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 consistenly implemented.
```

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]
```

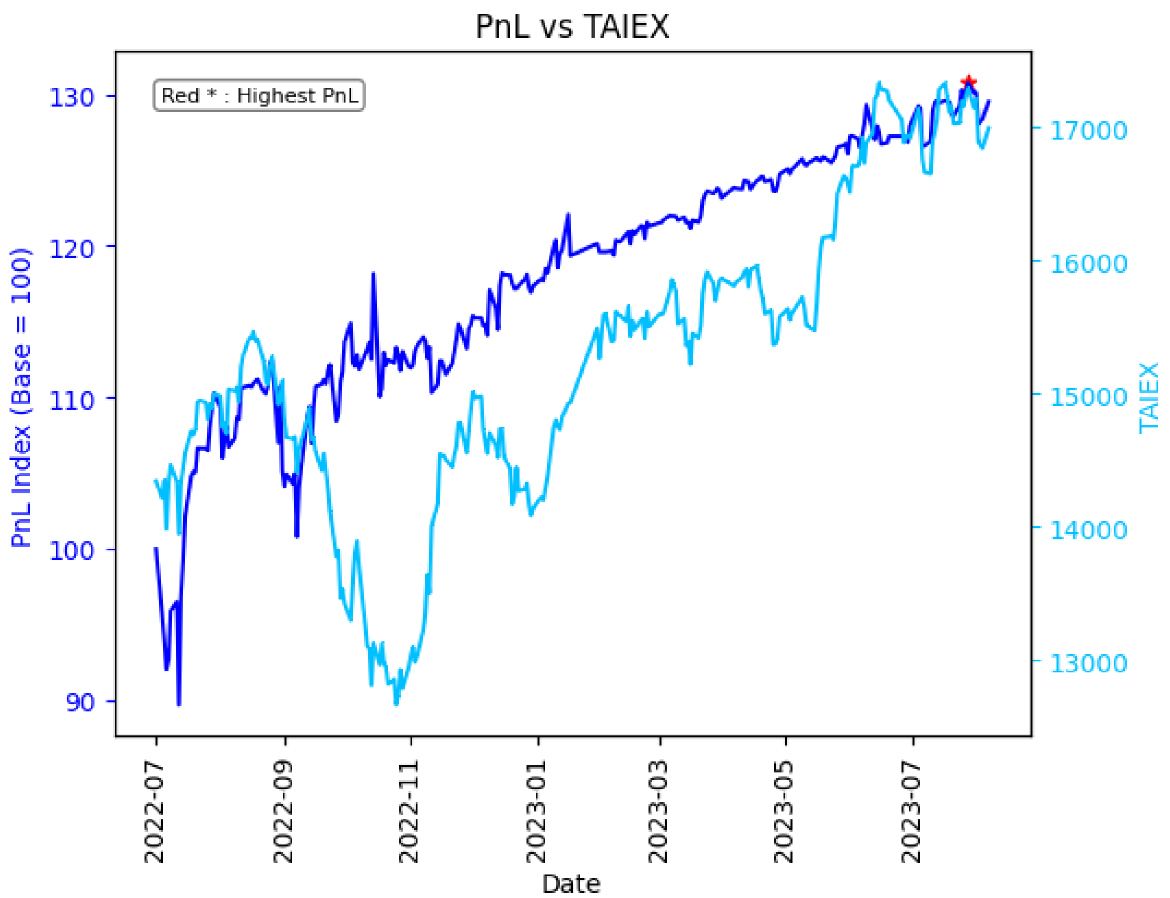
In [7]:

```python
# 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]:

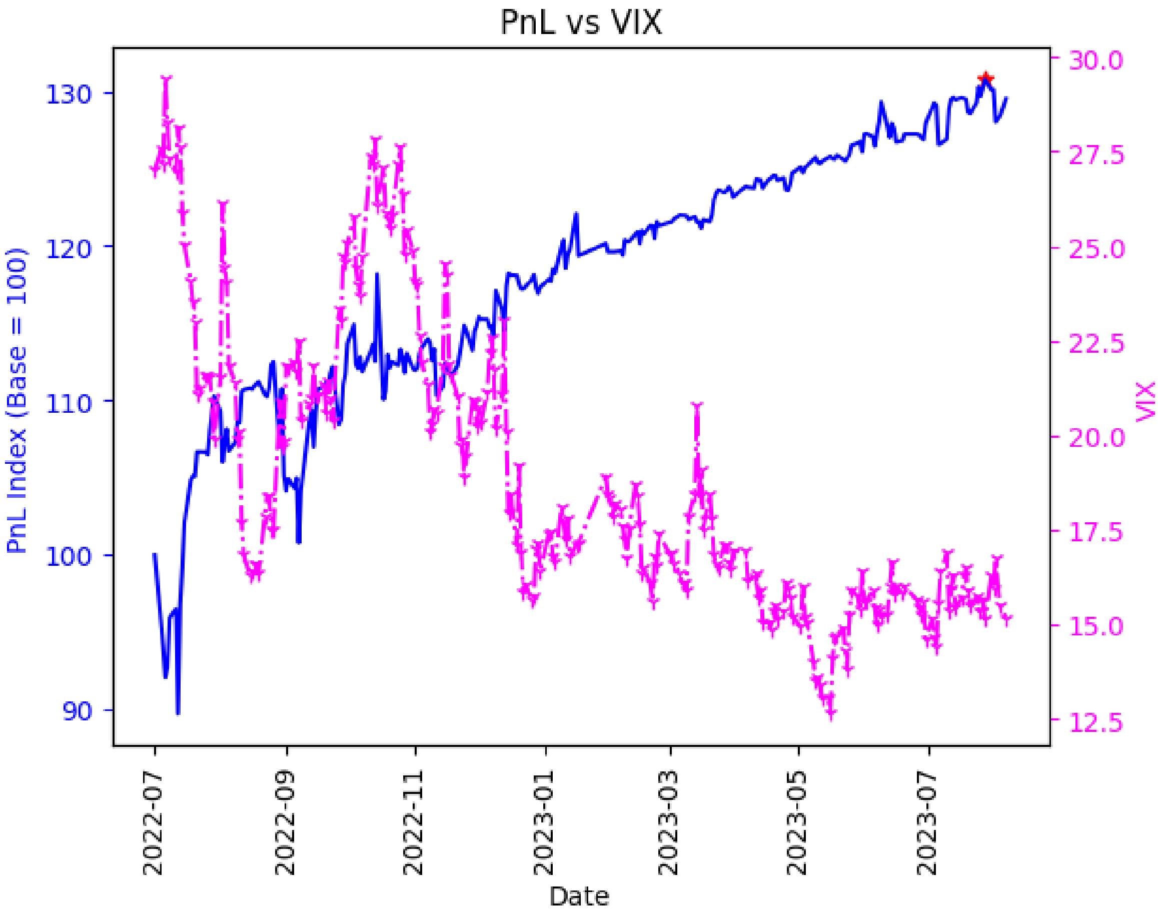
```python
#Pnl vs VIX
y3 = df["VIX"]
y3

# 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='*')
```

```python
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()
```

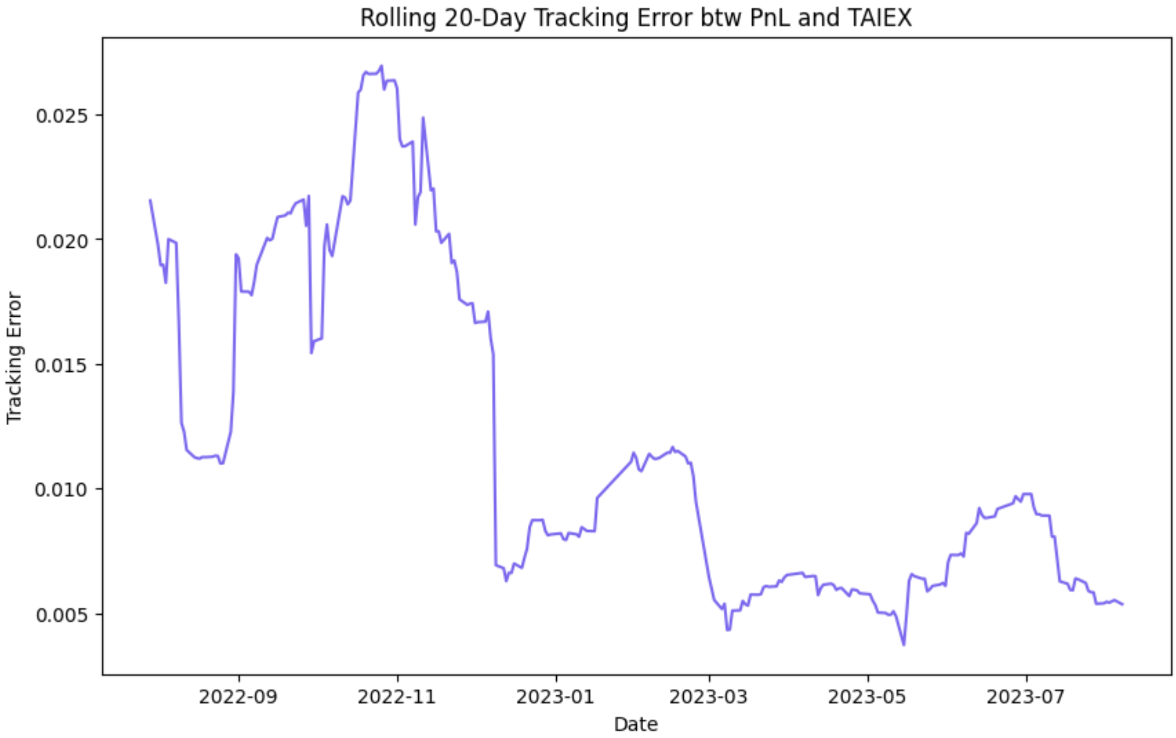


In [9]:
```python
#Tracking error between PnL and TAIEX
PNL_returns = df['PnL Index'].pct_change()
TAIEX_returns = df['TAIEX'].pct_change()
diff_returns = PNL_returns  - TAIEX_returns
tracking_error = diff_returns.std()


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 ver
#Due to the fact that my derivatives position is well hedged against the market sho
```



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: DataScaleW
arning: 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
```

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)-(PNL_returns*vix)
    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_squar

#* '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: 10.000001034896684
Minimum Tracking Error: 0.16505627223466332
Optimal VIX: 5.974113277907525
Minimum Tracking Error: 0.1593707089813009
```

In [12]:

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

```
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
```

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
```

In [ ]:

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In [ ]: