

Univariate GARCH Volatility & Diagnostics Report

Assets: CL=F, EUR_USD, GLD, MPC, PSX, SPY, VLO

This report estimates a GARCH(1,1) per asset, visualizes annualized conditional volatility, overlays realized volatility (100D)

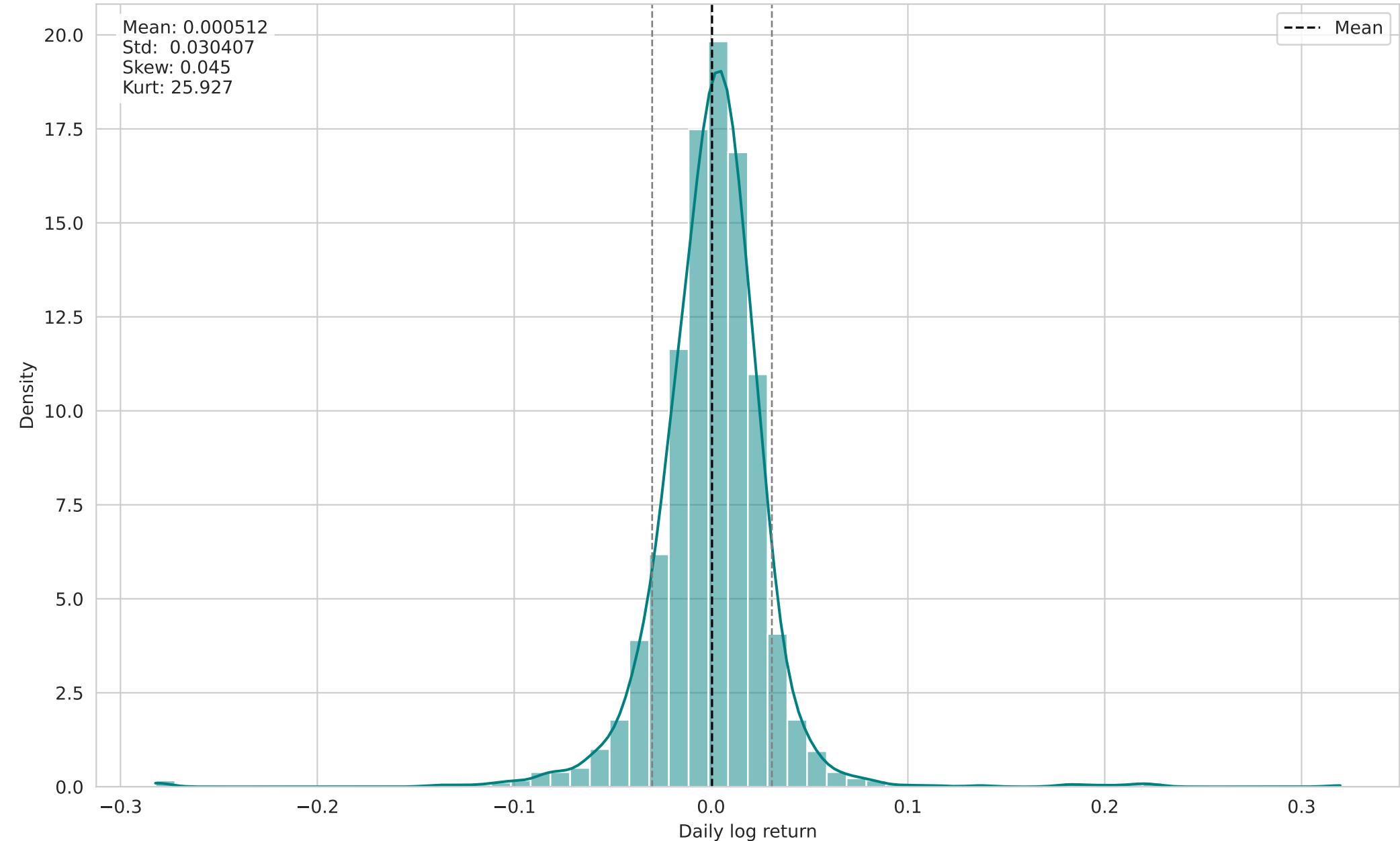
Report Settings

Metric	Value
Model	GARCH(1,1) with mean=constant; ML estimation
Innovation Distribution	Gaussian
Forecast Horizon (h)	90
Volatility Units	Annualized % (daily $\sigma * \sqrt{252} * 100$)
Realized Vol Window	100 trading days (annualized %)
ACF Shaded Band	95% bounds around 0 under H_0 (no autocorrelation)
Assets Included	CL=F, EUR_USD, GLD, MPC, PSX, SPY, VLO

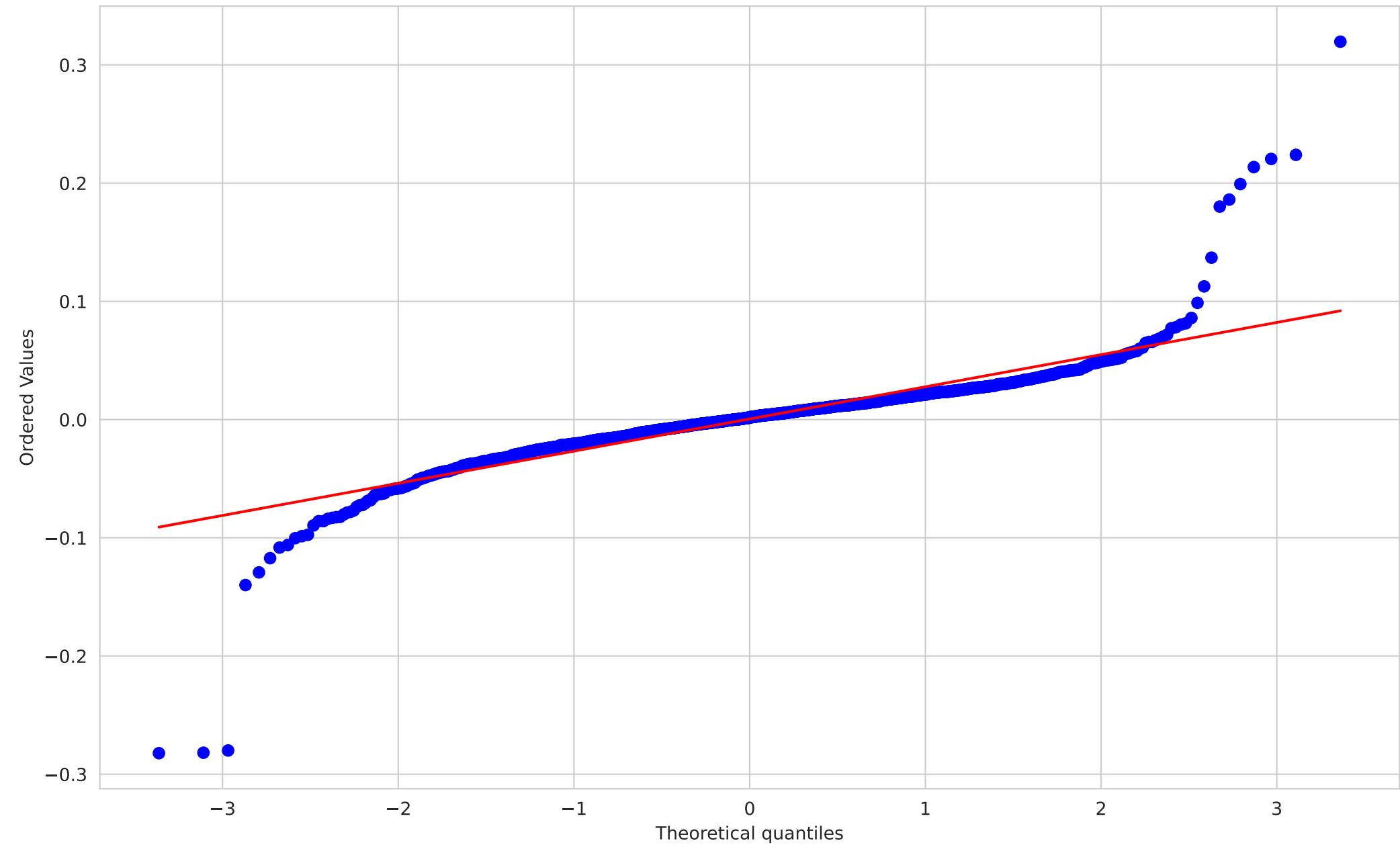
CL=F • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.000697	Estimated average daily return (constant mean in the return equation).
ω	1.848354e-05	Variance intercept; baseline level feeding the long-run variance.
α	0.100000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.880000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000924	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309283	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	4180.956160	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-8353.912319	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-8331.952435	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

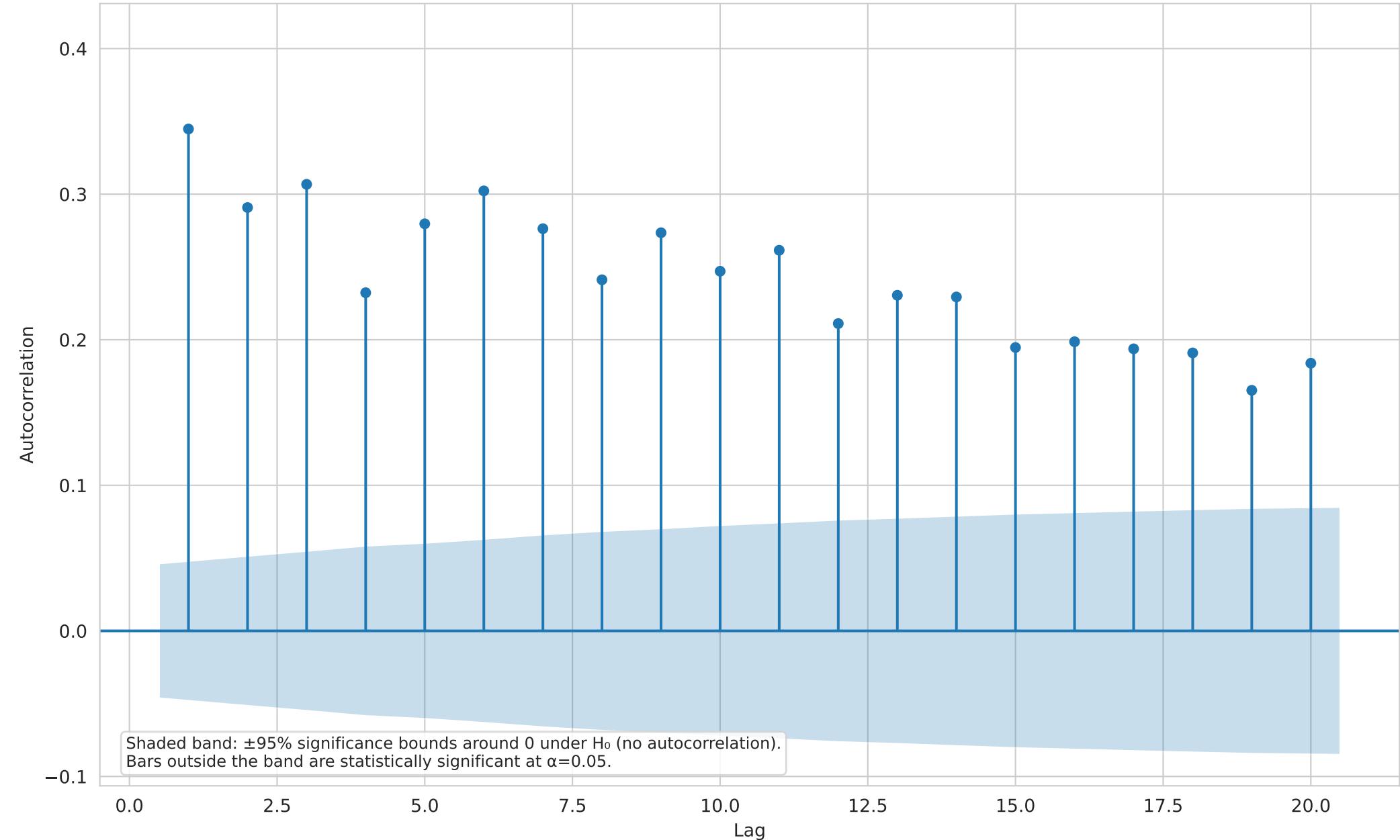
CL=F • Return Distribution



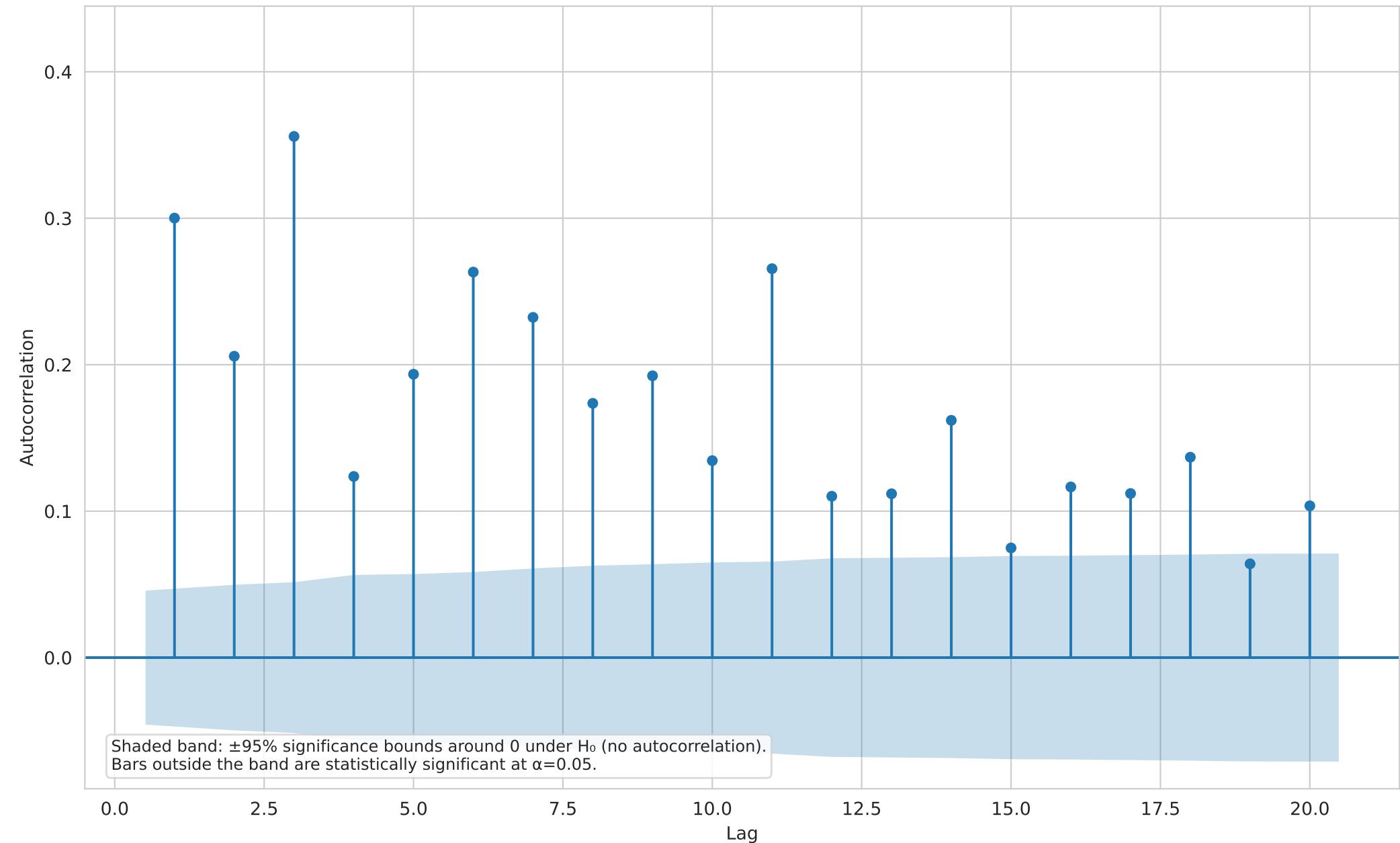
CL=F • Q-Q Plot (Normal)



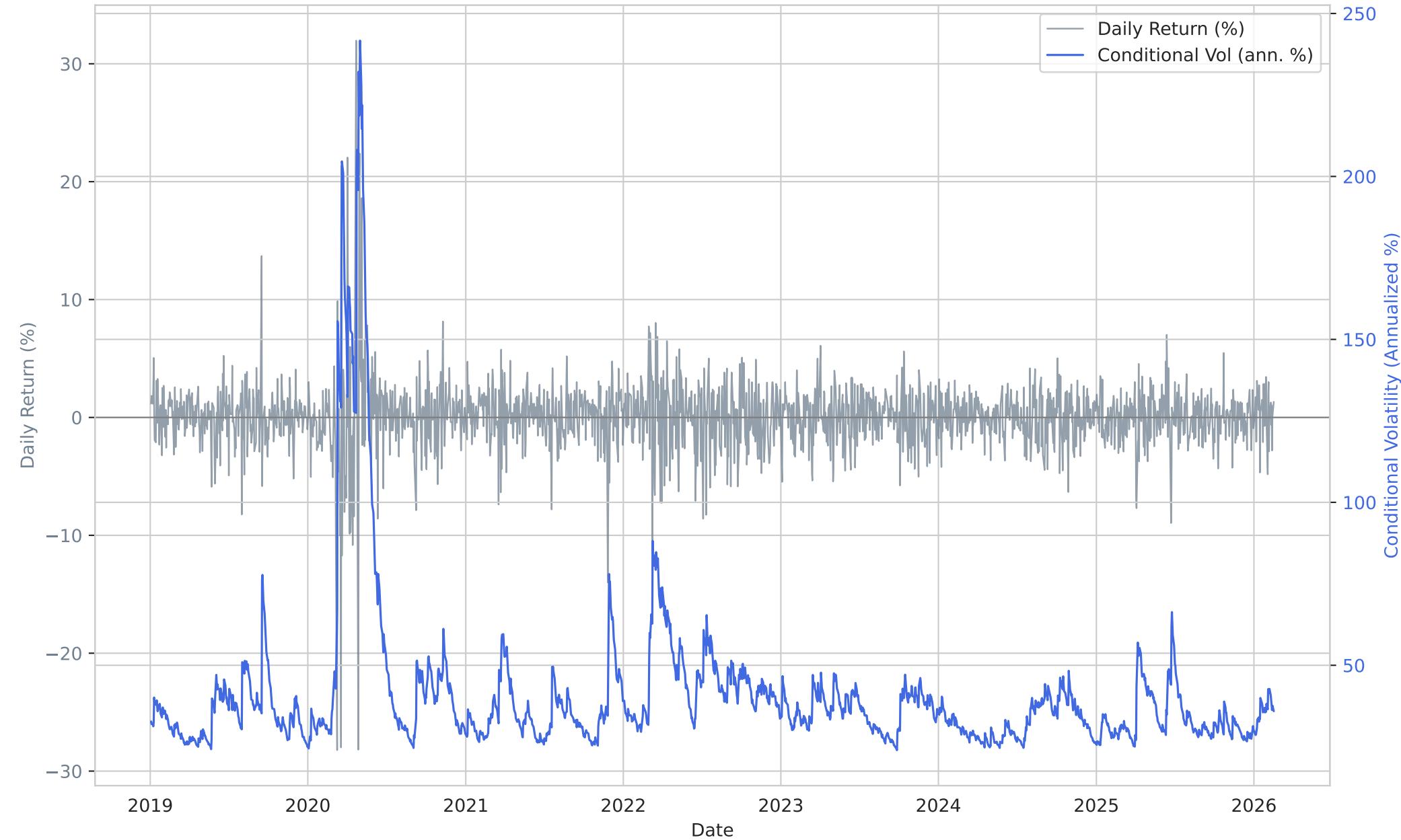
CL=F • ACF(|r|) [Lag 0 Omitted]



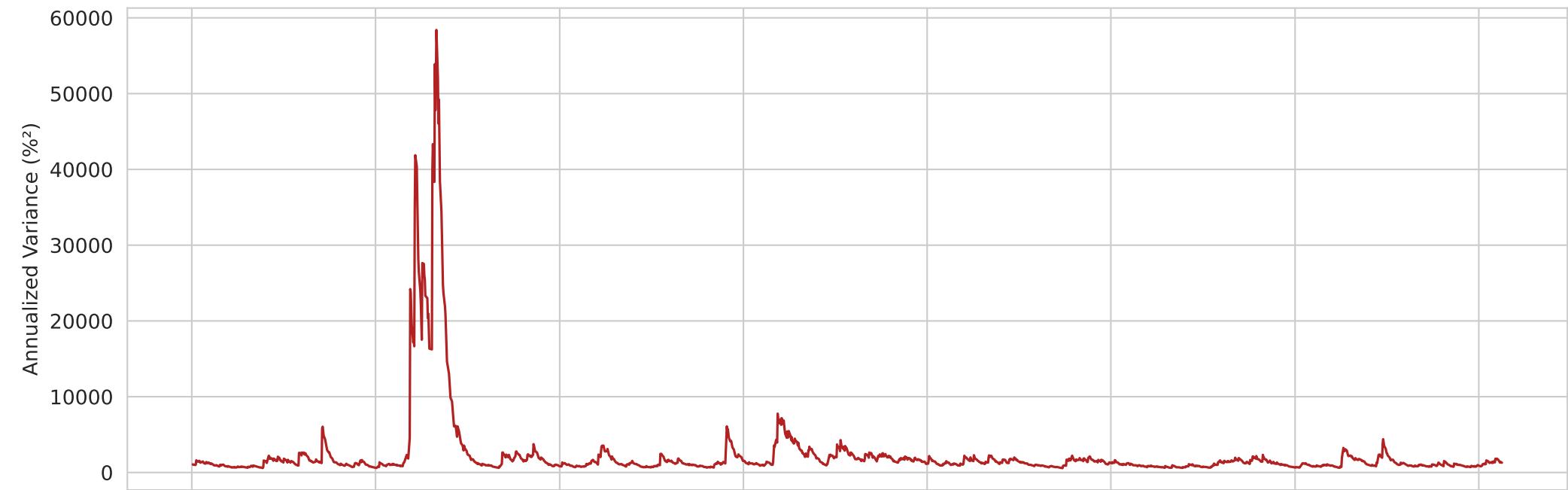
CL=F • ACF(r^2) [Lag 0 Omitted]



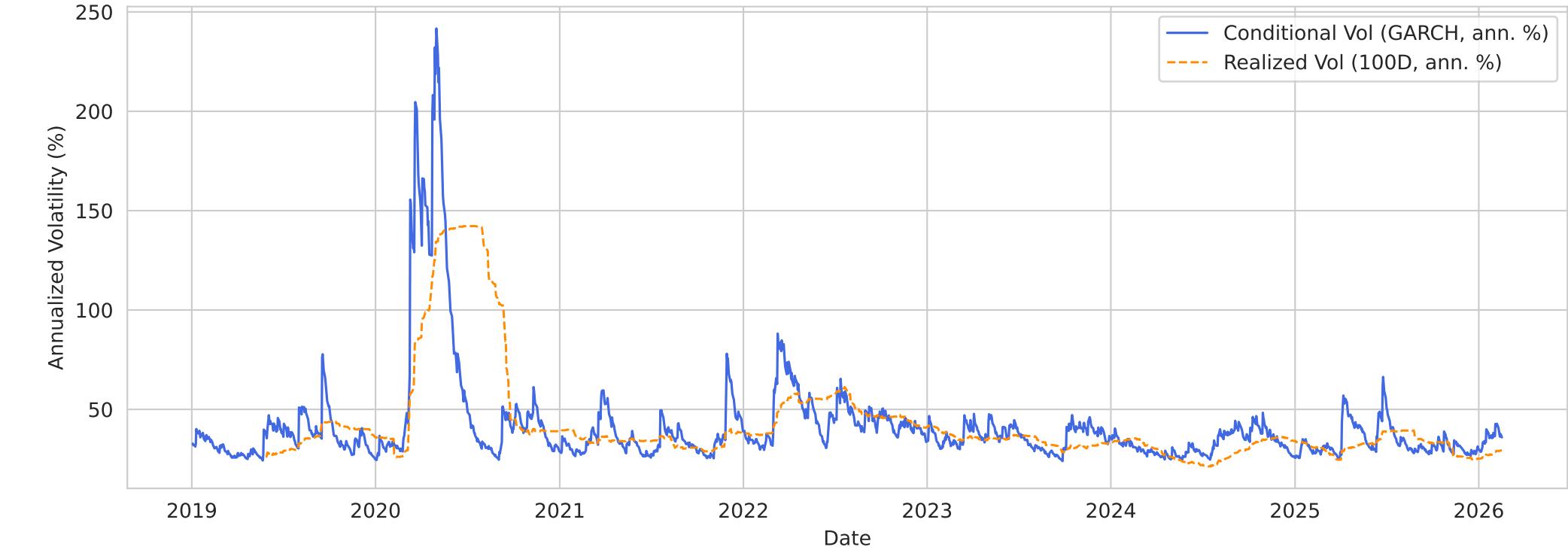
CL=F • Daily % Returns vs Conditional Volatility (Annualized %)



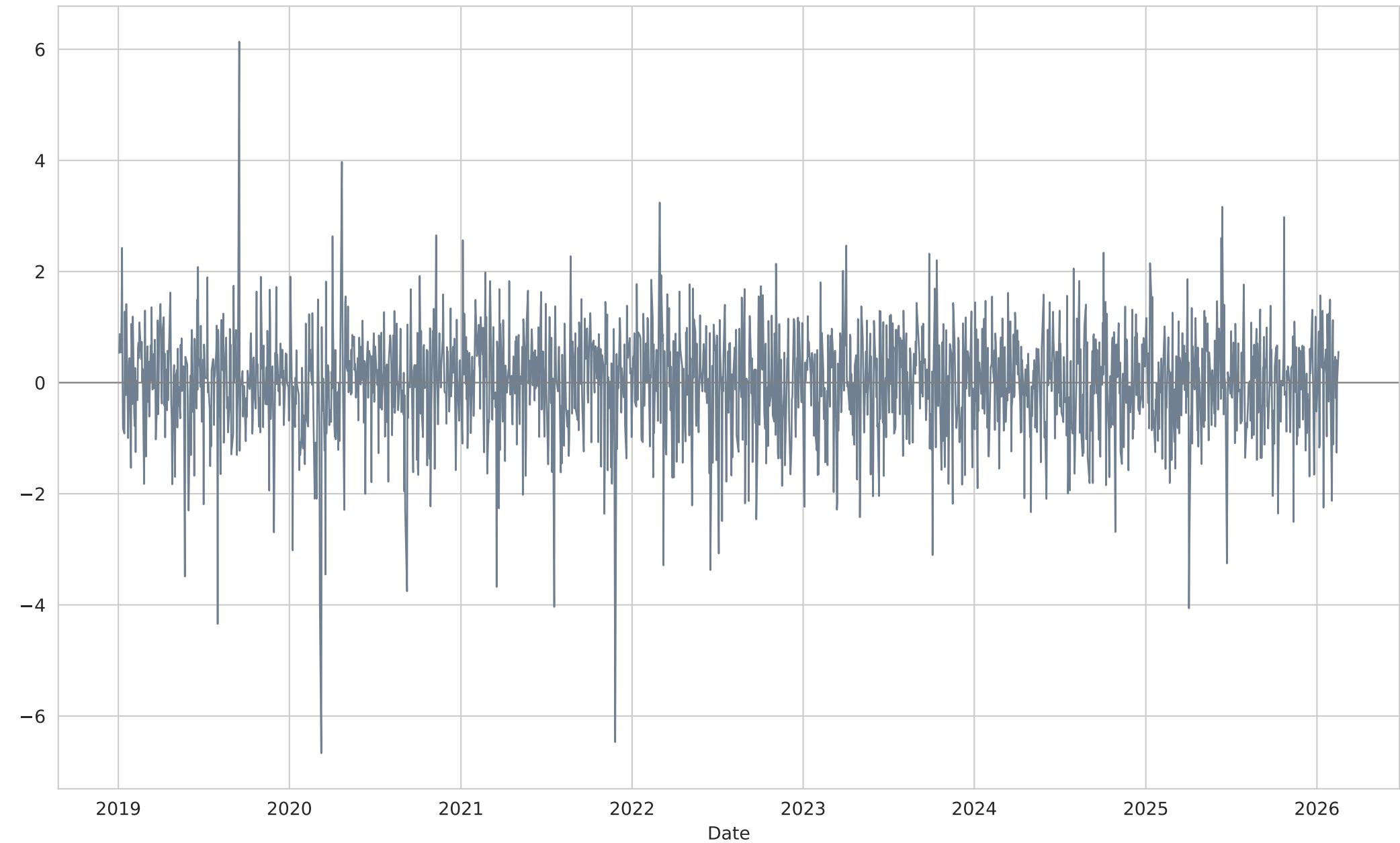
CL=F • Conditional Variance (Annualized, %²)



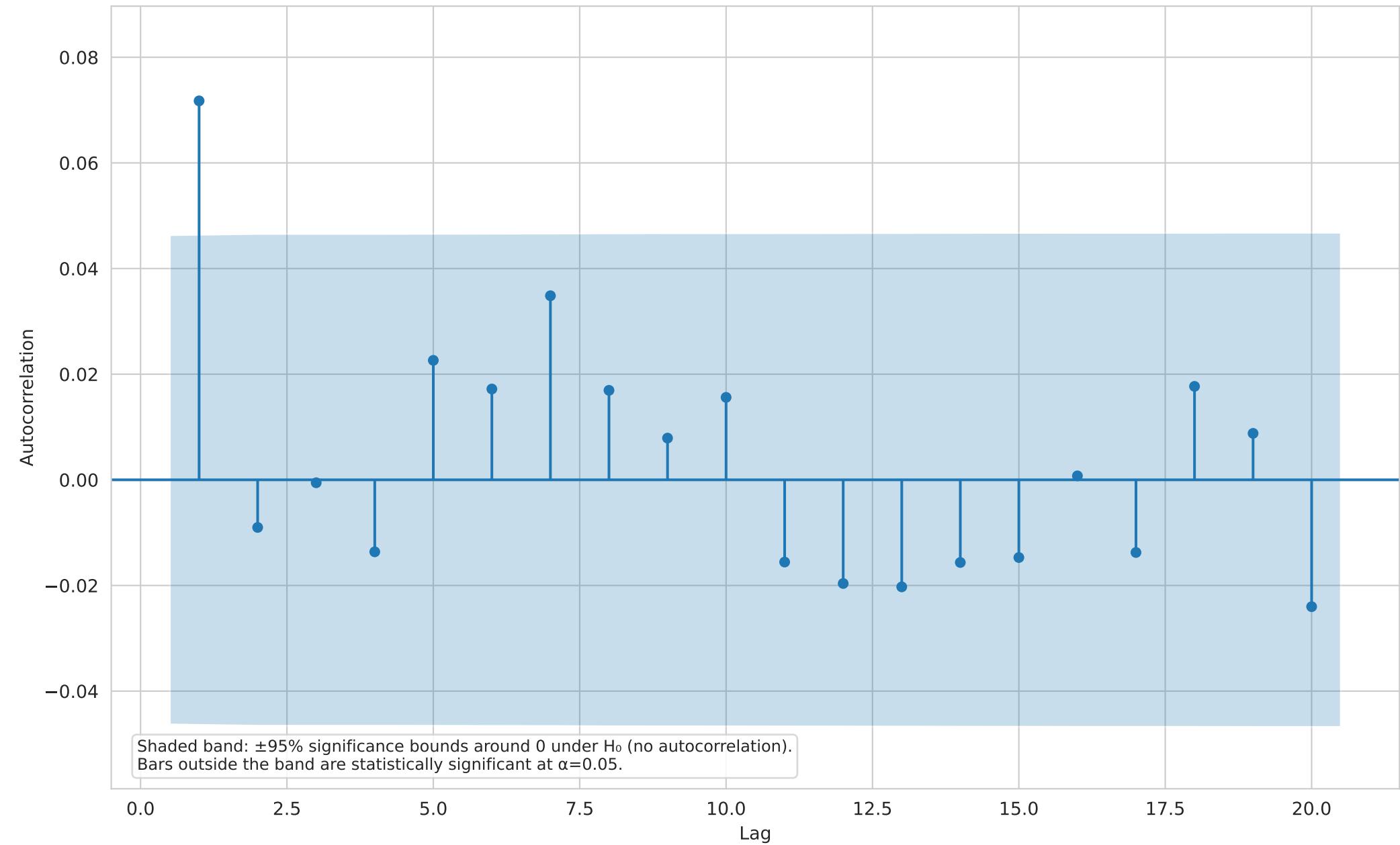
CL=F • Volatility (Annualized %) • Conditional vs Realized



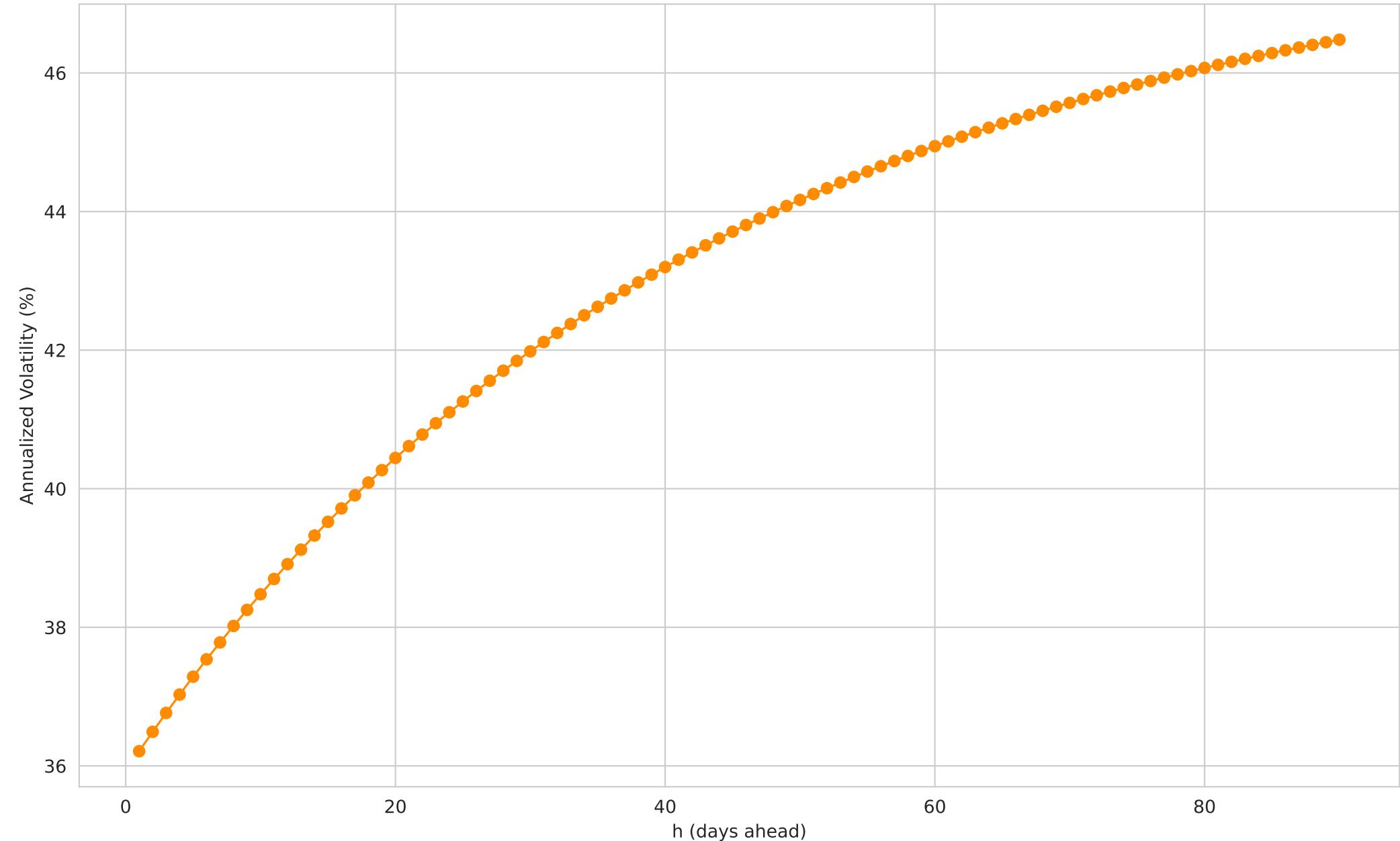
CL=F • Standardized Residuals



CL=F • ACF(Standardized Residuals²) [Lag 0 Omitted]



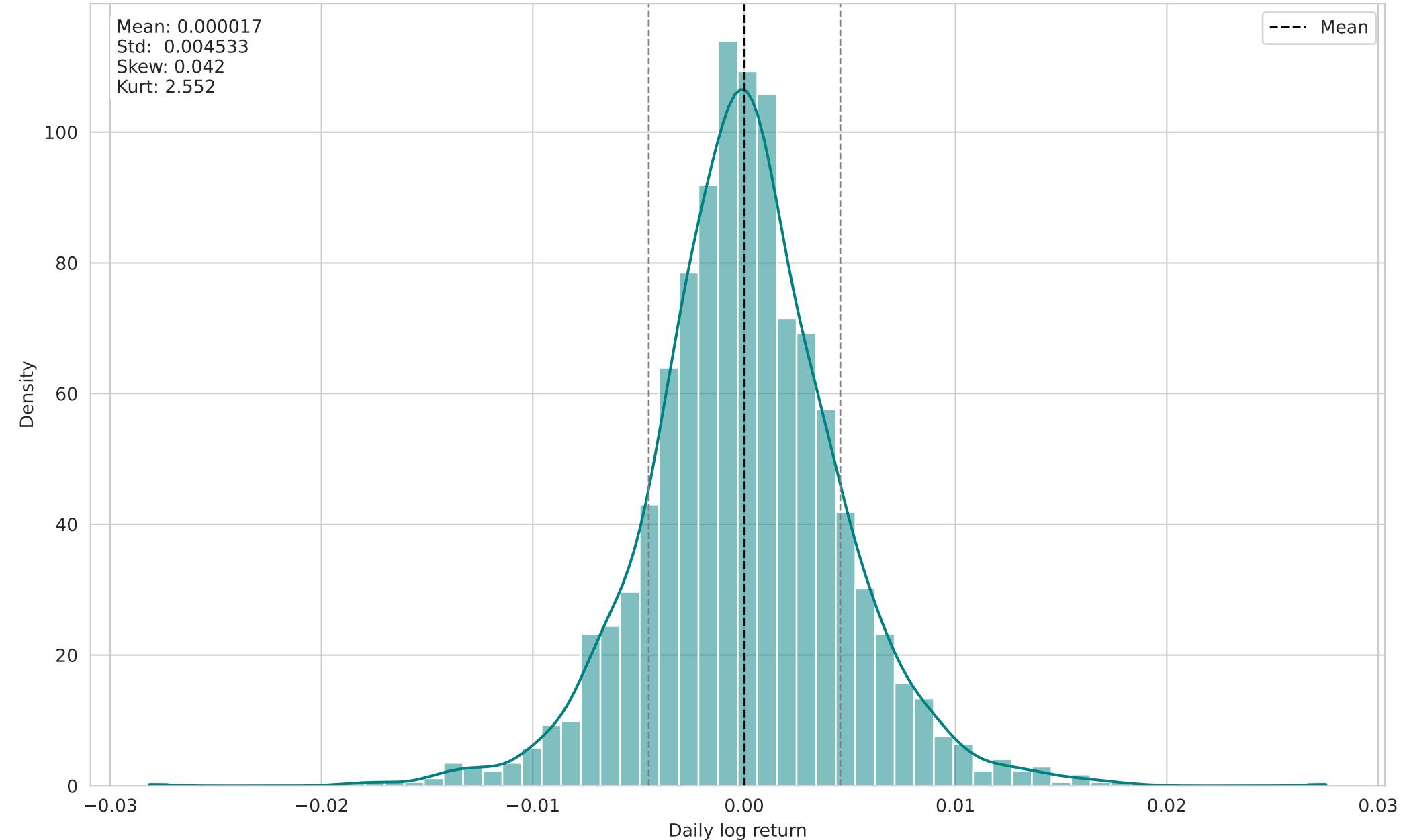
CL=F • h-Step Volatility Forecast (Annualized %, Closed-Form)



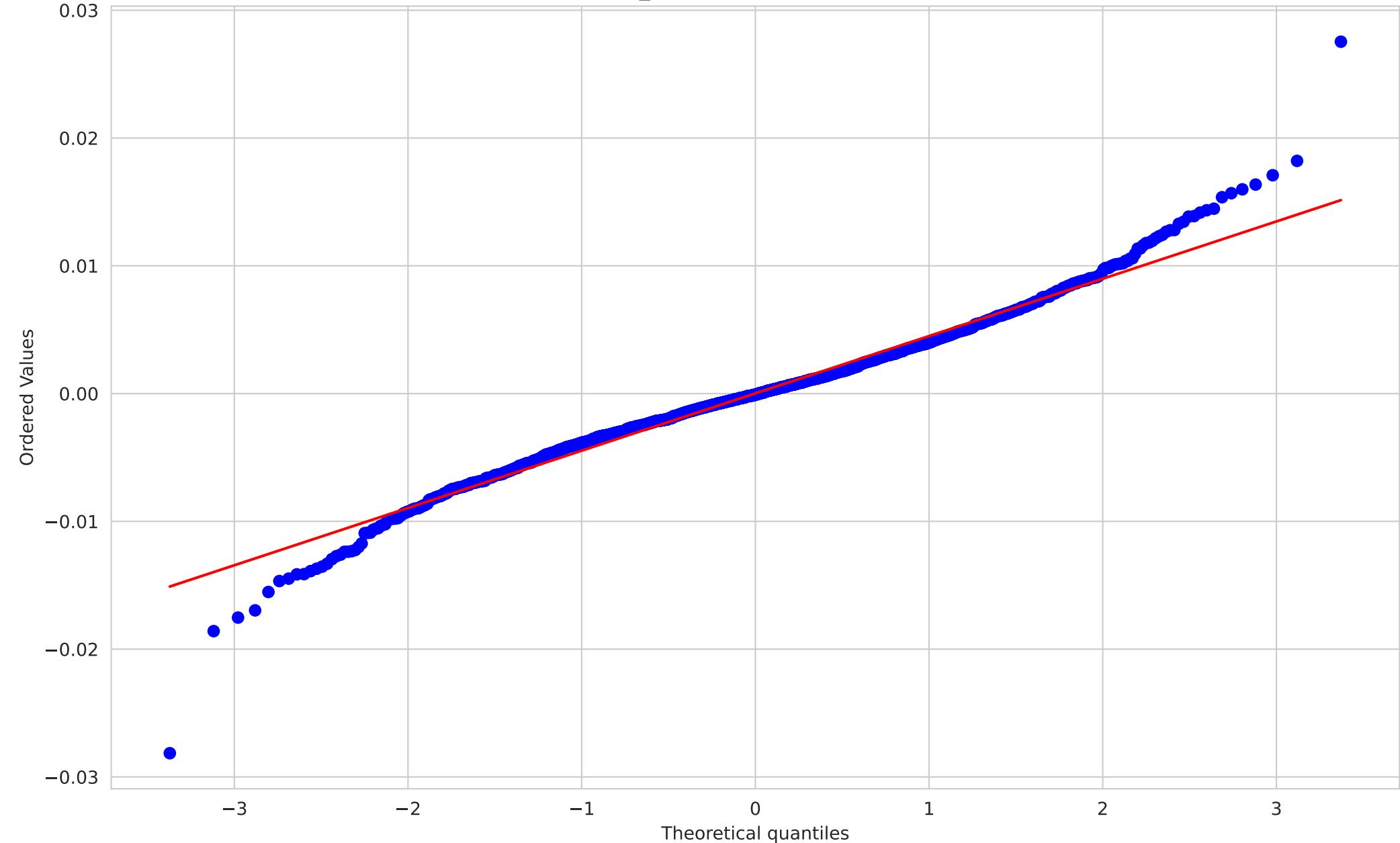
EUR_USD • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.004518	Estimated average daily return (constant mean in the return equation).
ω	4.106655e-07	Variance intercept; baseline level feeding the long-run variance.
α	0.050000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.930000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	2.053328e-05	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309636	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	6722.373639	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-1.343675e+04	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-1.341465e+04	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

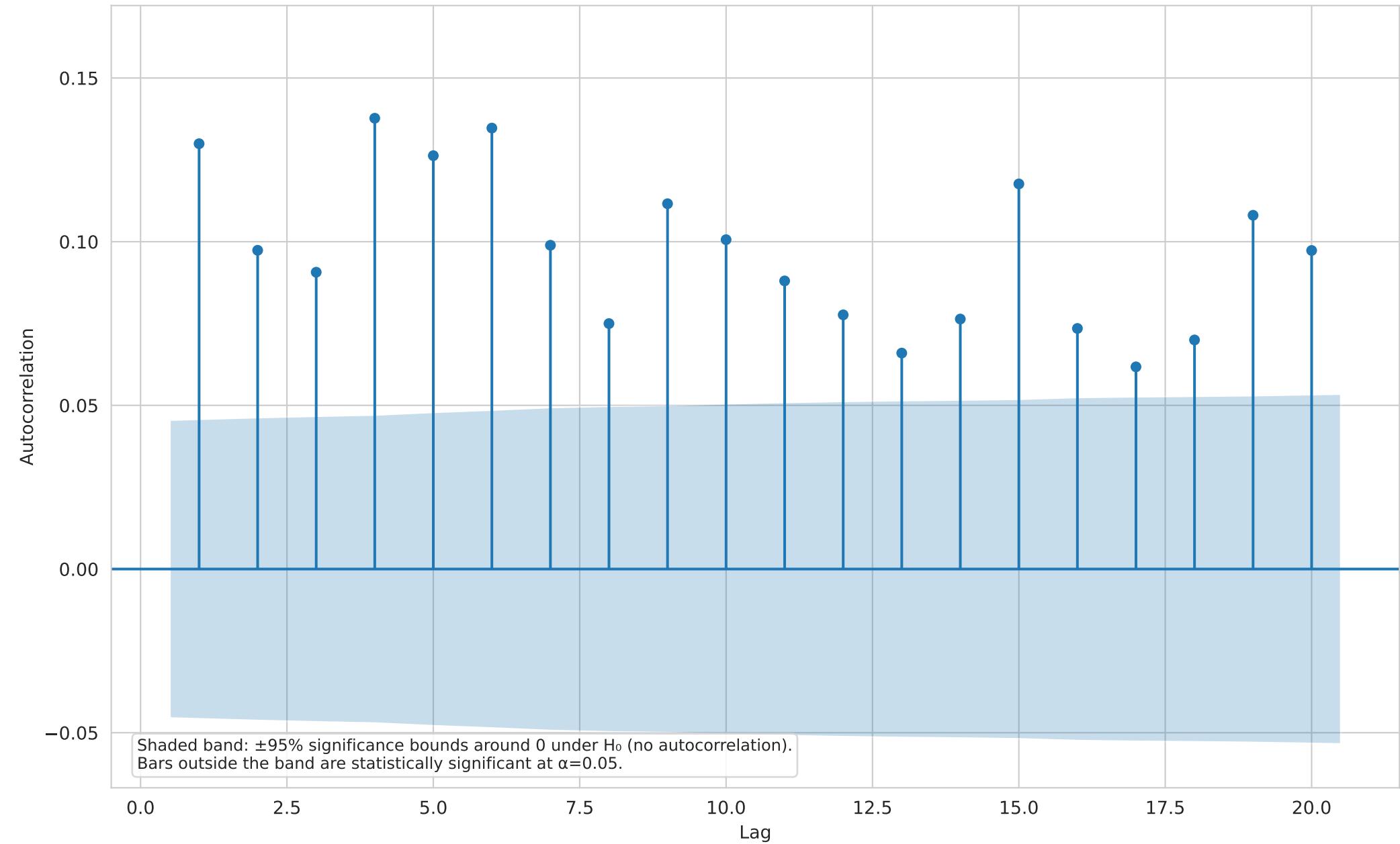
EUR_USD • Return Distribution



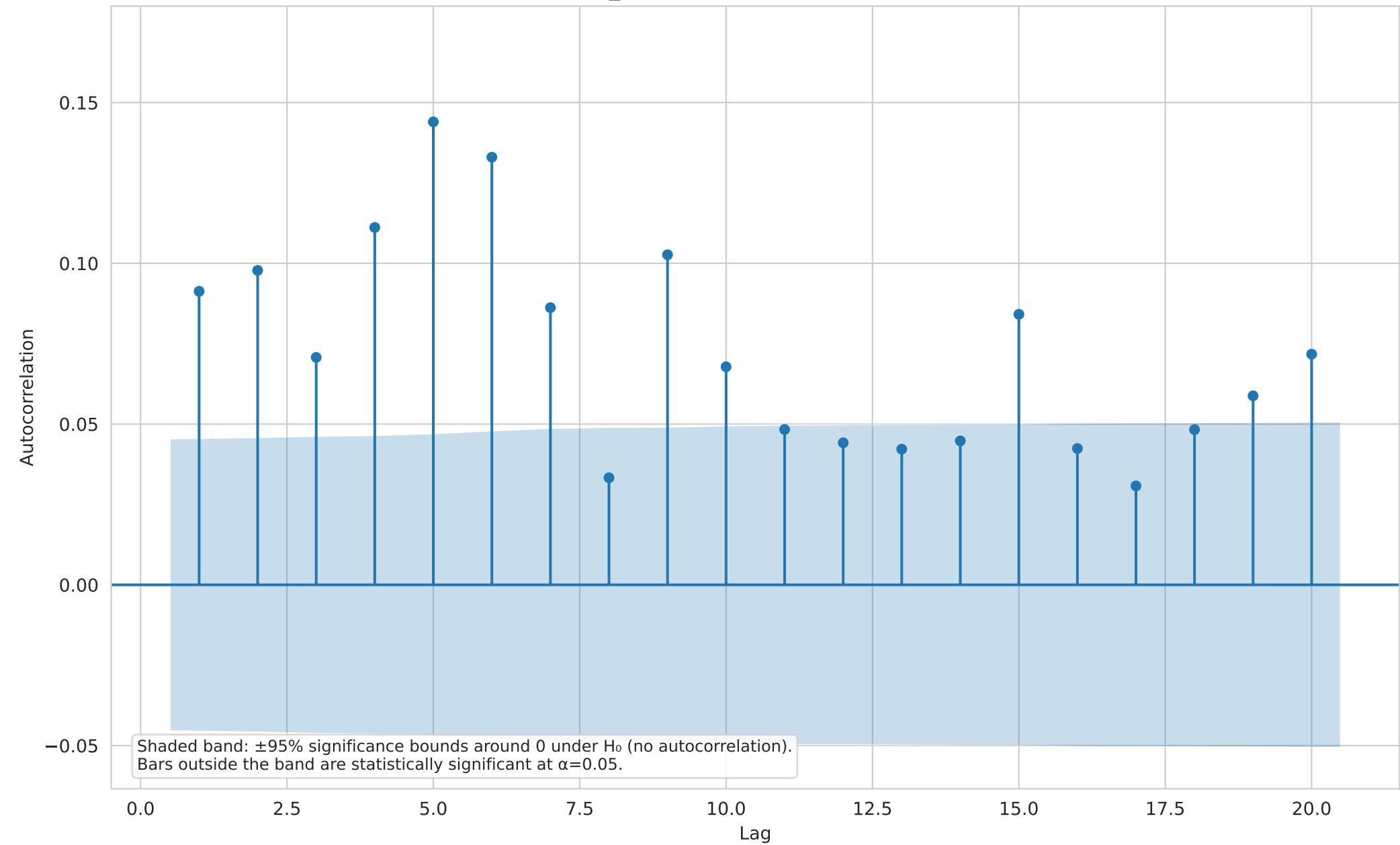
EUR_USD • Q-Q Plot (Normal)



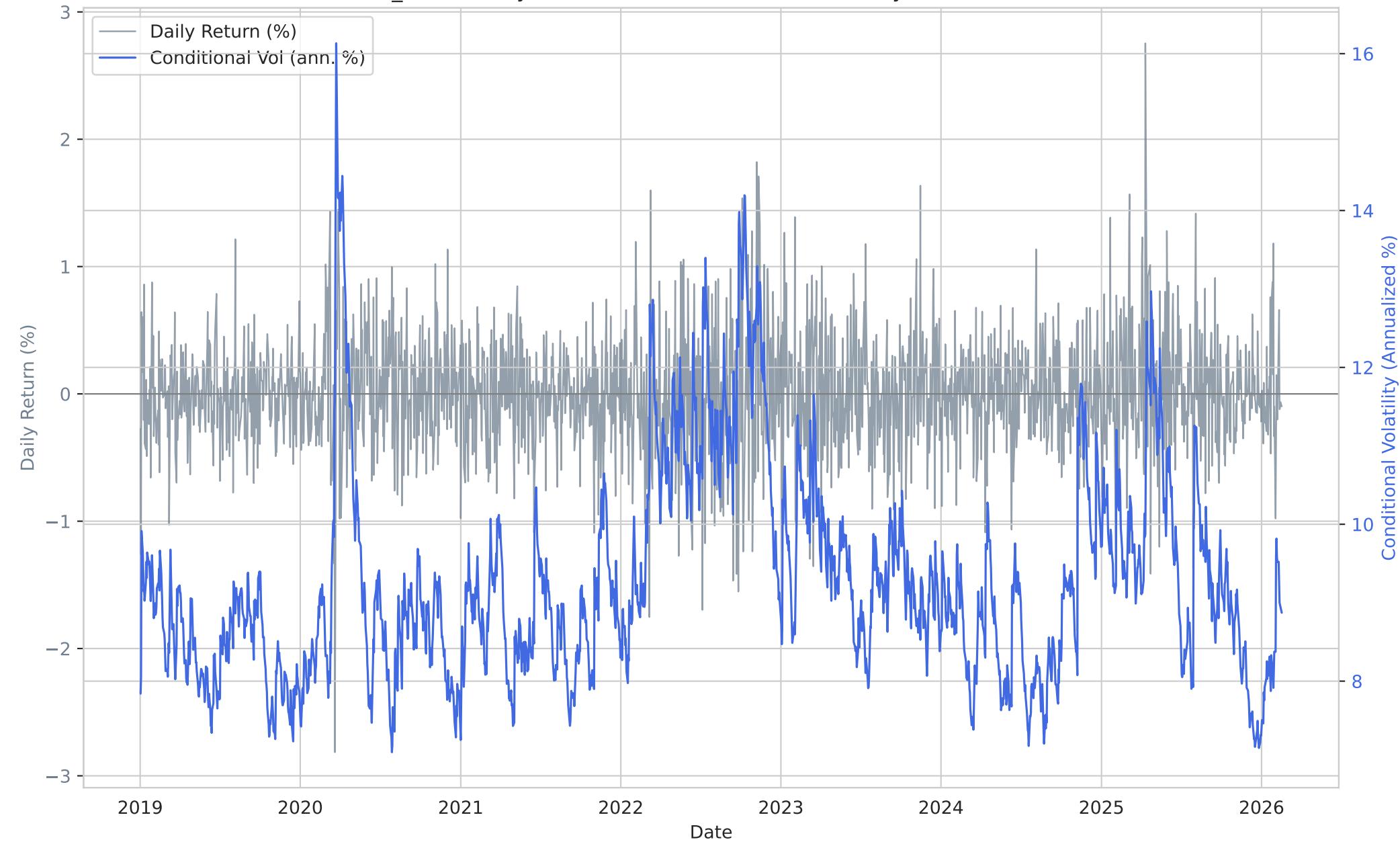
EUR_USD • ACF(|r|) [Lag 0 Omitted]



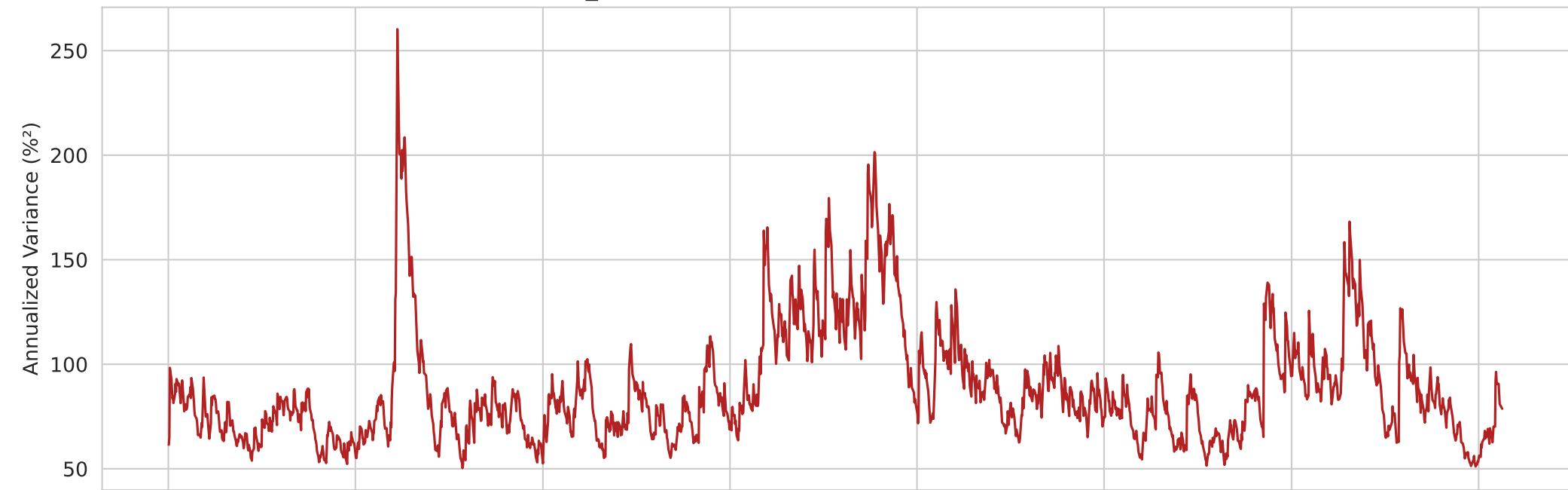
EUR_USD • ACF(r^2) [Lag 0 Omitted]



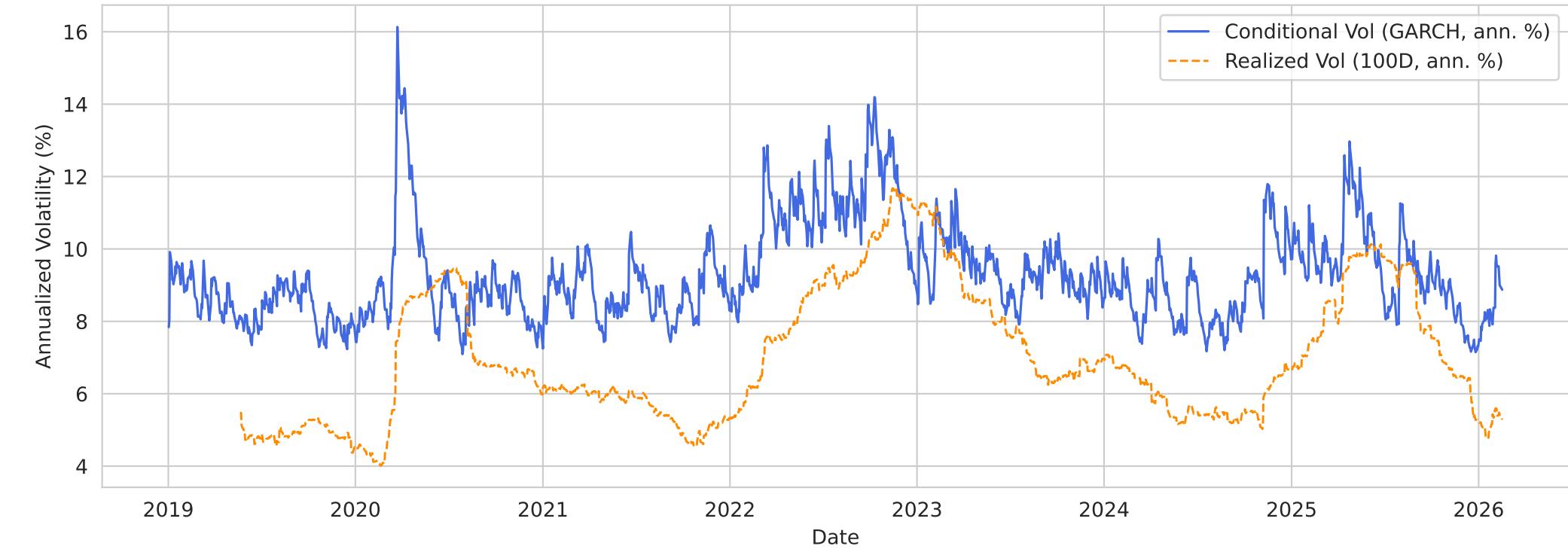
EUR_USD • Daily % Returns vs Conditional Volatility (Annualized %)



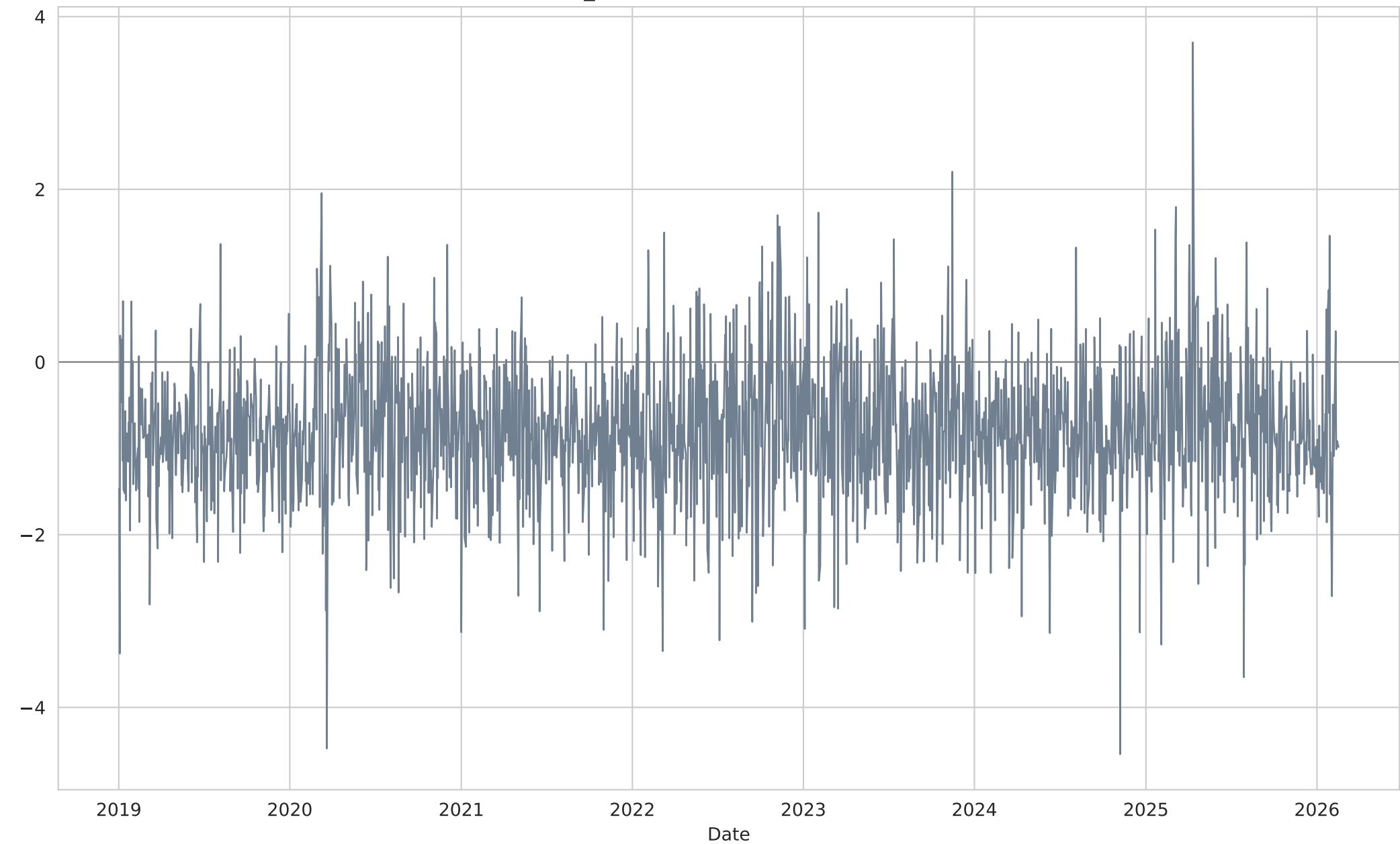
EUR_USD • Conditional Variance (Annualized, %²)



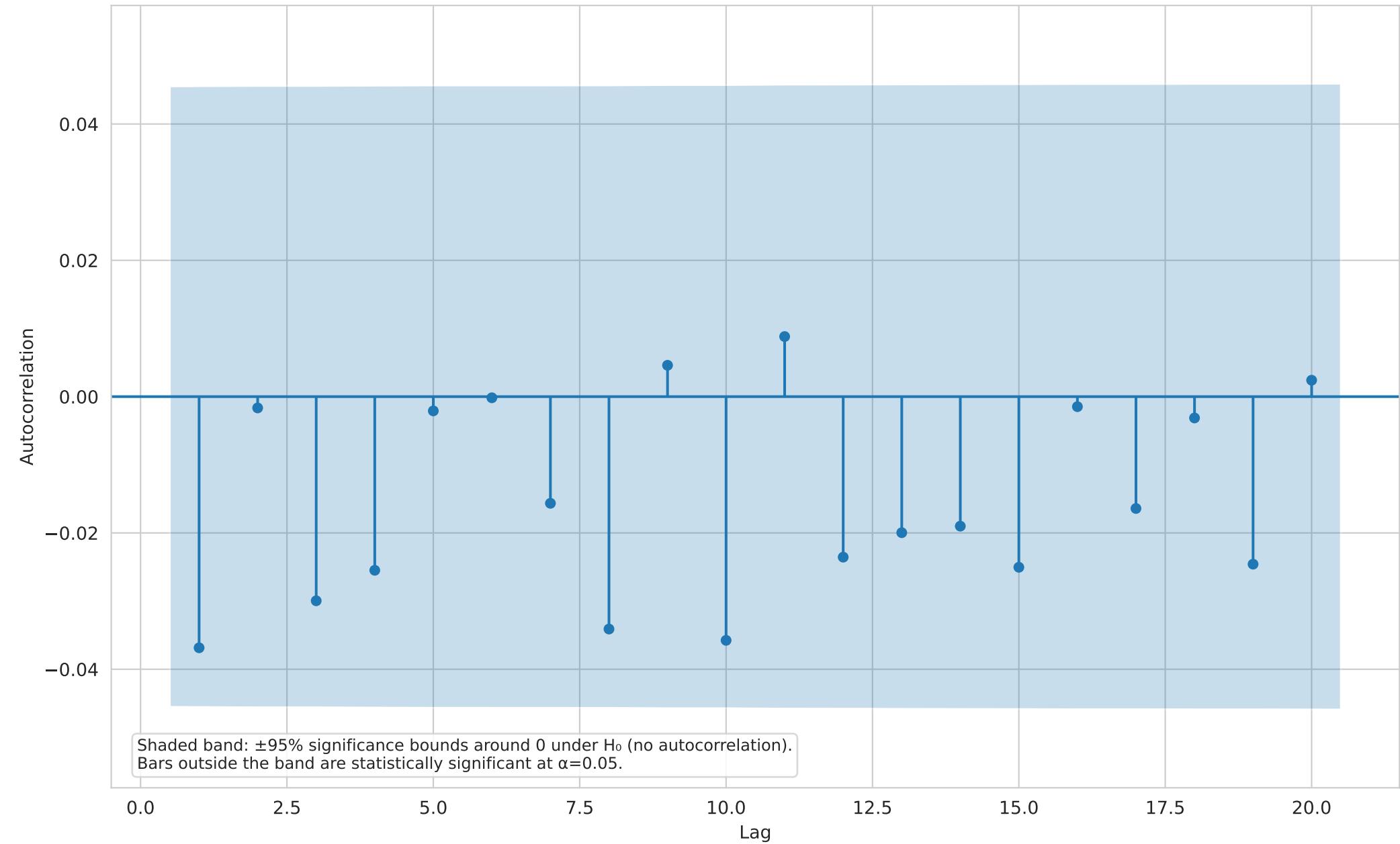
EUR_USD • Volatility (Annualized %) • Conditional vs Realized



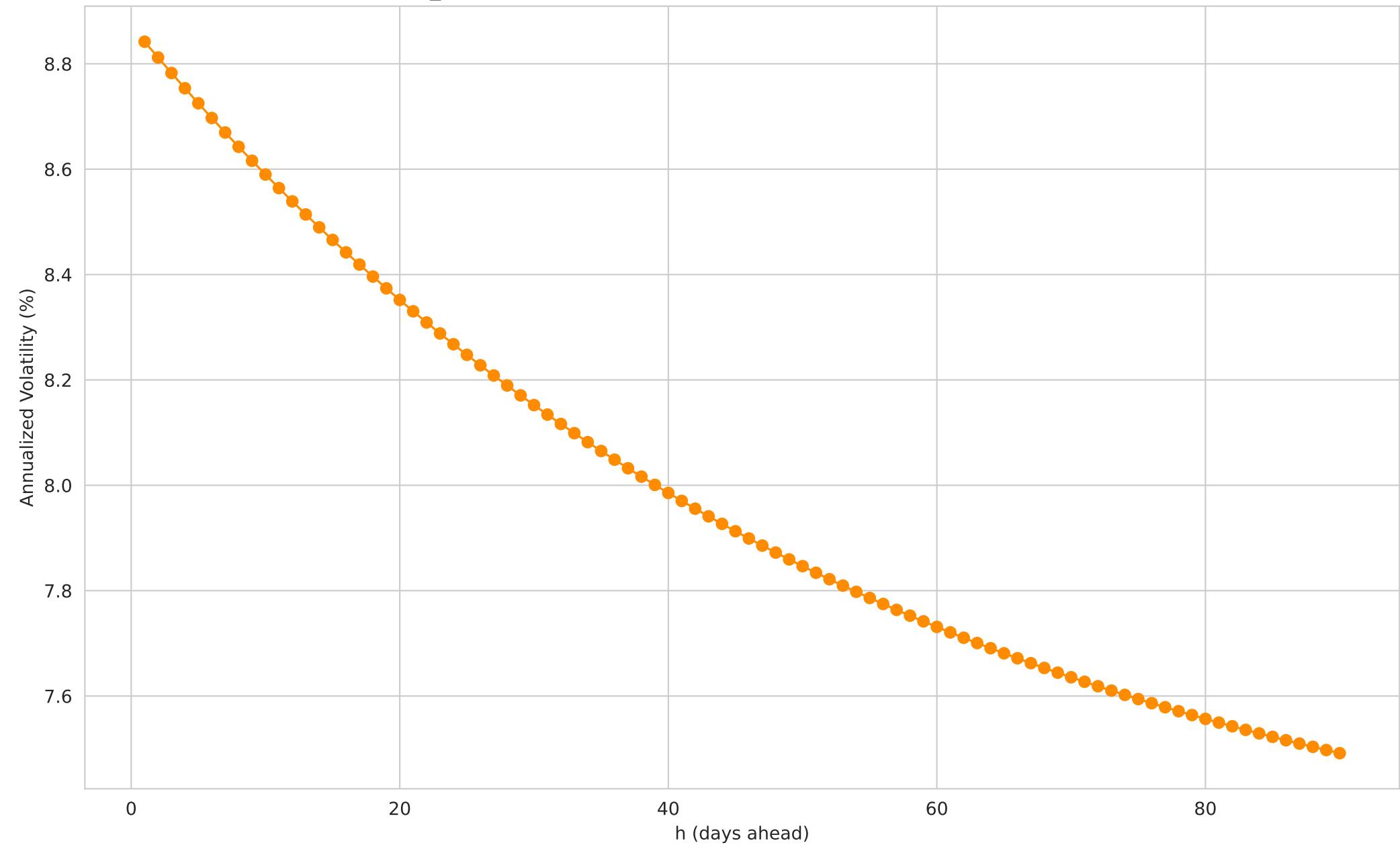
EUR_USD • Standardized Residuals



EUR_USD • ACF(Standardized Residuals²) [Lag 0 Omitted]



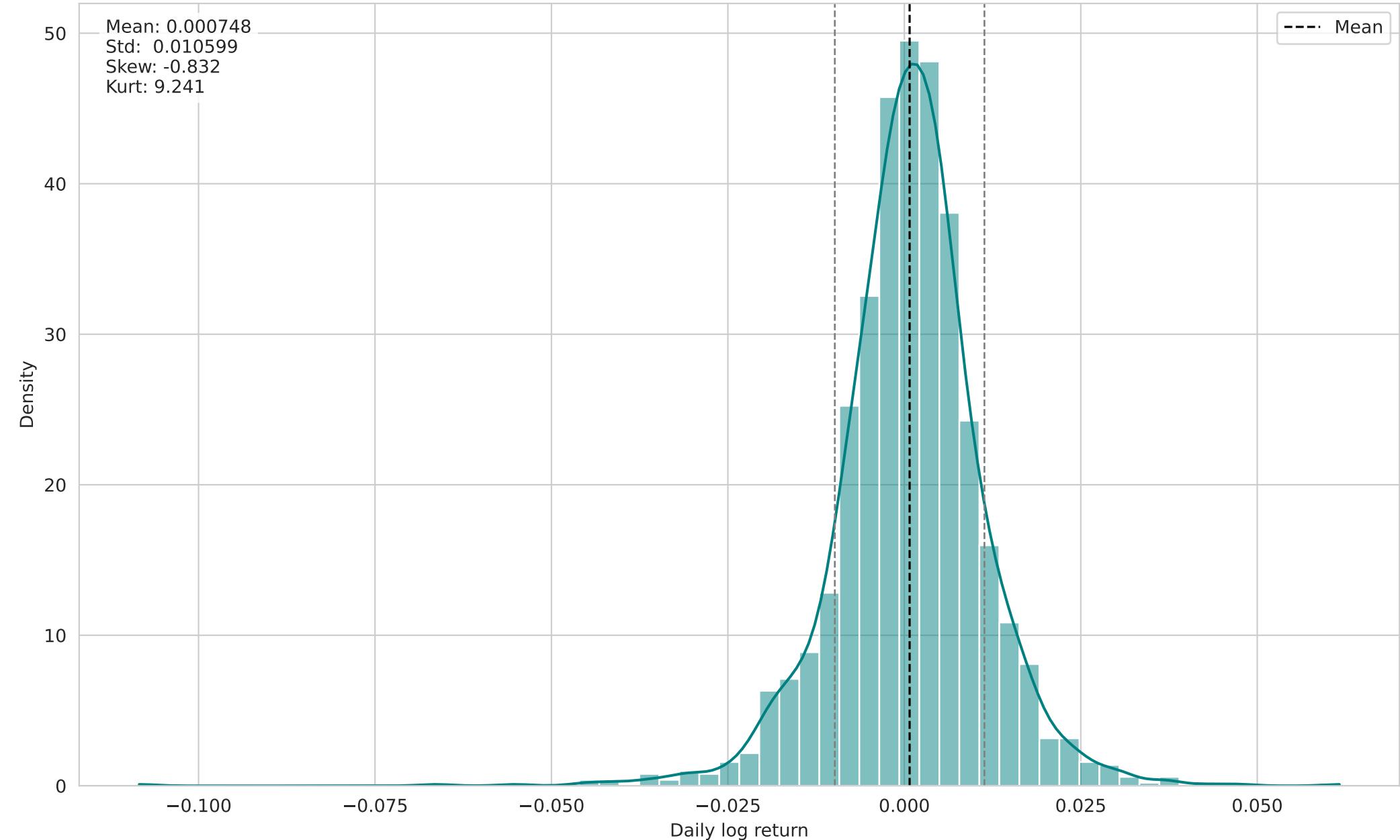
EUR_USD • h-Step Volatility Forecast (Annualized %, Closed-Form)



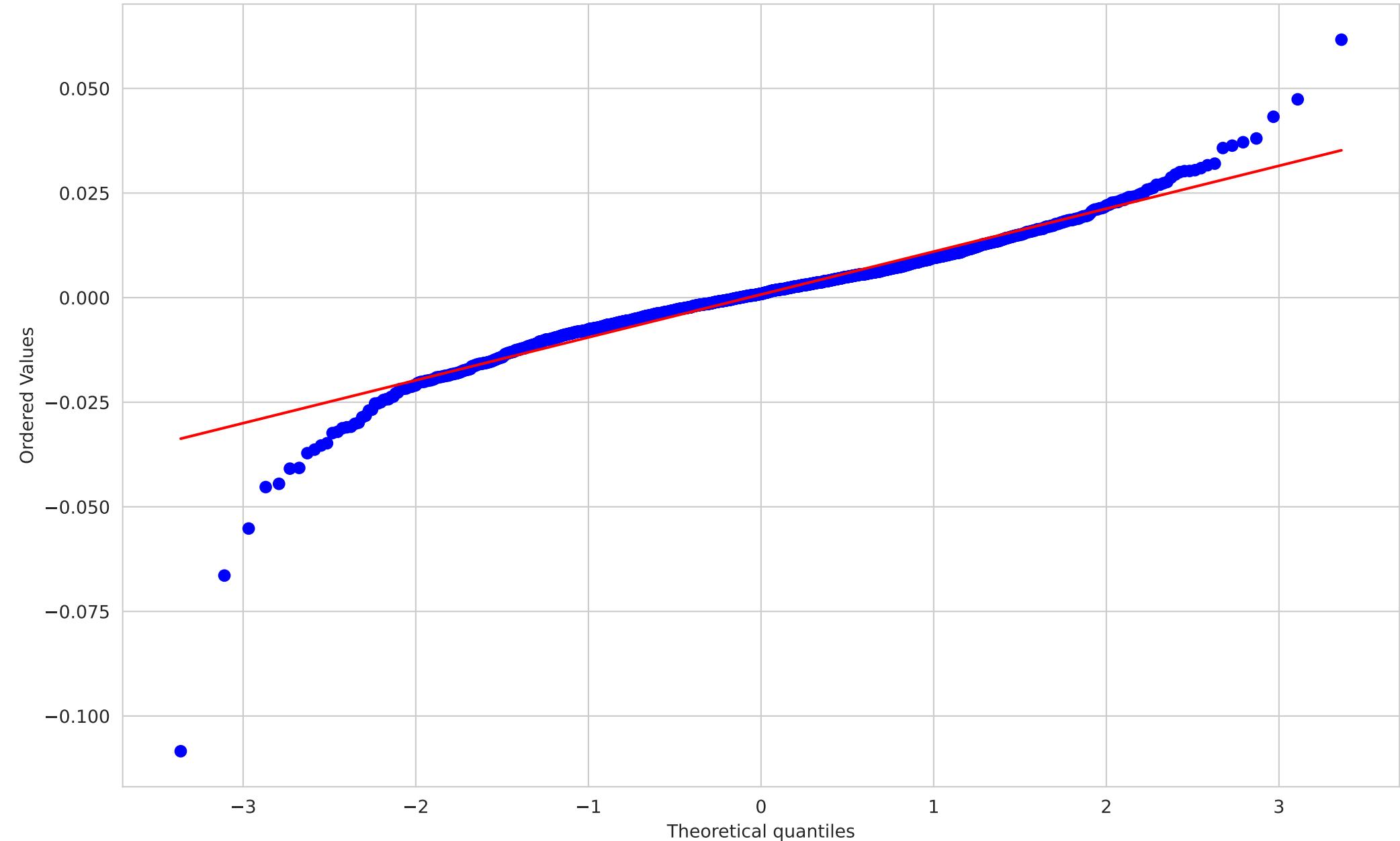
GLD • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.000384	Estimated average daily return (constant mean in the return equation).
ω	2.245379e-06	Variance intercept; baseline level feeding the long-run variance.
α	0.100000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.880000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000112	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309546	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	5756.585331	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-1.150517e+04	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-1.148321e+04	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

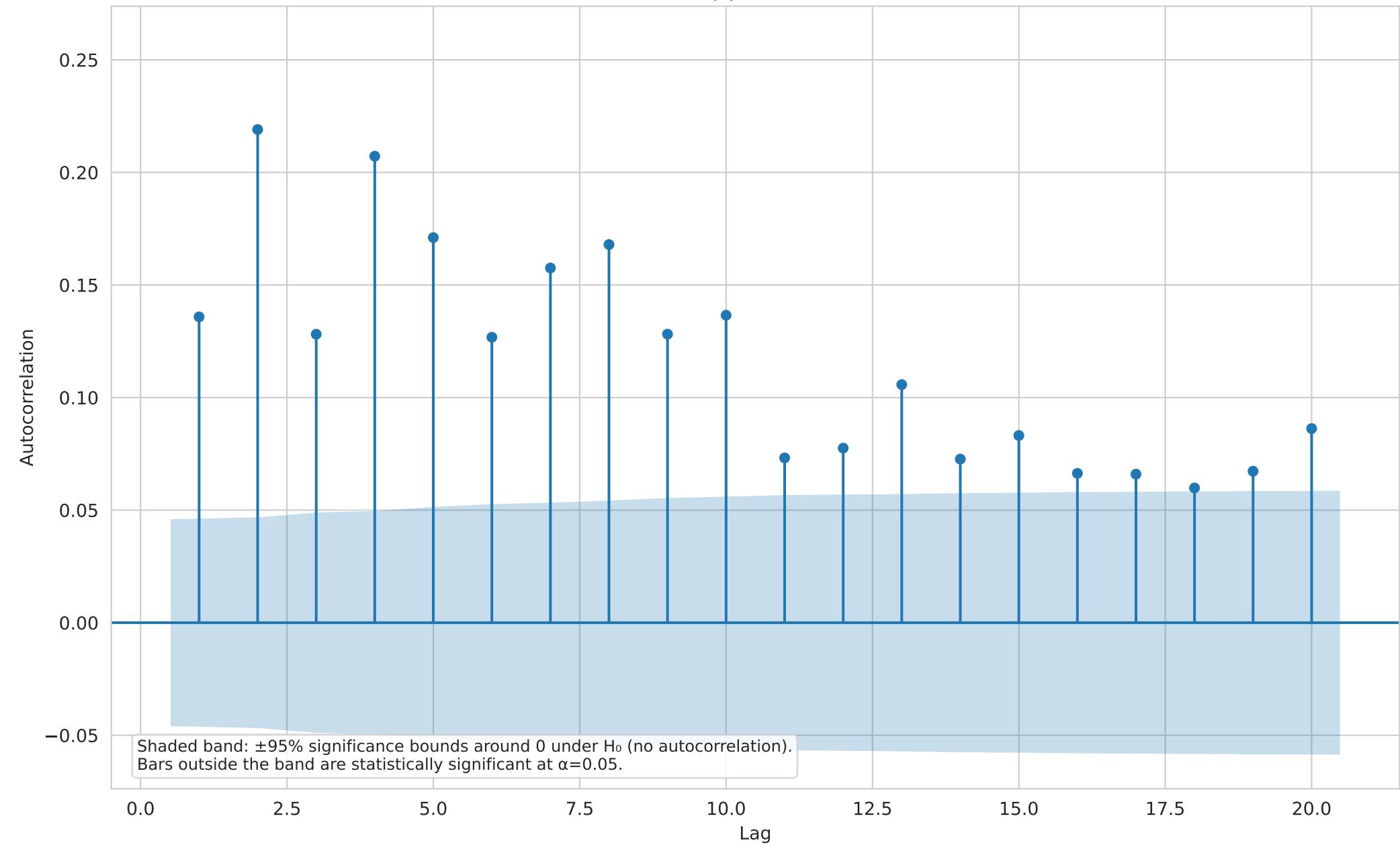
GLD • Return Distribution



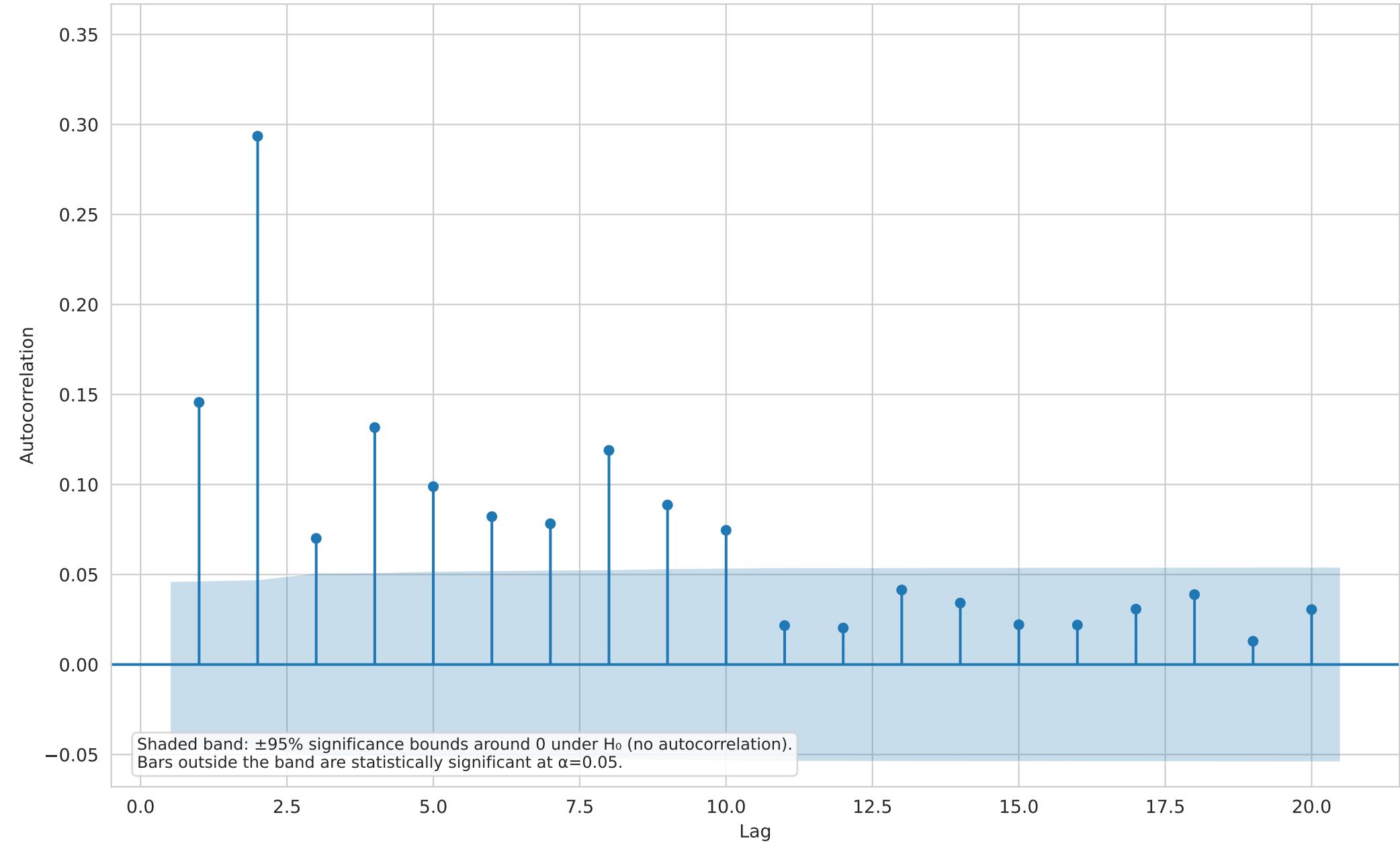
GLD • Q-Q Plot (Normal)



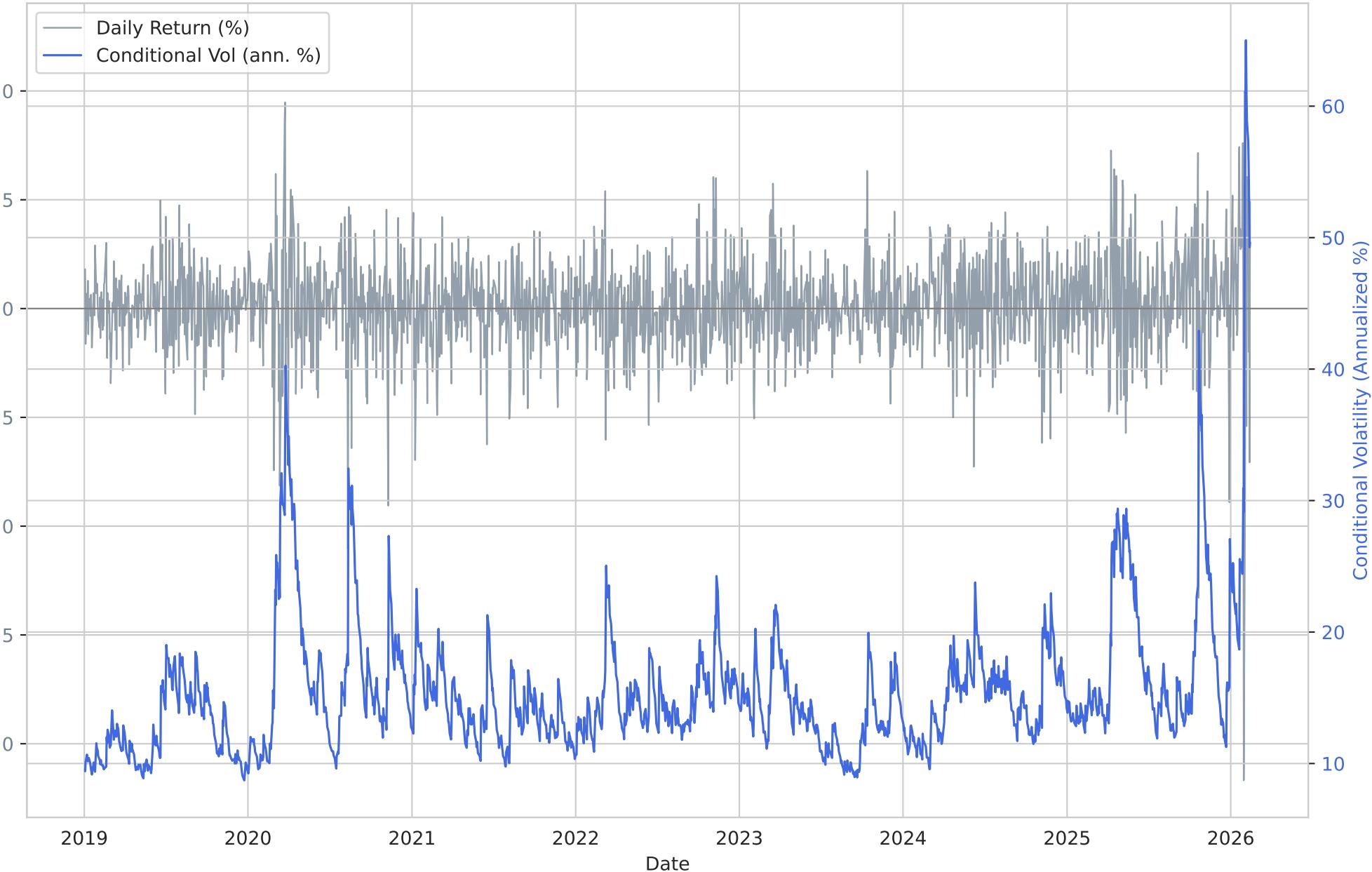
GLD • ACF(|r|) [Lag 0 Omitted]



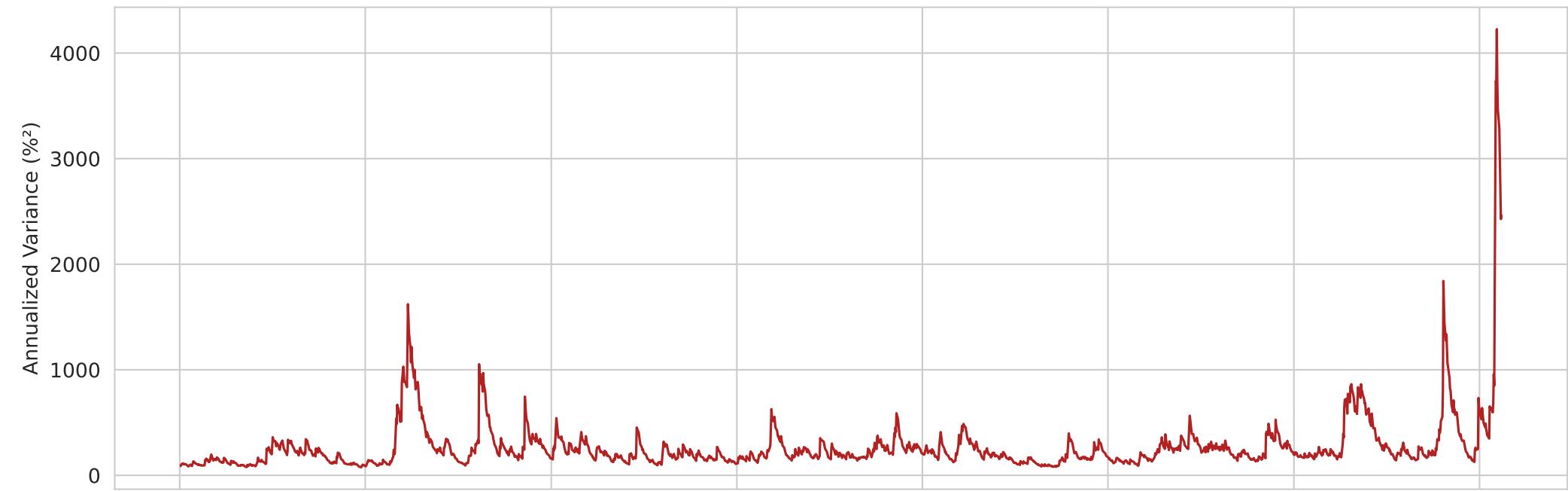
GLD • ACF(r^2) [Lag 0 Omitted]



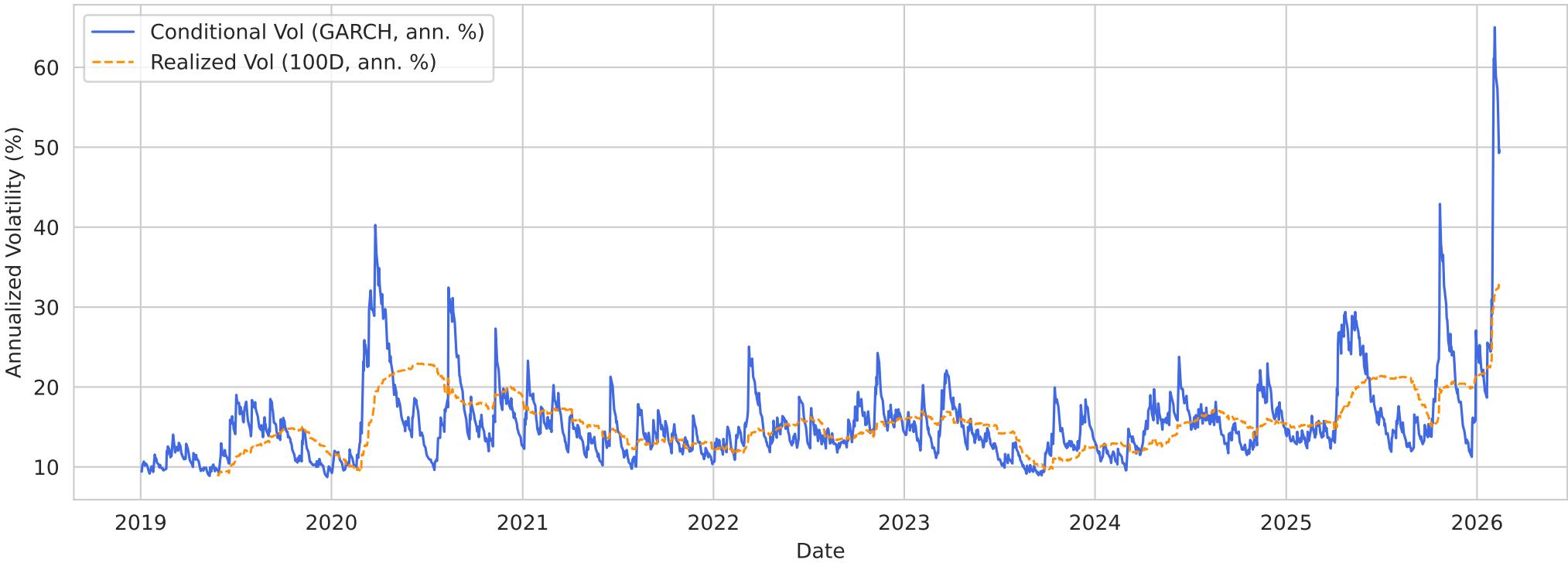
GLD • Daily % Returns vs Conditional Volatility (Annualized %)



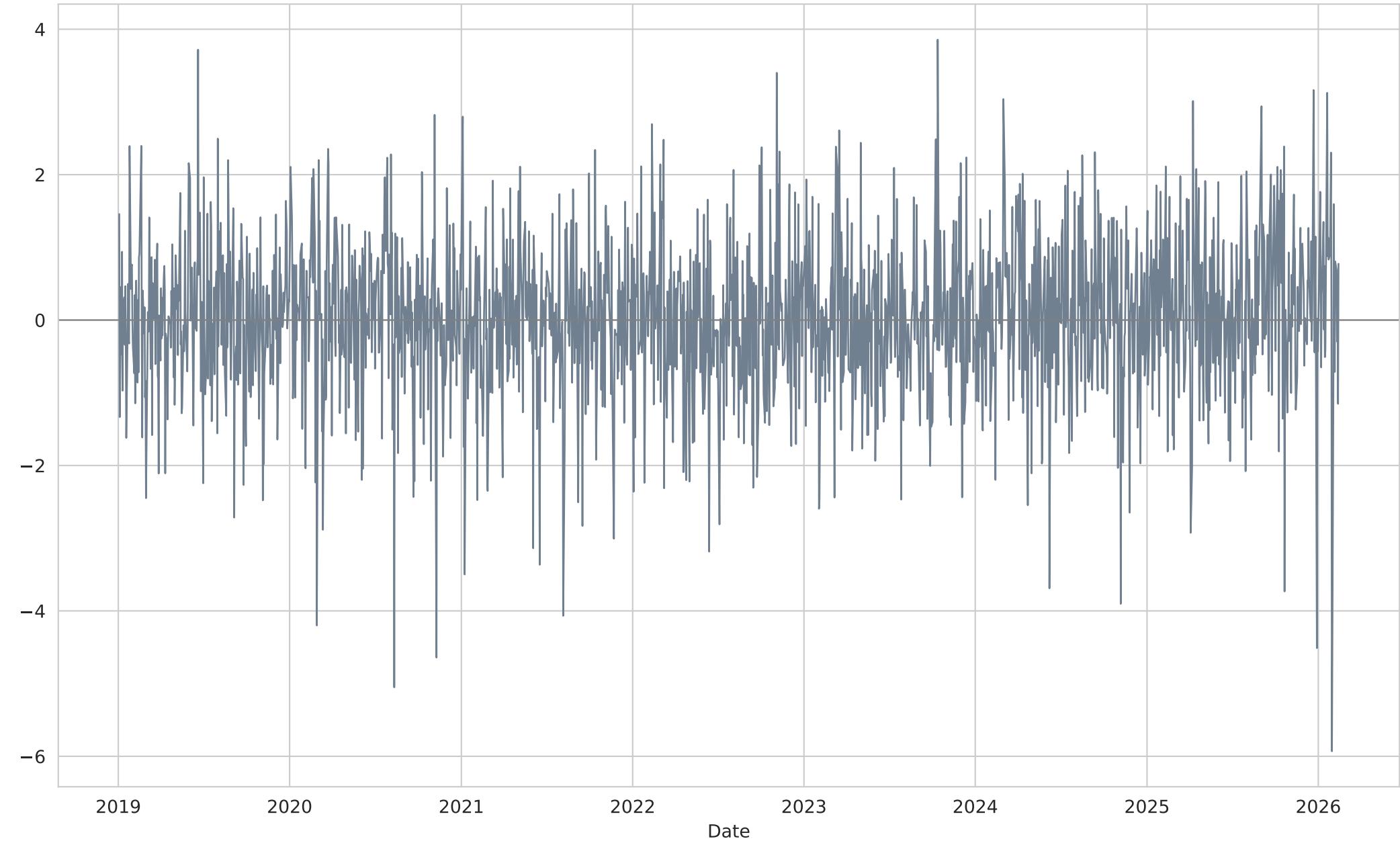
GLD • Conditional Variance (Annualized, %²)



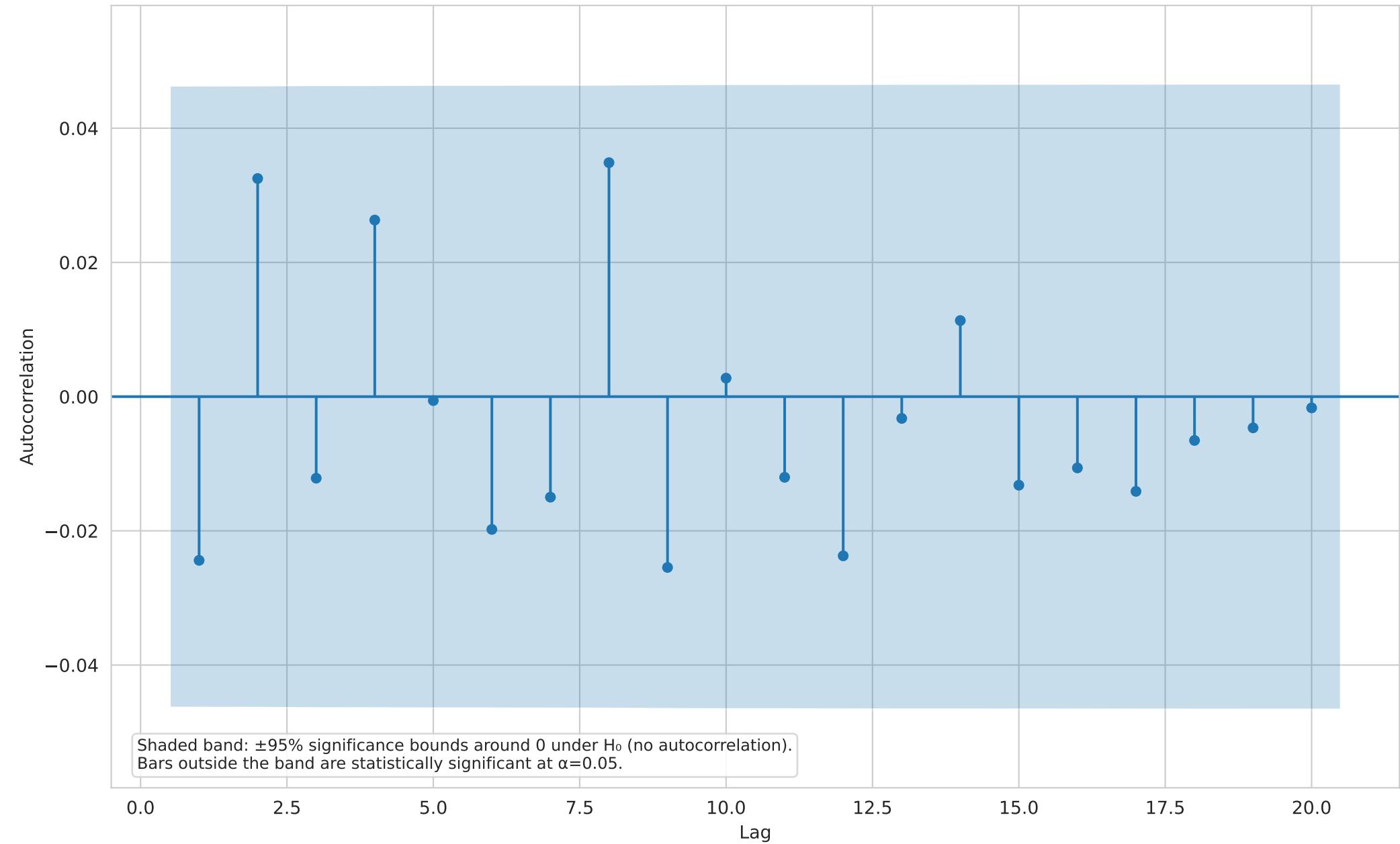
GLD • Volatility (Annualized %) • Conditional vs Realized



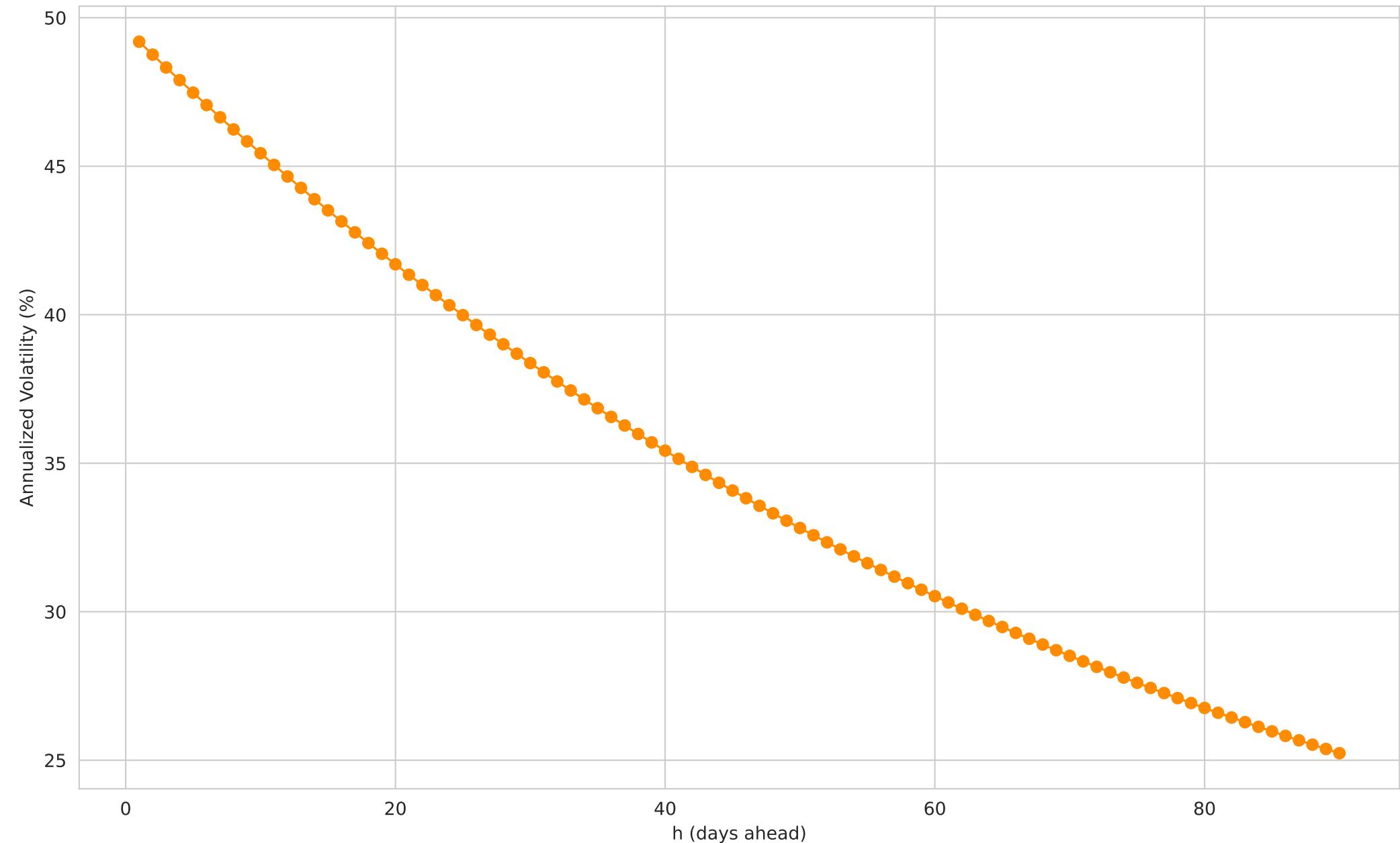
GLD • Standardized Residuals



GLD • ACF(Standardized Residuals²) [Lag 0 Omitted]



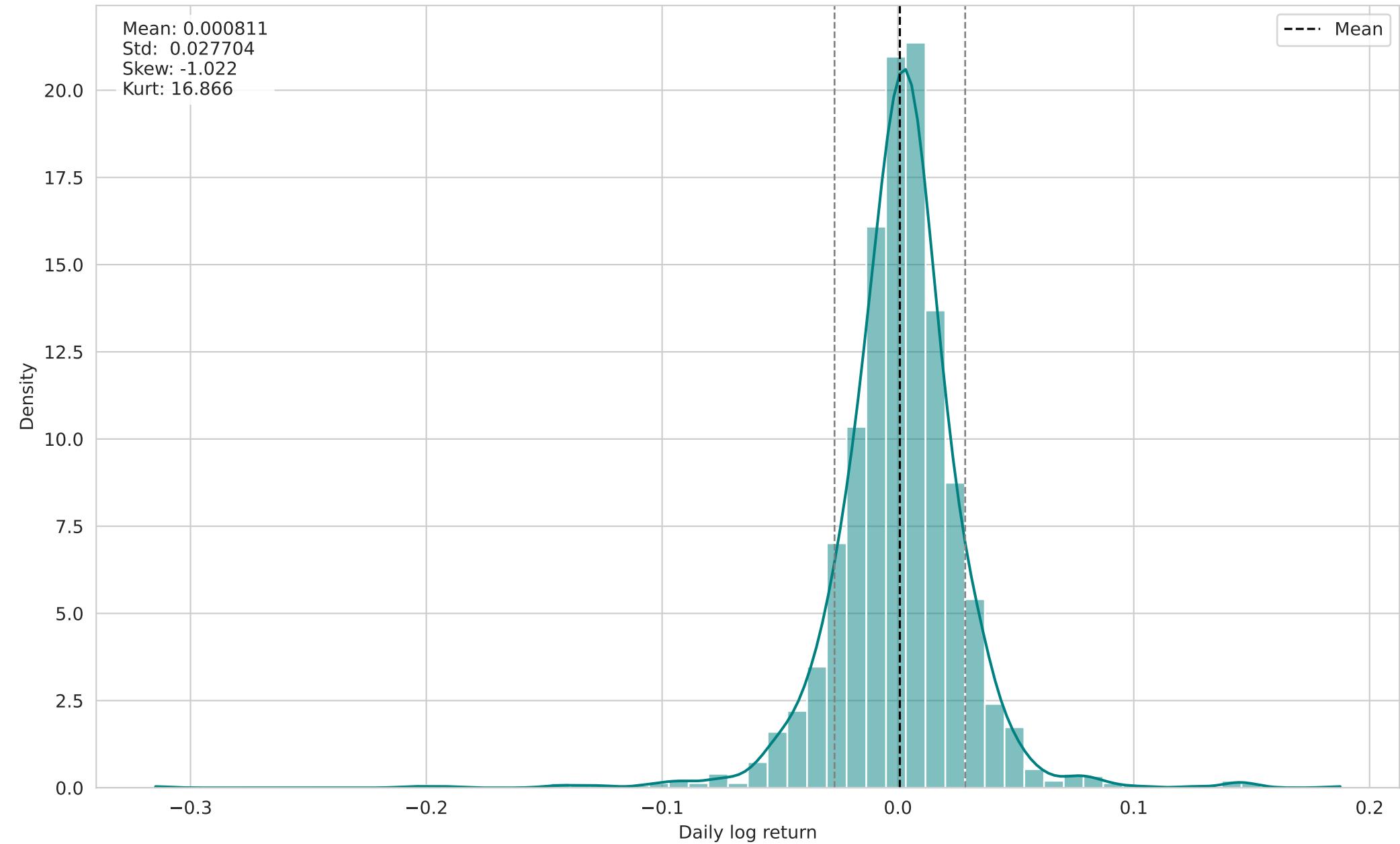
GLD • h-Step Volatility Forecast (Annualized %, Closed-Form)



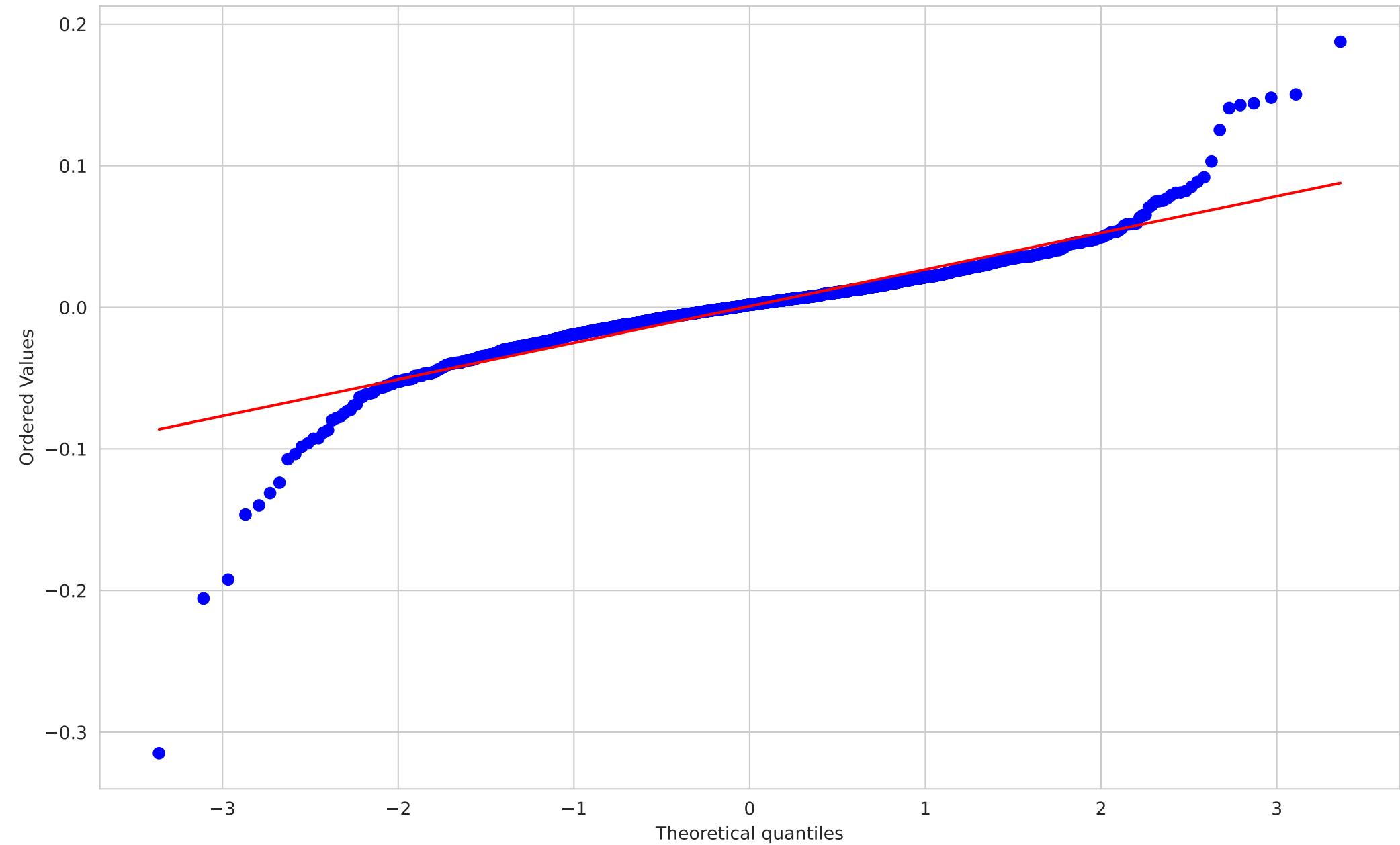
MPC • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.001235	Estimated average daily return (constant mean in the return equation).
ω	1.534174e-05	Variance intercept; baseline level feeding the long-run variance.
α	0.100000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.880000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000767	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309594	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	4203.115547	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-8398.231094	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-8376.273445	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

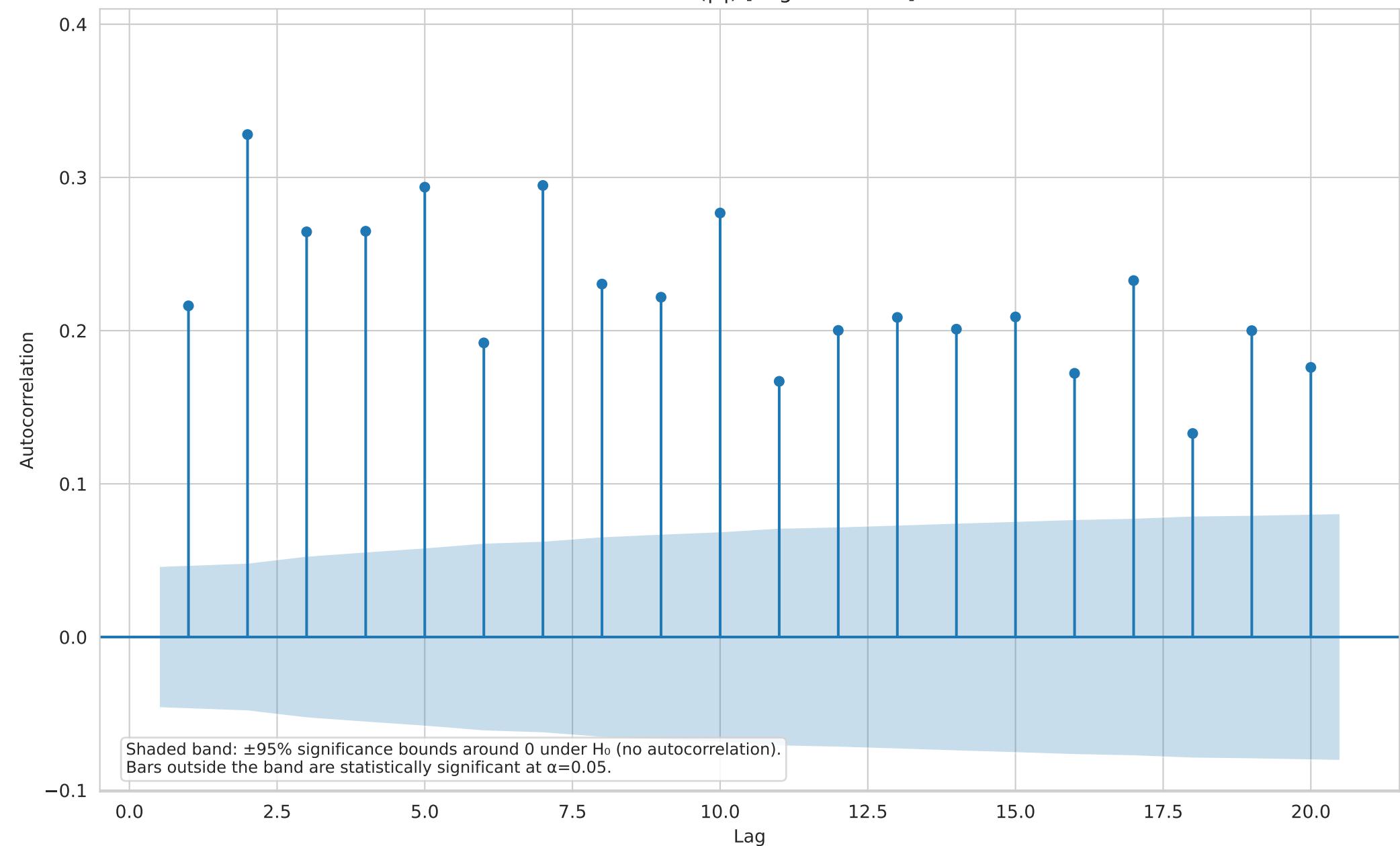
MPC • Return Distribution



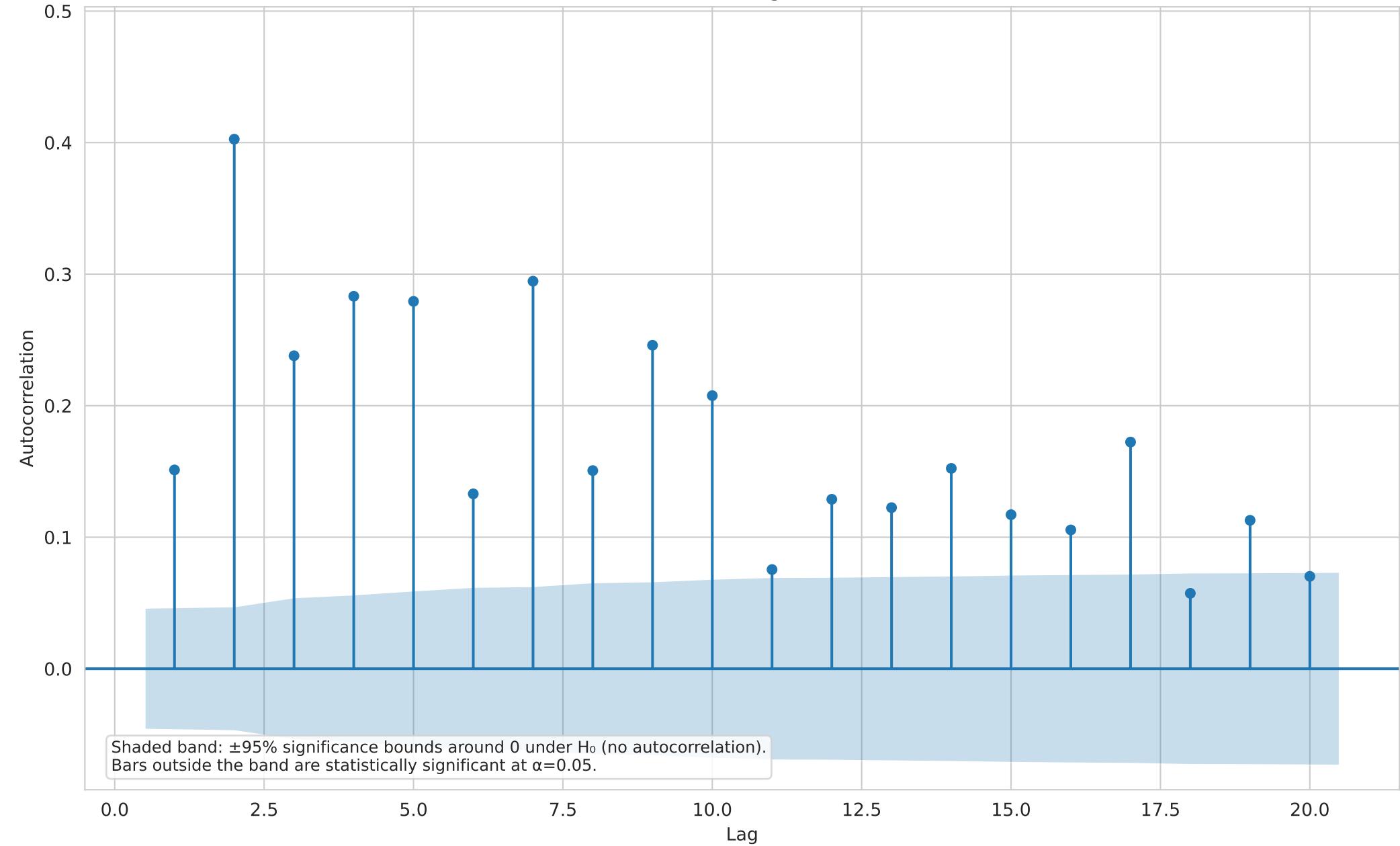
MPC • Q-Q Plot (Normal)



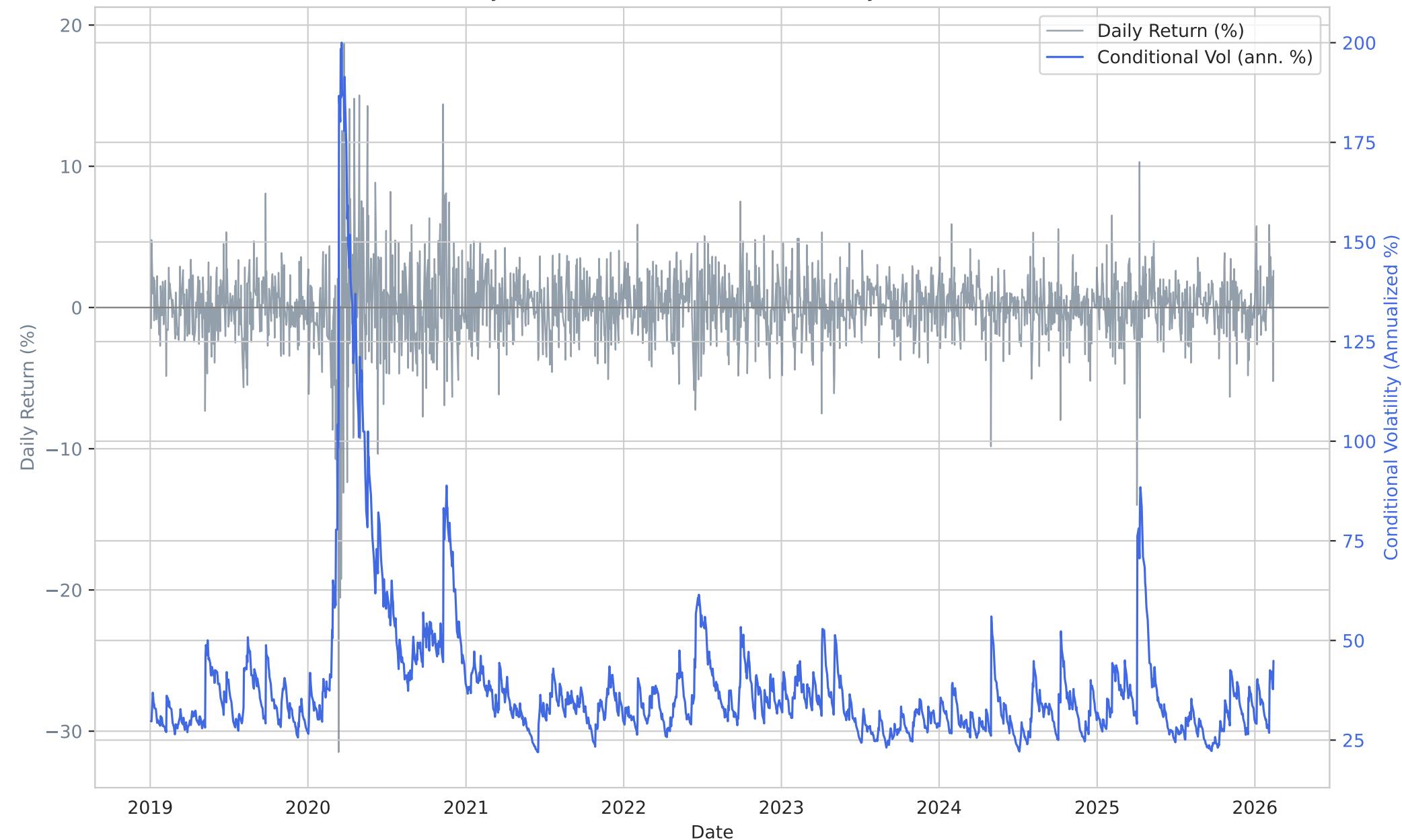
MPC • ACF($|r|$) [Lag 0 Omitted]



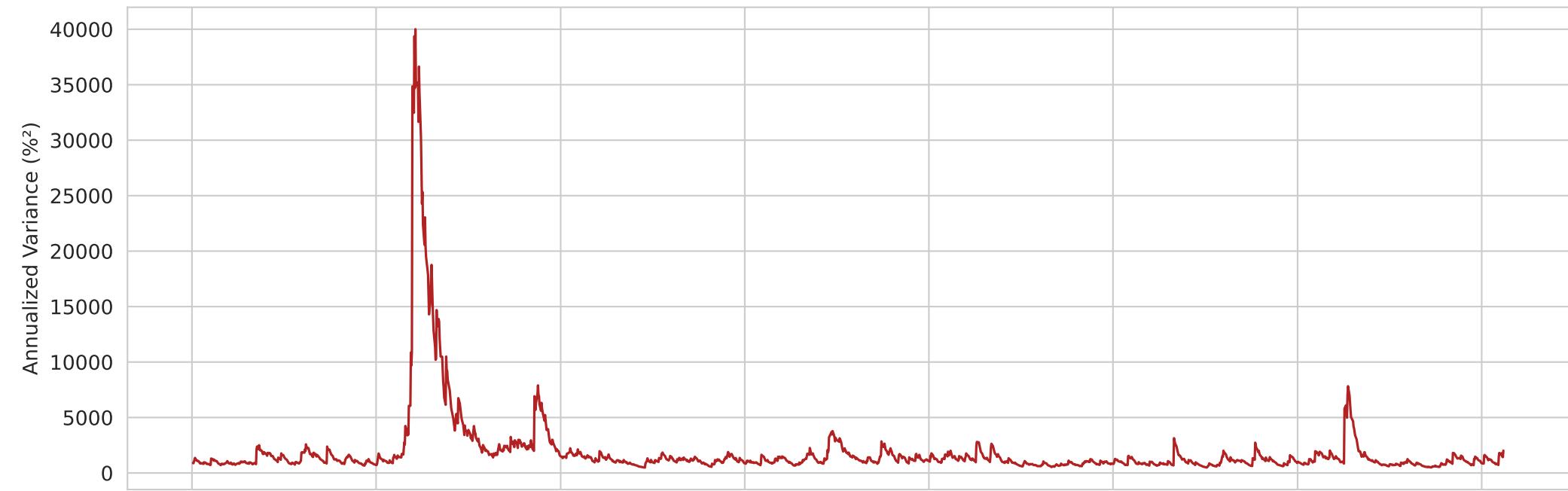
MPC • ACF(r^2) [Lag 0 Omitted]



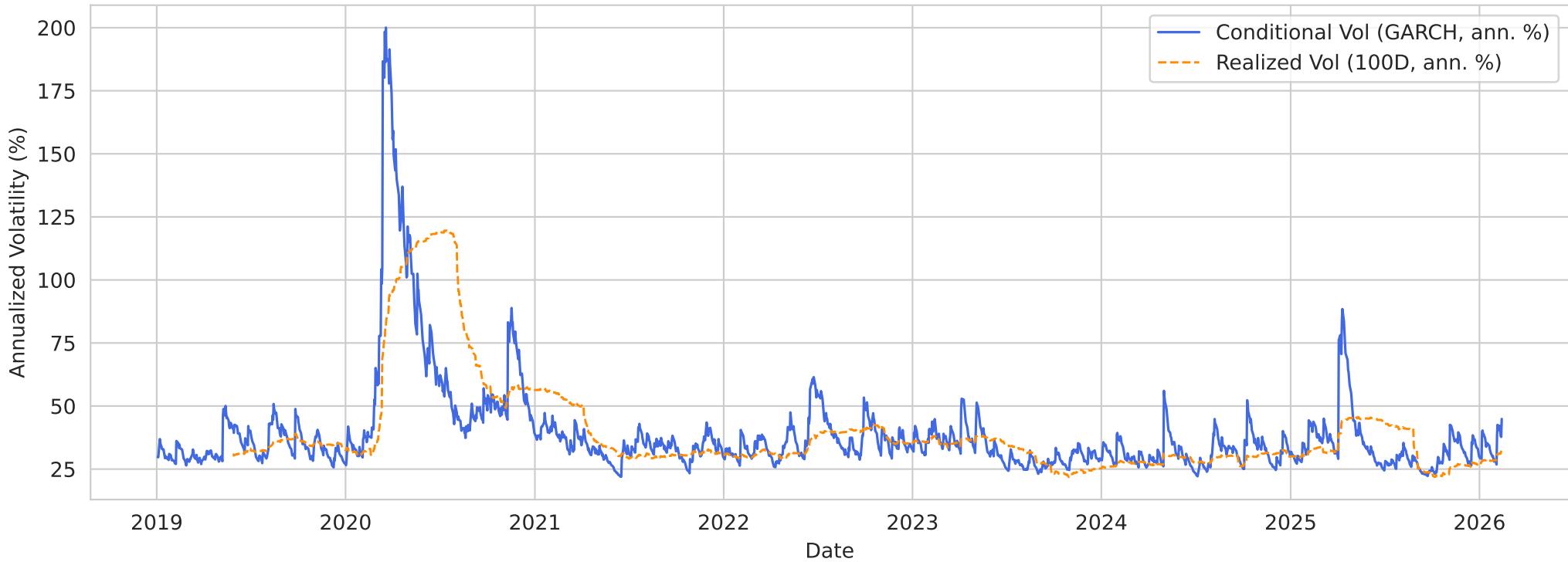
MPC • Daily % Returns vs Conditional Volatility (Annualized %)



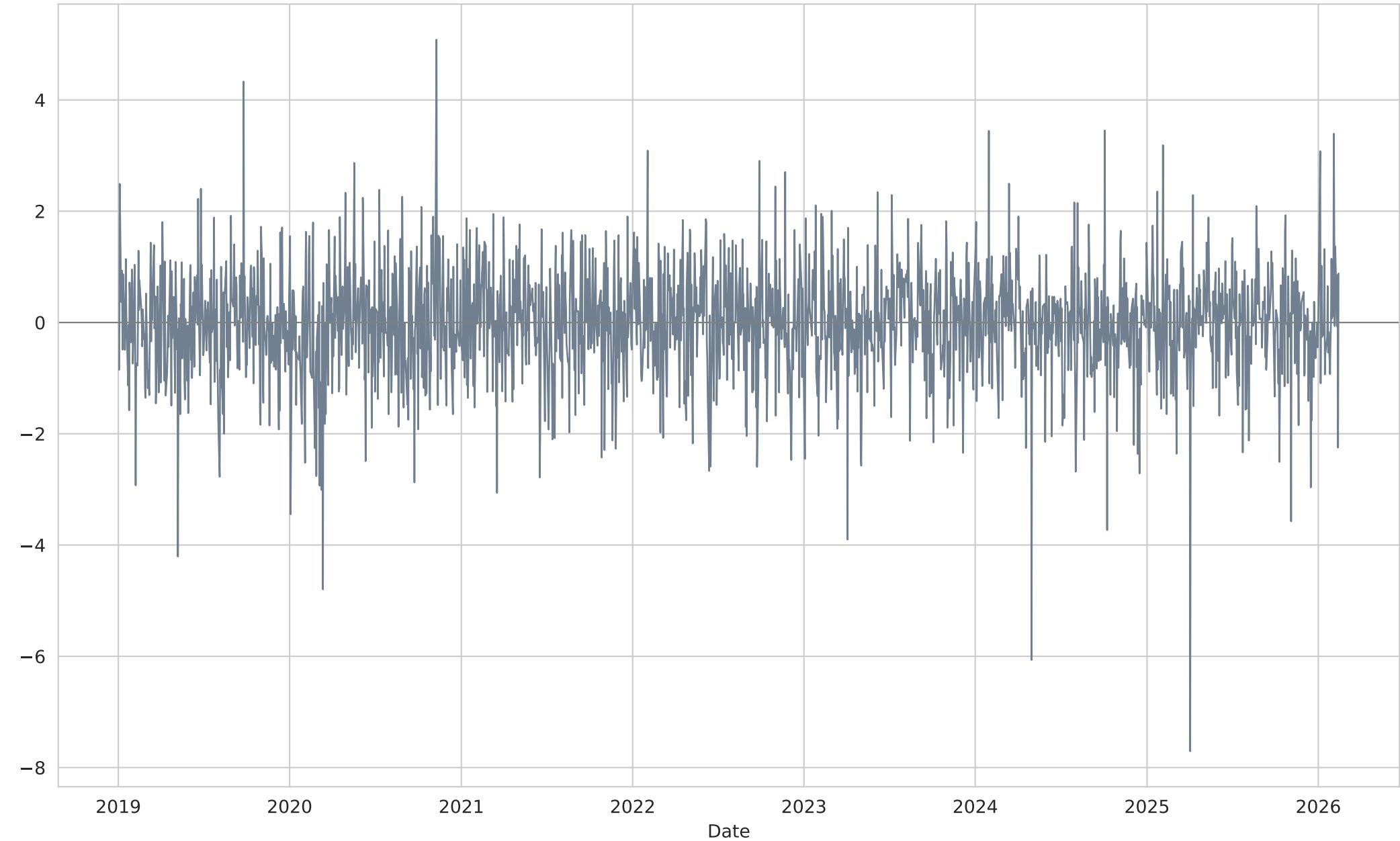
MPC • Conditional Variance (Annualized, %²)



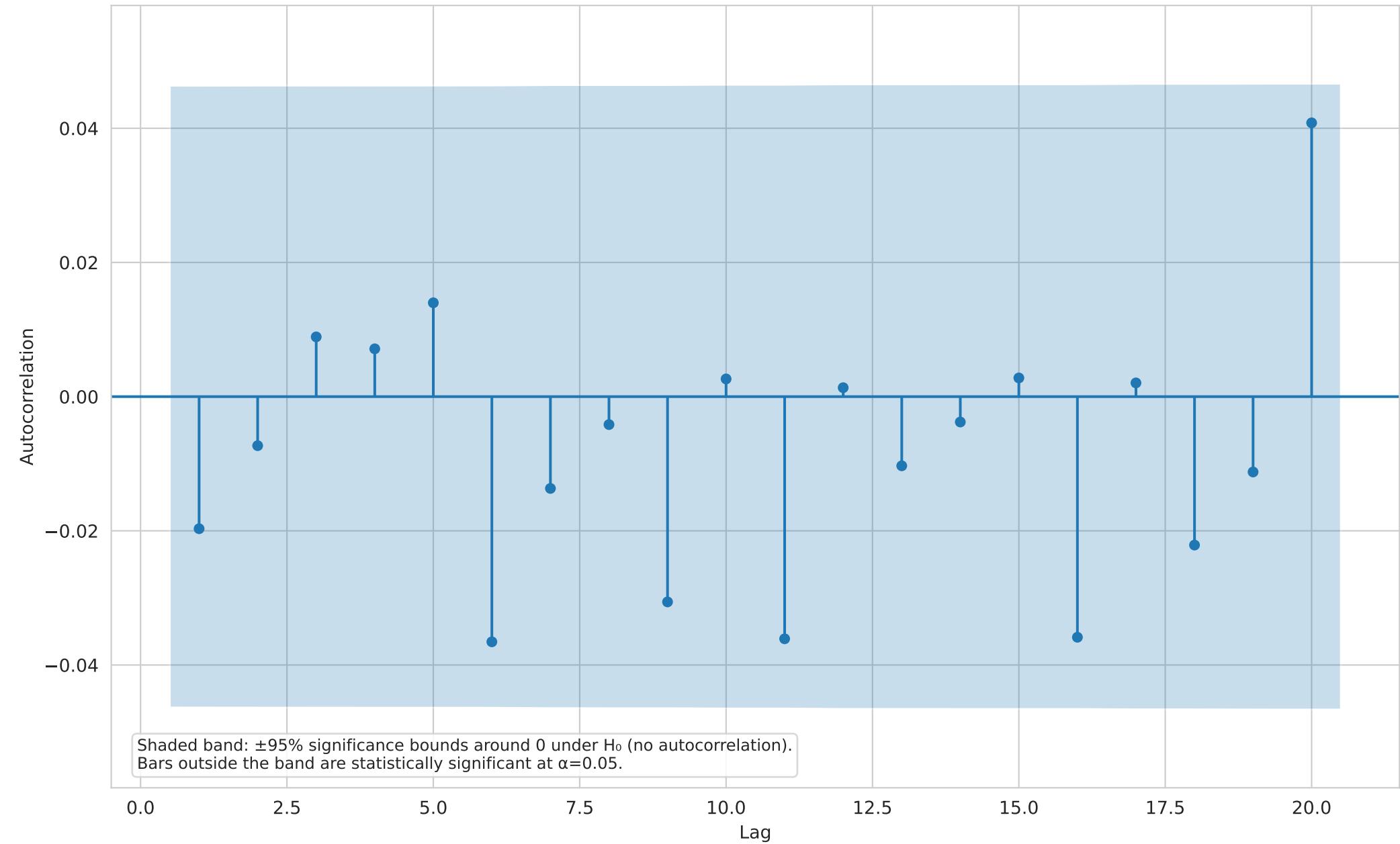
MPC • Volatility (Annualized %) • Conditional vs Realized



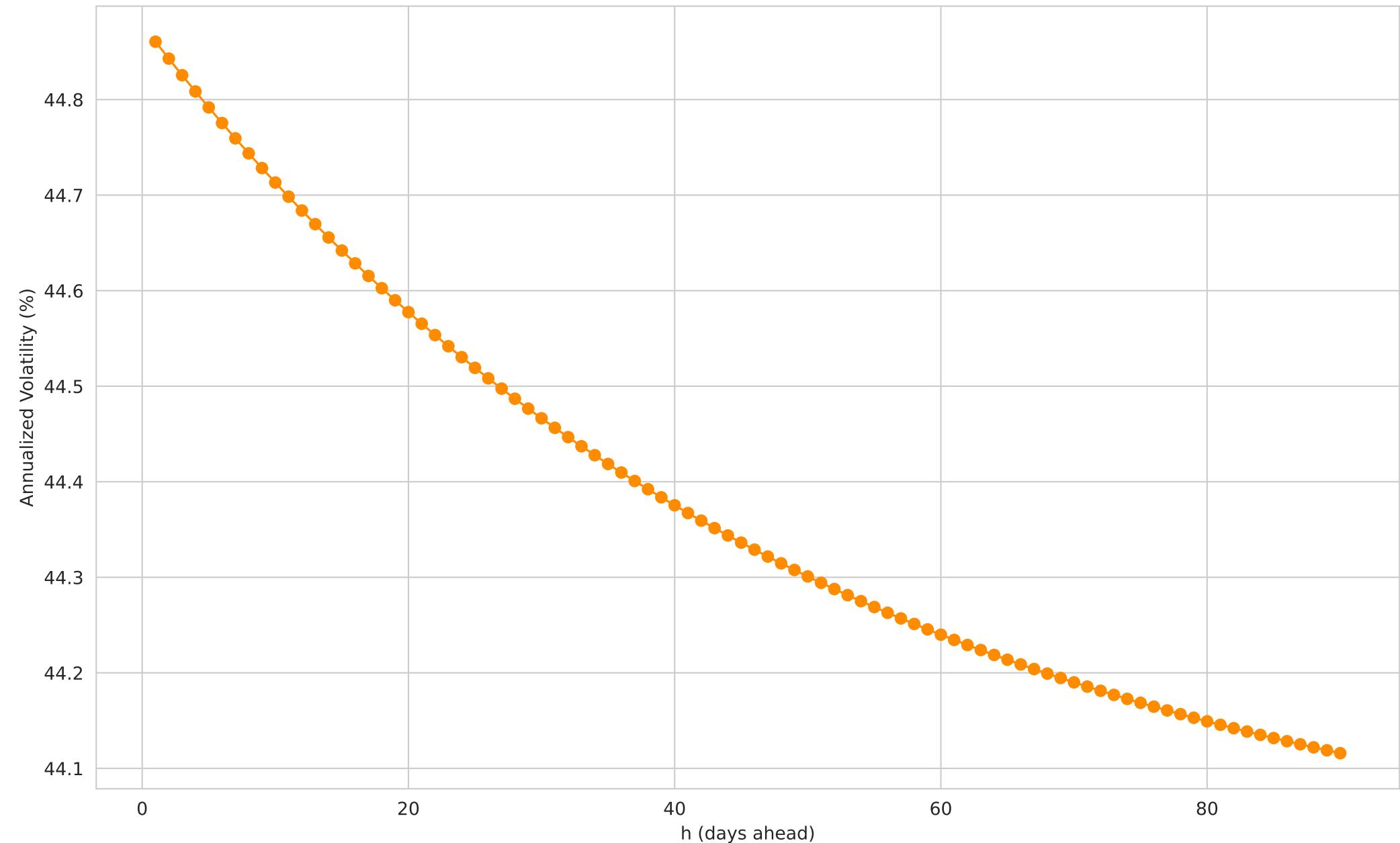
MPC • Standardized Residuals



MPC • ACF(Standardized Residuals²) [Lag 0 Omitted]



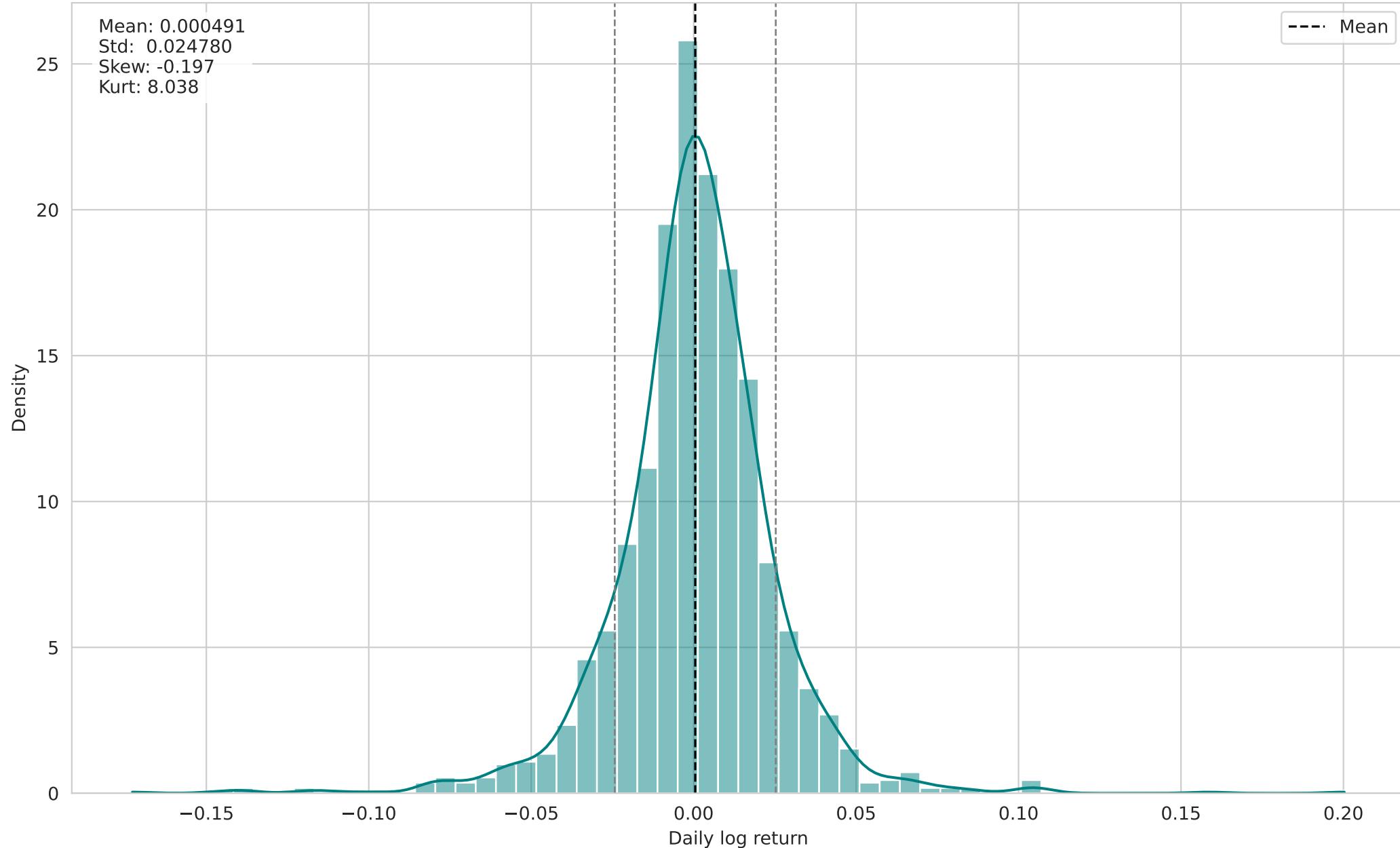
MPC • h-Step Volatility Forecast (Annualized %, Closed-Form)



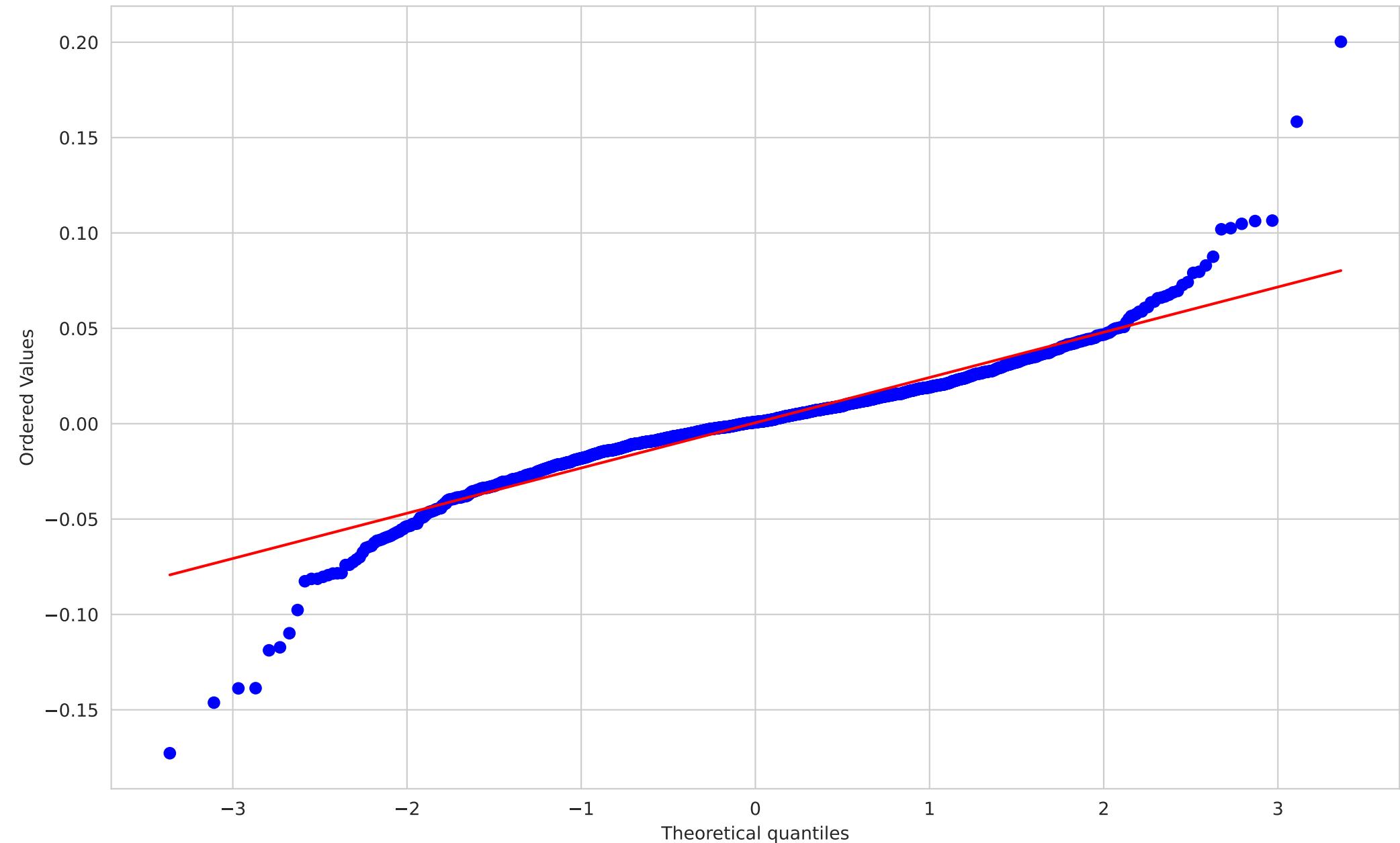
PSX • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.000796	Estimated average daily return (constant mean in the return equation).
ω	8.117445e-06	Variance intercept; baseline level feeding the long-run variance.
α	0.065584	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.921553	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.987137	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000631	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	53.539909	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	4332.290886	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-8656.581773	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-8634.624125	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

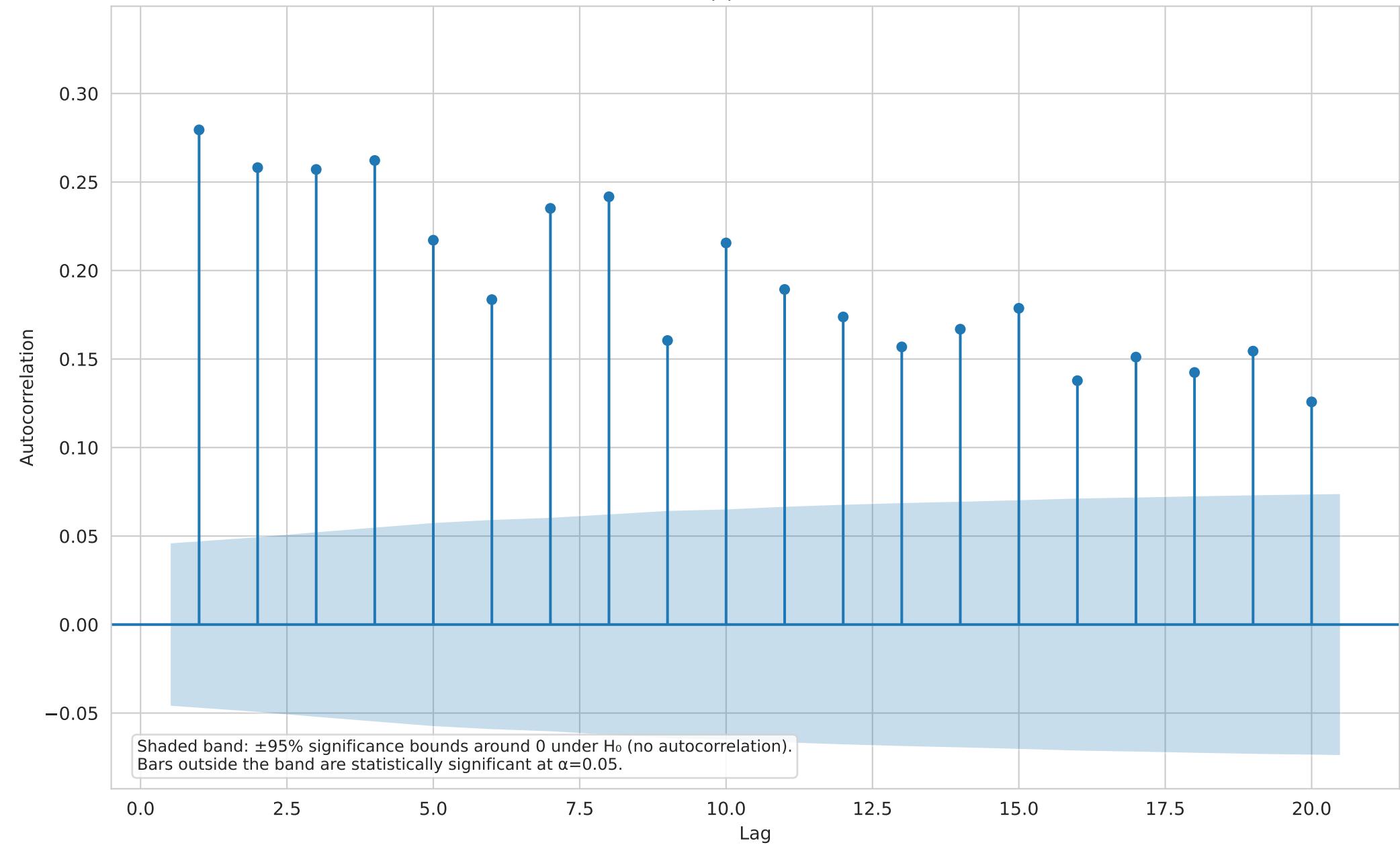
PSX • Return Distribution



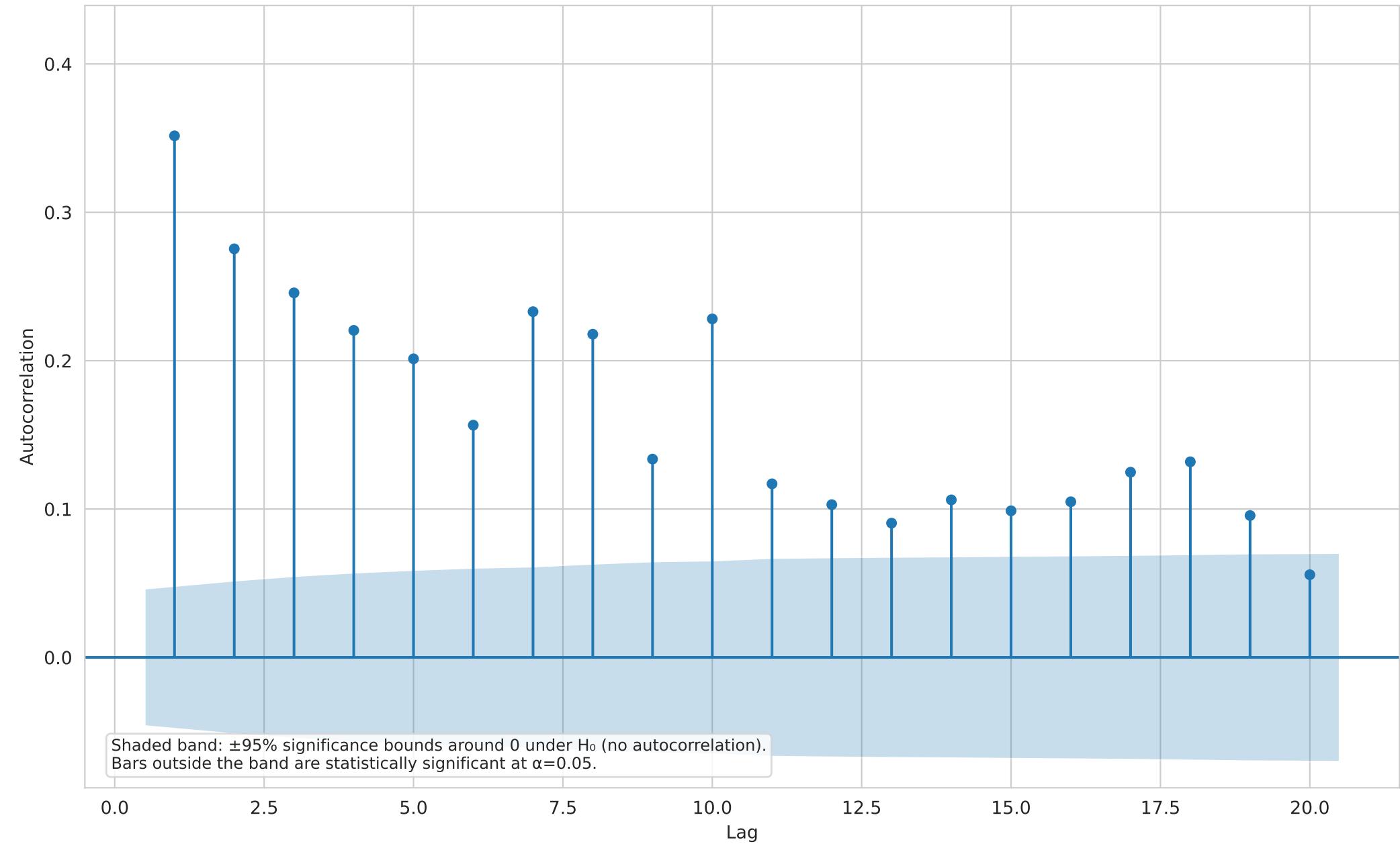
PSX • Q-Q Plot (Normal)



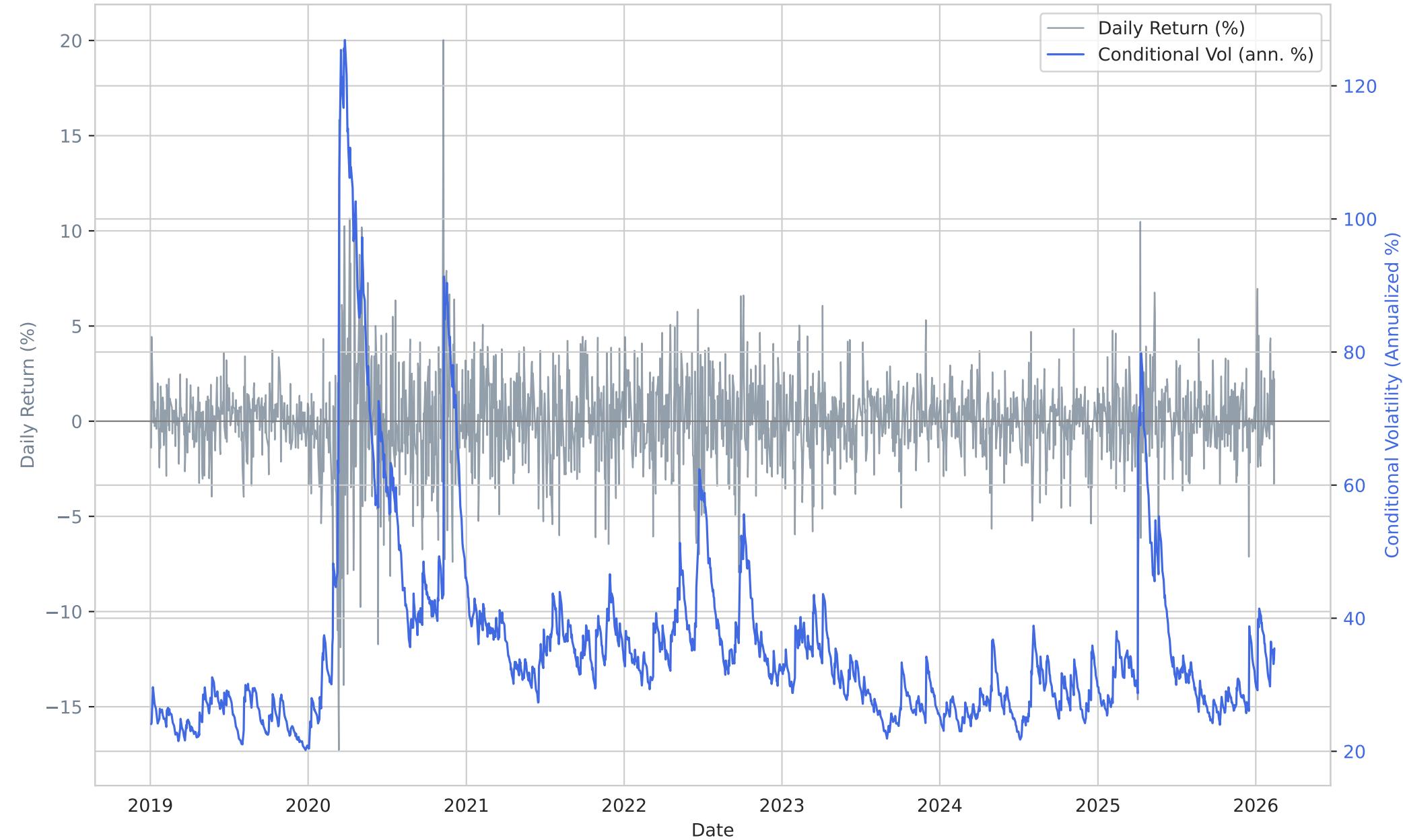
PSX • ACF(|r|) [Lag 0 Omitted]



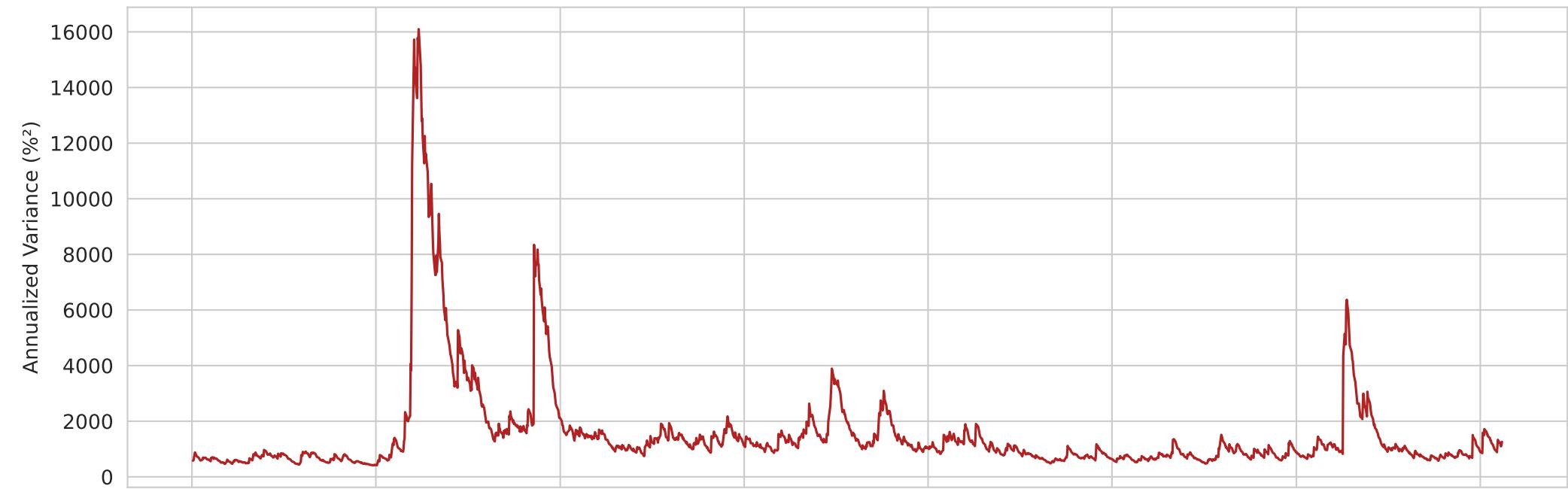
PSX • ACF(r^2) [Lag 0 Omitted]



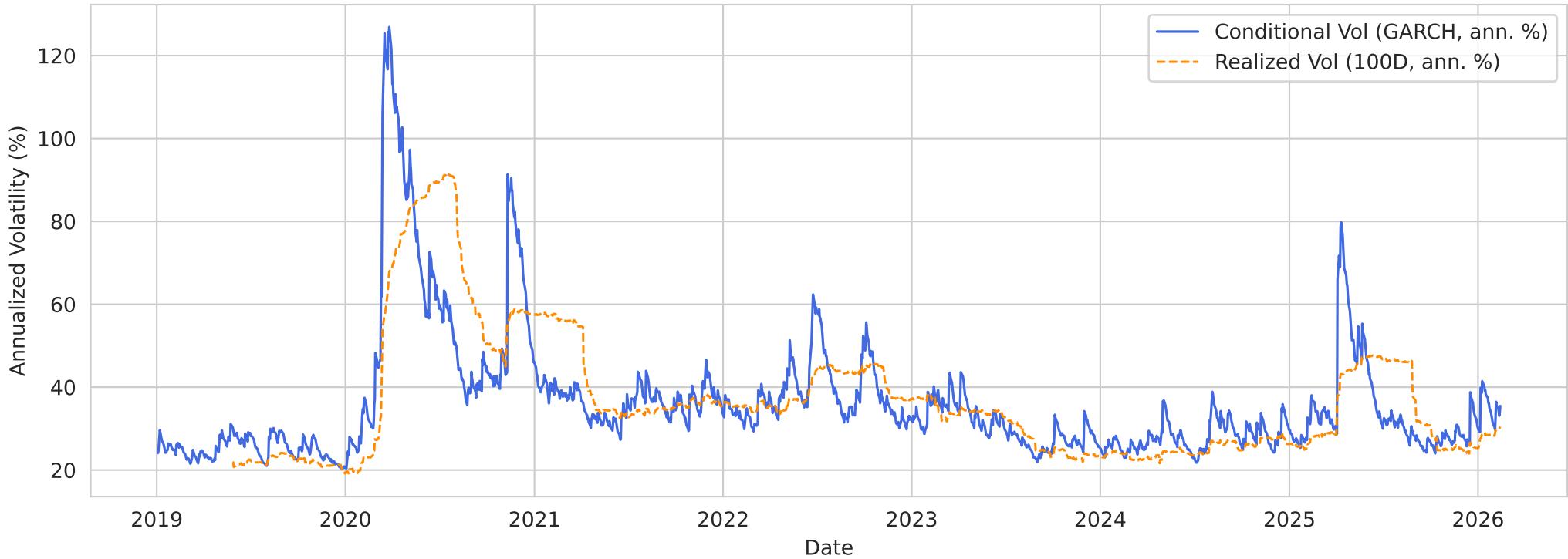
PSX • Daily % Returns vs Conditional Volatility (Annualized %)



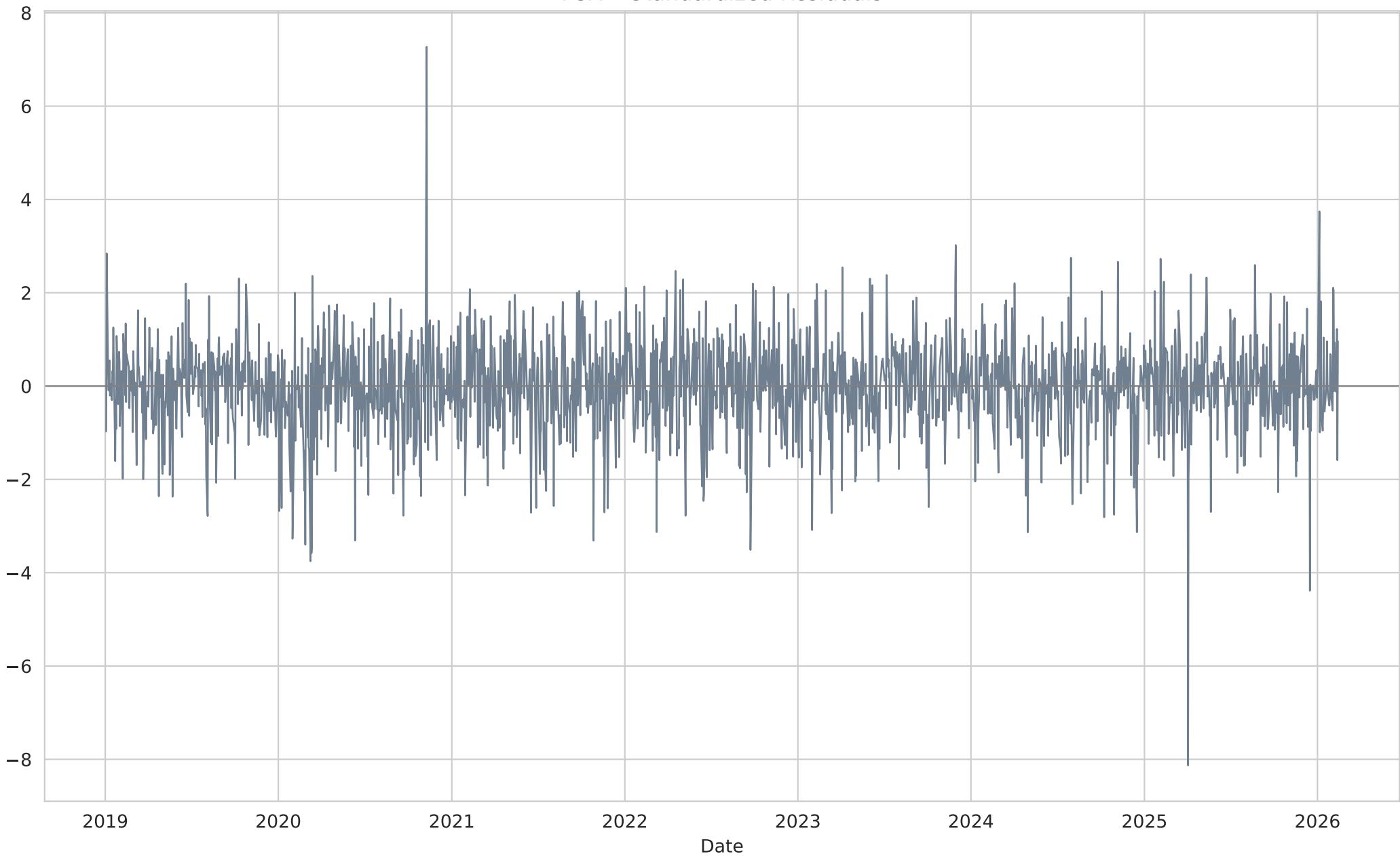
PSX • Conditional Variance (Annualized, %²)



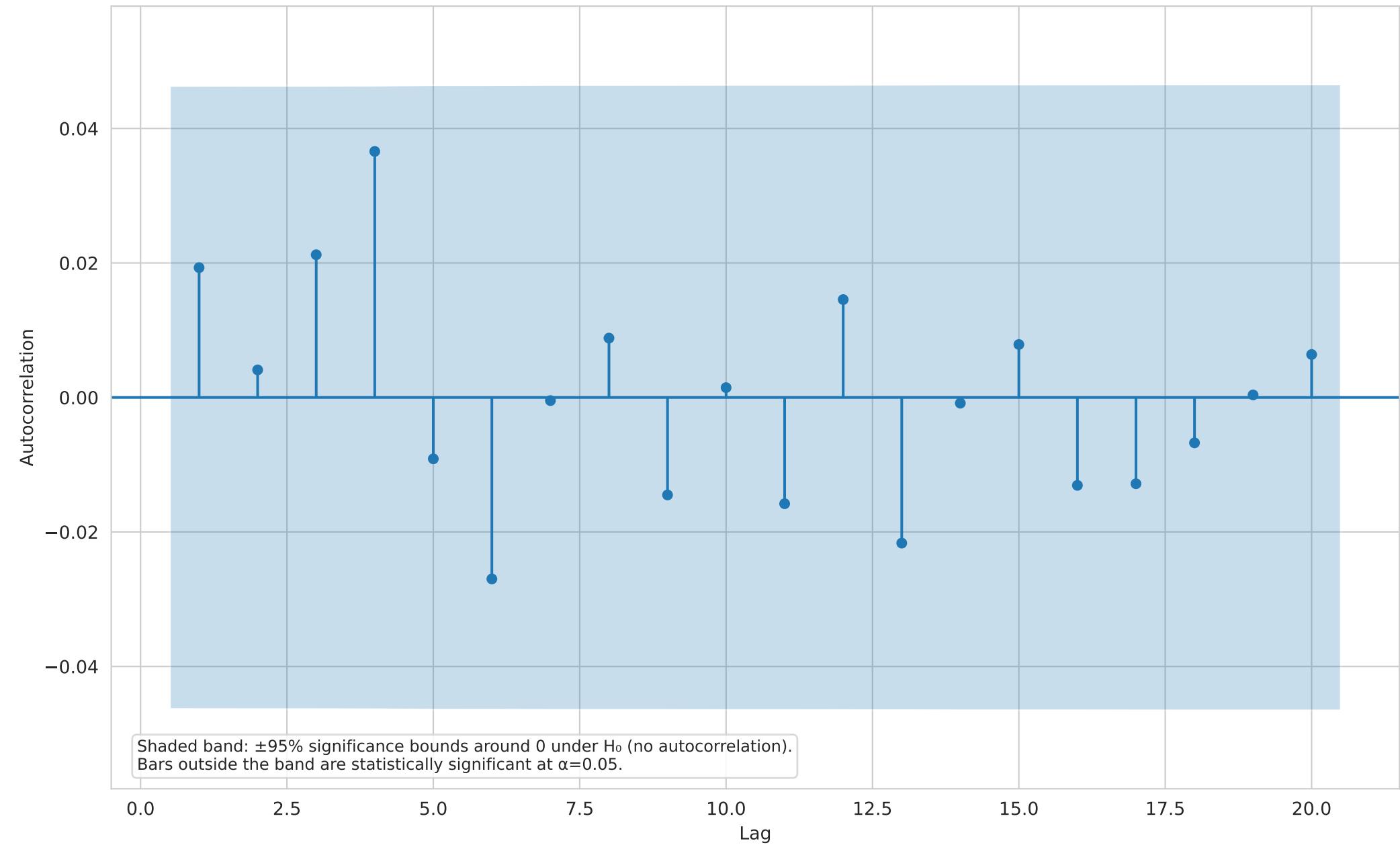
PSX • Volatility (Annualized %) • Conditional vs Realized



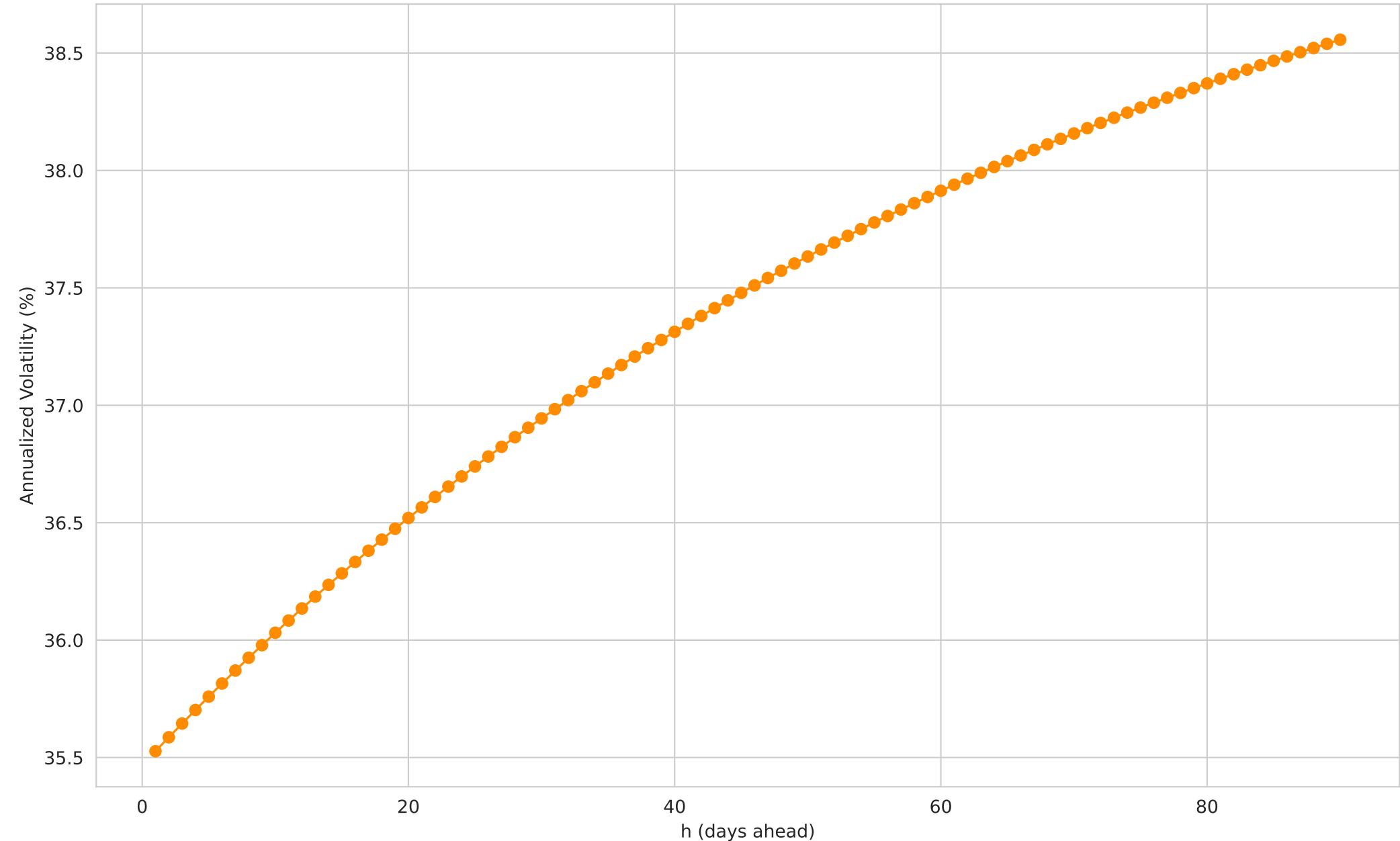
PSX • Standardized Residuals



PSX • ACF(Standardized Residuals²) [Lag 0 Omitted]



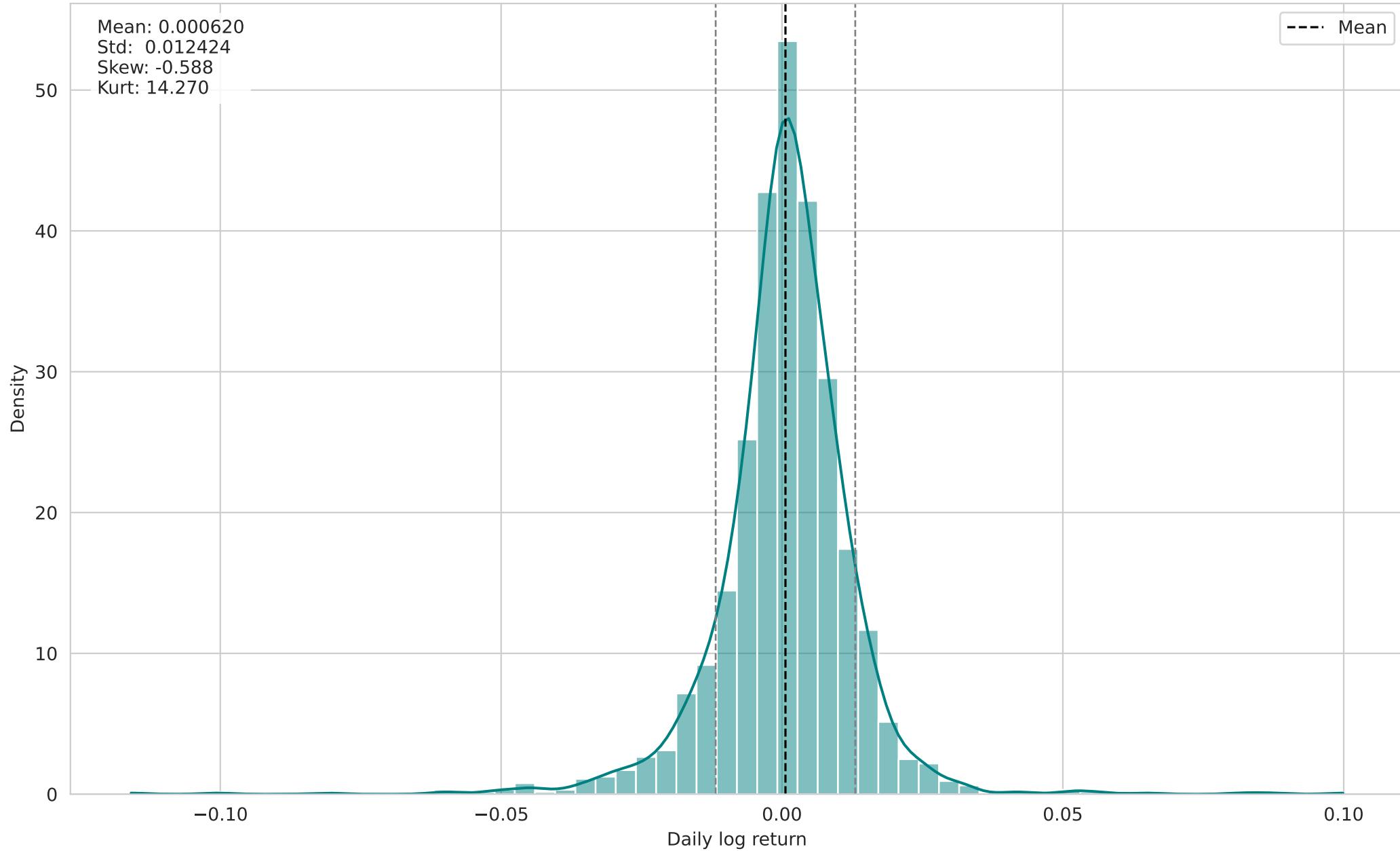
PSX • h-Step Volatility Forecast (Annualized %, Closed-Form)



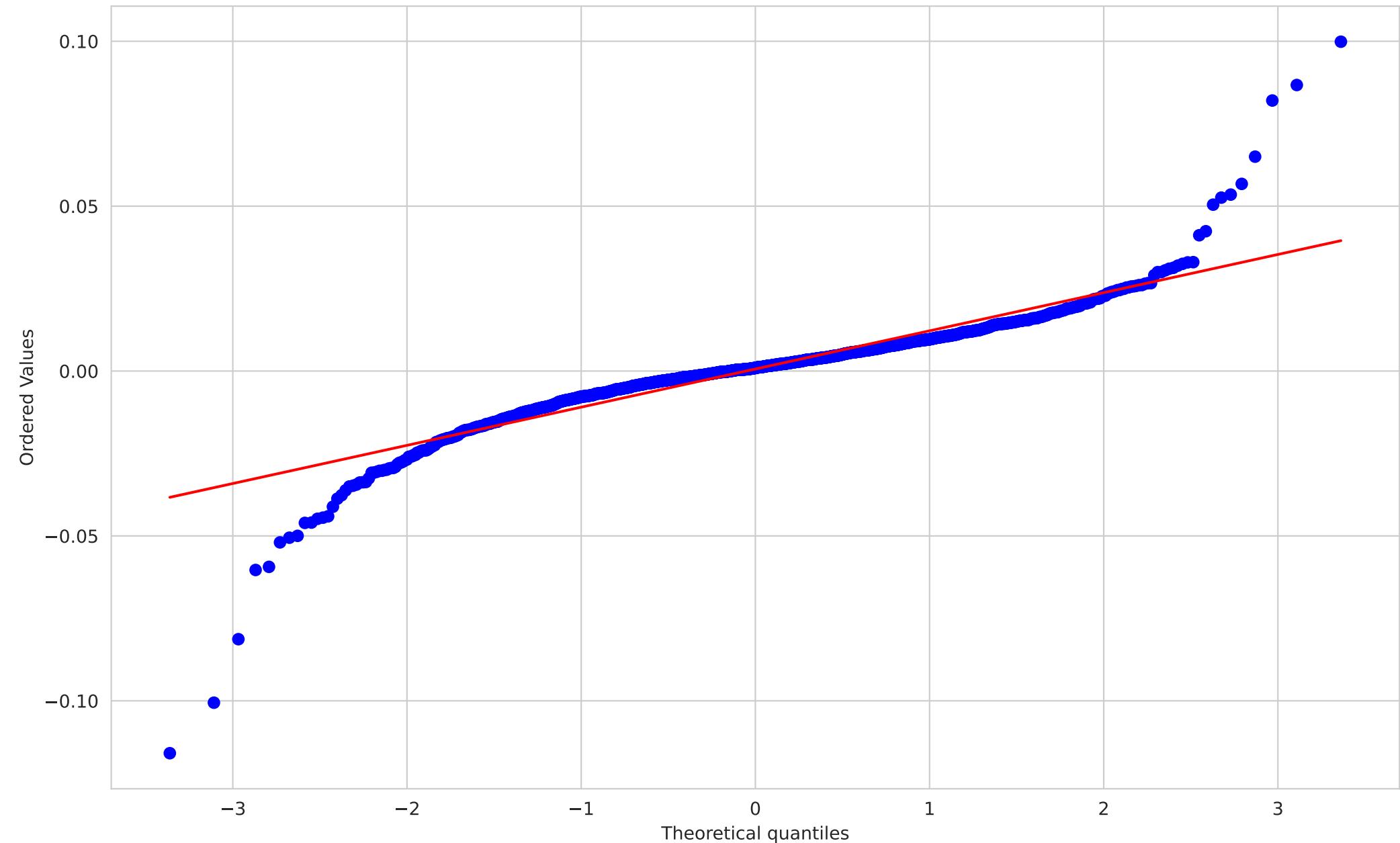
SPY • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.000901	Estimated average daily return (constant mean in the return equation).
ω	3.085275e-06	Variance intercept; baseline level feeding the long-run variance.
α	0.100000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.880000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000154	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309690	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	5747.942045	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-1.148788e+04	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-1.146593e+04	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

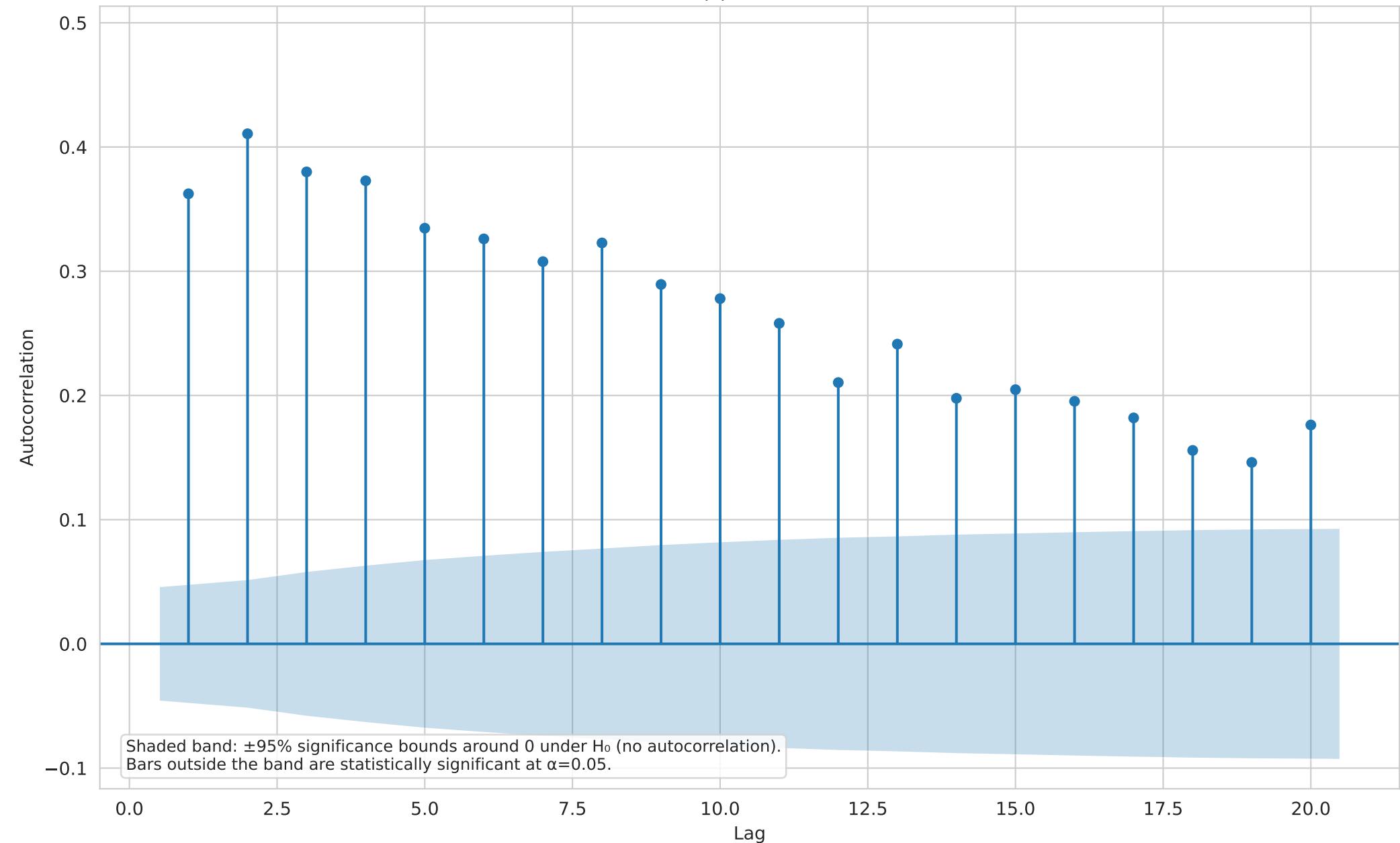
SPY • Return Distribution



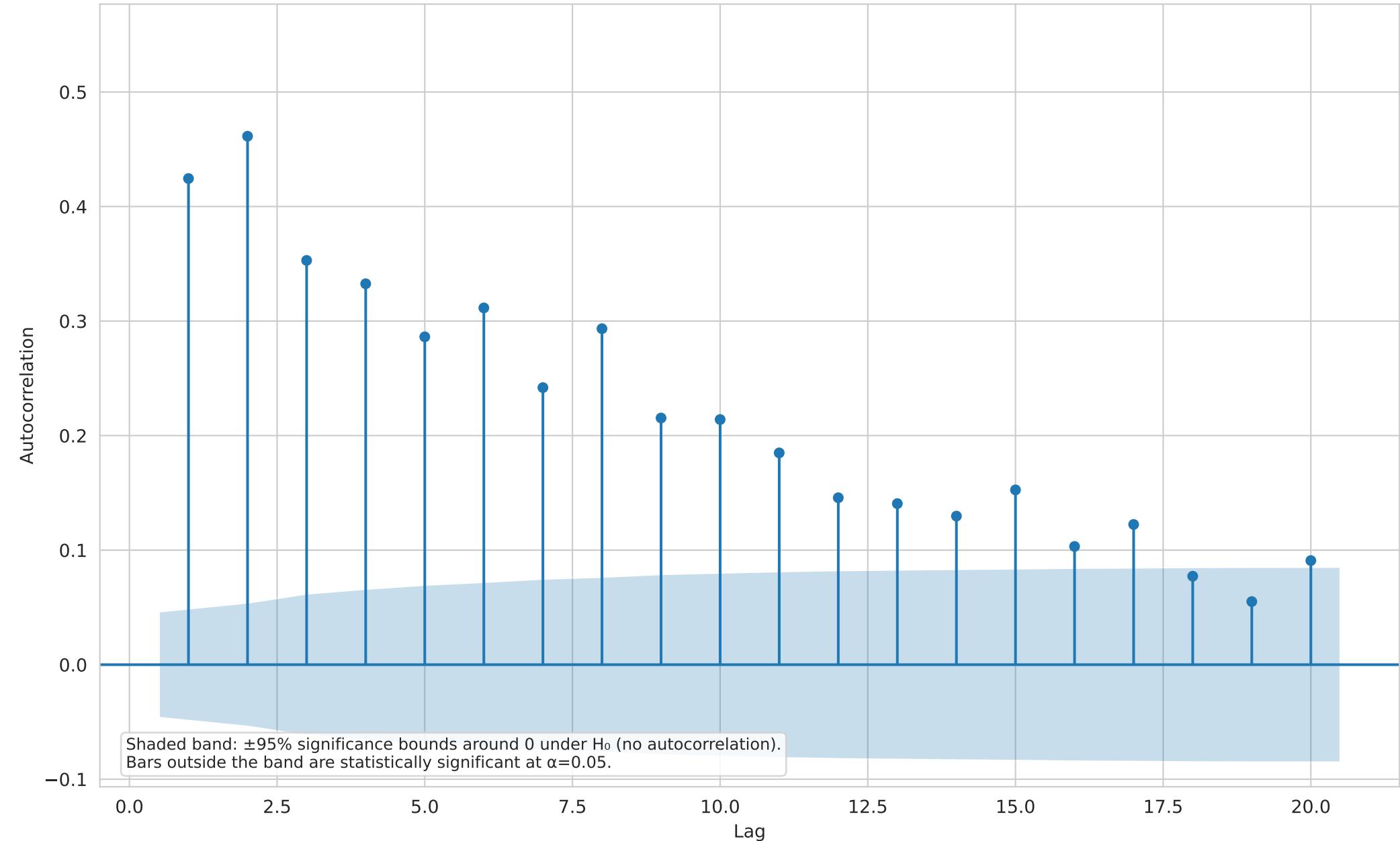
SPY • Q-Q Plot (Normal)



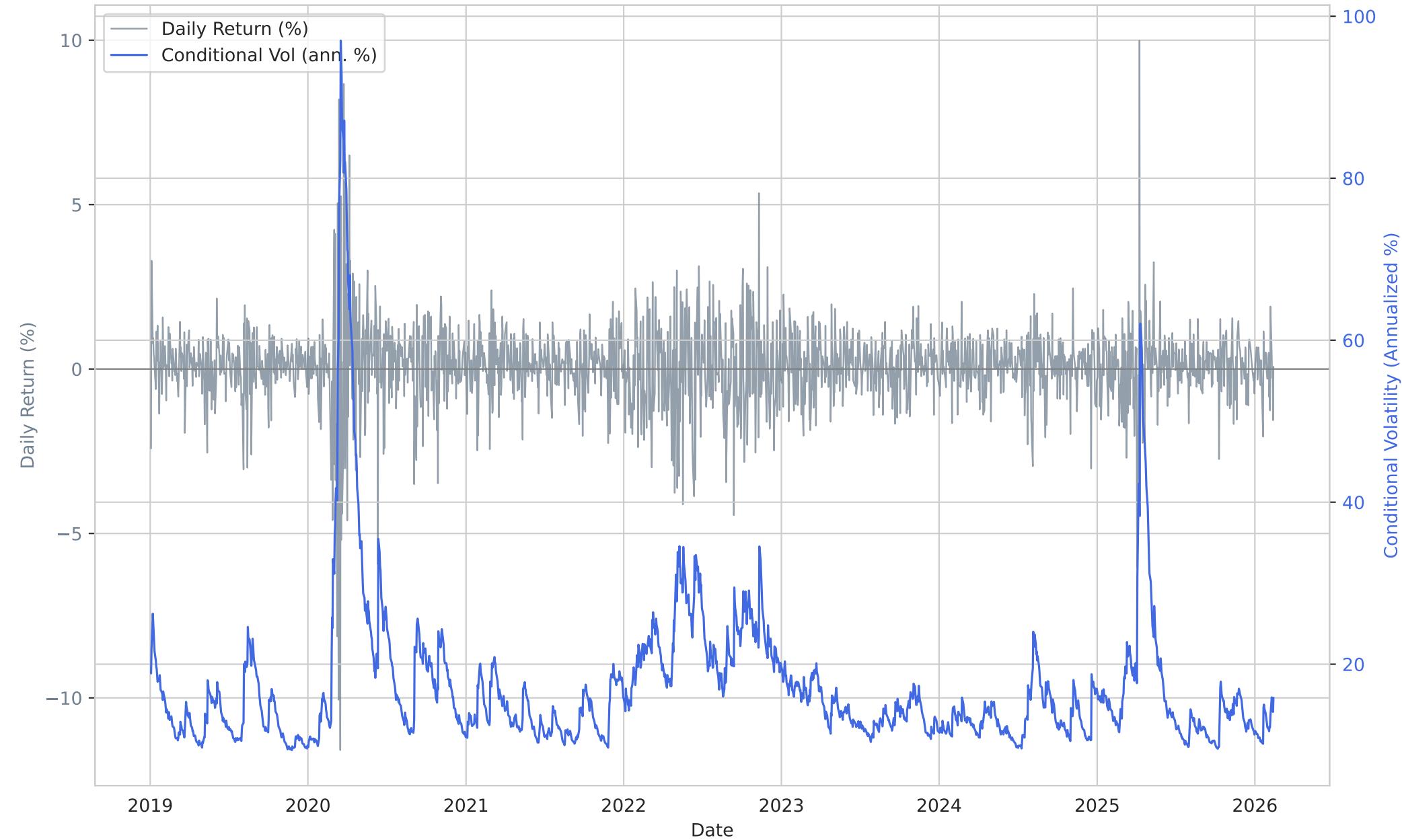
SPY • ACF(|r|) [Lag 0 Omitted]



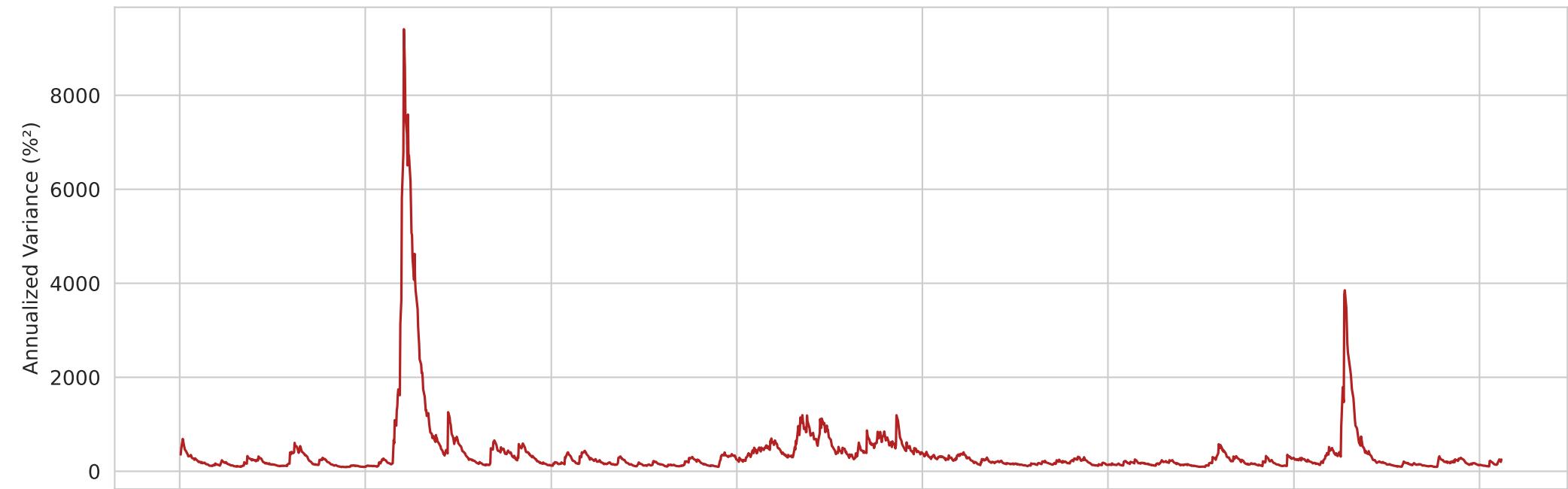
SPY • ACF(r^2) [Lag 0 Omitted]



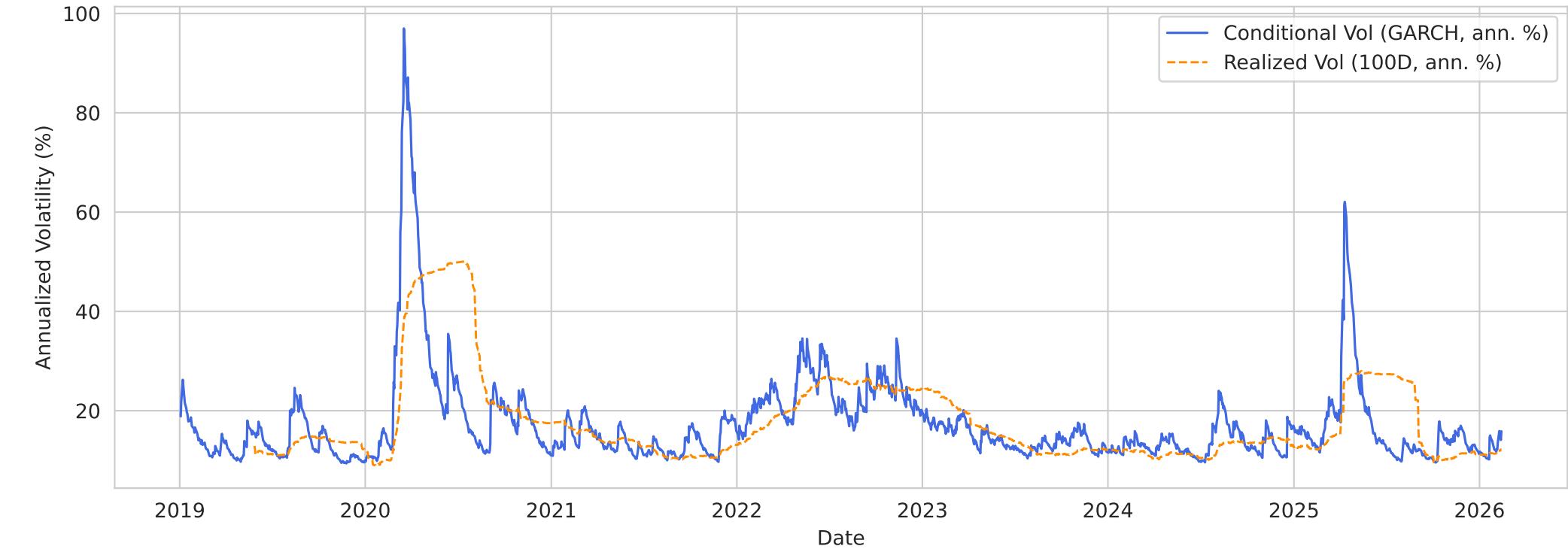
SPY • Daily % Returns vs Conditional Volatility (Annualized %)



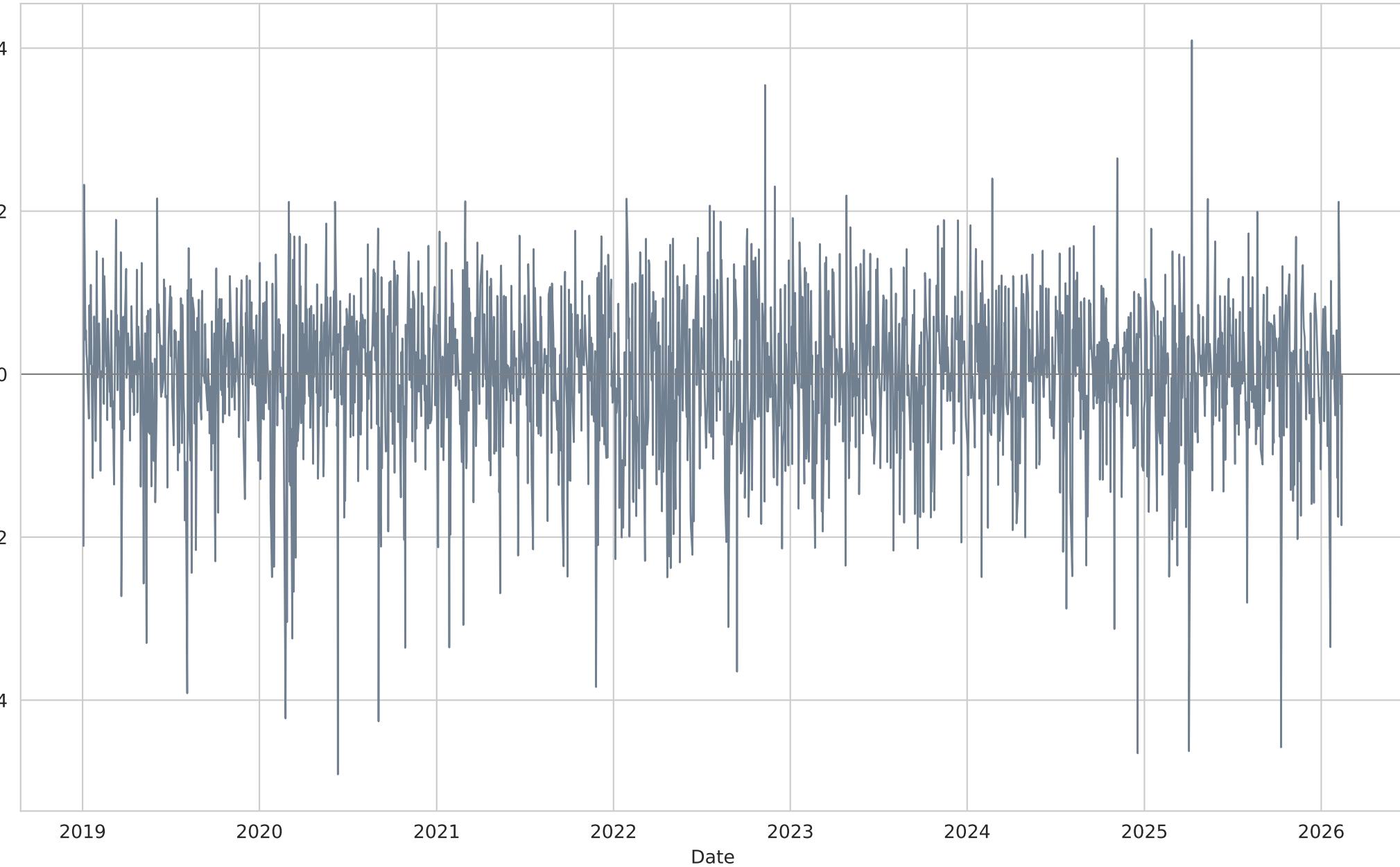
SPY • Conditional Variance (Annualized, %²)



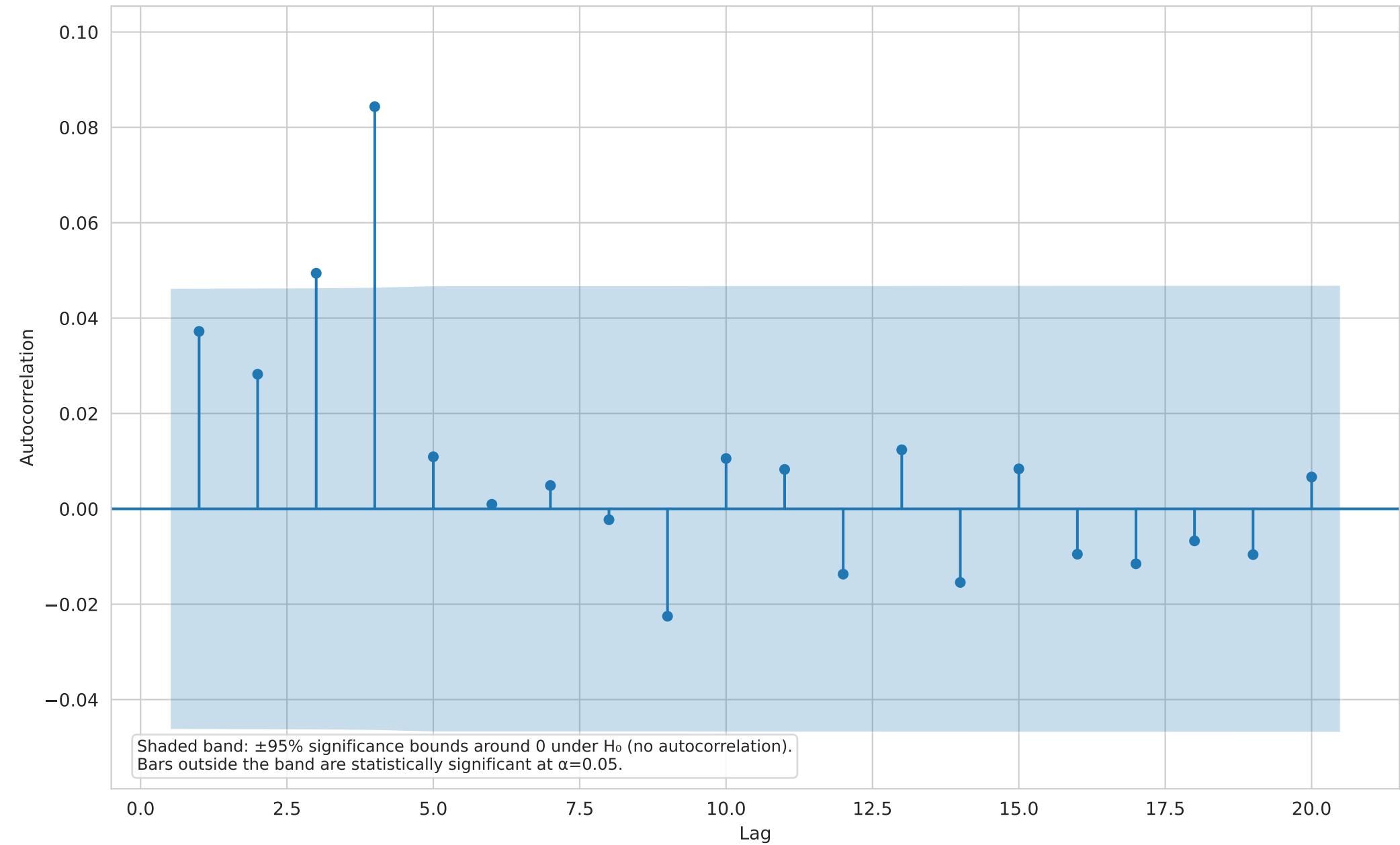
SPY • Volatility (Annualized %) • Conditional vs Realized



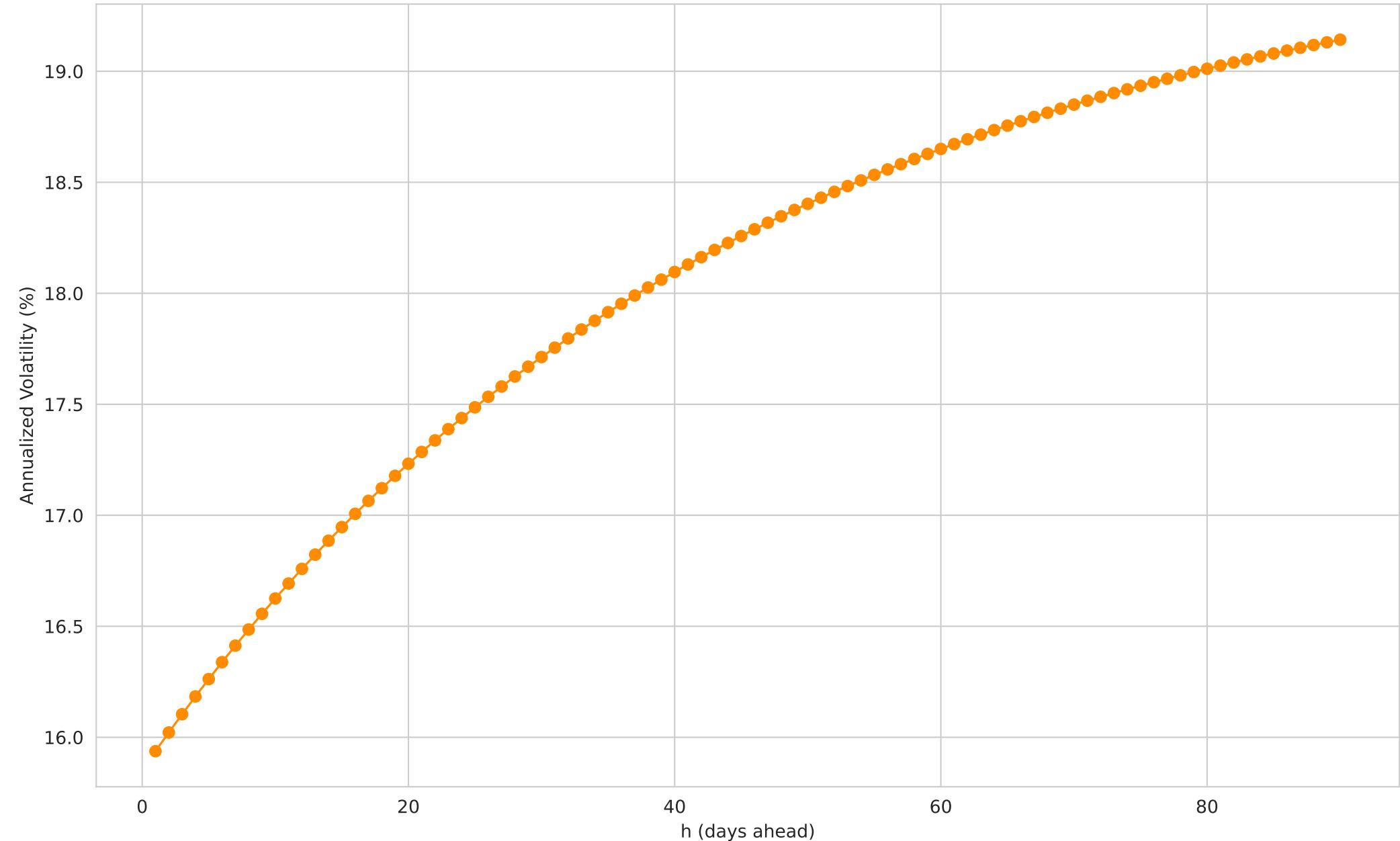
SPY • Standardized Residuals



SPY • ACF(Standardized Residuals²) [Lag 0 Omitted]



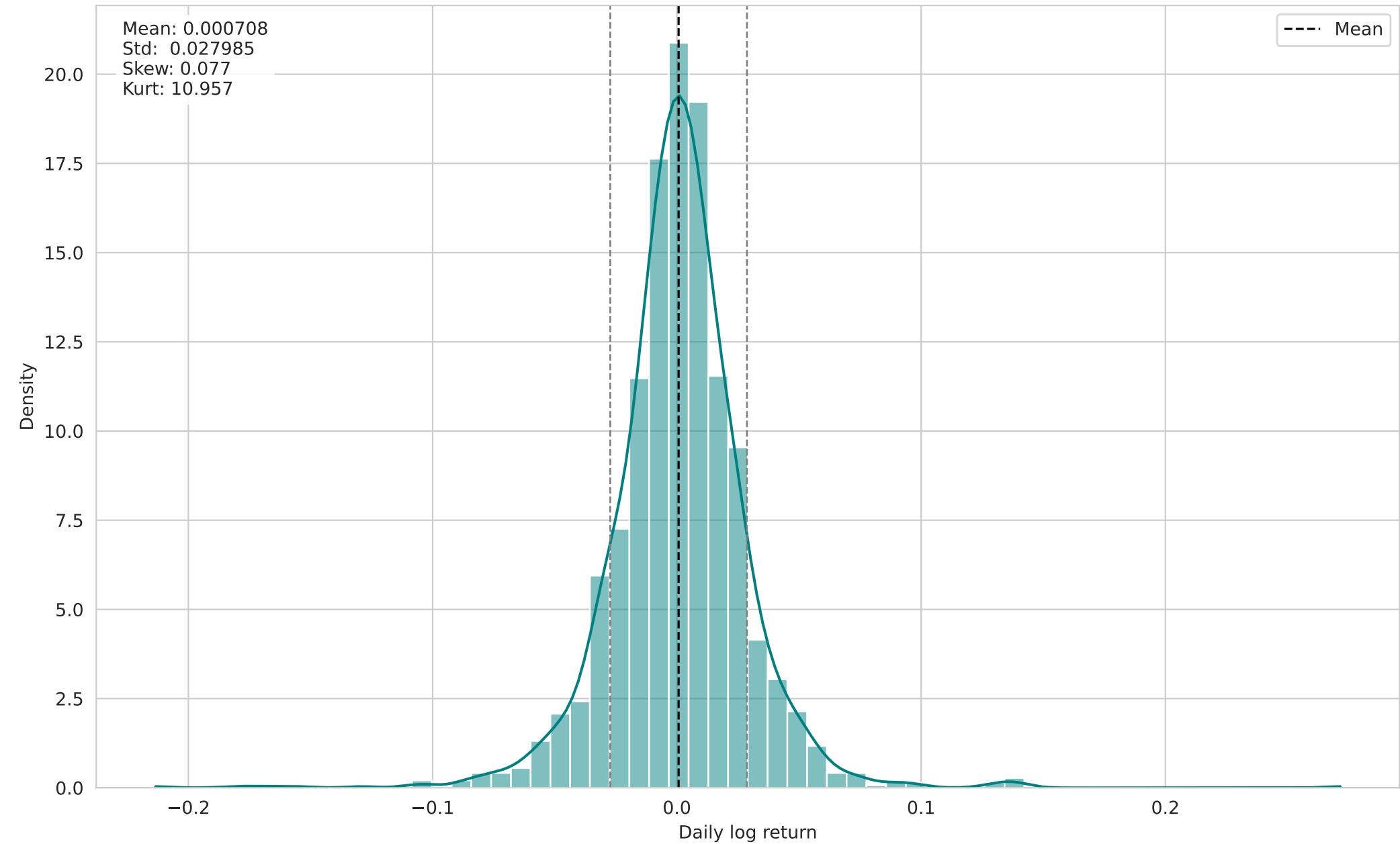
SPY • h-Step Volatility Forecast (Annualized %, Closed-Form)



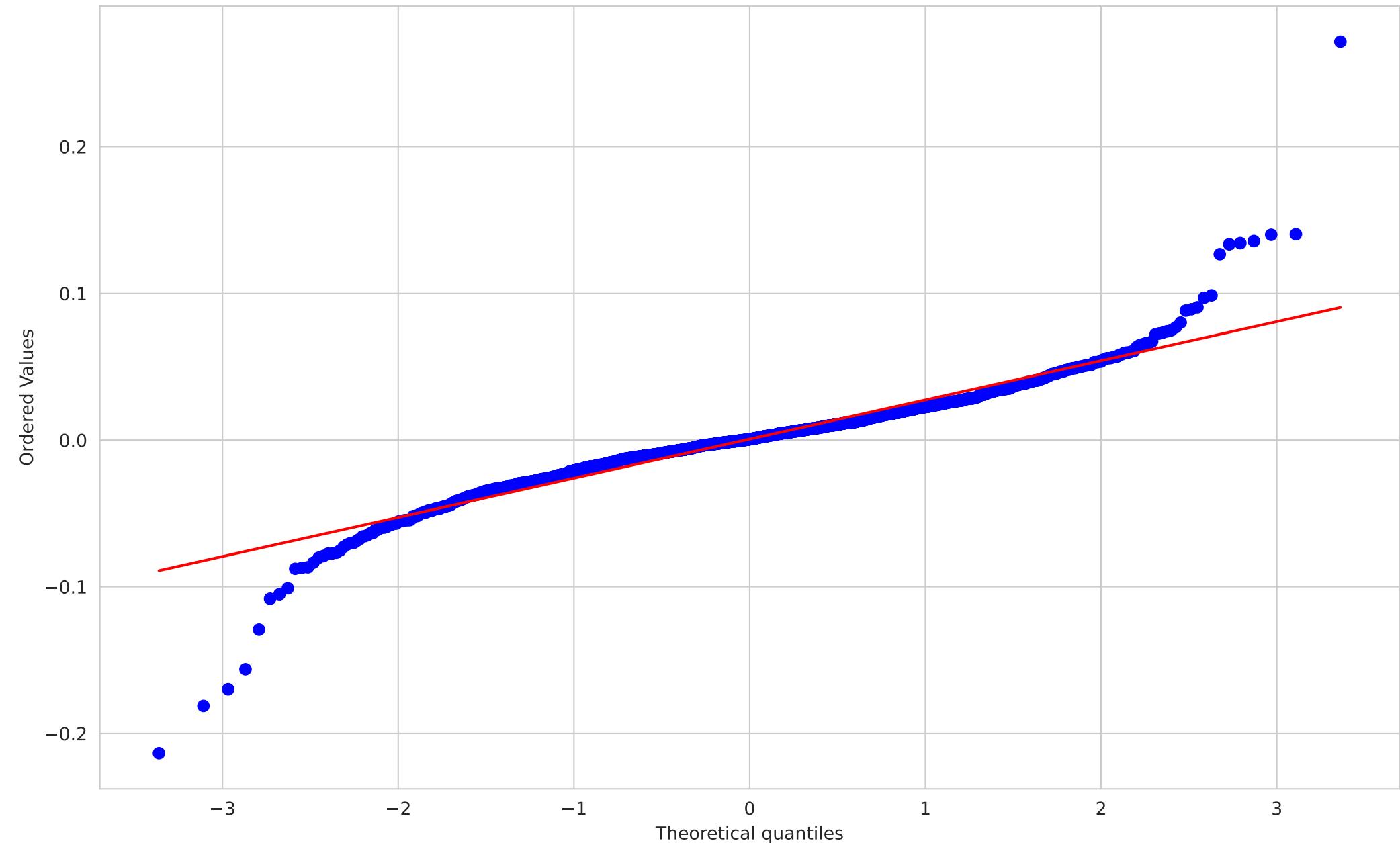
VLO • GARCH(1,1) Estimates

Metric	Value	Explanation
μ (mean)	0.001064	Estimated average daily return (constant mean in the return equation).
ω	1.565674e-05	Variance intercept; baseline level feeding the long-run variance.
α	0.050000	Shock (ARCH) effect; how strongly yesterday's squared residual increases today's variance.
β	0.930000	Persistence (GARCH) effect; how strongly yesterday's variance carries into today.
v (Student-t df)	—	Not estimated under Gaussian innovations.
$\alpha+\beta$ (persistence)	0.980000	Total variance persistence; closer to 1 implies slower mean reversion and stronger volatility clustering.
$\sigma^{\infty 2} = \omega/(1-\alpha-\beta)$	0.000783	Long-run (unconditional) variance implied by the model, assuming $\alpha+\beta < 1$.
Half-life (days)	34.309220	Approx. days for a volatility shock to decay by 50% (based on $\alpha+\beta$).
log-likelihood	4083.009895	Model fit objective value under maximum likelihood; higher is better (within same data/model).
AIC	-8158.019791	Akaike Information Criterion (penalized fit); lower is better for comparing models on the same data.
BIC	-8136.062143	Bayesian Information Criterion (stronger penalty than AIC); lower is better for comparing models on the same data.

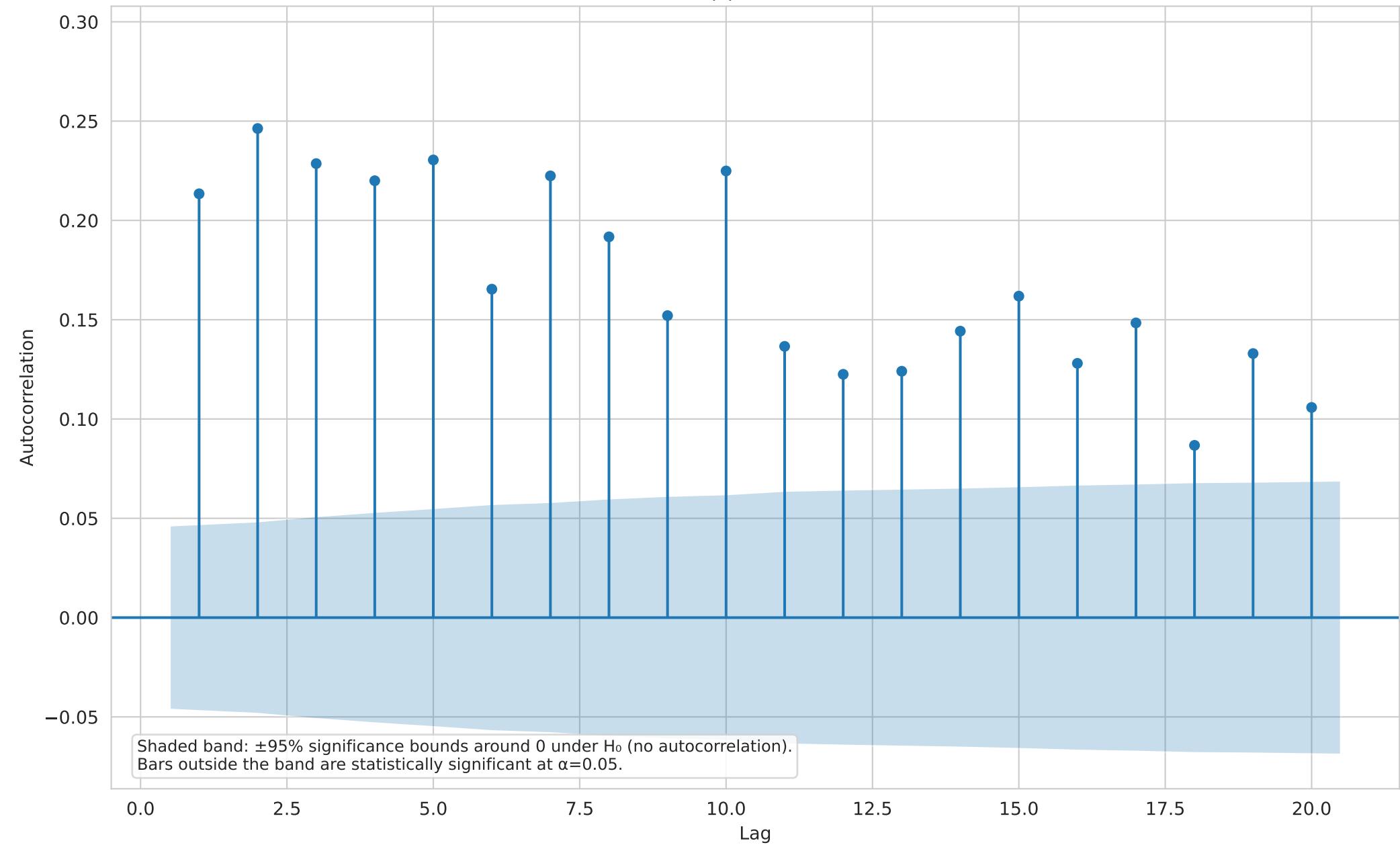
VLO • Return Distribution



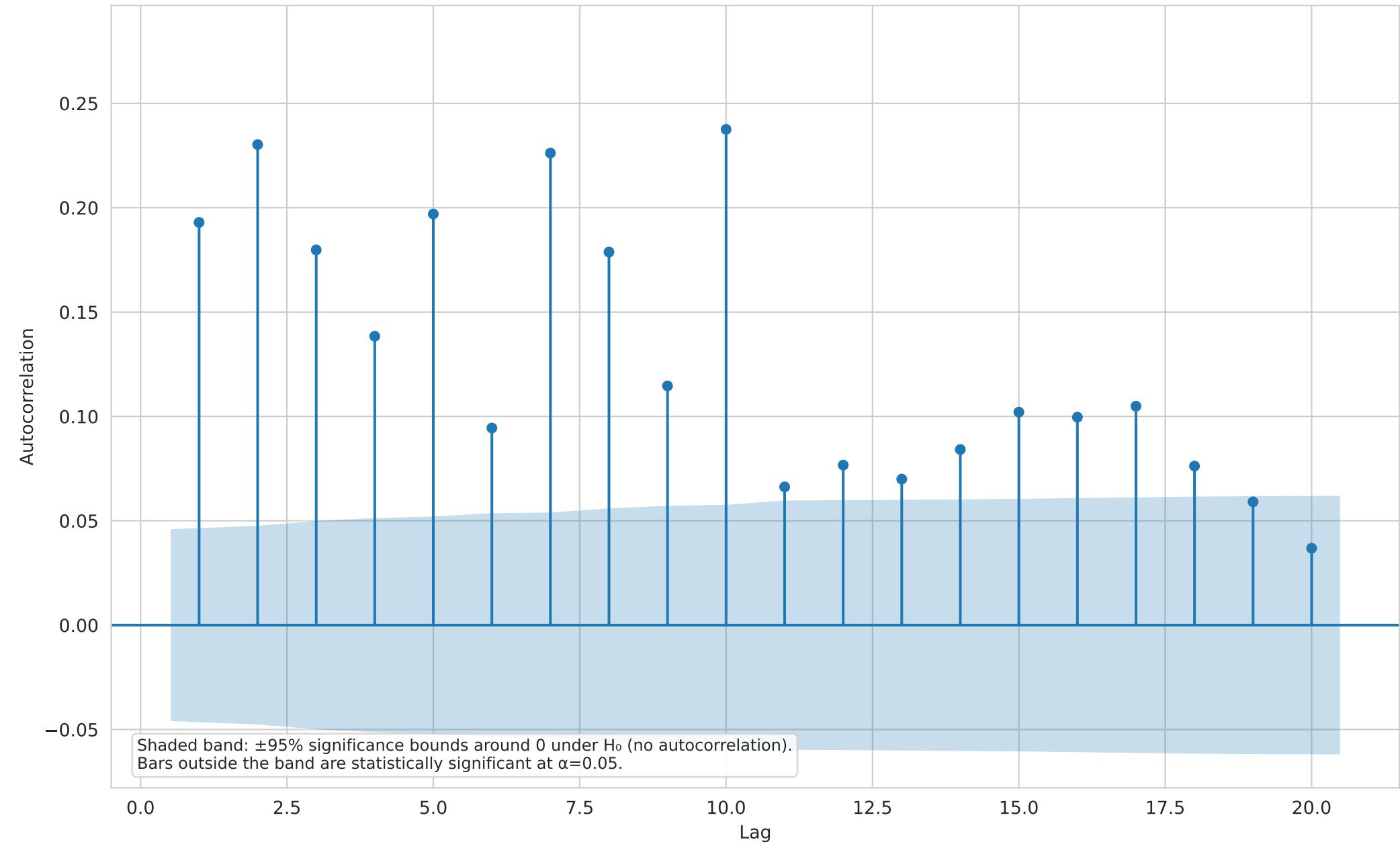
VLO • Q-Q Plot (Normal)



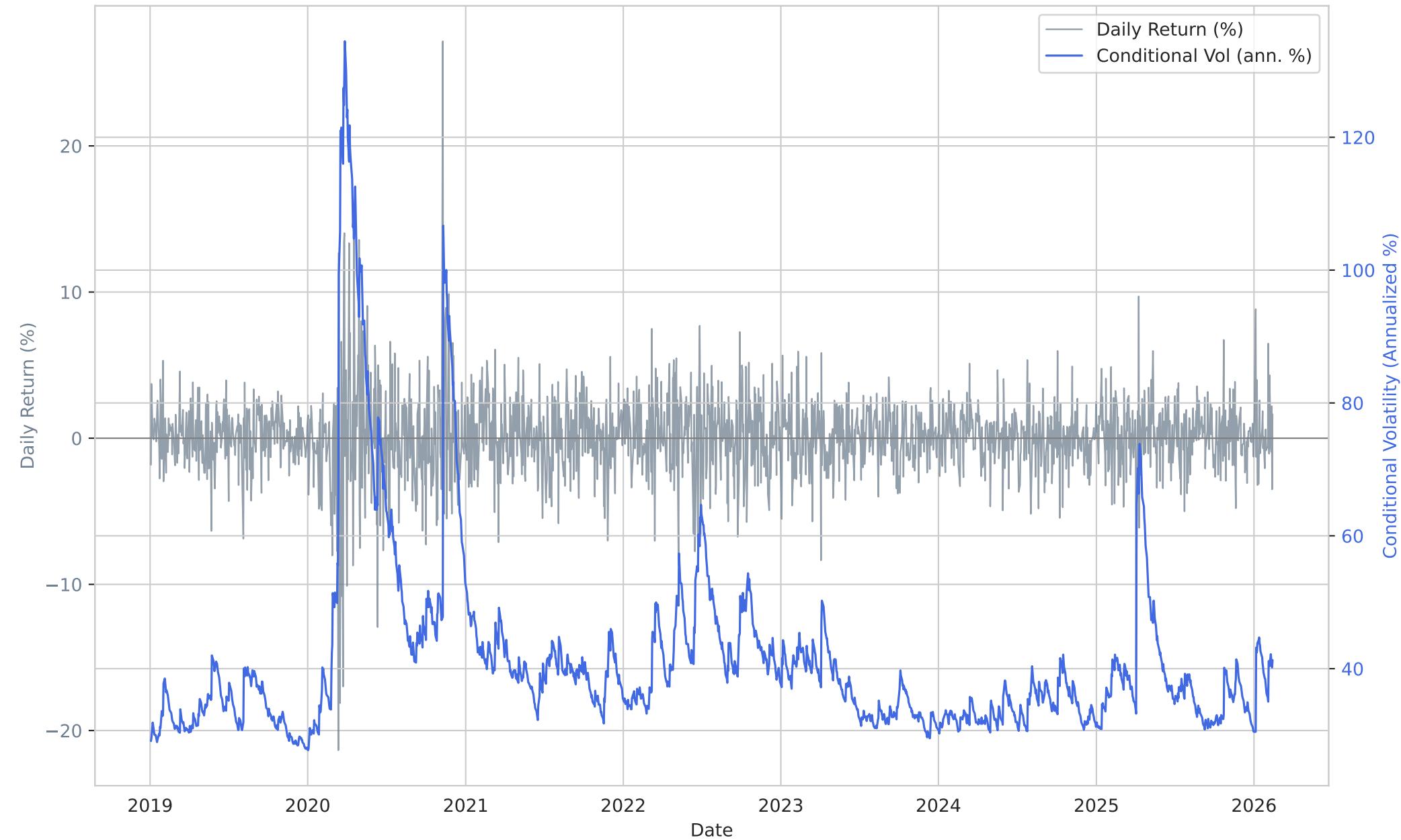
VLO • ACF(|r|) [Lag 0 Omitted]



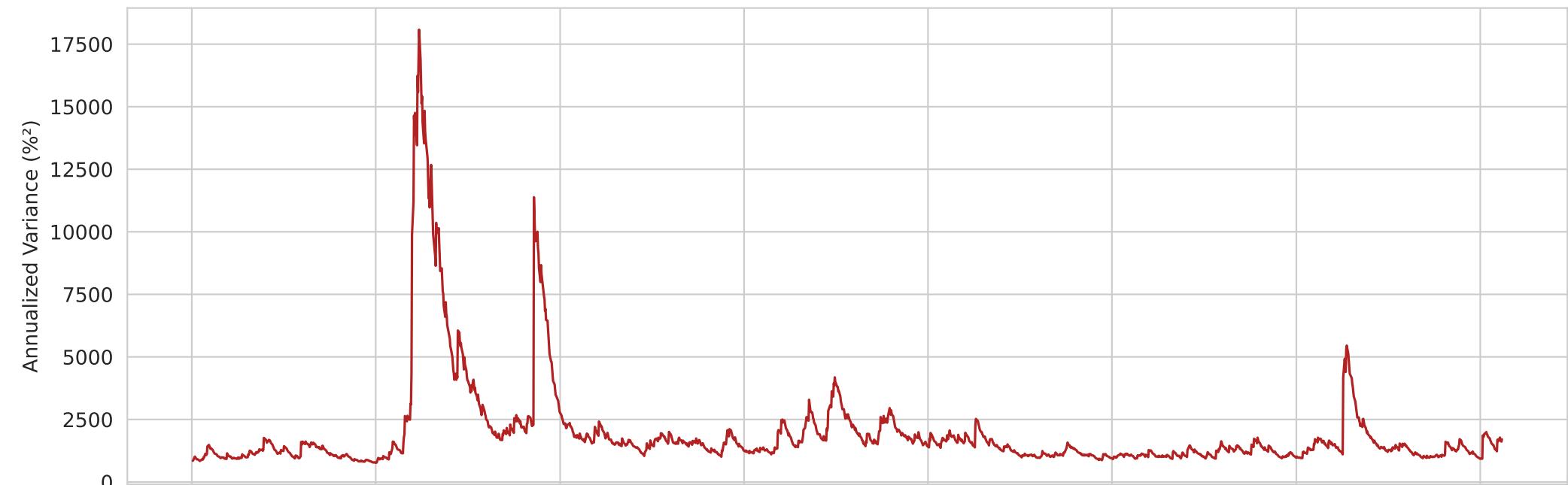
VLO • ACF(r^2) [Lag 0 Omitted]



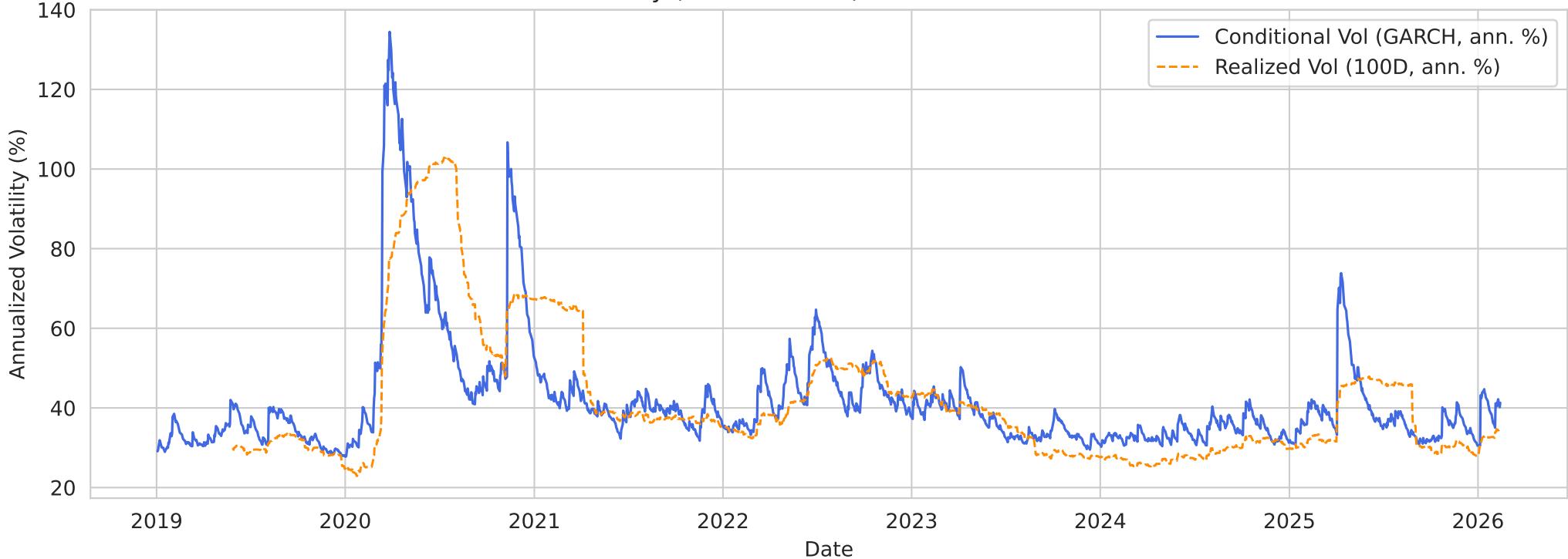
VLO • Daily % Returns vs Conditional Volatility (Annualized %)



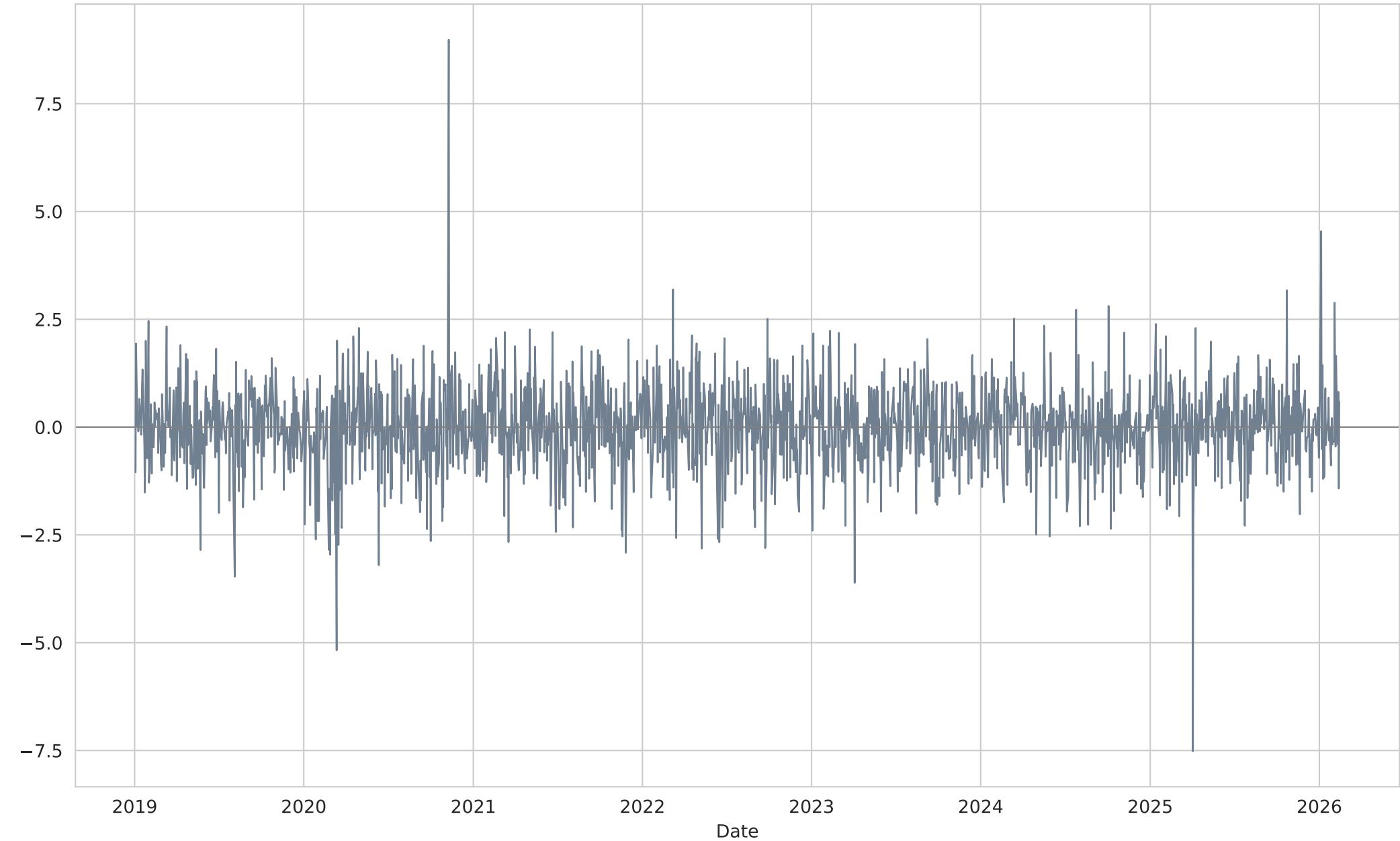
VLO • Conditional Variance (Annualized, %²)



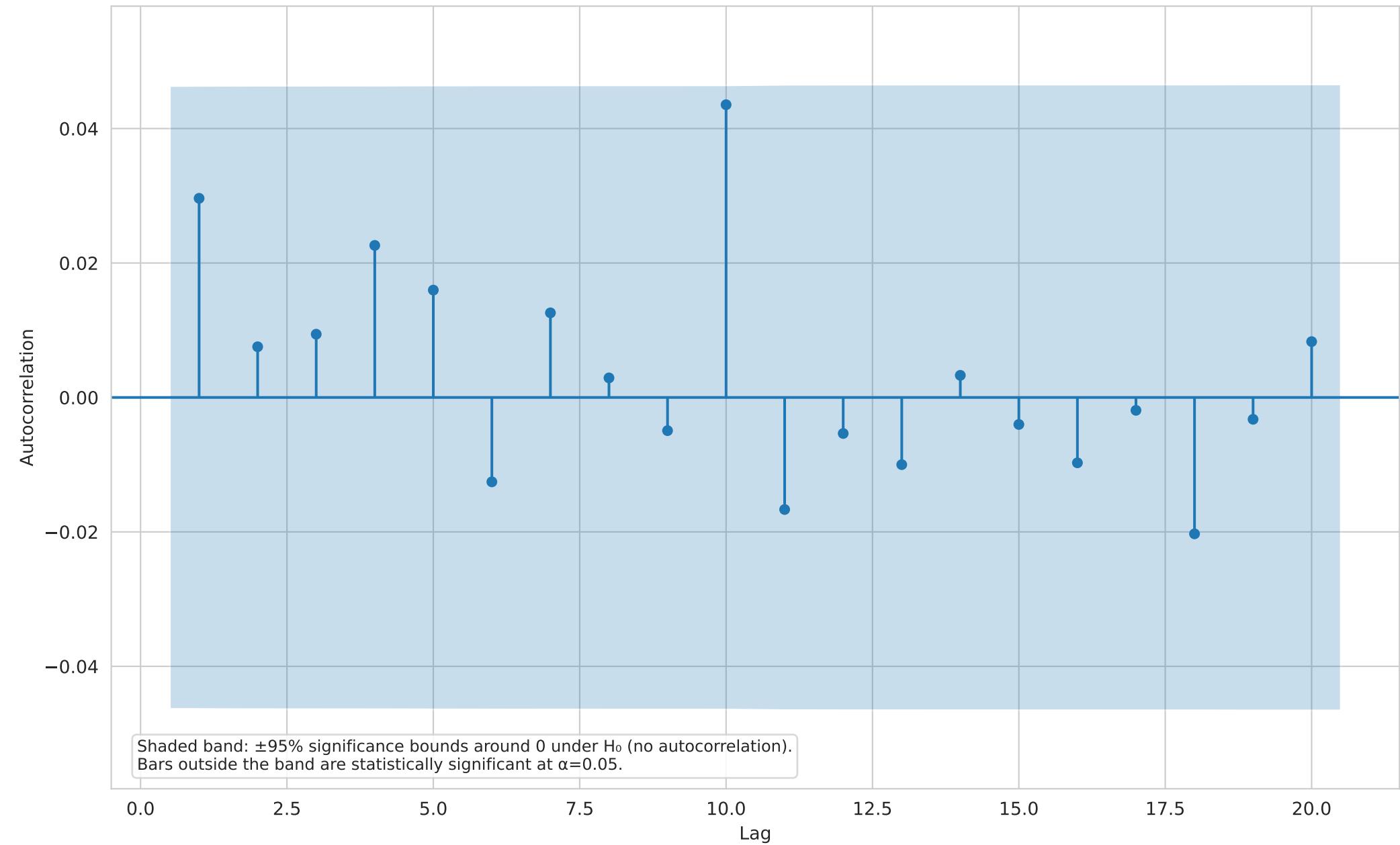
VLO • Volatility (Annualized %) • Conditional vs Realized



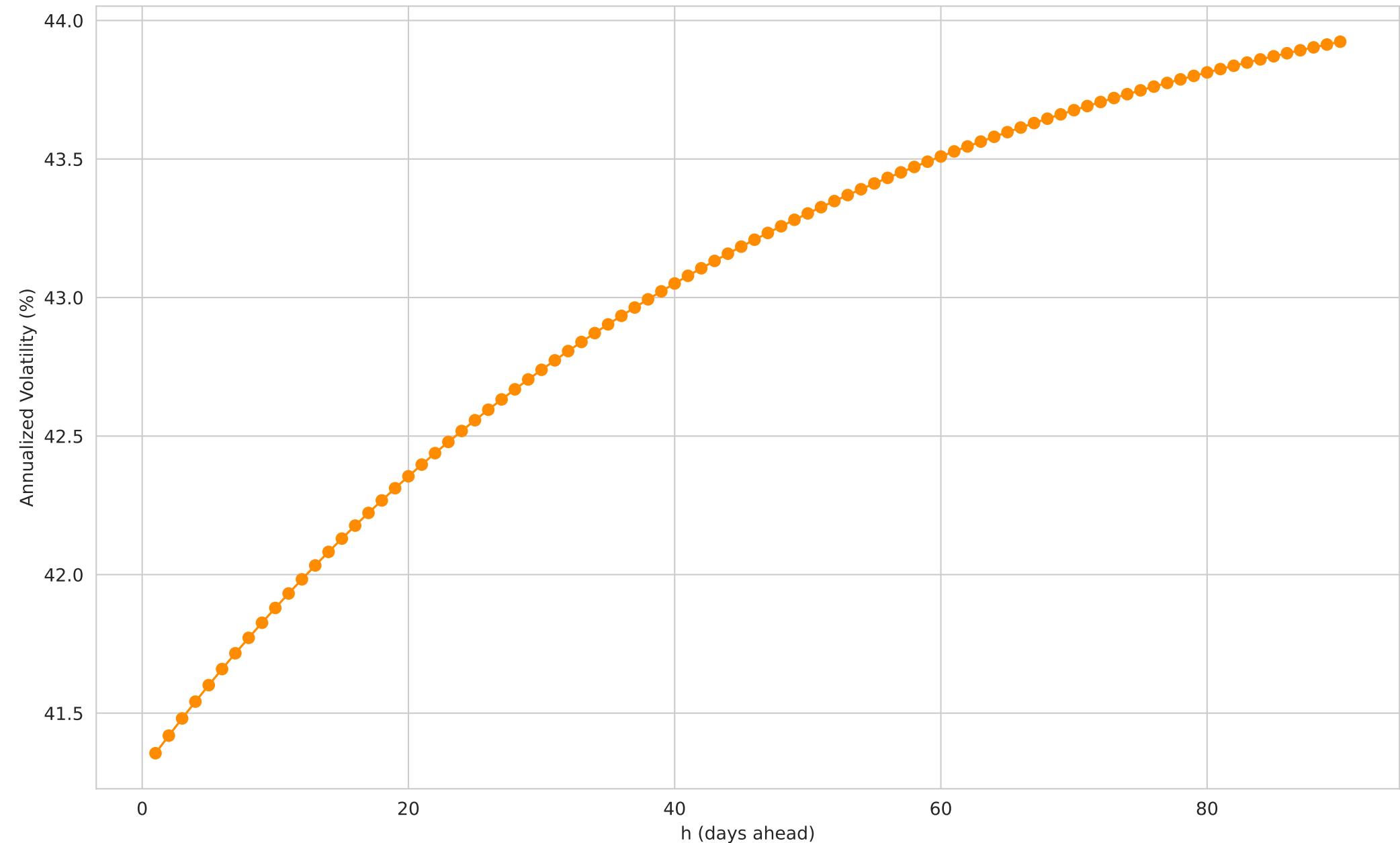
VLO • Standardized Residuals



VLO • ACF(Standardized Residuals²) [Lag 0 Omitted]



VLO • h-Step Volatility Forecast (Annualized %, Closed-Form)



Appendix • Cross-Asset Daily Log Return Correlation

