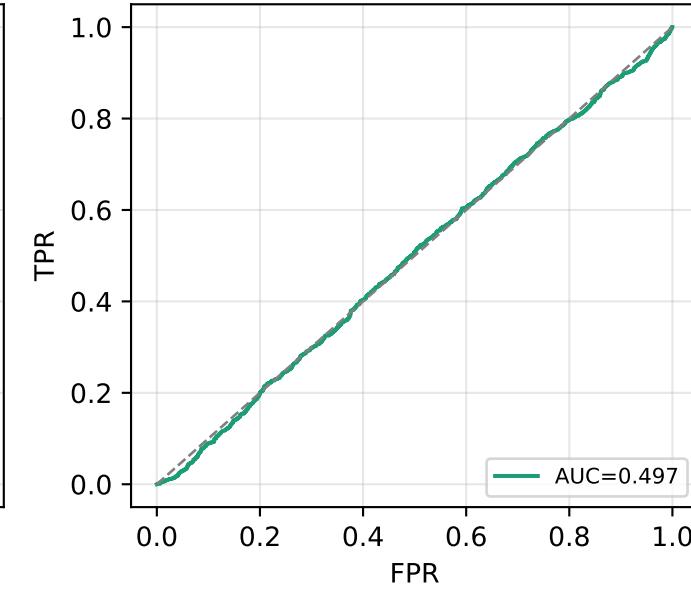
ROC — ret_MPC



ROC — HL_MPC



ROC — RefinerPeerAvg



Class-Wise Summary (Key Series)

| _^GSPC mean | ret_^GSPC std | ret_^GSPC min | ret_^GSPC median | ret_^GSPC max | ret_CL=F count | ret_CL=F mean | ret_CL=F std | ret_C |
|-------------|---------------|---------------|------------------|---------------|----------------|---------------|--------------|-------|
| 0.000755 | 0.010892 | -0.127652 | 0.000891 | 0.090895 | 1628.0 | 0.000652 | 0.025747 | -0 |
| 0.000226 | 0.010393 | -0.099945 | 0.000487 | 0.089683 | 1820.0 | -0.000658 | 0.025863 | -0 |

Report Metadata

Report path: /mnt/batch/tasks/shared/LS_root/mounts/clusters/dvandyk1/code/Users/dvandyk1/PycharmProjects/ML/ML_1000/ML_1000.ipynb
Rows in dataset: 3,448
Features (numeric): 78
sklearn available: True
scipy available: True
Generated: 2026-02-10 23:28:34