statistical_properties

May 10, 2024

1 Data statistical properties

[ ]:
```
import numpy as np
import seaborn as sns
import scipy.stats as stats
import matplotlib.pyplot as plt
import sys

sys.path.insert(1, "/Users/simon/Documents/II/Dissertation/")
from src.misc import load_processed_dataset

%load_ext autoreload
%autoreload 2
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

Features:

[ ]:
```
load_processed_dataset("jpm", "2019-01-1", "2024-01-1").columns
```

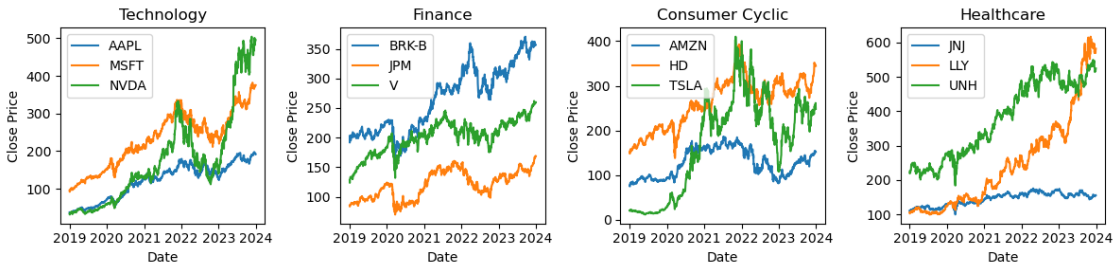
[ ]:
```
Index(['Open', 'High', 'Low', 'Close', 'Volume', 'log_return',
       'log_return_open', 'log_return_high', 'log_return_low',
       'log_return_volume', 'log_return_forecast', 'sma', 'wma', 'ema', 'dema',
       'tema', 'aroon', 'rsi', 'willr', 'cci', 'ad', 'mom', 'slowk', 'slowd',
       'macd', 'fed_funds_rate', '^N225', '^IXIC', '^FTSE', '^SPX', '^DJI'],
      dtype='object')
```

Data

[ ]:
```
all_stocks = [
    "aapl",
    "amzn",
    "avgo",
    "brk-b",
    "cost",
    "hd",
    "jnj",
    "jpm",
```

```
    "lly",
    "ma",
    "meta",
    "msft",
    "nvda",
    "pg",
    "tsla",
    "unh",
    "v",
    "xom",
]
sectors = {
    "technology": ["aapl", "msft", "nvda"],
    "finance": ["brk-b", "jpm", "v"],
    "consumer cyclic": ["amzn", "hd", "tsla"],
    "healthcare": ["jnj", "lly", "unh"],
}

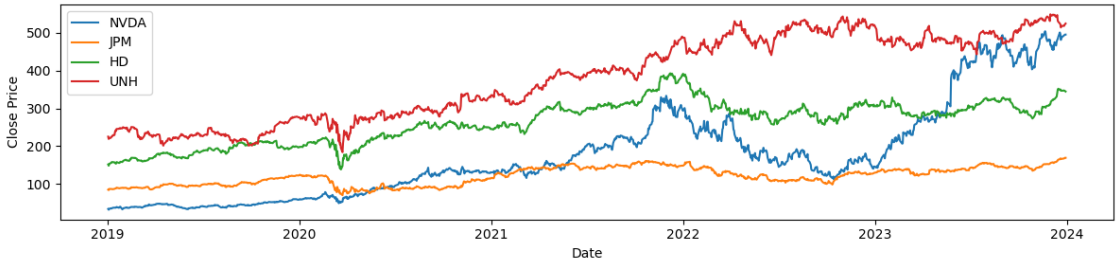
fig, axs = plt.subplots(1, 4, figsize=(12, 3))
for i, (name, stocks) in enumerate(sectors.items()):
    for s in stocks:
        df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
        axs[i].plot(df.index, df["Close"], label=s.upper())
    axs[i].set_xlabel("Date")
    axs[i].set_ylabel("Close Price")
    axs[i].legend()
    axs[i].set_title(name.title())
fig.tight_layout()
plt.show()
```



Stocks selection

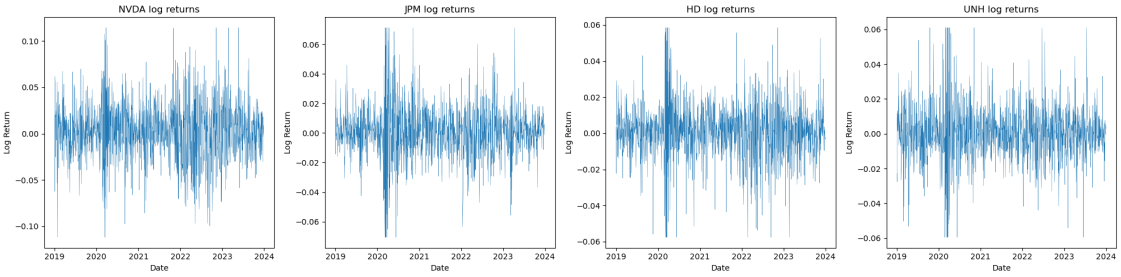
[ ]:
```
selected = ["nvda", "jpm", "hd", "unh"]
fig, ax = plt.subplots(1, 1, figsize=(12, 3))
for s in selected:
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
    ax.plot(df.index, df["Close"], label=s.upper())
```

```
ax.set_xlabel("Date")
ax.set_ylabel("Close Price")
ax.legend()
fig.tight_layout()
plt.show()
```



Log Returns Transformation

[ ]:
```
fig, axs = plt.subplots(1, 4, figsize=(20, 5))
for i, s in enumerate(selected):
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
    axs[i].plot(df.index, df["log_return"], linewidth=0.3)
    axs[i].set_xlabel("Date")
    axs[i].set_ylabel("Log Return")
    axs[i].set_title(f"{s.upper()} log returns")
fig.tight_layout()
plt.show()
```



[ ]:
```
selected = ["nvda", "jpm", "hd", "unh"]

fig, axs = plt.subplots(1, 4, figsize=(20, 5))
for i, s in enumerate(selected):
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
    sns.histplot(df["log_return_forecast"], kde=False, ax=axs[i], stat="count")
    axs[i].set_title(f"Distribution of {s.upper()} Log Return Forecast Prices")
    axs[i].set_xlabel("Log Return")
```

```
    axs[i].legend()
fig.tight_layout()
plt.show()
```

```
/Users/simon/anaconda3/envs/proj/lib/python3.9/site-
packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is
deprecated and will be removed in a future version. Convert inf values to NaN
before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
No artists with labels found to put in legend.  Note that artists whose label
start with an underscore are ignored when legend() is called with no argument.
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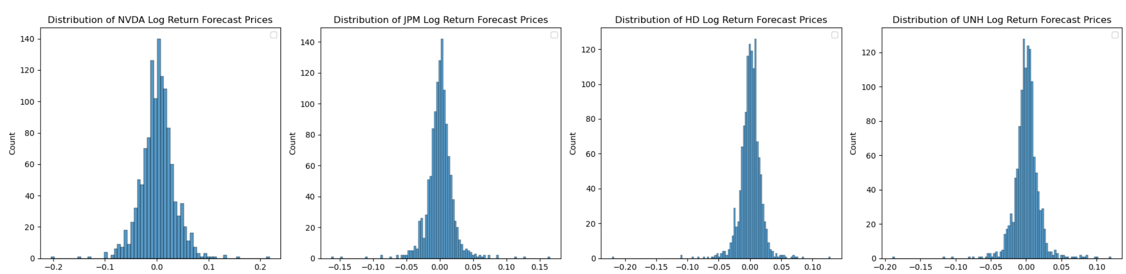

Outlier treatment

```
[ ]: fig, axs = plt.subplots(1, 4, figsize=(20, 5))
for i, s in enumerate(selected):
```

```python
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")

    mean = df["log_return"].mean()
    std = df["log_return"].std()
    log_return = df["log_return"]
    sns.histplot(log_return, kde=True, ax=axs[i], stat="density")
    axs[i].set_title(f"Distribution of {s.upper()} Normalised Log Return Prices")
    axs[i].set_xlabel("Normalised Log Return")

    x = np.linspace(min(log_return), max(log_return), 100)
    p = stats.norm.pdf(x, mean, std)
    axs[i].plot(x, p, "k", linewidth=1, label=f"Normal(0,1)", linestyle="--")
    axs[i].legend()
fig.tight_layout()
plt.show()
```

```
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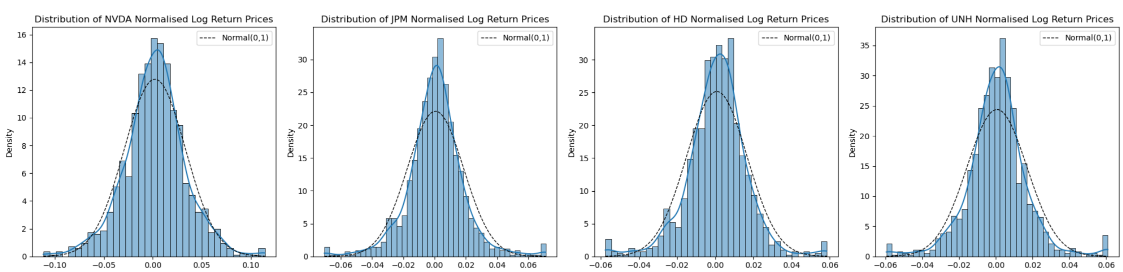

Q-Q Plot

[ ]:
```
import seaborn as sns
import scipy.stats as stats
import statsmodels.api as sm

fig, axs = plt.subplots(1, 4, figsize=(20, 5))
for i, s in enumerate(selected):
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
    mean = df["log_return"].mean()
    std = df["log_return"].std()
    log_return = (df["log_return"] - mean) / std
    # Q-Q plot
    stats.probplot(log_return, dist="norm", plot=axs[i])
    axs[i].set_title(f"Q-Q Plot of {s.upper()} Normalised Log Return Prices")
    axs[i].set_ylabel("Normalised Log Return")
fig.tight_layout()
plt.show()
```

Outlier treatment figures

[ ]:
```
cols = ["Close", "Open", "High", "Low", "Volume"]
stock = "PG"

fig, axs = plt.subplots(1, 5, figsize=(15, 3), sharey=True)
for i, c in enumerate(cols):
    df = load_processed_dataset(stock, "2000-01-1", "2024-01-1")
    log_ret = np.log(df[c] / df[c].shift(1))
    sns.histplot(log_ret, kde=False, ax=axs[i])
    axs[i].set_xlabel(f"Log Return {c}")
fig.tight_layout()
plt.show()
```

```
/Users/simon/anaconda3/envs/proj/lib/python3.9/site-
packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is
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```

```
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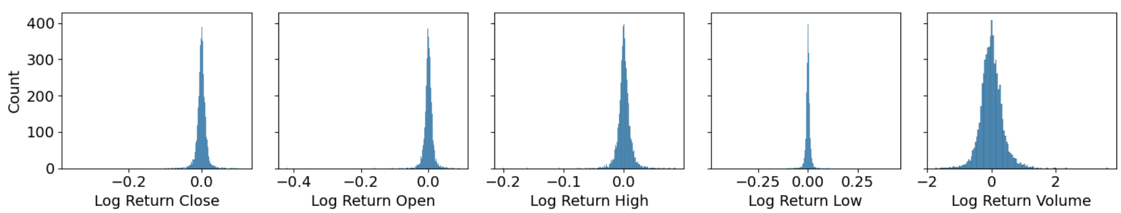

[ ]:

```python
cols = [
    "log_return",
    "log_return_open",
    "log_return_high",
    "log_return_low",
    "log_return_volume",
]
stock = "PG"

fig, axs = plt.subplots(1, 5, figsize=(15, 3), sharey=True)
for i, c in enumerate(cols):
    df = load_processed_dataset(stock, "2000-01-1", "2024-01-1")
    sns.histplot(df[f"{c}"], kde=False, ax=axs[i])
    axs[i].set_xlabel(
        " ".join(c.split("_")).title() + (" Close" if c == "log_return" else "")
```

```
    )
fig.tight_layout()
plt.show()
```

```
/Users/simon/anaconda3/envs/proj/lib/python3.9/site-
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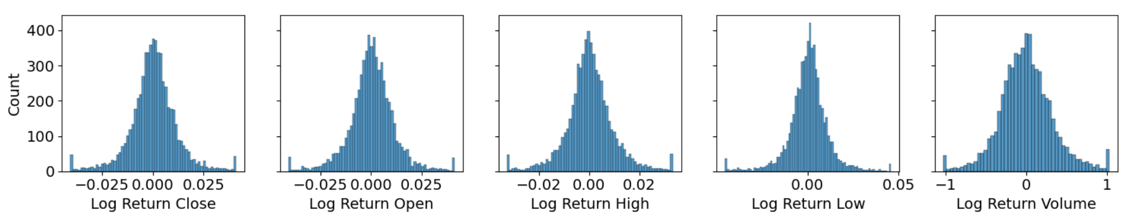


Now it is important to diagnose residuals. We would like to residuals to be uncorerelated and zero mean. If there is correlation between residuals, then there is information left in the residuals which can be used in computing the forecast. If the residuals have non-zero mean, then our forecasts are biased. Ideally, it woudld also be nice, but not necessary, to have constant variance and a normal distribution which make calculation of prediction intervals easier.

So residuals plot show whether our forecasts appear to account for all information. Talk about the - Mean of residuals close to zero? (Histogram) - Correlation in residuals series? (ACF) - Variation of residuals constant? (Time series, histogram) - Normal distribution (histogram) or tails too long?

Even when ignoring outlioers? If not normal, confidence intervals computed assuming a normal distribution will be inaccurate.

A prediction interval gives an interval in which we expect y_t to lie with a specified probability. A prediction interval for a h-step forecast is

$$\hat{y}_{T+h} \pm c\hat{\sigma}_h$$

where c depends on the coverage probability, $\hat{\sigma}_h$ is the estimated standard deviation of the h-step forecast distribution.

For one-step ahead forecasts, the standard deviation of the forecast is almost the same as the standard deviation of the residuals. So if we have a prediction of 531.48, and the standard deviation of our residuals is 6.21, our 95% interval is $531.48 \pm 1.96(6.21)$, since we are assuming a normal distirbution, and 95% of the probability mass in a normal distribution falls within 1.96 standard deviations on either side of it.

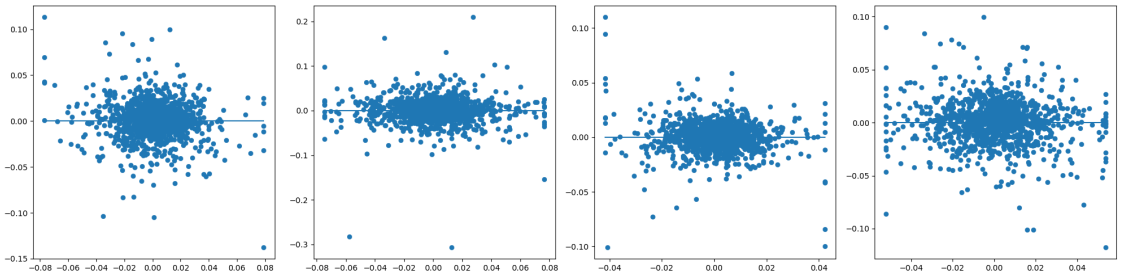
However, if a normal distribution for forecast errors is an unreasonable assumption, we can use bootstrapping. We sample from the residuals and repeatedly simulate a set of future values. Then we calculate percentiles for each forecast horizon.

NB. if transformations has been used, the prediction interval should be computed on the transformed scale, and the end points inverse-transformed to give a prediction interval on the original scale. May not be symmetric around point forecast.

Plotting return against its forecast

[ ]:
```
import seaborn as sns
import scipy.stats as stats
import statsmodels.api as sm

fig, axs = plt.subplots(1, 4, figsize=(20, 5))
for i, s in enumerate(selected):
    df = load_processed_dataset(s, "2019-01-1", "2024-01-1")
    feature = "Dividends"
    axs[i].scatter(df["log_return"], df["log_return_forecast"], label=s,␣
 ↪linewidth=0.3)
    x = np.linspace(start=df["log_return"].min(), stop=df["log_return"].max(),␣
 ↪num=100)
    y = np.zeros(len(x))
    axs[i].plot(x, y)
fig.tight_layout()
plt.show()
```



[ ]:
```
df = load_processed_dataset("nvda", "2004-01-1", "2024-01-1").sample(1000)
features = [
    "log_return",
    "log_return_open",
    "log_return_high",
    "log_return_low",
    "log_return_volume",
    "log_return_forecast",
    "sma",
    "wma",
    "ema",
    "dema",
    "tema",
    "aroon",
    "rsi",
    "willr",
    "cci",
    "ad",
    "mom",
    "slowk",
    "slowd",
    "macd",
    "fed_funds_rate",
    "^N225",
    "^IXIC",
    "^FTSE",
    "^SPX",
    "^DJI",
]
```

Pair plot between OHCLV features

[ ]:
```
features = [
    "log_return_forecast",
    "log_return_open",
    "log_return_high",
    "log_return_low",
    "log_return",
    "log_return_volume",
]
_ = sns.pairplot(df[features], kind="scatter", diag_kind="hist")
```

```
/Users/simon/anaconda3/envs/proj/lib/python3.9/site-
packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is
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```
before operating instead.
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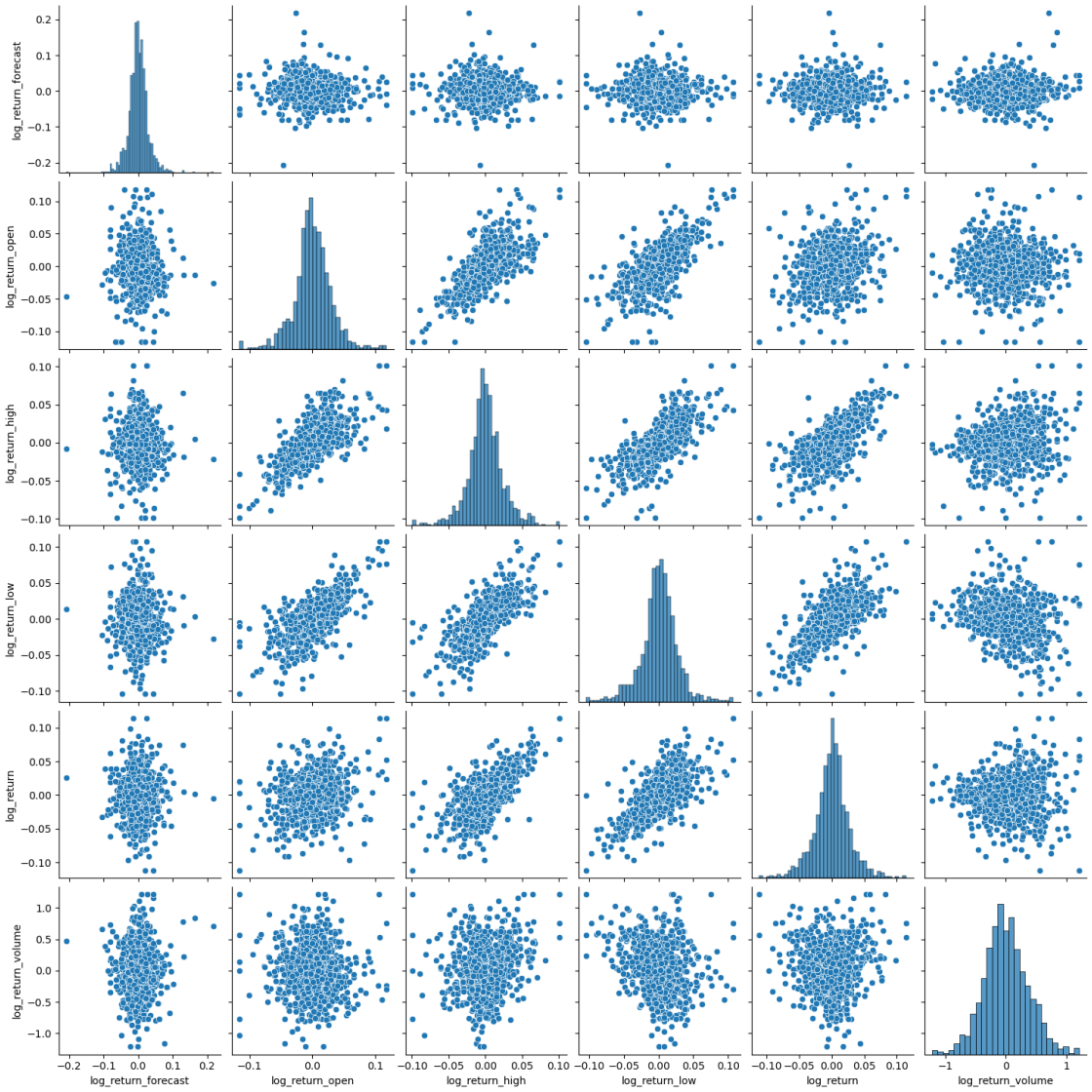

Pair plot between macroeconomic features

[ ]:
```
features = [
    "log_return_forecast",
    "fed_funds_rate",
    "^N225",
    "^IXIC",
    "^FTSE",
    "^SPX",
    "^DJI",
]
_ = sns.pairplot(df[features], kind="scatter", diag_kind="hist")
```

```
/Users/simon/anaconda3/envs/proj/lib/python3.9/site-
```

```
packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is
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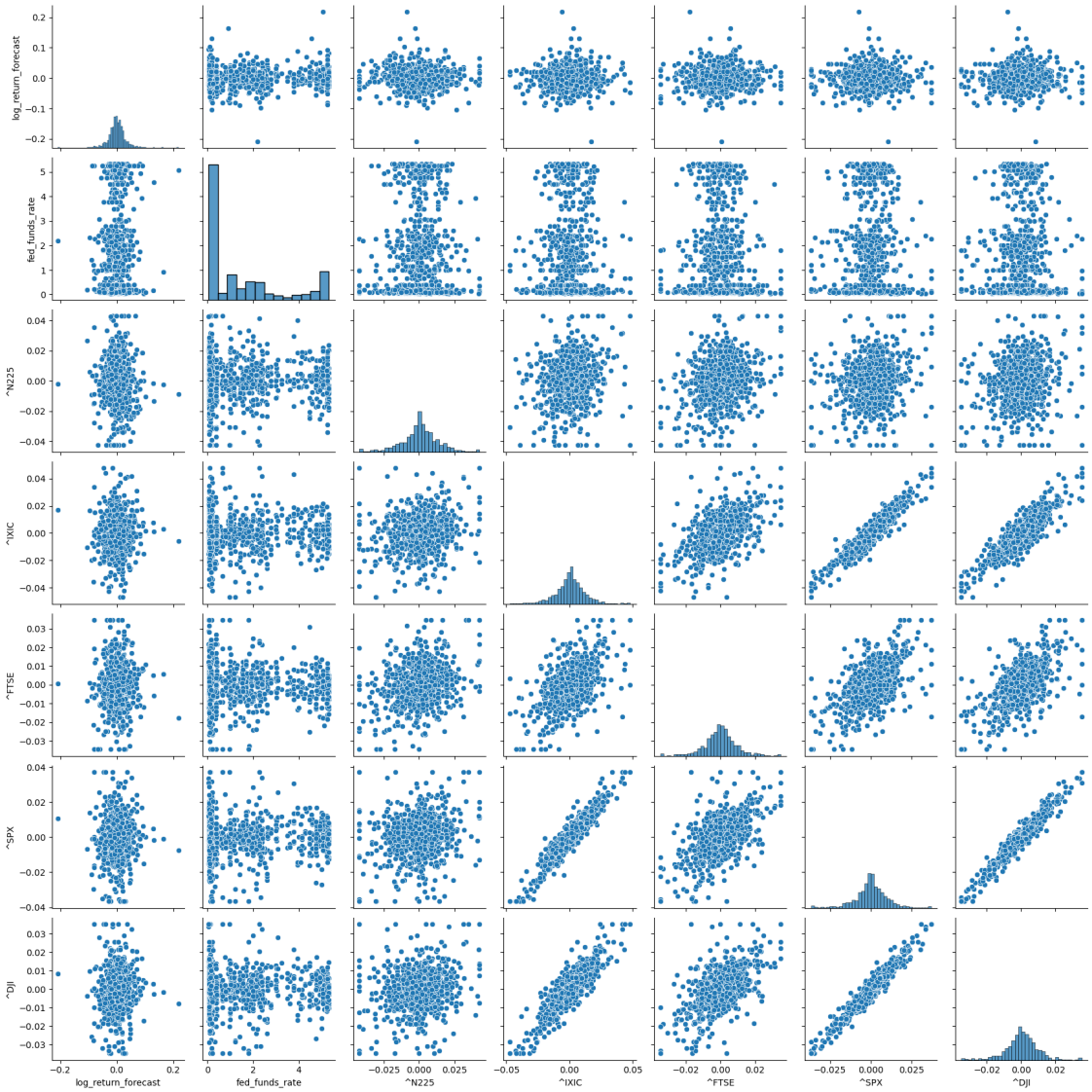
log_return_forecast
fed_funds_rate
^N225
^IXIC
^FTSE
^SPX
^DJI