

```
In [1]: #Disclaimer: The relative arbitrage strategy was
#not fully implemented until October, 2022.
#Prior to October, 2022, it was a mixture of mostly
#put spread and a few ITM call as well as futures
#for quick delta adjustment.
#Since then, this relative arbitrage strategy has
#been fully and consistently implemented.
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In [2]: import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
```

```
In [3]: # Load the Excel file
excel_file = pd.ExcelFile('E:\Derivatives Trading\TAIEX derivatives trading record

# Get the sheet you want to read
sheet_name = 'ForPython' # Replace with the name of the sheet you want to read
df = excel_file.parse(sheet_name)
```

```
In [4]: # Output data information
print(df.head())
```

	Date	PnL Index	TAIEX	VIX	Returns	Unnamed: 5	Unnamed: 6	\
0	2022-07-01	100.000000	14343.08	27.01	0.000000	NaN	NaN	
1	2022-07-04	95.577858	14217.06	27.56	-0.044221	NaN	NaN	
2	2022-07-05	93.953178	14349.20	27.18	-0.016998	NaN	NaN	
3	2022-07-06	92.057052	13985.51	29.40	-0.020182	NaN	NaN	
4	2022-07-07	92.698962	14335.27	28.26	0.006973	NaN	NaN	

	Base
0	100.0
1	NaN
2	NaN
3	NaN
4	NaN

```
In [5]: #*****Plotting setup*****#
# Generate some data
Date = df["Date"]
Date
y1 =df["PnL Index"]
y1
y2 = df["TAIEX"]
y2
```

```
Out[5]: 0      14343.08
1      14217.06
2      14349.20
3      13985.51
4      14335.27
...
261    17145.43
262    17212.87
263    16893.73
264    16843.68
265    16996.00
Name: TAIEX, Length: 266, dtype: float64
```

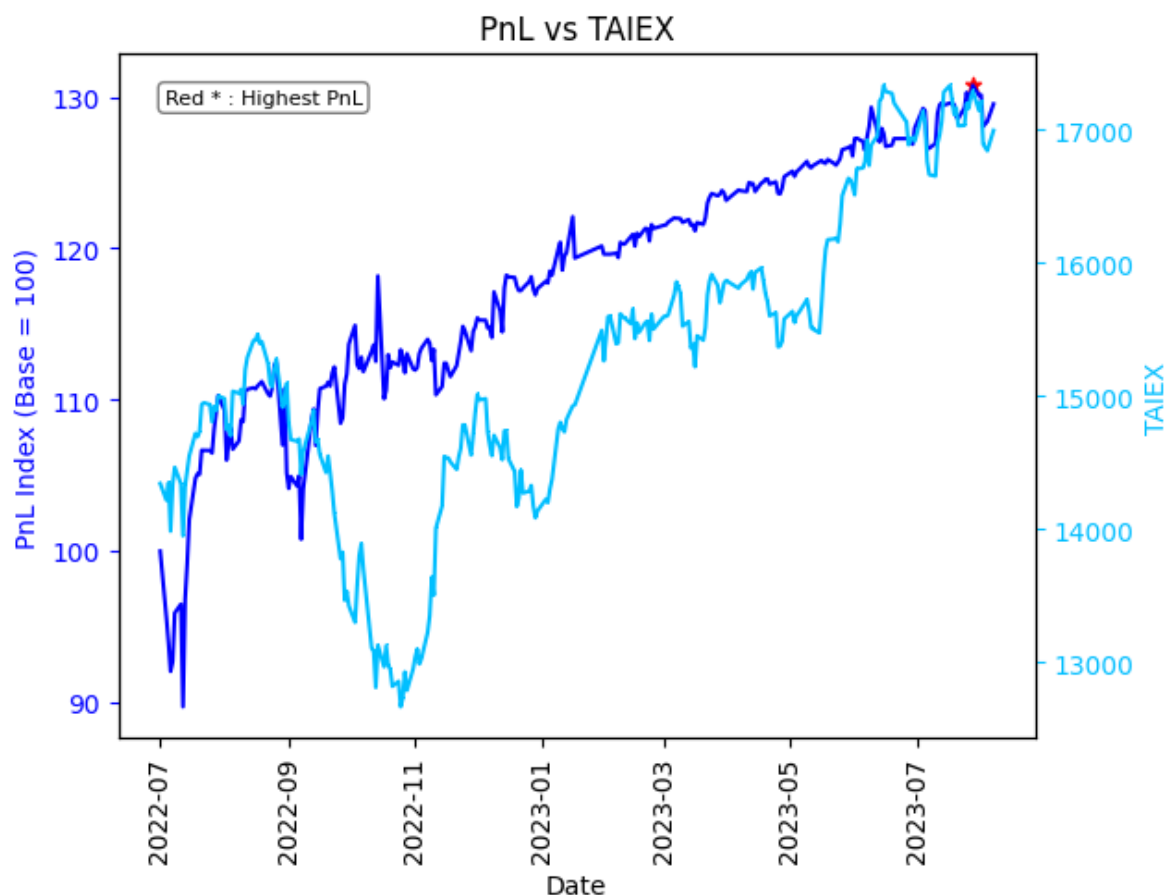
```
In [6]: # Get the maximum PnL value
max_pnl = df['PnL Index'].max()
max_pnl_date = df.loc[df['PnL Index']==max_pnl, 'Date'].values[0]
```

```
In [7]: # Create the plot and set the first y-axis (left)
fig, ax1 = plt.subplots()
plt.xticks(rotation=90)
ax1.plot(Date, y1, 'b-')
ax1.scatter(max_pnl_date, max_pnl, color='red', marker='*')
ax1.set_xlabel('Date')
ax1.set_ylabel('PnL Index (Base = 100)', color='b')
ax1.tick_params('y', colors='b')

# Set the second y-axis (right)
ax2 = ax1.twinx()
ax2.plot(Date, y2, color='deepskyblue', marker=',')
ax2.set_ylabel('TAIEX', color='deepskyblue')
ax2.tick_params('y', colors='deepskyblue')

# Add message box
msg = "Red * : Highest PnL"
props = dict(boxstyle='round', facecolor='white', alpha=0.5)
ax1.text(0.05, 0.95, msg, transform=ax1.transAxes, fontsize=8,
        verticalalignment='top', bbox=props)

# Show the plot
plt.title('PnL vs TAIEX')
plt.show()
```



```
In [8]: #PnL vs VIX
y3 = df["VIX"]
y3

# Create the plot and set the first y-axis (left)
fig, ax1 = plt.subplots()
plt.xticks(rotation=90)
ax1.plot(Date, y1, 'b-')
ax1.scatter(max_pnl_date, max_pnl, color='red', marker='*')
```

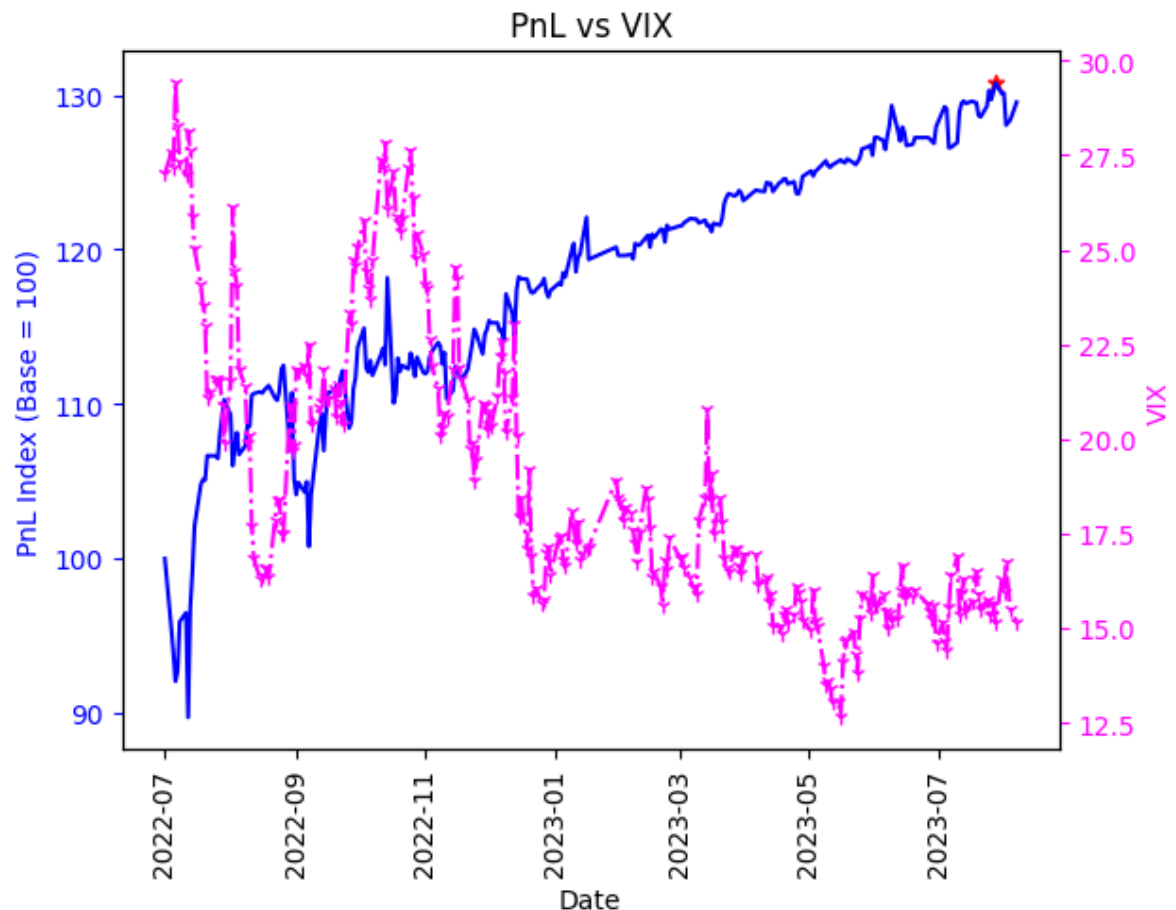
```

ax1.set_xlabel('Date')
ax1.set_ylabel('PnL Index (Base = 100)', color='b')
ax1.tick_params('y', colors='b')

# Set the second y-axis (right)
ax3 = ax1.twinx()
ax3.plot(Date, y3, 'fuchsia', marker='1', linestyle='-.')
ax3.set_ylabel('VIX', color='fuchsia')
ax3.tick_params('y', colors='fuchsia')

# Show the plot
plt.title('PnL vs VIX')
plt.show()

```



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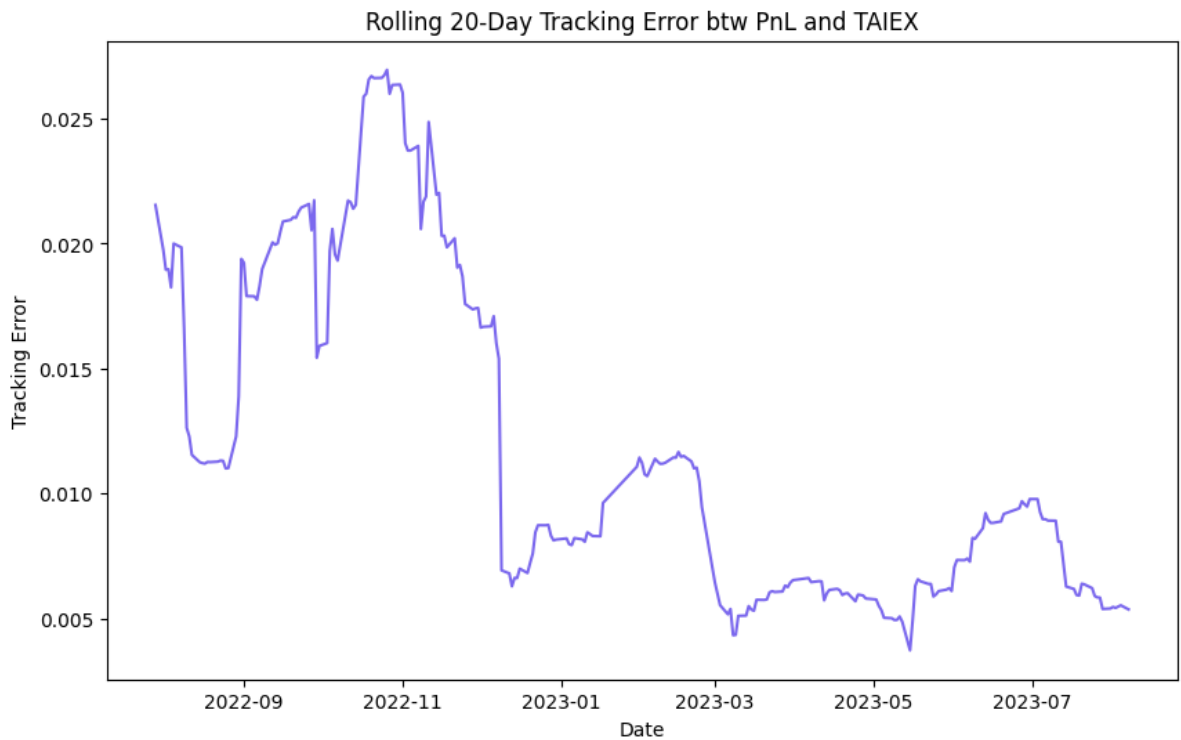
In [9]: #Tracking error between PnL and TAIEX
PNL_returns = df['PnL Index'].pct_change()
TAIEX_returns = df['TAIEX'].pct_change()
diff_returns = PNL_returns - TAIEX_returns
tracking_error = diff_returns.std()

roll_te = diff_returns.rolling(20).std()

plt.figure(figsize=(10, 6))
plt.title('Rolling 20-Day Tracking Error btw PnL and TAIEX')
plt.plot(df['Date'], roll_te, color='mediumslateblue')
plt.xlabel('Date')
plt.ylabel('Tracking Error')
plt.show()

#Comment
#Apparently, when market is in turmoil, tracking error will be widen, and vice versa
#Due to the fact that my derivatives position is well hedged against the market shock

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```
In [10]: #Historical volatility
#GARCH model volatility

from arch import arch_model
from scipy.stats import mstats

# Calculate log returns
log_returns = np.log(y2/y2.shift(1))

# Remove NaN values
log_returns = log_returns.dropna()

# Winsorize outliers
log_returns = mstats.winsorize(log_returns, limits=0.1)

# Fit GARCH model
garch = arch_model(log_returns, p=1, q=1, dist='StudentsT')
garch_fit = garch.fit(update_freq=10)

# Extract volatility
sigma = garch_fit.conditional_volatility
annual_vol = sigma.mean()*np.sqrt(250)*100

print(annual_vol)
```

C:\Users\sigma\anaconda3\lib\site-packages\arch\univariate\base.py:309: DataScaleWarning: y is poorly scaled, which may affect convergence of the optimizer when estimating the model parameters. The scale of y is 6.236e-05. Parameter estimation work better when this value is between 1 and 1000. The recommended rescaling is 100 * y.

This warning can be disabled by either rescaling y before initializing the model or by setting rescale=False.

```
warnings.warn(
```

```

Iteration:    10,    Func. Count:    102,    Neg. LLF: 3299.0589155597645
Iteration:    20,    Func. Count:    173,    Neg. LLF: 3562.6950001228165
Iteration:    30,    Func. Count:    243,    Neg. LLF: 3189.496320999765
Iteration:    40,    Func. Count:    310,    Neg. LLF: -883.4330706839412
Iteration:    50,    Func. Count:    375,    Neg. LLF: 11571.616834489405
Iteration:    60,    Func. Count:    441,    Neg. LLF: -906.2247176753225
Iteration:    70,    Func. Count:    501,    Neg. LLF: -906.8210592487558
Iteration:    80,    Func. Count:    569,    Neg. LLF: -906.2088999425978
Iteration:    90,    Func. Count:    637,    Neg. LLF: -908.9761598380353
Optimization terminated successfully    (Exit mode 0)
    Current function value: -909.1554610987425
    Iterations: 94
    Function evaluations: 677
    Gradient evaluations: 93
12.359567501645142

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In [11]: #####Scientific experiment#####
#Least Squares algo
from scipy.optimize import least_squares

# Set lower and upper bounds
bounds =(10, 45)

# Objective function
def f(vix, PNL_returns , TAIEX_returns):
    diff = (TAIEX_returns* annual_vol.std() )-(PNL_returns*vix.std())
    return diff.std()

# Set initial guess within bounds
x0 = [15.0]

# By using Trust Region Reflective (bounded)
result1 = least_squares(f, x0, bounds=bounds, method='trf', args=(TAIEX_returns,
optimal_vix = result1.x[0]

print("Optimal VIX:", optimal_vix)
print("Minimum Tracking Error:", f(optimal_vix, TAIEX_returns, PNL_returns))

# By using Levenberg-Marquardt algo (unbounded)
result2 = least_squares(f, x0, method='lm', args=(TAIEX_returns, PNL_returns))
optimal_vix = result2.x[0]

print("Optimal VIX:", optimal_vix)
print("Minimum Tracking Error:", f(optimal_vix, TAIEX_returns, PNL_returns))

#Source: https://github.com/scipy/scipy/blob/v1.9.1/scipy/optimize/_lsq/least_squares.py
##* 'lm' : Levenberg-Marquardt algorithm as implemented in MINPACK.
# Doesn't handle bounds and sparse Jacobians. Usually the most
# efficient method for small unconstrained problems.
##* 'trf' : Trust Region Reflective algorithm, particularly suitable
# for large sparse problems with bounds. Generally robust method.

Optimal VIX: 15.0
Minimum Tracking Error: 0.0
Optimal VIX: 15.0
Minimum Tracking Error: 0.0

```

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In [12]: #####Performance#####
#Sharpe ratio
# Read in the portfolio returns data from a CSV file
R_first=df["PnL Index"].iloc[0,]

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R_first
R_last=df["PnL Index"].iloc[165,] #Always excel's actual row-2
R_last
```

Out[12]: 121.98400800102736

```
In [13]: portfolio_returns=(R_last-R_first)/R_first
portfolio_returns
```

Out[13]: 0.21984008001027364

```
In [14]: daily_returns=df["Returns"]
daily_returns
```

Out[14]:

0	0.000000
1	-0.044221
2	-0.016998
3	-0.020182
4	0.006973
...	
261	-0.005165
262	0.000384
263	-0.016087
264	0.002588
265	0.009022

Name: Returns, Length: 266, dtype: float64

```
In [15]: # Max Drawdown Calculation for PnL Index
cumulative_returns = (1 + df["Returns"]).cumprod()
cumulative_max = cumulative_returns.cummax()
drawdown = (cumulative_returns / cumulative_max) - 1
max_drawdown = drawdown.min()

print("Max Drawdown:", max_drawdown)
```

Max Drawdown: -0.10420949154156467

```
In [16]: # Calculate the Profit Factor
positive_returns = daily_returns[daily_returns > 0].sum()
negative_returns = daily_returns[daily_returns < 0].sum()

# Avoid division by zero
if negative_returns != 0:
    profit_factor = abs(positive_returns / negative_returns)
else:
    profit_factor = float('inf')

print("Profit Factor:", profit_factor)
```

Profit Factor: 1.3190982750193194

```
In [17]: # Calculate the excess returns and standard deviation
risk_free_rate = 0.0145 # Taiwan savings rate
excess_returns = portfolio_returns - risk_free_rate
std_dev = np.std(daily_returns)
print("Standard Deviation of Daily Return:", std_dev)
```

Standard Deviation of Daily Return: 0.013835182312420003

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In [18]: # Calculate the Sharpe ratio
Sharpe_Ratio = excess_returns / std_dev
print("Sharpe Ratio:", Sharpe_Ratio)
```

Sharpe Ratio: 14.841877423323686

```
In [19]: #Annualized Sharpe ratio  
Annualized_Sharpe_Ratio=Sharpe_Ratio*np.sqrt(250)  
print("Annualized Sharpe Ratio:", Annualized_Sharpe_Ratio)  
  
Annualized Sharpe Ratio: 234.67068705366958
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In [ ]:
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