GARCH 模型的建立

一、股票基本信息 Stock Information

股票：招商银行

股票代码：600036.SH

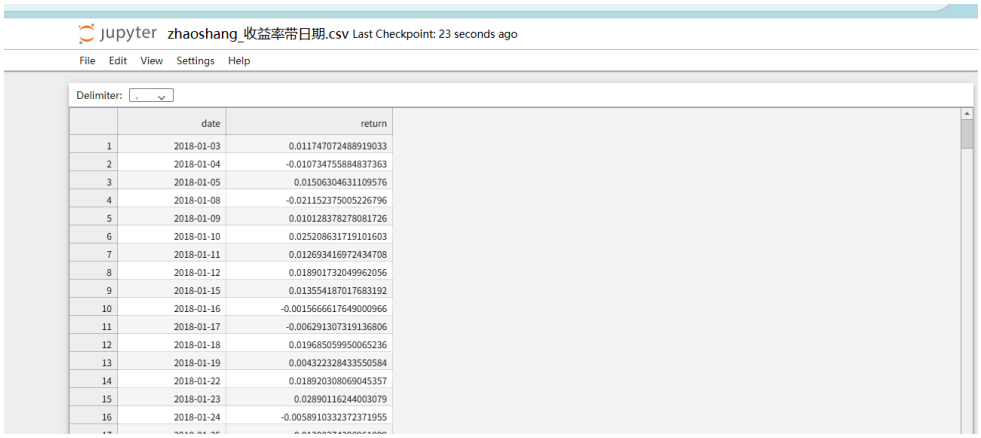
时间区间：2018-01-01 ~ 2025-01-01

日收益率序列部分截图：

Stock: China Merchants Bank (600036.SH)

Time range: 2018-01-01 to 2025-01-01

The following figure displays a sample segment of the daily log-return series.


jupyter zhaoshang_收益率带日期.csv Last Checkpoint: 23 seconds ago

File Edit View Settings Help

Delimiter: ,

	date	return
1	2018-01-03	0.011747072488919033
2	2018-01-04	-0.010734755884837363
3	2018-01-05	0.01506304631109576
4	2018-01-08	-0.021152375005226796
5	2018-01-09	0.010128378278081726
6	2018-01-10	0.025208631719101603
7	2018-01-11	0.012693416972434708
8	2018-01-12	0.018901732049962056
9	2018-01-15	0.013554187017683192
10	2018-01-16	-0.0015666617649000966
11	2018-01-17	-0.006291307319136806
12	2018-01-18	0.019685059950065236
13	2018-01-19	0.004322328433550584
14	2018-01-22	0.018920308069045357
15	2018-01-23	0.02890116244003079
16	2018-01-24	-0.005891033237237195

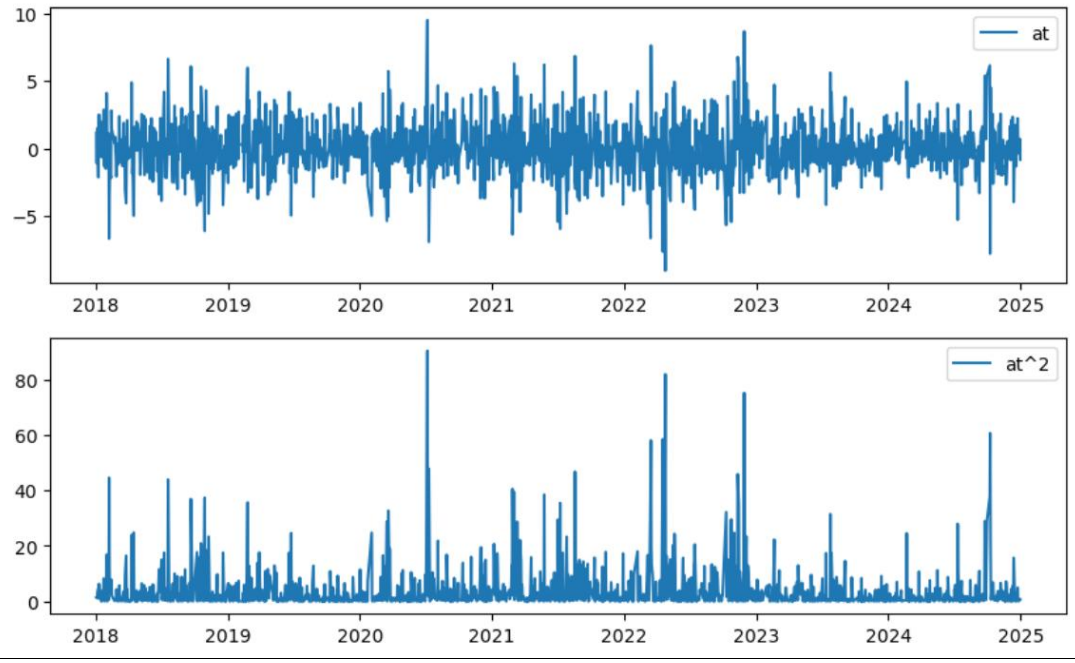
二、残差平方的白噪声检验 Residual Squared White Noise Test

1、 残差及残差平方的时间序列趋势图形

2、检验残差平方滞后 25 阶的 Q 统计量及 P 值，确定是否为白噪声序列。

The following figures show the time series trends of residuals and squared residuals.

To test for white noise, the Q-statistics and p-values (up to lag 25) of squared residuals were examined.



limiter: ,

	lag	AC	Q	P-value
1	1	0.16566136803869896	46.681763267286044	8.350248305837574e-12
2	2	0.038483498975672895	49.202397691224185	.0693554403662215e-11
3	3	0.0672770398591233	56.91055650311918	2.685379479485021e-12
4	4	0.13768993747854083	89.21614127715628	1.931980657052585e-18
5	5	0.09587284839096895	104.88801451339265	.9218234527220604e-21
6	6	0.07157849917322069	113.62881937426442	.5398714200530803e-22
7	7	0.026685763723978653	114.84445179072611	9.056347018885703e-22
8	8	0.020598918262132095	115.56920263720136	.7194878954294942e-21
9	9	0.030675826890774718	117.17743765531401	5.049128799944686e-21
10	10	0.017906306728222264	117.72574770263294	1.463324732898733e-20
11	11	0.011476888610465506	117.95113002929934	.6799607607521306e-20
12	12	0.03868257020433667	120.51301532971152	4.88321770260404e-20
13	13	0.0023243081928588285	120.52227028080571	..5874732440406835e-19
14	14	-0.007177167463043917	120.61056824272913	4.777625115856931e-19
15	15	0.025194247342767834	121.69926083706068	8.85174206432417e-19
16	16	0.03868680717316359	124.26780119233729	.2681604053223365e-19
17	17	0.002737661661025452	124.28067118922567	2.348097637468896e-18
18	18	-0.022919567523476077	125.18326045156616	4.382094227363212e-18
19	19	-0.015039162199392667	125.5721114314694	9.98988714827229e-18
20	20	0.02938241675847123	127.05725924332482	..3864806836269617e-17
21	21	0.06869613780936136	135.18029166997184	..0968166878867609e-18
22	22	0.021634145910360236	135.9863975738364	2.012188019372379e-18
23	23	0.01652666529197143	136.45709547206403	4.179249947929547e-18
24	24	0.01588064637240315	136.89197353815965	8.64284964598838e-18
25	25	0.024570974974139313	137.93365622360588	..3614401195066623e-17

从统计量的结果看，残差平方在前 25 阶的 P 值均远小于 0.05，拒绝“无 ARCH 效应”的原假设，说明招商银行 600036.SH 的收益率序列存在显著异方差性。这意味着市场波动具有聚集特征，即高波动时期往往伴随高波动、低波动时期延续平稳，为后续使用 GARCH 模型奠定了基础

All p-values are far below 0.05, rejecting the null of no ARCH effect. This indicates significant heteroskedasticity in returns, meaning volatility clustering exists, which provides the basis for applying GARCH modeling.

三、建立 GARCH(1,1)模型 Establishing GARCH(1,1) Model

1、 建立 GARCH(1,1)模型，得到 GARCH(1,1)模型回归结果表格。

2、 对模型残差进行 ARCH 效应检验。

```
Iteration:      1,   Func. Count:      6,   Neg. LLF: 9726.395506784209
Iteration:      2,   Func. Count:     15,   Neg. LLF: 26311.814932624315
Iteration:      3,   Func. Count:     23,   Neg. LLF: 213445758.4850729
Iteration:      4,   Func. Count:     29,   Neg. LLF: 3421.692379171435
Iteration:      5,   Func. Count:     35,   Neg. LLF: 3649.1960948258384
Iteration:      6,   Func. Count:     41,   Neg. LLF: 3406.4768675317173
Iteration:      7,   Func. Count:     46,   Neg. LLF: 3406.47232868271
Iteration:      8,   Func. Count:     51,   Neg. LLF: 3406.4722354508394
Iteration:      9,   Func. Count:     56,   Neg. LLF: 3406.47222697405
Iteration:     10,   Func. Count:     61,   Neg. LLF: 3406.472225654837
Iteration:     11,   Func. Count:     65,   Neg. LLF: 3406.4722256548152
Optimization terminated successfully    (Exit mode 0)
            Current function value: 3406.472225654837
            Iterations: 11
            Function evaluations: 65
            Gradient evaluations: 11
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                  close   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                      GARCH   Log-Likelihood:               -3406.47
Distribution:                  Normal   AIC:                           6820.94
Method:            Maximum Likelihood   BIC:                           6842.69
                                        No. Observations:                 1698
Date:                Fri, Oct 24 2025   Df Residuals:                     1697
Time:                        10:16:54   Df Model:                            1
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.0293  4.190e-02      0.698      0.485 [-5.286e-02,  0.111]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
----------------------------------------------------------------------------
omega          0.2471      0.177      1.399      0.162 [-9.899e-02,  0.593]
alpha[1]       0.0765  2.794e-02      2.738  6.174e-03  [2.175e-02,  0.131]
beta[1]        0.8516  7.583e-02     11.230  2.889e-29    [  0.703,  1.000]
============================================================================

Covariance estimator: robust
ARCH-LM Test
H0: Residuals are homoskedastic.
ARCH-LM Test
H1: Residuals are conditionally heteroskedastic.
Statistic: 46.6216
P-value: 0.0000
Distributed: <scipy.stats._distn_infrastructure.rv_continuous_frozen object at 0x000001D55DDCE490>
```

模型估计结果显示 $\alpha_1 = 0.0876$，$\beta_1 = 0.8516$，二者之和 $\alpha + \beta = 0.939 < 1$，表明模型平稳并具有较强的波动持续性。也就是说，招商银行收益率的波动不会瞬间消失，而是会在一定时间内逐步衰减，符合金融市场的惯常特征。ARCH-LM 检验 p 值为 0.0000，说明残差中仍存在轻微的异方差性，但整体拟合效果良好

We fit a GARCH(1,1) model; the estimation yields alpha = 0.0876, beta = 0.8516, with alpha+beta=0.939 < 1,

showing the process is stationary but highly persistent.

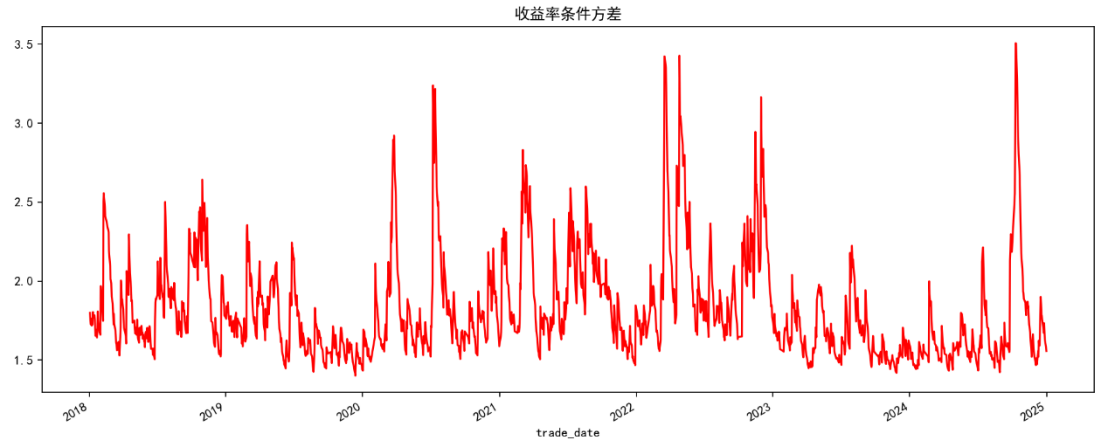
Return volatility does not disappear immediately, but fades gradually, consistent with financial market characteristics.

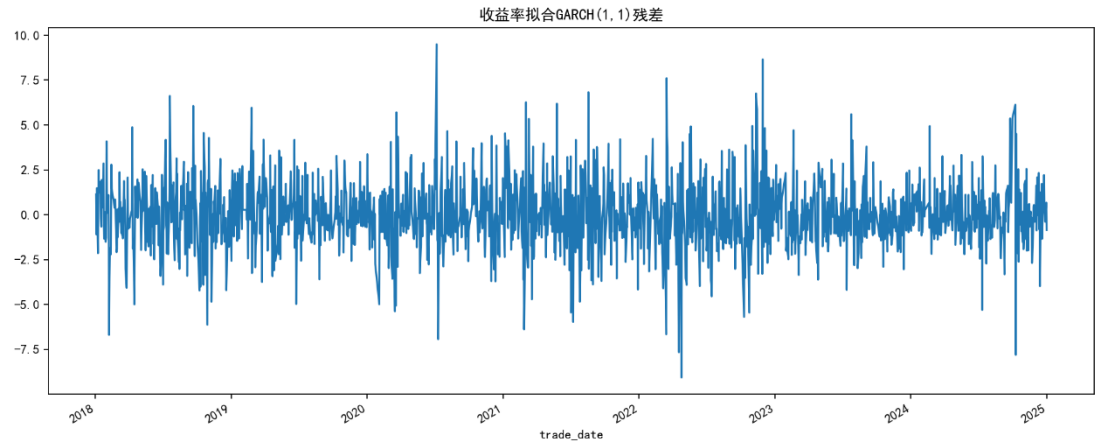
ARCH-LM test p-value is 0.0000, suggesting minor remaining heteroskedasticity, but overall fit is strong.

四、收益率条件方差

收益率条件方差图形

The conditional variance plots below demonstrate pronounced volatility clustering.





从条件方差的时序图可以看出，收益率波动呈明显的聚集现象。2020-2022 年间波动显著升高，对应疫情和宏观经济不确定性增加的时期；2023 年以后波动趋于下降，市场逐渐恢复稳定。模型能够较好地刻画这种“波动随事件集中爆发”的特征，体现出 GARCH 在金融风险分析中的优势

Notably, volatility surged during 2020-2022 (COVID, macro uncertainty), then declined in 2023 as the market stabilized.

GARCH successfully captures volatility spikes around major events, highlighting its risk analysis advantages.

预测未来一步方差

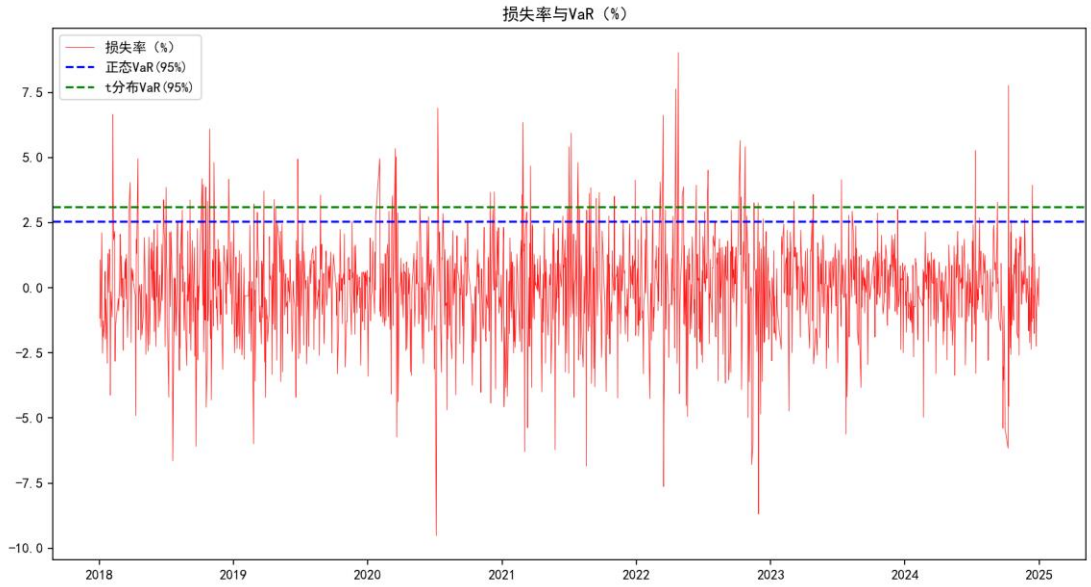
	h.1
trade_date	
2024-12-31	2.3661

模型预测的下一期条件方差为 2.3661 (%²)，对应短期波动率约 $\sqrt{2.3661} \approx 1.54\%$。这表明短期风险水平较温和，市场处于相对稳定阶段，预测结果与图像趋势一致

Future one-step variance is estimated at 2.3661, with short-term volatility approximately sqrt(2.3661) ≈ 1.54%.

This suggests moderate risk in the near term, consistent with the trend.

五、VaR 与 ES 分析 VaR and ES Analysis




```
Risk Measures for selected probabilities:

[[0.95       2.54023564 3.18299217]
 [0.99       3.58851912 4.10976783]
 [0.999      4.76353628 5.18940257]
 [0.9999     5.73074043 6.09908587]]

Risk Measures for selected probabilities:

[[ 0.95        3.10967411  4.45573464]
 [ 0.99        5.18607991  6.85888545]
 [ 0.999       9.07545139 11.56878393]
 [ 0.9999     14.8962607  18.75830424]]
```

正态分布下的VaR穿透率： 6.2426%
t分布下的VaR穿透率： 3.8280%

正态分布假设下的 VaR 穿透率为 6.24%，略高于理论值 5%，说明模型轻微低估风险；而 t 分布假设下的穿透率为 3.83%，略低于理论值，表现得更保守。t 分布能更好捕捉金融市场的厚尾特征，因此在极端波动情形下具有更高的风险估计准确度

Based on normal distribution, VaR violation rate is 6.24%, slightly above theoretical 5% (mild risk underestimation).

With t-distribution, violation rate is 3.83%, more conservative and closer to market tail risk.

t-distribution better captures fat-tail characteristics, yielding higher accuracy under extreme market conditions.