规则基准策略回测结果分析（rule_based）

本 Notebook 解析 `回测/res/dynamic_weights.json`（由天软回测 XML 转换而来），构建结构化的 `DataFrame`，计算尽可能全面的绩效与风险指标，并进行可视化与解释。

分析内容包括：

- A. 环境与数据读取
- B. 数据清洗与对齐
- C. 核心收益曲线可视化
- D. 指标计算（收益 / 风险 / 相对基准）
- E. 风险分析与归因
- F. 与框架自带统计结果交叉验证
- G. 结论与后续扩展方向

A. 环境与数据读取

In [1]:
```
import json
from pathlib import Path

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
from scipy import stats
from sklearn.linear_model import LinearRegression

plt.style.use('seaborn-v0_8-darkgrid')
plt.rcParams['figure.figsize'] = (10, 6)
plt.rcParams['axes.titlesize'] = 14
plt.rcParams['axes.labelsize'] = 12
plt.rcParams['legend.fontsize'] = 10
plt.rcParams['axes.grid'] = True
# 中文字体与负号支持
plt.rcParams['font.sans-serif'] = ['PingFang SC', 'Songti SC', 'Microsoft Ya
plt.rcParams['axes.unicode_minus'] = False

DATA_PATH = Path('回测/res/rule_based.json')
assert DATA_PATH.exists(), '找不到数据文件: %s' % DATA_PATH

with DATA_PATH.open('r', encoding='utf-8') as f:
    ts_data = json.load(f)

list(ts_data.keys())
```

Out[1]:
```
['每期收益率',
 '累计收益率',
 '月度绝对收益(原始)',
 '月度超额收益(原始)',
 '多空月度收益(原始)',
 '收益率检验',
 '换手率',
 '因子显著性统计',
 '因子区分度检验',
 '因子延续性检验',
 '因子稳定性检验',
 '回测状态']
```

In [2]:
```
# 查看各个 section 的示例结构
for key, value in ts_data.items():
    if isinstance(value, list) and value:
        print('=== %s ===' % key)
        df_preview = pd.DataFrame(value)
        display(df_preview.head(3))
    else:
        print('=== %s === (非列表或为空) -> 跳过预览' % key)
    print()
```

=== 每期收益率 ===

	开始日	截止日	交易点数	基准	第1组	第2组	第3组	第4组	第5组
0	2024-02-01	2024-02-29	1	1.15	-0.10	-0.10	-0.10	-0.10	-0.10
1	2024-03-01	2024-03-29	21	0.07	0.29	1.76	1.48	-2.17	-2.92
2	2024-04-01	2024-04-30	20	2.04	4.10	1.13	-0.53	1.54	3.20

=== 累计收益率 ===

	开始日	截止日	交易点数	基准	第1组	第2组	第3组	第4组	第5组
0	2024-02-01	2024-02-29	1	1.15	-0.10	-0.10	-0.10	-0.10	-0.10
1	2024-03-01	2024-03-29	21	1.23	0.19	1.66	1.38	-2.26	-3.01
2	2024-04-01	2024-04-30	20	3.30	4.30	2.80	0.84	-0.75	0.09

=== 月度绝对收益(原始) ===

	开始日	开始日_str	截止日	截止日_str	交易点数	基准	第1组	第2组	第3组	第4组	第5组
0	45323.0	2024-01-31	45351.0	2024-02-28	1	1.15	-0.10	-0.10	-0.10	-0.10	-0.10
1	45352.0	2024-02-29	45380.0	2024-03-28	21	0.07	0.29	1.76	1.48	-2.17	-2.92
2	45383.0	2024-03-31	45412.0	2024-04-29	20	2.04	4.10	1.13	-0.53	1.54	3.20

=== 月度超额收益(原始) ===

	开始日	开始日_str	截止日	截止日_str	交易点数	基准	第1组	第2组	第3组	第4组	第5组
0	45323.0	2024-01-31	45351.0	2024-02-28	1	1.15	-1.25	-1.25	-1.25	-1.25	-1.25
1	45352.0	2024-02-29	45380.0	2024-03-28	21	0.07	0.22	1.68	1.40	-2.24	-2.99
2	45383.0	2024-03-31	45412.0	2024-04-29	20	2.04	2.06	-0.92	-2.57	-0.50	1.16

=== 多空月度收益(原始) ===

	开始日	开始日_str	截止日	截止日_str	交易点数	第一组vs最后一组	第一组vs最后一组->累计
0	45323.0	2024-01-31	45351.0	2024-02-28	1	0.00	0.00
1	45352.0	2024-02-29	45380.0	2024-03-28	21	3.21	3.21
2	45383.0	2024-03-31	45412.0	2024-04-29	20	0.90	4.21

=== 收益率检验 ===

	组名	整体@平均收益(%)	整体@标准差(%)	整体@夏普比率	整体@胜率(%)	整体@最大回撤%(日线)	近1年@平均收益(%)	近1年@标准差(%)	近1年@夏普比率	近1年@胜率(%)	...	近2年@平均收益(%)	近2年@标准差(%)	近2年@夏普比率
0	第1组	0.83	8.35	0.10	55.56	-19.47	None	None	None	None	...	None	None	None
1	第2组	1.32	8.00	0.16	55.56	-17.37	None	None	None	None	...	None	None	None
2	第3组	0.95	4.93	0.19	55.56	-11.31	None	None	None	None	...	None	None	None

3 rows × 21 columns

=== 换手率 ===

	开始日	截止日	基准	第1组	第2组	第3组	第4组	第5组
0	2024-03-29	2024-02-29	0.0	50.0	60.0	50.0	60.0	20.0
1	2024-04-30	2024-03-29	0.0	50.0	60.0	70.0	70.0	50.0
2	2024-05-31	2024-04-30	0.0	10.0	30.0	40.0	40.0	20.0

=== 因子显著性统计 ===

	组名	整体@超额均值(%)	整体@跟踪误差(%)	整体@信息比率	整体@超额概率(%)	整体@T-Stat	整体@P-Value	近1年@超额均值(%)	近1年@跟踪误差(%)	近1年@信息比率	...	近2年@信息比率	近2年@超额概率(%)	近2年@T-Stat
0	第1组	-0.28	2.37	-0.12	55.56	-0.36	36.44	None	None	None	...	None	None	None
1	第2组	0.20	2.58	0.08	55.56	0.23	58.97	None	None	None	...	None	None	None
2	第3组	-0.16	2.71	-0.06	55.56	-0.18	43.12	None	None	None	...	None	None	None

3 rows × 25 columns

=== 因子区分度检验 ===

	项目	整体@平均收益(%)	整体@标准差(%)	整体@夏普比率	整体@胜率(%)	整体@T-Stat	整体@P-Value	近1年@平均收益(%)	近1年@标准差(%)	近1年@夏普比率	...	近2年@夏普比率	近2年@胜率(%)	近2年@T-Stat
0	第一组vs最后一组	-2.45	5.07	-0.48	33.33	-1.45	9.29	None	None	None	...	None	None	None

1 rows × 25 columns

=== 因子延续性检验 ===

	因子截止日	检验开始日	检验截止日	IC	P-value
0	2024-02-29	2024-03-01	2024-03-29	0.17	0.23
1	2024-03-29	2024-03-30	2024-04-30	0.00	0.98
2	2024-04-30	2024-05-01	2024-05-31	-0.27	0.06

=== 因子稳定性检验 ===

	开始日	上期截止日	间隔期数	自相关系数	买入衰减(%)	买入反转(%)	卖出衰减(%)	卖出反转(%)
0	2024-03-29	2024-02-29	1	0.74	50.0	0.0	80.0	0.0
1	2024-04-30	2024-03-29	1	0.58	50.0	0.0	50.0	0.0
2	2024-05-31	2024-04-30	1	0.94	90.0	0.0	80.0	0.0

=== 回测状态 ===（非列表或为空） -> 跳过预览

辅助函数：日期解析、数值处理与 section 归一化

In [3]:

```python
from datetime import datetime, timedelta


def excel_serial_to_datetime(serial):
    """将 Excel / 天软常见的序列日转换为 pandas Timestamp。

    采用 1899-12-30 为基准（serial=1 -> 1900-01-01）。
    """
    try:
        serial = float(serial)
    except (TypeError, ValueError):
        return None
    base_date = datetime(1899, 12, 30)
    return pd.Timestamp(base_date + timedelta(days=int(serial)))


def parse_date_series(s):
    """智能解析日期列：既支持字符串日期，也支持 Excel 序列日。"""
    if s.dropna().empty:
        return pd.to_datetime(s, errors='coerce')

    if np.issubdtype(s.dtype, np.datetime64):
        return s

    if s.dtype == 'object':
        parsed = pd.to_datetime(s, errors='coerce')
        if parsed.notna().mean() > 0.8:
            return parsed
        try:
            as_num = pd.to_numeric(s, errors='coerce')
            return as_num.apply(excel_serial_to_datetime)
        except Exception:
            return parsed

    if np.issubdtype(s.dtype, np.number):
        return s.apply(excel_serial_to_datetime)

    return pd.to_datetime(s, errors='coerce')
```

```python
def to_float_df(df):
    """将所有可转为数值的列转为 float，其余保留原类型；'-' 等缺失转 NaN。"""
    df = df.copy()
    for col in df.columns:
        if df[col].dtype == 'object':
            df[col] = df[col].replace('-', np.nan)
        try:
            num = pd.to_numeric(df[col], errors='coerce')
            if num.notna().mean() > 0.5:
                df[col] = num.astype(float)
        except Exception:
            pass
    return df


def normalize_section_to_df(key, value):
    """将顶层某个 section（通常是 list[dict]）归一化为 DataFrame。"""
    if not isinstance(value, list) or len(value) == 0:
        print('[WARN] section `%s` 不是非空列表，跳过解析' % key)
        return None
    df = pd.DataFrame(value)
    df = to_float_df(df)
    for col in list(df.columns):
        col_str = str(col)
        if ('开始日' in col_str) or ('起始日' in col_str):
            df['start_date'] = parse_date_series(df[col])
        if ('截止日' in col_str) or ('终止日' in col_str) or ('结束日' in col_s
            df['end_date'] = parse_date_series(df[col])
    if 'end_date' in df.columns:
        df['date'] = df['end_date']
    elif 'start_date' in df.columns:
        df['date'] = df['start_date']
    return df


def rename_group_cols(df):
    """统一分组列命名：benchmark, g1..g5, ls。"""
    df = df.copy()
    mapping = {}
    for col in df.columns:
        col_str = str(col)
        if '基准' in col_str:
            mapping[col] = 'benchmark'
        elif ('第1组' in col_str) or ('1组' in col_str):
            mapping[col] = 'g1'
        elif ('第2组' in col_str) or ('2组' in col_str):
            mapping[col] = 'g2'
        elif ('第3组' in col_str) or ('3组' in col_str):
            mapping[col] = 'g3'
        elif ('第4组' in col_str) or ('4组' in col_str):
            mapping[col] = 'g4'
        elif ('第5组' in col_str) or ('5组' in col_str):
            mapping[col] = 'g5'
        elif '第一组vs最后一组' in col_str or '一组vs' in col_str:
            mapping[col] = 'ls'
```

```
    return df.rename(columns=mapping)


sections = {}
for key, value in ts_data.items():
    df_sec = normalize_section_to_df(key, value)
    if df_sec is not None:
        sections[key] = rename_group_cols(df_sec)

print('可用 section:', list(sections.keys()))

# 看看“每期收益率”示例
if '每期收益率' in sections:
    display(sections['每期收益率'].head())
else:
    # 回退到任意一个 section
    first_key = list(sections.keys())[0]
    display(sections[first_key].head())
```

[WARN] section `回测状态` 不是非空列表，跳过解析
可用 section: ['每期收益率', '累计收益率', '月度绝对收益(原始)', '月度超额收益(原始)', '多空月度收益(原始)', '收益率检验', '换手率', '因子显著性统计', '因子区分度检验', '因子延续性检验', '因子稳定性检验']

	开始日	截止日	交易点数	benchmark	g1	g2	g3	g4	g5	start_date	end_da
0	2024-02-01	2024-02-29	1.0	1.15	-0.10	-0.10	-0.10	-0.10	-0.10	2024-02-01	2024-0
1	2024-03-01	2024-03-29	21.0	0.07	0.29	1.76	1.48	-2.17	-2.92	2024-03-01	2024-0
2	2024-04-01	2024-04-30	20.0	2.04	4.10	1.13	-0.53	1.54	3.20	2024-04-01	2024-0
3	2024-05-01	2024-05-31	20.0	-0.08	-2.57	1.25	1.43	-1.04	3.28	2024-05-01	2024-0
4	2024-06-01	2024-06-28	19.0	-2.73	-5.23	-0.40	1.37	-0.54	-7.25	2024-06-01	2024-0

B. 数据清洗与对齐（以“每期收益率”为主时间轴）

In [4]:
```
# 1) 选择 "每期收益率" 作为主时间轴
main_key = None
for k in ['每期收益率', '月度收益率', 'PeriodReturn']:
    if k in sections:
        main_key = k
        break
if main_key is None:
    raise ValueError('找不到合适的主时间轴 section（例如 每期收益率）')
```

```python
main_df = sections[main_key].copy()
if 'date' not in main_df.columns:
    raise ValueError('主时间轴 DataFrame 中缺少 date 列，无法对齐')

main_df = main_df.sort_values('date').reset_index(drop=True)
main_df.set_index('date', inplace=True)

# 2) 其余 section 外连接到主时间轴
aligned = main_df.copy()
for key, df_sec in sections.items():
    if key == main_key:
        continue
    if 'date' not in df_sec.columns:
        print('[INFO] section `%s` 无 date 列，跳过对齐' % key)
        continue
    tmp = df_sec.set_index('date').sort_index()
    # 丢弃各 section 自己的 start_date / end_date，避免重复列名冲突
    tmp = tmp.drop(columns=['start_date', 'end_date'], errors='ignore')
    new_cols = {}
    for c in tmp.columns:
        new_cols[c] = '%s__%s' % (key, c)
    tmp = tmp.rename(columns=new_cols)
    aligned = aligned.join(tmp, how='outer')

aligned.head()
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Cell In[4], line 31
     29             new_cols[c] = '%s__%s' % (key, c)
     30     tmp = tmp.rename(columns=new_cols)
---> 31     aligned = aligned.join(tmp, how=       )
     33 aligned.head()

File /opt/anaconda3/envs/dl/lib/python3.11/site-packages/pandas/core/frame.py:10757, in DataFrame.join(self, other, on, how, lsuffix, rsuffix, sort, validate)
  10747     if how == "cross":
  10748         return merge(
  10749             self,
  10750             other,
   (...)  10755             validate=validate,
  10756         )
> 10757     return merge(
  10758         self,
  10759         other,
  10760         left_on=on,
  10761         how=how,
  10762         left_index=on is None,
  10763         right_index=True,
  10764         suffixes=(lsuffix, rsuffix),
  10765         sort=sort,
  10766         validate=validate,
  10767     )
  10768 else:
  10769     if on is not None:

File /opt/anaconda3/envs/dl/lib/python3.11/site-packages/pandas/core/reshape/merge.py:184, in merge(left, right, how, on, left_on, right_on, left_index, right_index, sort, suffixes, copy, indicator, validate)
    169 else:
    170     op = _MergeOperation(
    171         left_df,
    172         right_df,
   (...)    182         validate=validate,
    183     )
--> 184     return op.get_result(copy=copy)

File /opt/anaconda3/envs/dl/lib/python3.11/site-packages/pandas/core/reshape/merge.py:888, in _MergeOperation.get_result(self, copy)
    884     self.left, self.right = self._indicator_pre_merge(self.left, self.right)
    886 join_index, left_indexer, right_indexer = self._get_join_info()
--> 888 result = self._reindex_and_concat(
    889     join_index, left_indexer, right_indexer, copy=copy
    890 )
    891 result = result.__finalize__(self, method=self._merge_type)
    893 if self.indicator:

File /opt/anaconda3/envs/dl/lib/python3.11/site-packages/pandas/core/reshape/merge.py:840, in _MergeOperation._reindex_and_concat(self, join_index, left_indexer, right_indexer, copy)
```

```
    837 left = self.left[:]
    838 right = self.right[:]
--> 840 llabels, rlabels = _items_overlap_with_suffix(
    841     self.left._info_axis, self.right._info_axis, self.suffixes
    842 )
    844 if left_indexer is not None and not is_range_indexer(left_indexer, l
en(left)):
    845     # Pinning the index here (and in the right code just below) is n
ot
    846     #  necessary, but makes the `.take` more performant if we have
e.g.
    847     #  a MultiIndex for left.index.
    848     lmgr = left._mgr.reindex_indexer(
    849         join_index,
    850         left_indexer,
   (...)    855         use_na_proxy=True,
    856     )

File /opt/anaconda3/envs/dl/lib/python3.11/site-packages/pandas/core/reshap
e/merge.py:2721, in _items_overlap_with_suffix(left, right, suffixes)
   2718 lsuffix, rsuffix = suffixes
   2720 if not lsuffix and not rsuffix:
-> 2721     raise ValueError(f"columns overlap but no suffix specified: {to_
rename}")
   2723 def renamer(x, suffix: str | None):
   2724     """
   2725     Rename the left and right indices.
   2726
   (...)   2737     x : renamed column name
   2738     """

ValueError: columns overlap but no suffix specified: Index(['start_date', 'e
nd_date'], dtype='object')
```

收益率单位说明与标准化

In [30]:

```python
# 从 "月度绝对收益(原始)" 中提取主要月度收益序列
abs_key = None
for k in ['月度绝对收益(原始)', '月度绝对收益', 'AbsoluteMonthlyReturn']:
    if k in sections:
        abs_key = k
        break

if abs_key is None:
    print('[WARN] 找不到 月度绝对收益(原始) section，将尝试从主表中推断收益列')
    monthly_ret_df = main_df.copy()
else:
    monthly_ret_df = sections[abs_key].copy().set_index('date').sort_index()

monthly_ret_df = rename_group_cols(monthly_ret_df)

# 为 benchmark/g1..g5 创建百分比版和小数版
returns_cols = [c for c in ['benchmark', 'g1', 'g2', 'g3', 'g4', 'g5'] if c
for col in returns_cols:
    monthly_ret_df[col + '_pct'] = monthly_ret_df[col]
```

```
    monthly_ret_df[col] = monthly_ret_df[col + '_pct'] / 100.0

# 若存在多空表，则提取 ls 列
ls_key = None
for k in ['多空月度收益(原始)', '多空月度收益', 'LongShortMonthlyReturn']:
    if k in sections:
        ls_key = k
        break

if ls_key is not None:
    ls_df = rename_group_cols(sections[ls_key]).set_index('date').sort_index
    if 'ls' in ls_df.columns:
        # 可能存在多个名为 ls 的列（列名重复时 pandas 返回 DataFrame），只取第一列
        ls_col = ls_df['ls']
        if isinstance(ls_col, pd.DataFrame):
            ls_col = ls_col.iloc[:, 0]
        monthly_ret_df['ls_pct'] = ls_col
        monthly_ret_df['ls'] = ls_col / 100.0
else:
    if ('g1' in monthly_ret_df.columns) and ('g5' in monthly_ret_df.columns)
        monthly_ret_df['ls'] = monthly_ret_df['g1'] - monthly_ret_df['g5']
        monthly_ret_df['ls_pct'] = monthly_ret_df['ls'] * 100.0

monthly_ret_df[[c for c in ['benchmark', 'g5'] if c in monthly_ret_df.columr
```

Out[30]:

date	benchmark	g5
2024-02-28	0.0115	-0.0010
2024-03-28	0.0007	-0.0292
2024-04-29	0.0204	0.0320
2024-05-30	-0.0008	0.0328
2024-06-27	-0.0273	-0.0725

C. 核心收益曲线可视化（累计收益 / 超额 / 多空）

In [31]:

```
def build_nav_from_return(r):
    r = r.dropna()
    return (1.0 + r).cumprod()

nav = pd.DataFrame(index=monthly_ret_df.index.sort_values())
if 'benchmark' in monthly_ret_df.columns:
    nav['benchmark'] = build_nav_from_return(monthly_ret_df['benchmark'])
if 'g5' in monthly_ret_df.columns:
    nav['g5'] = build_nav_from_return(monthly_ret_df['g5'])
if 'g1' in monthly_ret_df.columns:
    nav['g1'] = build_nav_from_return(monthly_ret_df['g1'])
if 'ls' in monthly_ret_df.columns:
    nav['ls'] = build_nav_from_return(monthly_ret_df['ls'])
```

```
nav.head()
```

Out[31]:

date	benchmark	g5	g1	ls
2024-02-28	1.011500	0.999000	0.999000	1.000000
2024-03-28	1.012208	0.969829	1.001897	1.032100
2024-04-29	1.032857	1.000864	1.042975	1.041389
2024-05-30	1.032031	1.033692	1.016170	0.980468
2024-06-27	1.003856	0.958749	0.963025	1.000273

In [32]:

```
# 1) 累计收益曲线：benchmark vs g5（可选 g1）
fig, ax = plt.subplots()
cols_to_plot = [c for c in ['benchmark', 'g5', 'g1'] if c in nav.columns]
nav[cols_to_plot].plot(ax=ax)
ax.set_title('累计收益曲线（单位：倍数，初始=1）')
ax.set_ylabel('净值')
ax.xaxis.set_major_formatter(mdates.DateFormatter('%Y-%m'))
plt.xticks(rotation=45)
plt.legend()
plt.tight_layout()
plt.show()

# 2) 超额累计收益曲线：g5 - benchmark
if ('benchmark' in monthly_ret_df.columns) and ('g5' in monthly_ret_df.colum
    excess = monthly_ret_df['g5'] - monthly_ret_df['benchmark']
    nav_excess = build_nav_from_return(excess)
    fig, ax = plt.subplots()
    nav_excess.plot(ax=ax, color='C3')
    ax.set_title('超额累计收益曲线（g5 - benchmark）')
    ax.set_ylabel('超额净值（倍数）')
    ax.xaxis.set_major_formatter(mdates.DateFormatter('%Y-%m'))
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()

# 3) 多空累计曲线：ls
if 'ls' in nav.columns:
    fig, ax = plt.subplots()
    nav['ls'].plot(ax=ax, color='C4')
    ax.set_title('多空累计收益曲线（ls）')
    ax.set_ylabel('净值（倍数）')
    ax.xaxis.set_major_formatter(mdates.DateFormatter('%Y-%m'))
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
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font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
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y:10: UserWarning: Glyph 25968 (\N{CJK UNIFIED IDEOGRAPH-6570}) missing from
font(s) Arial.
  plt.tight_layout()
```

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
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  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
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om font(s) Arial.
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om font(s) Arial.
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om font(s) Arial.
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```

```
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 20301 (\N{CJK UNIFIED IDEOGRAPH-4F4D}) missing from font(s) Arial.
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/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 25968 (\N{CJK UNIFIED IDEOGRAPH-6570}) missing from font(s) Arial.
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/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 65292 (\N{FULLWIDTH COMMA}) missing from font(s) Arial.
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/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 65289 (\N{FULLWIDTH RIGHT PARENTHESIS}) missing from font(s) Arial.
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```

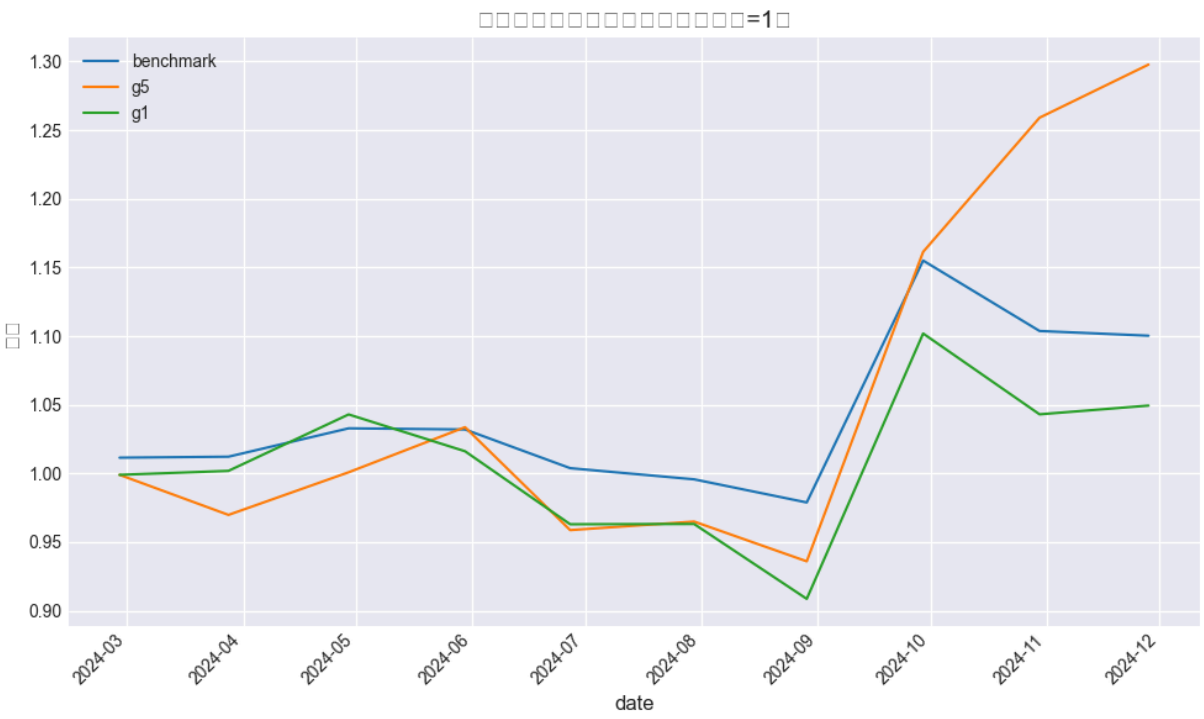

```
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font(s) Arial.
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font(s) Arial.
  plt.tight_layout()
```

```
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
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py:170: UserWarning: Glyph 32447 (\N{CJK UNIFIED IDEOGRAPH-7EBF}) missing fr
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```

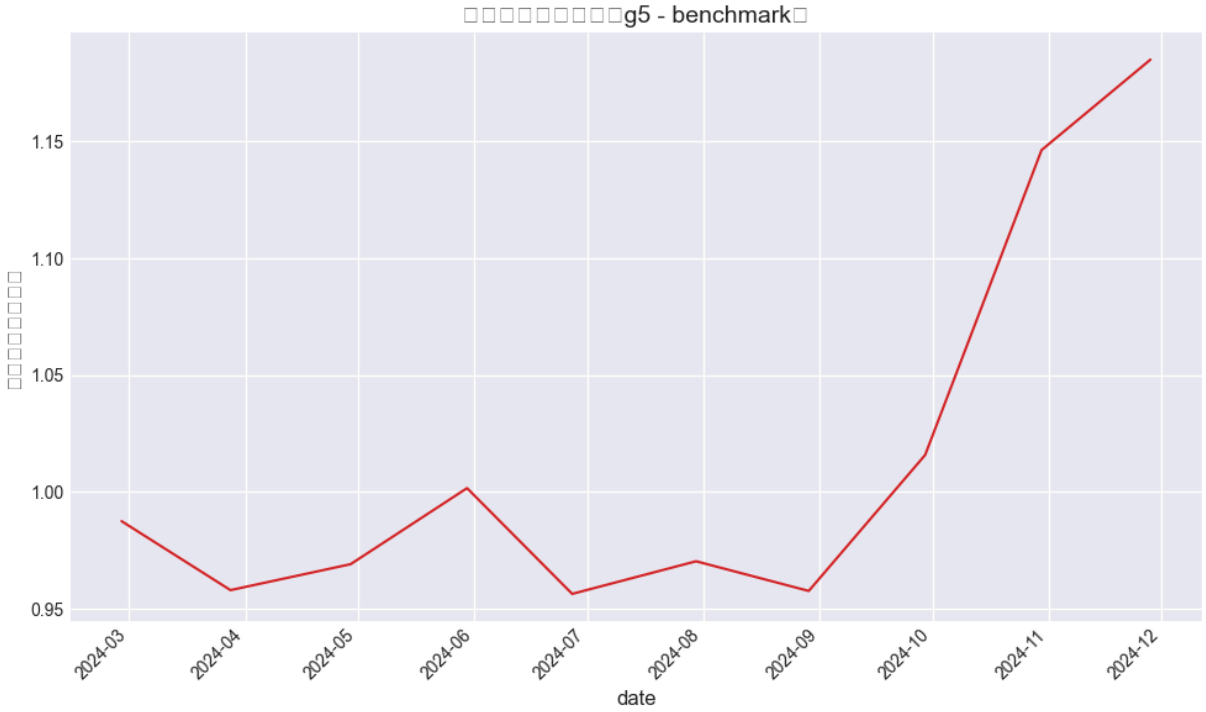
□□□□□□□□□g5 - benchmark□
1.15
1.10
1.05
1.00
0.95
□□□□□□□□
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
date

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
y:34: UserWarning: Glyph 20928 (\N{CJK UNIFIED IDEOGRAPH-51C0}) missing from
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y:34: UserWarning: Glyph 65289 (\N{FULLWIDTH RIGHT PARENTHESIS}) missing fro
m font(s) Arial.
  plt.tight_layout()
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font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
y:34: UserWarning: Glyph 25910 (\N{CJK UNIFIED IDEOGRAPH-6536}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
y:34: UserWarning: Glyph 30410 (\N{CJK UNIFIED IDEOGRAPH-76CA}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
y:34: UserWarning: Glyph 26354 (\N{CJK UNIFIED IDEOGRAPH-66F2}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/594610146.p
y:34: UserWarning: Glyph 32447 (\N{CJK UNIFIED IDEOGRAPH-7EBF}) missing from
font(s) Arial.
  plt.tight_layout()
```

```
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 20928 (\N{CJK UNIFIED IDEOGRAPH-51C0}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 20540 (\N{CJK UNIFIED IDEOGRAPH-503C}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 65288 (\N{FULLWIDTH LEFT PARENTHESIS}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 20493 (\N{CJK UNIFIED IDEOGRAPH-500D}) missing fr
om font(s) Arial.
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py:170: UserWarning: Glyph 25968 (\N{CJK UNIFIED IDEOGRAPH-6570}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 65289 (\N{FULLWIDTH RIGHT PARENTHESIS}) missing f
rom font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 22810 (\N{CJK UNIFIED IDEOGRAPH-591A}) missing fr
om font(s) Arial.
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py:170: UserWarning: Glyph 31354 (\N{CJK UNIFIED IDEOGRAPH-7A7A}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 32047 (\N{CJK UNIFIED IDEOGRAPH-7D2F}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 35745 (\N{CJK UNIFIED IDEOGRAPH-8BA1}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 25910 (\N{CJK UNIFIED IDEOGRAPH-6536}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 30410 (\N{CJK UNIFIED IDEOGRAPH-76CA}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 26354 (\N{CJK UNIFIED IDEOGRAPH-66F2}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 32447 (\N{CJK UNIFIED IDEOGRAPH-7EBF}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```

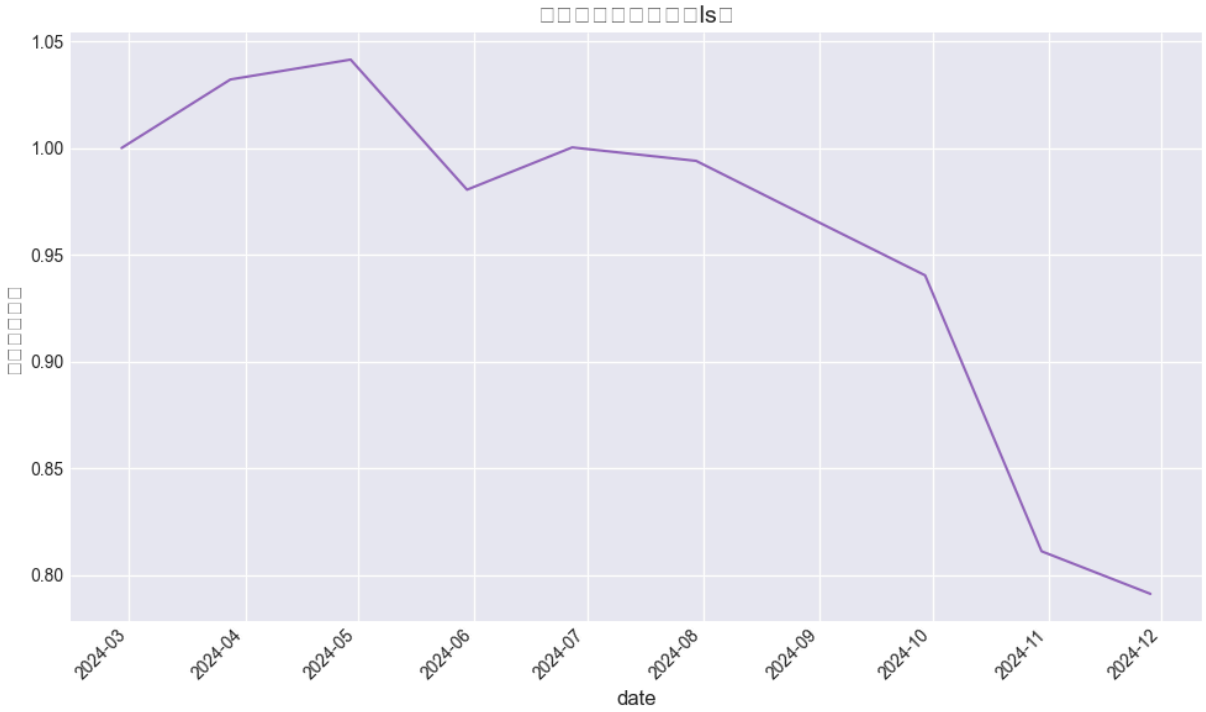

D. 指标计算（收益 / 风险 / 相对基准）

In [33]:

```python
PER_YEAR = 12  # 月度数据


def cagr(returns, periods_per_year=PER_YEAR):
    r = returns.dropna()
    if r.empty:
        return np.nan
    total_return = (1.0 + r).prod() - 1.0
    years = float(len(r)) / float(periods_per_year)
    if years <= 0:
        return np.nan
    return (1.0 + total_return) ** (1.0 / years) - 1.0


def annualized_vol(returns, periods_per_year=PER_YEAR):
    r = returns.dropna()
    if r.empty:
        return np.nan
    return r.std(ddof=1) * np.sqrt(periods_per_year)


def sharpe_ratio(returns, rf=0.0, periods_per_year=PER_YEAR):
    r = returns.dropna()
    if r.empty:
        return np.nan
    excess = r - rf / float(periods_per_year)
    vol = excess.std(ddof=1)
    if vol == 0:
        return np.nan
    return (excess.mean() * periods_per_year) / (vol * np.sqrt(periods_per_y
```

```python
def sortino_ratio(returns, rf=0.0, periods_per_year=PER_YEAR):
    r = returns.dropna()
    if r.empty:
        return np.nan
    excess = r - rf / float(periods_per_year)
    downside = excess[excess < 0]
    if downside.empty:
        return np.nan
    downside_vol = downside.std(ddof=1) * np.sqrt(periods_per_year)
    if downside_vol == 0:
        return np.nan
    return cagr(returns, periods_per_year) / downside_vol


def max_drawdown(returns):
    r = returns.dropna()
    if r.empty:
        return np.nan
    wealth = (1.0 + r).cumprod()
    peak = wealth.cummax()
    dd = wealth / peak - 1.0
    return dd.min()


def drawdown_series(returns):
    r = returns.dropna()
    wealth = (1.0 + r).cumprod()
    peak = wealth.cummax()
    return wealth / peak - 1.0


def calmar_ratio(returns):
    mdd = max_drawdown(returns)
    if (mdd >= 0) or np.isnan(mdd):
        return np.nan
    return cagr(returns) / abs(mdd)


def win_rate(returns):
    r = returns.dropna()
    if r.empty:
        return np.nan
    return (r > 0).mean()


def max_monthly_stats(returns):
    r = returns.dropna()
    if r.empty:
        return np.nan, np.nan
    return r.min(), r.max()


def skew_kurtosis(returns):
    r = returns.dropna()
```

```
    if len(r) < 3:
        return np.nan, np.nan
    return stats.skew(r), stats.kurtosis(r, fisher=True)


def var_cvar(returns, alpha=0.95):
    r = returns.dropna()
    if r.empty:
        return np.nan, np.nan
    losses = -r
    var = np.quantile(losses, alpha)
    cvar = losses[losses >= var].mean()
    return var, cvar


def tracking_error_and_ir(strategy, benchmark):
    aligned = pd.concat([strategy, benchmark], axis=1, join='inner').dropna(
    if aligned.shape[0] == 0:
        return np.nan, np.nan
    excess = aligned.iloc[:, 0] - aligned.iloc[:, 1]
    te = annualized_vol(excess)
    if np.isnan(te) or te == 0:
        return te, np.nan
    ir = cagr(excess) / te
    return te, ir


def alpha_beta(strategy, benchmark):
    aligned = pd.concat([strategy, benchmark], axis=1, join='inner').dropna(
    if aligned.shape[0] < 3:
        return {
            'alpha': np.nan,
            'beta': np.nan,
            'alpha_t': np.nan,
            'beta_t': np.nan,
            'r2': np.nan,
        }
    y = aligned.iloc[:, 0].values.reshape(-1, 1)
    x = aligned.iloc[:, 1].values.reshape(-1, 1)
    reg = LinearRegression().fit(x, y)
    beta = float(reg.coef_[0, 0])
    alpha = float(reg.intercept_[0])
    y_pred = reg.predict(x).ravel()
    resid = aligned.iloc[:, 0].values - y_pred
    ss_res = np.sum(resid ** 2)
    ss_tot = np.sum((aligned.iloc[:, 0].values - aligned.iloc[:, 0].mean())
    if ss_tot != 0:
        r2 = 1.0 - ss_res / ss_tot
    else:
        r2 = np.nan

    n = len(aligned)
    if n > 2:
        se2 = ss_res / float(n - 2)
        sx2 = np.sum((x - x.mean()) ** 2)
        if sx2 != 0:
```

```
            se_beta = np.sqrt(se2 / sx2)
            beta_t = beta / se_beta if se_beta != 0 else np.nan
        else:
            beta_t = np.nan
        if sx2 != 0:
            se_alpha = np.sqrt(se2 * (1.0 / n + x.mean() ** 2 / sx2))
        else:
            se_alpha = np.nan
        if (se_alpha is not None) and (se_alpha != 0) and (not np.isnan(se_a
            alpha_t = alpha / se_alpha
        else:
            alpha_t = np.nan
    else:
        alpha_t = np.nan
        beta_t = np.nan

    return {
        'alpha': alpha * PER_YEAR,  # 年化 alpha 近似
        'beta': beta,
        'alpha_t': alpha_t,
        'beta_t': beta_t,
        'r2': r2,
    }
```

In [34]:

```
# 构建需要评估的序列：benchmark, g5, excess, ls
series_dict = {}
if 'benchmark' in monthly_ret_df.columns:
    series_dict['benchmark'] = monthly_ret_df['benchmark']
if 'g5' in monthly_ret_df.columns:
    series_dict['g5'] = monthly_ret_df['g5']
if ('benchmark' in monthly_ret_df.columns) and ('g5' in monthly_ret_df.colum
    series_dict['excess_g5_vs_bm'] = monthly_ret_df['g5'] - monthly_ret_df['
if 'ls' in monthly_ret_df.columns:
    series_dict['ls'] = monthly_ret_df['ls']

metrics = []
for name, r in series_dict.items():
    c = cagr(r)
    v = annualized_vol(r)
    s = sharpe_ratio(r)
    so = sortino_ratio(r)
    mdd = max_drawdown(r)
    cal = calmar_ratio(r)
    wr = win_rate(r)
    mn, mx = max_monthly_stats(r)
    sk, ku = skew_kurtosis(r)
    var95, cvar95 = var_cvar(r, 0.95)
    te, ir = (np.nan, np.nan)
    ab = {'alpha': np.nan, 'beta': np.nan, 'alpha_t': np.nan, 'beta_t': np.r
    if (name != 'benchmark') and ('benchmark' in series_dict):
        te, ir = tracking_error_and_ir(r, series_dict['benchmark'])
        ab = alpha_beta(r, series_dict['benchmark'])
    metrics.append({
        'series': name,
        'CAGR': c,
        'AnnVol': v,
```

```
        'Sharpe': s,
        'Sortino': so,
        'MaxDD': mdd,
        'Calmar': cal,
        'WinRate': wr,
        'MinMonth': mn,
        'MaxMonth': mx,
        'Skew': sk,
        'Kurtosis': ku,
        'VaR95': var95,
        'CVaR95': cvar95,
        'TrackingError': te,
        'InfoRatio': ir,
        'Alpha': ab['alpha'],
        'Beta': ab['beta'],
        'Alpha_t': ab['alpha_t'],
        'Beta_t': ab['beta_t'],
        'R2': ab['r2'],
    })

metrics_df = pd.DataFrame(metrics).set_index('series')
metrics_df
```

Out[34]:

series	CAGR	AnnVol	Sharpe	Sortino	MaxDD	Calmar	W
benchmark	0.121533	0.215217	0.623927	2.103121	-0.052243	2.326298	
g5	0.367070	0.297667	1.185620	3.594193	-0.094477	3.885282	
excess_g5_vs_bm	0.226084	0.174254	1.254723	4.184487	-0.045200	5.001866	
ls	-0.245021	0.167784	-1.574879	-1.492080	-0.240258	-1.019824	

E. 风险分析与归因

In [35]:

```
# 回撤曲线与滚动指标（以 g5 为主策略，若存在）
if 'g5' in series_dict:
    strat = series_dict['g5']
    dd = drawdown_series(strat)
    fig, ax = plt.subplots()
    dd.plot(ax=ax, color='C1')
    ax.set_title('g5 策略回撤曲线')
    ax.set_ylabel('回撤比例')
    ax.xaxis.set_major_formatter(mdates.DateFormatter('%Y-%m'))
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()

    window = 6
    roll_sharpe = strat.rolling(window).apply(lambda x: sharpe_ratio(x), raw
    roll_vol = strat.rolling(window).std() * np.sqrt(PER_YEAR)
    if 'benchmark' in series_dict:
        roll_excess = (strat - series_dict['benchmark']).rolling(window).mea
```

```
    else:
        roll_excess = pd.Series(index=strat.index, dtype=float)

    fig, axes = plt.subplots(3, 1, sharex=True, figsize=(10, 10))
    roll_sharpe.plot(ax=axes[0], color='C0')
    axes[0].set_title('Rolling Sharpe (window=6 months)')
    roll_vol.plot(ax=axes[1], color='C2')
    axes[1].set_title('Rolling Volatility (Ann., window=6 months)')
    roll_excess.plot(ax=axes[2], color='C3')
    axes[2].set_title('Rolling Excess Return vs Benchmark (Ann.)')
    axes[2].xaxis.set_major_formatter(mdates.DateFormatter('%Y-%m'))
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
else:
    print('g5 不存在，跳过回撤与滚动指标分析')
```

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/458417224.p
y:11: UserWarning: Glyph 22238 (\N{CJK UNIFIED IDEOGRAPH-56DE}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/458417224.p
y:11: UserWarning: Glyph 25764 (\N{CJK UNIFIED IDEOGRAPH-64A4}) missing from
font(s) Arial.
  plt.tight_layout()
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font(s) Arial.
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/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/458417224.p
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/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/458417224.p
y:11: UserWarning: Glyph 30053 (\N{CJK UNIFIED IDEOGRAPH-7565}) missing from
font(s) Arial.
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y:11: UserWarning: Glyph 26354 (\N{CJK UNIFIED IDEOGRAPH-66F2}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/458417224.p
y:11: UserWarning: Glyph 32447 (\N{CJK UNIFIED IDEOGRAPH-7EBF}) missing from
font(s) Arial.
  plt.tight_layout()
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 22238 (\N{CJK UNIFIED IDEOGRAPH-56DE}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 25764 (\N{CJK UNIFIED IDEOGRAPH-64A4}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 27604 (\N{CJK UNIFIED IDEOGRAPH-6BD4}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
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om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
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om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 30053 (\N{CJK UNIFIED IDEOGRAPH-7565}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```
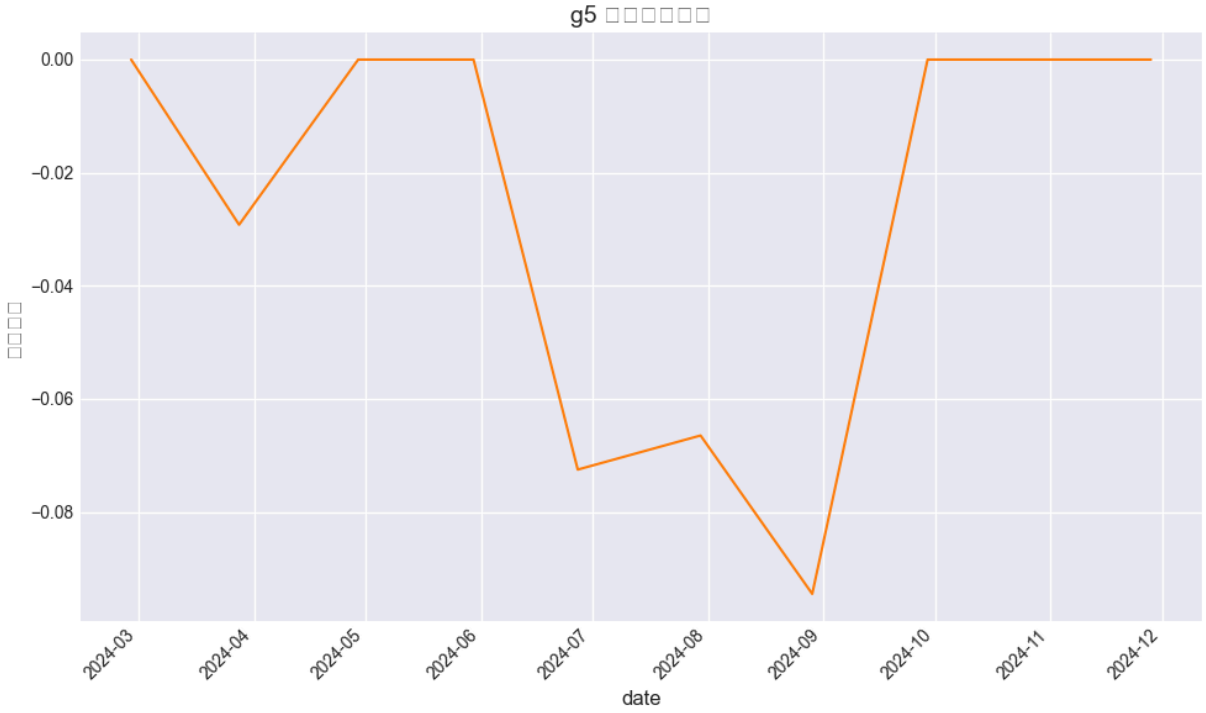
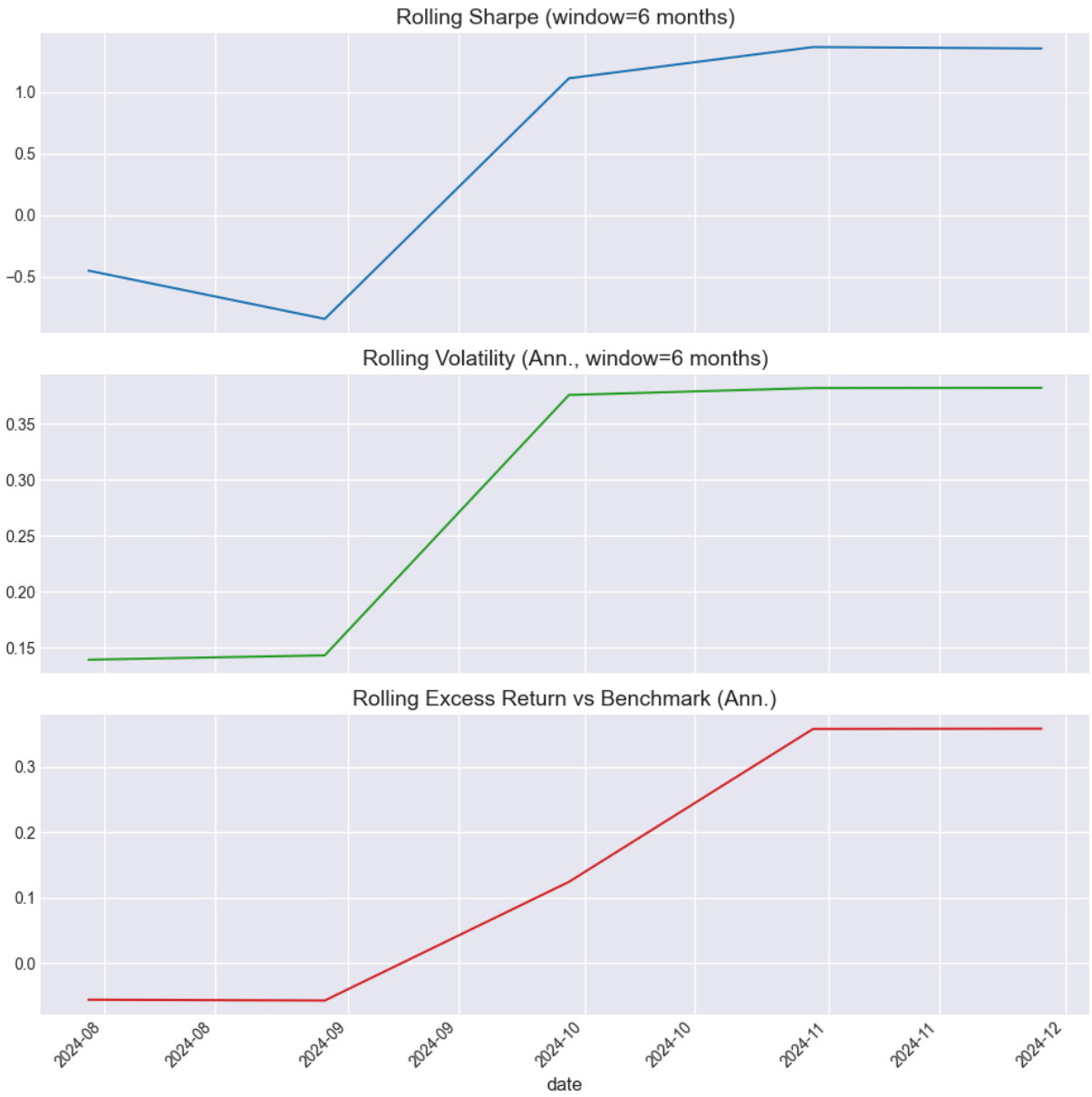

```
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 26354 (\N{CJK UNIFIED IDEOGRAPH-66F2}) missing from font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 32447 (\N{CJK UNIFIED IDEOGRAPH-7EBF}) missing from font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```





In [36]:
```python
# 回归分析：g5 ~ benchmark
if ('g5' in series_dict) and ('benchmark' in series_dict):
    ab = alpha_beta(series_dict['g5'], series_dict['benchmark'])
    print('回归结果（g5 ~ benchmark）：')
    for k in ['alpha', 'beta', 'alpha_t', 'beta_t', 'r2']:
        v = ab.get(k, np.nan)
        if isinstance(v, (int, float)) and (not np.isnan(v)):
            print('  %s: %.4f' % (k, v))
        else:
            print('  %s: %s' % (k, v))
else:
    print('缺少 g5 或 benchmark，无法做回归分析')
```

```
回归结果（g5 ~ benchmark）：
  alpha: 0.2014
  beta: 1.1287
  alpha_t: 0.9897
  beta_t: 3.9937
  r2: 0.6660
```

In [37]:

```python
# 分组对比：g1..g5 月度收益分布 & ls 分布
group_cols = [c for c in ['g1', 'g2', 'g3', 'g4', 'g5'] if c in monthly_ret_
if group_cols:
    fig, ax = plt.subplots()
    monthly_ret_df[group_cols].plot(kind='box', ax=ax)
    ax.set_title('分组月度收益分布（小数）')
    ax.set_ylabel('月度收益')
    plt.tight_layout()
    plt.show()
else:
    print('未找到 g1..g5 列，跳过分组对比箱线图')

if 'ls' in monthly_ret_df.columns:
    fig, ax = plt.subplots()
    monthly_ret_df['ls'].plot(kind='hist', bins=20, alpha=0.7, ax=ax)
    ax.set_title('多空（月度）收益分布 ls')
    ax.set_xlabel('月度收益')
    plt.tight_layout()
    plt.show()
else:
    print('未找到 ls 列，跳过多空分布图')
```

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 26376 (\N{CJK UNIFIED IDEOGRAPH-6708}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
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font(s) Arial.
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font(s) Arial.
  plt.tight_layout()
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py:8: UserWarning: Glyph 20998 (\N{CJK UNIFIED IDEOGRAPH-5206}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 32452 (\N{CJK UNIFIED IDEOGRAPH-7EC4}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 24067 (\N{CJK UNIFIED IDEOGRAPH-5E03}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 65288 (\N{FULLWIDTH LEFT PARENTHESIS}) missing from
font(s) Arial.
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/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 23567 (\N{CJK UNIFIED IDEOGRAPH-5C0F}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:8: UserWarning: Glyph 25968 (\N{CJK UNIFIED IDEOGRAPH-6570}) missing from
font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
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py:170: UserWarning: Glyph 26376 (\N{CJK UNIFIED IDEOGRAPH-6708}) missing fr
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/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 24230 (\N{CJK UNIFIED IDEOGRAPH-5EA6}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.
py:170: UserWarning: Glyph 25910 (\N{CJK UNIFIED IDEOGRAPH-6536}) missing fr
om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```

```
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 30410 (\N{CJK UNIFIED IDEOGRAPH-76CA}) missing from font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 20998 (\N{CJK UNIFIED IDEOGRAPH-5206}) missing from font(s) Arial.
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/opt/anaconda3/envs/dl/lib/python3.11/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 65289 (\N{FULLWIDTH RIGHT PARENTHESIS}) missing from font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```

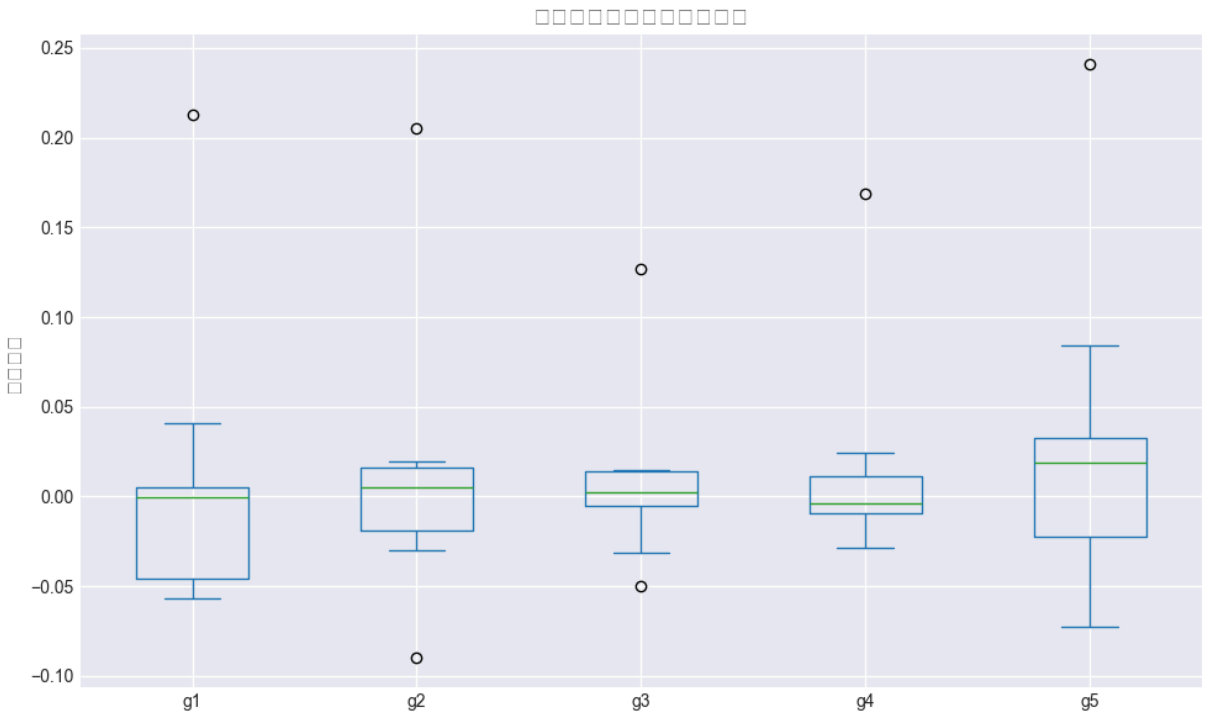

```
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
py:18: UserWarning: Glyph 26376 (\N{CJK UNIFIED IDEOGRAPH-6708}) missing fro
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py:18: UserWarning: Glyph 22810 (\N{CJK UNIFIED IDEOGRAPH-591A}) missing fro
m font(s) Arial.
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py:18: UserWarning: Glyph 31354 (\N{CJK UNIFIED IDEOGRAPH-7A7A}) missing fro
m font(s) Arial.
  plt.tight_layout()
/var/folders/49/t84jntk56wn101s6026p72cc0000gn/T/ipykernel_21621/3963513725.
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```

```
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om font(s) Arial.
  fig.canvas.print_figure(bytes_io, **kw)
```

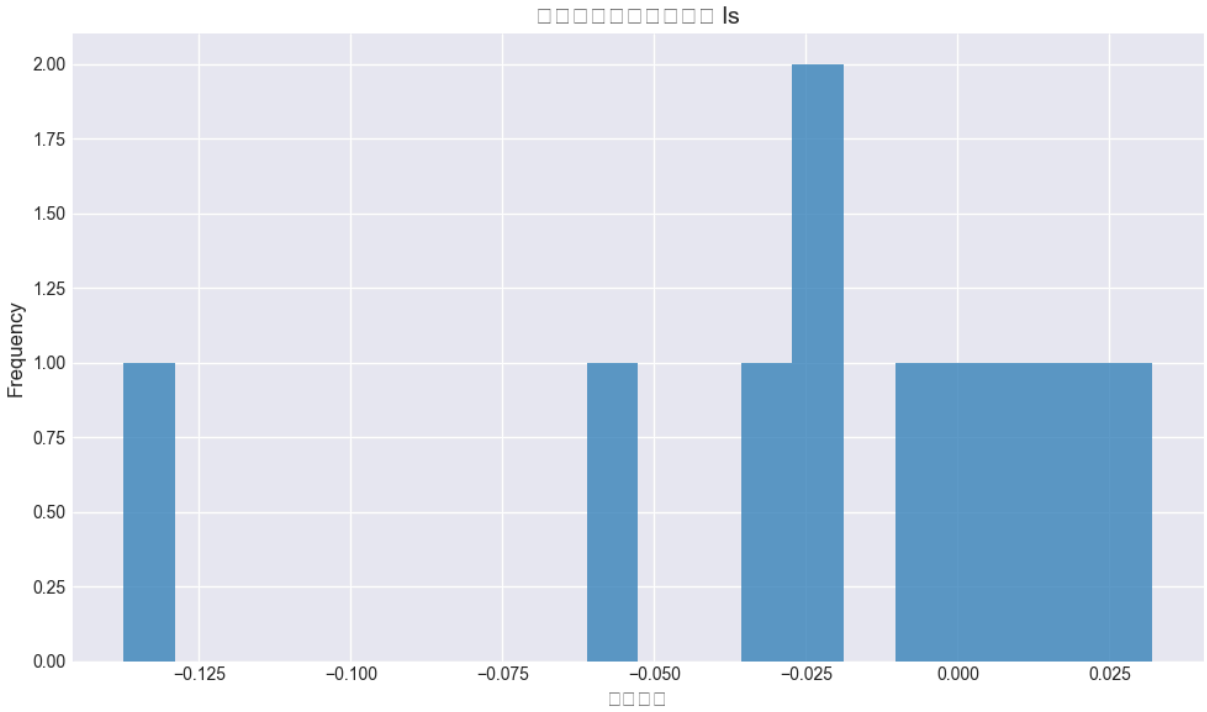

In [38]:
```python
# 相关性分析
if ('g5' in series_dict) and ('benchmark' in series_dict):
    corr_g5_bm = series_dict['g5'].corr(series_dict['benchmark'])
    print('Corr(g5, benchmark) = %.4f' % corr_g5_bm)
    excess = series_dict['g5'] - series_dict['benchmark']
    corr_excess_bm = excess.corr(series_dict['benchmark'])
    print('Corr(excess, benchmark) = %.4f' % corr_excess_bm)
else:
    print('缺少 g5 或 benchmark，跳过相关性分析')
```

```
Corr(g5, benchmark) = 0.8161
Corr(excess, benchmark) = 0.1590
```

F. 与框架自带统计结果交叉验证

In [39]:
```python
# 尝试展示框架输出的各类检验与统计表
check_keys = [
    '收益率检验',
    '因子显著性统计',
    '因子区分度检验',
    '因子延续性检验',
    '因子稳定性检验',
]
for k in check_keys:
    if k in sections:
        print('=== %s ===' % k)
        display(sections[k].head())
    else:
        print('[INFO] section `%s` 不存在，跳过' % k)

print('\n当前我们计算的核心指标汇总：')
display(metrics_df)
print('\n注意：框架内置统计可能基于日度数据或使用不同的年化口径，因此与本 Notebook 基于
```

```
=== 收益率检验 ===
```

	组名	整体@平均收益(%)	整体@标准差(%)	整体@夏普比率	整体@胜率(%)	整体@最大回撤%(日线)	近1年@平均收益(%)	近1年@标准差(%)	近1年@夏普比率	近1年@胜率(%)	...	近2年@平均收益(%)	近2年@标准差(%)	近2年@夏普比率
0	第1组	0.83	8.35	0.10	55.56	-19.47	None	None	None	None	...	None	None	None
1	第2组	1.32	8.00	0.16	55.56	-17.37	None	None	None	None	...	None	None	None
2	第3组	0.95	4.93	0.19	55.56	-11.31	None	None	None	None	...	None	None	None
3	第4组	1.50	5.99	0.25	33.33	-8.89	None	None	None	None	...	None	None	None
4	第5组	3.28	9.04	0.36	66.67	-16.91	None	None	None	None	...	None	None	None

5 rows × 21 columns

```
=== 因子显著性统计 ===
```

	组名	整体@超额均值(%)	整体@跟踪误差(%)	整体@信息比率	整体@超额概率(%)	整体@T-Stat	整体@P-Value	近1年@超额均值(%)	近1年@跟踪误差(%)	近1年@信息比率	...	近2年@信息比率	近2年@超额概率(%)	近2年@T-Stat
0	第1组	-0.28	2.37	-0.12	55.56	-0.36	36.44	None	None	None	...	None	None	None
1	第2组	0.20	2.58	0.08	55.56	0.23	58.97	None	None	None	...	None	None	None
2	第3组	-0.16	2.71	-0.06	55.56	-0.18	43.12	None	None	None	...	None	None	None
3	第4组	0.38	1.78	0.22	55.56	0.65	73.17	None	None	None	...	None	None	None
4	第5组	2.16	5.21	0.42	66.67	1.25	87.61	None	None	None	...	None	None	None

5 rows × 25 columns

=== 因子区分度检验 ===

	项目	整体@平均收益(%)	整体@标准差(%)	整体@夏普比率	整体@胜率(%)	整体@T-Stat	整体@P-Value	近1年@平均收益(%)	近1年@标准差(%)	近1年@夏普比率	...	近2年@夏普比率	近2年@胜率(%)	近2年@T-Stat
0	第一组vs最后一组	-2.45	5.07	-0.48	33.33	-1.45	9.29	None	None	None	...	None	None	None

1 rows × 25 columns

=== 因子延续性检验 ===

	因子截止日	检验开始日	检验截止日	IC	P-value	end_date	start_date	date
0	2024-02-29	2024-03-01	2024-03-29	0.17	0.23	2024-03-29	2024-03-01	2024-03-29
1	2024-03-29	2024-03-30	2024-04-30	0.00	0.98	2024-04-30	2024-03-30	2024-04-30
2	2024-04-30	2024-05-01	2024-05-31	-0.27	0.06	2024-05-31	2024-05-01	2024-05-31
3	2024-05-31	2024-06-01	2024-06-28	-0.02	0.87	2024-06-28	2024-06-01	2024-06-28
4	2024-06-28	2024-06-29	2024-07-31	0.00	0.98	2024-07-31	2024-06-29	2024-07-31

=== 因子稳定性检验 ===

	开始日	上期截止日	间隔期数	自相关系数	买入衰减(%)	买入反转(%)	卖出衰减(%)	卖出反转(%)	start_date	end_date	date
0	2024-03-29	2024-02-29	1.0	0.74	50.0	0.0	80.0	0.0	2024-03-29	2024-02-29	2024-02-29
1	2024-04-30	2024-03-29	1.0	0.58	50.0	0.0	50.0	0.0	2024-04-30	2024-03-29	2024-03-29
2	2024-05-31	2024-04-30	1.0	0.94	90.0	0.0	80.0	0.0	2024-05-31	2024-04-30	2024-04-30
3	2024-06-28	2024-05-31	1.0	0.84	50.0	0.0	70.0	0.0	2024-06-28	2024-05-31	2024-05-31
4	2024-07-31	2024-06-28	1.0	0.97	80.0	0.0	100.0	0.0	2024-07-31	2024-06-28	2024-06-28

当前我们计算的核心指标汇总：

series	CAGR	AnnVol	Sharpe	Sortino	MaxDD	Calmar	Wi
benchmark	0.121533	0.215217	0.623927	2.103121	-0.052243	2.326298	
g5	0.367070	0.297667	1.185620	3.594193	-0.094477	3.885282	
excess_g5_vs_bm	0.226084	0.174254	1.254723	4.184487	-0.045200	5.001866	
ls	-0.245021	0.167784	-1.574879	-1.492080	-0.240258	-1.019824	

注意：框架内置统计可能基于日度数据或使用不同的年化口径，因此与本 Notebook 基于月度数据的结果可能存在差异。

G. 结论与后续扩展方向

In [40]:
```
from IPython.display import Markdown, display
```

```python
def generate_conclusion(metrics_df):
    lines = []
    lines.append('## 策略表现小结')
    if 'g5' in metrics_df.index:
        m = metrics_df.loc['g5']
        lines.append('- 主策略 g5 的年化收益约为 %.2f%% ，年化波动约为 %.2f%% ，Sh
                     % (m['CAGR'] * 100.0, m['AnnVol'] * 100.0, m['Sharpe']))
        lines.append('- g5 的最大回撤约为 %.2f%%，Calmar 比率约为 %.2f。'
                     % (m['MaxDD'] * 100.0, m['Calmar']))
        lines.append('- 月度胜率约为 %.2f%% ，最差 / 最好单月收益分别约为 %.2f%% /
                     % (m['WinRate'] * 100.0, m['MinMonth'] * 100.0, m['MaxM
    if ('benchmark' in metrics_df.index) and ('g5' in metrics_df.index):
        mb = metrics_df.loc['benchmark']
        mg = metrics_df.loc['g5']
        lines.append('- 相比基准，g5 在年化收益（%.2f%% 超额）和风险暴露（Beta≈%.2f
                     % ((mg['CAGR'] - mb['CAGR']) * 100.0, mg['Beta']))
    if 'ls' in metrics_df.index:
        ml = metrics_df.loc['ls']
        lines.append('- 多空组合 ls 的年化收益约为 %.2f%% ，Sharpe 约为 %.2f，用于
                     % (ml['CAGR'] * 100.0, ml['Sharpe']))

    lines.append('- 滚动指标（Sharpe / 波动率 / 超额收益）显示策略在不同阶段的稳定性，
    lines.append('- 若换手率信息可用，可进一步结合交易成本假设，评估净收益与资金容量。'
    lines.append('')
    lines.append('## 后续扩展：多策略对比框架')
    lines.append('- 可以在本 Notebook 基础上，将 `DATA_PATH` 参数化，并对 equal_w
    lines.append('- 为四个策略分别构建月度收益序列与指标表，最终拼接为一个多索引 DataF
    lines.append('- 可视化上叠加四条累计收益 / 超额曲线，并对比其回撤、Sharpe、Calma
    lines.append('- 对于 IC / 区分度 / 稳定性等因子层面的统计，也可以在多策略维度进行
    return '\n'.join(lines)


display(Markdown(generate_conclusion(metrics_df)))
```

策略表现小结

- 主策略 g5 的年化收益约为 36.71%，年化波动约为 29.77%，Sharpe 约为 1.19。
- g5 的最大回撤约为 -9.45%，Calmar 比率约为 3.89。
- 月度胜率约为 60.00%，最差 / 最好单月收益分别约为 -7.25% / 24.07%。
- 相比基准，g5 在年化收益（24.55% 超额）和风险暴露（Beta≈1.13）上的表现值得进一步对比。
- 多空组合 ls 的年化收益约为 -24.50%，Sharpe 约为 -1.57，用于刻画因子截面的区分能力。
- 滚动指标（Sharpe / 波动率 / 超额收益）显示策略在不同阶段的稳定性，可结合回撤曲线定位表现较差的时段。
- 若换手率信息可用，可进一步结合交易成本假设，评估净收益与资金容量。

后续扩展：多策略对比框架

- 可以在本 Notebook 基础上，将 `DATA_PATH` 参数化，并对 equal_weights、rule_based、dynamic_weights（当前）、dynamic_weights_without_regime 四个策略依次读取对应 JSON。
- 为四个策略分别构建月度收益序列与指标表，最终拼接为一个多索引 DataFrame（level0=策略名称，level1=指标名）。
- 可视化上叠加四条累计收益 / 超额曲线，并对比其回撤、Sharpe、Calmar 等关键风险收益指标。
- 对于 IC / 区分度 / 稳定性等因子层面的统计，也可以在多策略维度进行并列展示，帮助筛选更稳定、可扩展的组合方式。

In [ ]:

In [ ]: