Carrie Final Project Data Analysis

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1 Opportunity dataset

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1.0.1 Import Necessary Libraries

```
[1]: # Import All Necessary Libraries
     import numpy as np
     import pandas as pd
     import matplotlib.pyplot as plt
     import seaborn as sns
     import scipy.stats as stats
     import cvxpy as cp
```

1.0.2 Load Opportunity Dataset

```
[2]: # Load Opportunity Dataset
     df = pd.read_csv('Opportunity_Set.csv', parse_dates=['Date'], index_col='Date')
      ↪      # Load Dataset as Dataframe
     print(df.head())                                                            ↪
      ↪      # Diaplay 1st 5 inDataframe
```

```
            Vanguard LifeStrategy Income Fund (VASIX)  \
Date
2014-11-30                                    0.0094
2014-12-31                                   -0.0005
2015-01-31                                    0.0141
2015-02-28                                    0.0033
2015-03-31                                    0.0018


            Vanguard Total World Stock ETF (VT)  \
Date
2014-11-30                              0.0126
2014-12-31                             -0.0199
2015-01-31                             -0.0163
2015-02-28                              0.0595
2015-03-31                             -0.0121
```

```
            PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)  \
Date
2014-11-30                                       0.0414
2014-12-31                                       0.0612
2015-01-31                                       0.1600
2015-02-28                                      -0.1007
2015-03-31                                       0.0117


            AQR Diversified Arbitrage I (ADAIX)  iShares Gold Trust (IAU)  \
Date
2014-11-30                             -0.0066                   -0.0053
2014-12-31                             -0.0117                    0.0133
2015-01-31                             -0.0059                    0.0865
2015-02-28                              0.0069                   -0.0579
2015-03-31                              0.0000                   -0.0222


            Bitcoin Market Price USD (^BTC)  \
Date
2014-11-30                       0.0969
2014-12-31                      -0.1777
2015-01-31                      -0.2677
2015-02-28                       0.1062
2015-03-31                      -0.0150


            AQR Risk-Balanced Commodities Strategy I (ARCIX)  \
Date
2014-11-30                                         -0.0726
2014-12-31                                         -0.0412
2015-01-31                                         -0.0287
2015-02-28                                          0.0044
2015-03-31                                         -0.0573


            AQR Long-Short Equity I (QLEIX)  \
Date
2014-11-30                       0.0248
2014-12-31                       0.0140
2015-01-31                       0.0156
2015-02-28                       0.0236
2015-03-31                      -0.0027


            AQR Style Premia Alternative I (QSPIX)  \
Date
2014-11-30                            0.0412
2014-12-31                            0.0002
2015-01-31                           -0.0112
2015-02-28                           -0.0390
2015-03-31                            0.0256
```

```
                AQR Equity Market Neutral I (QMNIX)  \
Date
2014-11-30                                   0.0257
2014-12-31                                   0.0195
2015-01-31                                   0.0290
2015-02-28                                  -0.0078
2015-03-31                                   0.0049


                AQR Macro Opportunities I (QGMIX)  \
Date
2014-11-30                                   0.0154
2014-12-31                                   0.0039
2015-01-31                                  -0.0070
2015-02-28                                   0.0091
2015-03-31                                   0.0261


                AGF U.S. Market Neutral Anti-Beta (BTAL)  \
Date
2014-11-30                                         0.0235
2014-12-31                                         0.0294
2015-01-31                                         0.0320
2015-02-28                                        -0.0568
2015-03-31                                         0.0000


                AQR Managed Futures Strategy HV I (QMHIX)  \
Date
2014-11-30                                          0.1159
2014-12-31                                          0.0461
2015-01-31                                          0.0721
2015-02-28                                         -0.0108
2015-03-31                                          0.0655


                Invesco DB US Dollar Bullish (UUP)  \
Date
2014-11-30                                   0.0165
2014-12-31                                   0.0213
2015-01-31                                   0.0484
2015-02-28                                   0.0028
2015-03-31                                   0.0278


                ProShares VIX Mid-Term Futures (VIXM)
Date
2014-11-30                                    -0.0298
2014-12-31                                     0.0553
2015-01-31                                     0.0762
2015-02-28                                    -0.1145
2015-03-31                                     0.0033
```

1.0.3 Dataframe Info

```
[3]: # Dataframe Info
     df.info()
                    # General information about the dataset
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 118 entries, 2014-11-30 to 2024-08-31
Data columns (total 15 columns):
 #   Column                                           Non-Null Count  Dtype
---  ------                                           --------------  -----
 0   Vanguard LifeStrategy Income Fund (VASIX)        118 non-null    float64
 1   Vanguard Total World Stock ETF (VT)              118 non-null    float64
 2   PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)     118 non-null    float64
 3   AQR Diversified Arbitrage I (ADAIX)              118 non-null    float64
 4   iShares Gold Trust (IAU)                         118 non-null    float64
 5   Bitcoin Market Price USD (^BTC)                  118 non-null    float64
 6   AQR Risk-Balanced Commodities Strategy I (ARCIX) 118 non-null    float64
 7   AQR Long-Short Equity I (QLEIX)                  118 non-null    float64
 8   AQR Style Premia Alternative I (QSPIX)           118 non-null    float64
 9   AQR Equity Market Neutral I (QMNIX)              118 non-null    float64
 10  AQR Macro Opportunities I (QGMIX)                118 non-null    float64
 11  AGF U.S. Market Neutral Anti-Beta (BTAL)         118 non-null    float64
 12  AQR Managed Futures Strategy HV I (QMHIX)        118 non-null    float64
 13  Invesco DB US Dollar Bullish (UUP)               118 non-null    float64
 14  ProShares VIX Mid-Term Futures (VIXM)            118 non-null    float64
dtypes: float64(15)
memory usage: 14.8 KB
```

1.0.4 Descriptive statistics

```
[4]: # Descriptive Statistics
     # Describe
     summary_stats = df.describe()
                    # Create a Dataframe of Descriptive Statistics
     summary_stats
                    # Display the Dataframe of Descriptive Statistics
```

```
[4]:        Vanguard LifeStrategy Income Fund (VASIX)  \
     count                           118.000000
     mean                              0.002883
     std                               0.016261
     min                              -0.049200
     25%                              -0.002900
     50%                               0.004700
     75%                               0.009700
     max                               0.050400
```

```
        Vanguard Total World Stock ETF (VT)  \
count                          118.000000
mean                             0.008376
std                              0.043483
min                             -0.147600
25%                             -0.018850
50%                              0.012250
75%                              0.030525
max                              0.123700

        PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)  \
count                                 118.000000
mean                                    0.001381
std                                     0.060799
min                                    -0.134300
25%                                    -0.041300
50%                                     0.000800
75%                                     0.037725
max                                     0.175900

        AQR Diversified Arbitrage I (ADAIX)  iShares Gold Trust (IAU)  \
count                          118.000000                118.000000
mean                             0.004370                  0.007036
std                              0.016923                  0.040440
min                             -0.081500                 -0.083600
25%                             -0.003275                 -0.019725
50%                              0.004300                 -0.000400
75%                              0.009775                  0.029250
max                              0.074300                  0.112200

        Bitcoin Market Price USD (^BTC)  \
count                          118.000000
mean                             0.066718
std                              0.221176
min                             -0.406000
25%                             -0.080100
50%                              0.046800
75%                              0.182350
max                              0.720000

        AQR Risk-Balanced Commodities Strategy I (ARCIX)  \
count                                 118.000000
mean                                    0.005475
std                                     0.046905
min                                    -0.144200
25%                                    -0.022500
50%                                     0.001600
```

```
75%                                                     0.039500
max                                                     0.121700


        AQR Long-Short Equity I (QLEIX)  \
count                          118.000000
mean                             0.008895
std                              0.033046
min                             -0.082100
25%                             -0.010925
50%                              0.009150
75%                              0.025425
max                              0.115800


        AQR Style Premia Alternative I (QSPIX)  \
count                                118.000000
mean                                   0.005400
std                                    0.038787
min                                   -0.078100
25%                                   -0.014750
50%                                    0.000000
75%                                    0.017450
max                                    0.140800


        AQR Equity Market Neutral I (QMNIX)  AQR Macro Opportunities I (QGMIX)  \
count                          118.000000                         118.000000
mean                             0.005330                           0.002896
std                              0.028727                           0.021807
min                             -0.061400                          -0.071200
25%                             -0.010275                          -0.008550
50%                              0.001550                           0.002150
75%                              0.020950                           0.015050
max                              0.110700                           0.066800


        AGF U.S. Market Neutral Anti-Beta (BTAL)  \
count                                118.000000
mean                                   0.001880
std                                    0.042857
min                                   -0.149600
25%                                   -0.021775
50%                                   -0.000650
75%                                    0.026825
max                                    0.094800


        AQR Managed Futures Strategy HV I (QMHIX)  \
count                                 118.000000
mean                                    0.003564
std                                     0.047422
```

```
min                                           -0.088500
25%                                           -0.030075
50%                                           -0.001050
75%                                            0.036000
max                                            0.127500

        Invesco DB US Dollar Bullish (UUP)  \
count                            118.000000
mean                               0.002768
std                                0.019131
min                               -0.047300
25%                               -0.013000
50%                                0.004000
75%                                0.016425
max                                0.048400

        ProShares VIX Mid-Term Futures (VIXM)
count                            118.000000
mean                              -0.008486
std                                0.093629
min                               -0.180100
25%                               -0.059250
50%                               -0.018150
75%                                0.020825
max                                0.628900
```

```python
# Display Skew and Kurtosis and Descriptives
from scipy.stats import skew, kurtosis
skewness = skew(df)                                              #␣
 ↪Create an Array of Skewness of each asset
kurt = kurtosis(df)                                             #␣
 ↪Create an Array of Kurtosis of each asset

# Creating a dataframe to display the results
results_df = pd.DataFrame({
    'Mean' : df.mean(),
    'Median' : df.median(),
    'Standard Deviation' : df.std(),
    'Skewness': skewness,
    'Kurtosis': kurt
})

results_df
```

```
[5]:                                                  Mean    Median  \
    Vanguard LifeStrategy Income Fund (VASIX)     0.002883  0.00470
    Vanguard Total World Stock ETF (VT)           0.008376  0.01225
```

```
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)            0.001381  0.00080
AQR Diversified Arbitrage I (ADAIX)                     0.004370  0.00430
iShares Gold Trust (IAU)                                0.007036 -0.00040
Bitcoin Market Price USD (^BTC)                         0.066718  0.04680
AQR Risk-Balanced Commodities Strategy I (ARCIX)        0.005475  0.00160
AQR Long-Short Equity I (QLEIX)                         0.008895  0.00915
AQR Style Premia Alternative I (QSPIX)                  0.005400  0.00000
AQR Equity Market Neutral I (QMNIX)                     0.005330  0.00155
AQR Macro Opportunities I (QGMIX)                       0.002896  0.00215
AGF U.S. Market Neutral Anti-Beta (BTAL)                0.001880 -0.00065
AQR Managed Futures Strategy HV I (QMHIX)               0.003564 -0.00105
Invesco DB US Dollar Bullish (UUP)                      0.002768  0.00400
ProShares VIX Mid-Term Futures (VIXM)                  -0.008486 -0.01815


                                                        Standard Deviation  \
Vanguard LifeStrategy Income Fund (VASIX)                         0.016261
Vanguard Total World Stock ETF (VT)                               0.043483
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)                     0.060799
AQR Diversified Arbitrage I (ADAIX)                               0.016923
iShares Gold Trust (IAU)                                          0.040440
Bitcoin Market Price USD (^BTC)                                   0.221176
AQR Risk-Balanced Commodities Strategy I (ARCIX)                  0.046905
AQR Long-Short Equity I (QLEIX)                                   0.033046
AQR Style Premia Alternative I (QSPIX)                            0.038787
AQR Equity Market Neutral I (QMNIX)                               0.028727
AQR Macro Opportunities I (QGMIX)                                 0.021807
AGF U.S. Market Neutral Anti-Beta (BTAL)                          0.042857
AQR Managed Futures Strategy HV I (QMHIX)                         0.047422
Invesco DB US Dollar Bullish (UUP)                                0.019131
ProShares VIX Mid-Term Futures (VIXM)                             0.093629


                                                        Skewness   Kurtosis
Vanguard LifeStrategy Income Fund (VASIX)              -0.240603   1.472664
Vanguard Total World Stock ETF (VT)                    -0.426024   0.928619
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)           0.378626   0.262557
AQR Diversified Arbitrage I (ADAIX)                    0.089222   8.083715
iShares Gold Trust (IAU)                               0.374345  -0.113385
Bitcoin Market Price USD (^BTC)                        0.599982   0.526931
AQR Risk-Balanced Commodities Strategy I (ARCIX)       0.105015   0.078234
AQR Long-Short Equity I (QLEIX)                        0.016090   1.162428
AQR Style Premia Alternative I (QSPIX)                 1.015599   1.697636
AQR Equity Market Neutral I (QMNIX)                    0.637322   1.282440
AQR Macro Opportunities I (QGMIX)                      0.102938   1.169489
AGF U.S. Market Neutral Anti-Beta (BTAL)              -0.365865   0.913209
AQR Managed Futures Strategy HV I (QMHIX)              0.294539  -0.303861
Invesco DB US Dollar Bullish (UUP)                    -0.079627  -0.337540
ProShares VIX Mid-Term Futures (VIXM)                  2.869086  17.097321
```

1.0.5 Histogram

```
[6]:  # Descriptive Plots
      # Histogram
      plt.figure(figsize=(14, 10))

      # Iterate through each fund and create a histogram
      for i, column in enumerate(df.columns[:-1], 1):  # Exclude the last
       ↪'DBSCAN_Cluster' column
          plt.subplot(4, 4, i)  # Creating a grid of subplots
          plt.hist(df[column], bins=20, alpha=0.7, color='blue', edgecolor='black')
          plt.title(column, fontsize=10)
          plt.xlabel('Returns', fontsize=8)
          plt.ylabel('Frequency', fontsize=8)

      plt.tight_layout()
      plt.show()
```
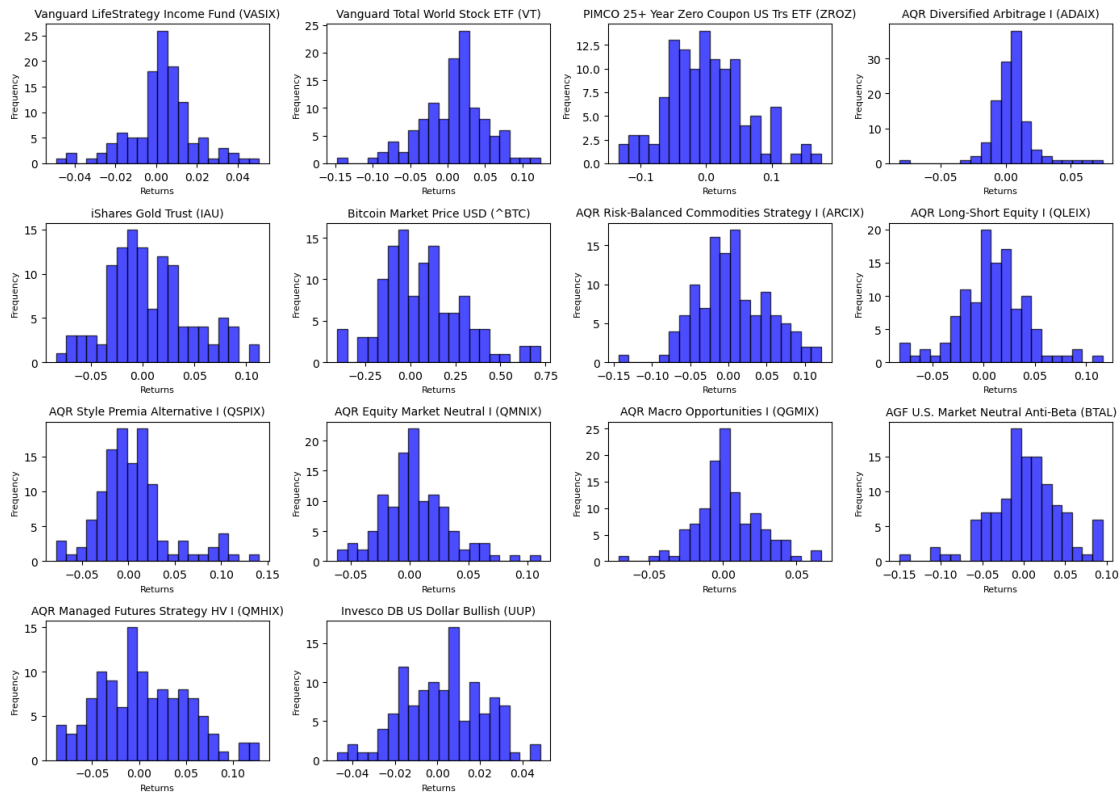
1.0.6 Boxplot

```
[7]: # Descriptive Plots
     # Boxplot
     plt.figure(figsize=(14, 8))

     df.boxplot()
     plt.title('Fund Returns', fontsize=16)
     plt.ylabel('Returns')
     plt.xticks(rotation=90)
     plt.grid(True)

     # Show the plot
     plt.tight_layout()
     plt.show()
```
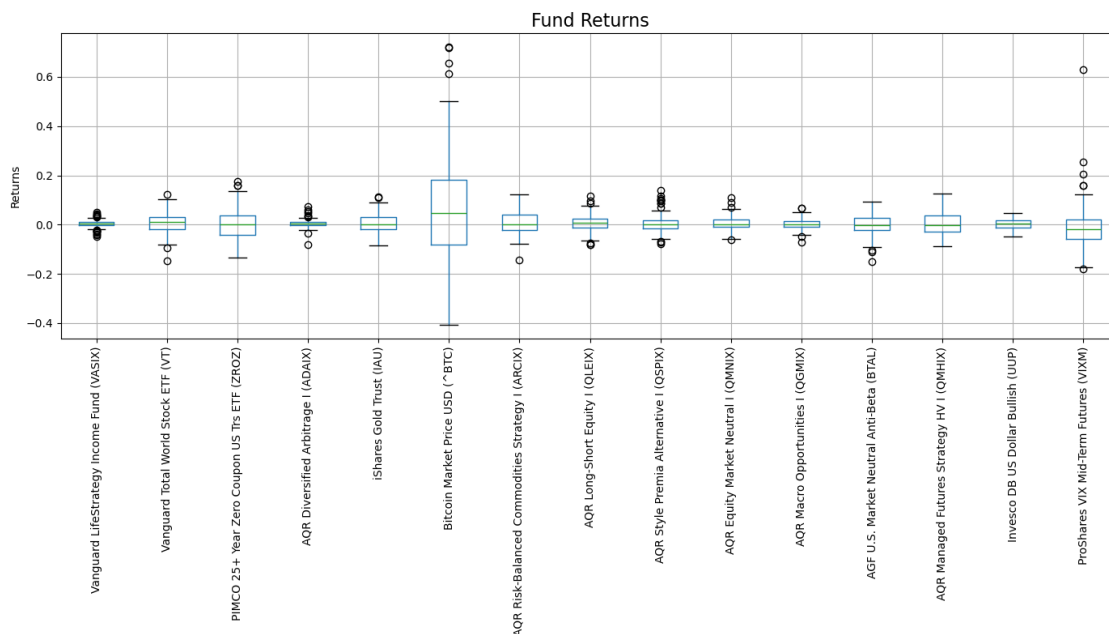

1.0.7 Time Series

```
[8]: # Descriptive Plots
     # Plot Time Series
     plt.figure(figsize=(14, 8))

     df.plot(ax=plt.gca(), legend=False, alpha=0.8)
     plt.title('Time Series of Fund Returns', fontsize=16)
     plt.xlabel('Date')
     plt.ylabel('Returns')
```

```
plt.grid(True)
plt.legend(loc='upper left', bbox_to_anchor=(1, 1))
plt.tight_layout()
plt.show()
```


Time Series of Fund Returns
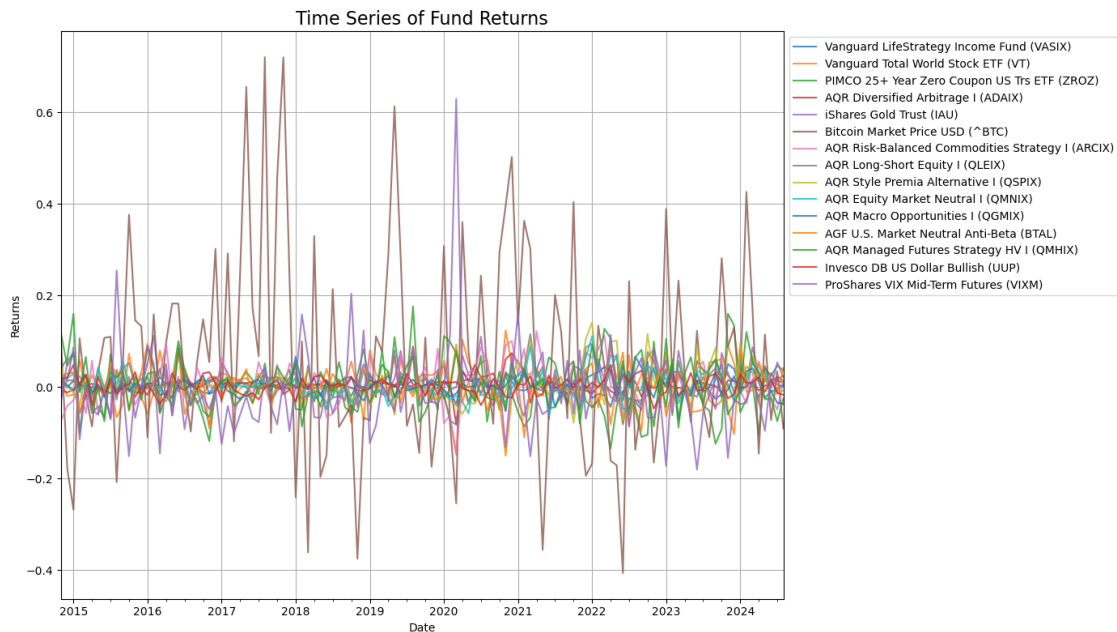
[9]:
```
# Descriptive Plots
# Plot Time Series - Rolling Mean
rolling_mean = df.rolling(window=12).mean()

plt.figure(figsize=(14, 8))
rolling_mean.plot(ax=plt.gca(), legend=False, alpha=0.8)
plt.title('Rolling Mean (12-month)', fontsize=16)
plt.xlabel('Date')
plt.ylabel('Mean')
plt.grid(True)
plt.legend(loc='upper left', bbox_to_anchor=(1, 1))
plt.tight_layout()
plt.show()
```

Rolling Mean (12-month)
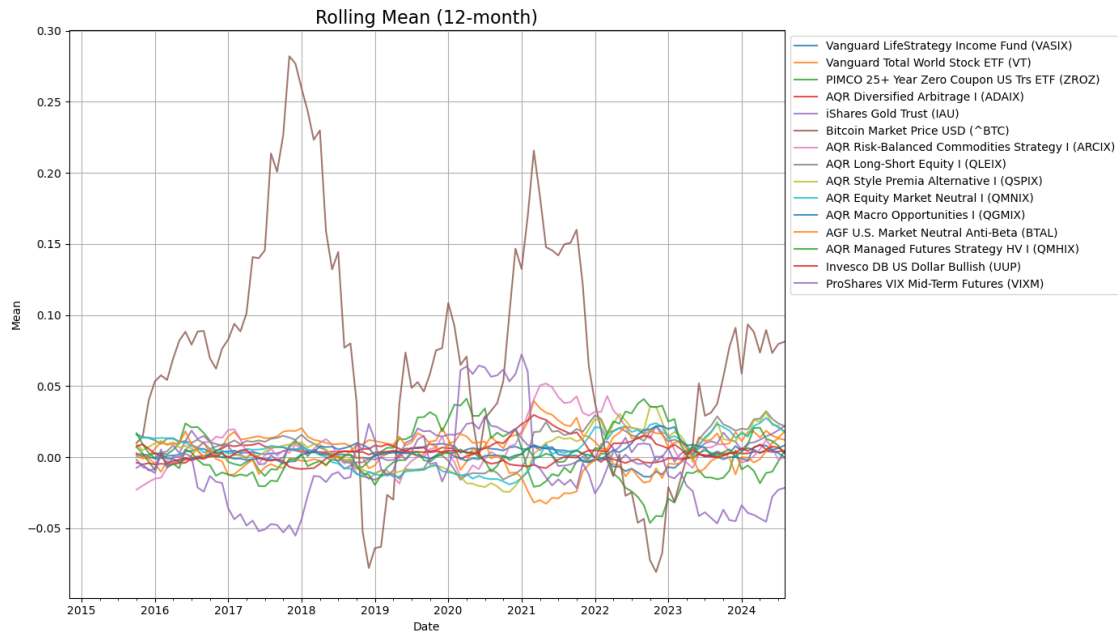
1.0.8 Correlation Matrix

```
[10]: # Calculate the correlation matrix between the different funds
      correlation_matrix = df.corr()
      correlation_matrix
```

[10]:   Vanguard LifeStrategy Income
      Fund (VASIX) \
      Vanguard LifeStrategy Income Fund (VASIX)
      1.000000
      Vanguard Total World Stock ETF (VT)
      0.797772
      PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
      0.619699
      AQR Diversified Arbitrage I (ADAIX)
      0.393475
      iShares Gold Trust (IAU)
      0.367826
      Bitcoin Market Price USD (^BTC)
      0.287900
      AQR Risk-Balanced Commodities Strategy I (ARCIX)
      0.247432
      AQR Long-Short Equity I (QLEIX)
      0.219485
      AQR Style Premia Alternative I (QSPIX)
      -0.156694

AQR Equity Market Neutral I (QMNIX)
-0.231995
AQR Macro Opportunities I (QGMIX)
-0.353287
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.396115
AQR Managed Futures Strategy HV I (QMHIX)
-0.431737
Invesco DB US Dollar Bullish (UUP)
-0.511921
ProShares VIX Mid-Term Futures (VIXM)
-0.485680

Vanguard Total World Stock ETF
(VT) \
Vanguard LifeStrategy Income Fund (VASIX)
0.797772
Vanguard Total World Stock ETF (VT)
1.000000
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
0.109775
AQR Diversified Arbitrage I (ADAIX)
0.514891
iShares Gold Trust (IAU)
0.136955
Bitcoin Market Price USD (^BTC)
0.324214
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.477805
AQR Long-Short Equity I (QLEIX)
0.460751
AQR Style Premia Alternative I (QSPIX)
0.007711
AQR Equity Market Neutral I (QMNIX)
-0.139991
AQR Macro Opportunities I (QGMIX)
-0.080182
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.640102
AQR Managed Futures Strategy HV I (QMHIX)
-0.343223
Invesco DB US Dollar Bullish (UUP)
-0.495324
ProShares VIX Mid-Term Futures (VIXM)
-0.718278

PIMCO 25+ Year Zero Coupon US

```
Trs ETF (ZROZ)  \
Vanguard LifeStrategy Income Fund (VASIX)
0.619699
Vanguard Total World Stock ETF (VT)
0.109775
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
1.000000
AQR Diversified Arbitrage I (ADAIX)
-0.008409
iShares Gold Trust (IAU)
0.419812
Bitcoin Market Price USD (^BTC)
0.083288
AQR Risk-Balanced Commodities Strategy I (ARCIX)
-0.150134
AQR Long-Short Equity I (QLEIX)
-0.202543
AQR Style Premia Alternative I (QSPIX)
-0.287704
AQR Equity Market Neutral I (QMNIX)
-0.238885
AQR Macro Opportunities I (QGMIX)
-0.322309
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.119725
AQR Managed Futures Strategy HV I (QMHIX)
-0.114056
Invesco DB US Dollar Bullish (UUP)
-0.225970
ProShares VIX Mid-Term Futures (VIXM)
0.064462


                                        AQR Diversified Arbitrage I
(ADAIX)  \
Vanguard LifeStrategy Income Fund (VASIX)
0.393475
Vanguard Total World Stock ETF (VT)
0.514891
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.008409
AQR Diversified Arbitrage I (ADAIX)
1.000000
iShares Gold Trust (IAU)
0.036317
Bitcoin Market Price USD (^BTC)
0.277072
AQR Risk-Balanced Commodities Strategy I (ARCIX)
```

0.439992
AQR Long-Short Equity I (QLEIX)
0.085852
AQR Style Premia Alternative I (QSPIX)
-0.100675
AQR Equity Market Neutral I (QMNIX)
-0.231412
AQR Macro Opportunities I (QGMIX)
0.115521
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.489470
AQR Managed Futures Strategy HV I (QMHIX)
-0.214968
Invesco DB US Dollar Bullish (UUP)
-0.274885
ProShares VIX Mid-Term Futures (VIXM)
-0.345754

	iShares Gold Trust (IAU) \
Vanguard LifeStrategy Income Fund (VASIX)	0.367826
Vanguard Total World Stock ETF (VT)	0.136955
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)	0.419812
AQR Diversified Arbitrage I (ADAIX)	0.036317
iShares Gold Trust (IAU)	1.000000
Bitcoin Market Price USD (^BTC)	0.089561
AQR Risk-Balanced Commodities Strategy I (ARCIX)	0.380276
AQR Long-Short Equity I (QLEIX)	0.033452
AQR Style Premia Alternative I (QSPIX)	-0.152538
AQR Equity Market Neutral I (QMNIX)	-0.013239
AQR Macro Opportunities I (QGMIX)	-0.158983
AGF U.S. Market Neutral Anti-Beta (BTAL)	0.165409
AQR Managed Futures Strategy HV I (QMHIX)	0.058928
Invesco DB US Dollar Bullish (UUP)	-0.458180
ProShares VIX Mid-Term Futures (VIXM)	0.099998

                                           Bitcoin Market Price USD
(^BTC) \
Vanguard LifeStrategy Income Fund (VASIX)
0.287900
Vanguard Total World Stock ETF (VT)
0.324214
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
0.083288
AQR Diversified Arbitrage I (ADAIX)
0.277072
iShares Gold Trust (IAU)
0.089561

Bitcoin Market Price USD (^BTC)
1.000000
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.168327
AQR Long-Short Equity I (QLEIX)
0.097437
AQR Style Premia Alternative I (QSPIX)
-0.037460
AQR Equity Market Neutral I (QMNIX)
-0.116087
AQR Macro Opportunities I (QGMIX)
-0.062044
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.223792
AQR Managed Futures Strategy HV I (QMHIX)
-0.047346
Invesco DB US Dollar Bullish (UUP)
-0.153065
ProShares VIX Mid-Term Futures (VIXM)
-0.217431

                                        AQR Risk-Balanced Commodities

Strategy I (ARCIX) \
Vanguard LifeStrategy Income Fund (VASIX)
0.247432
Vanguard Total World Stock ETF (VT)
0.477805
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.150134
AQR Diversified Arbitrage I (ADAIX)
0.439992
iShares Gold Trust (IAU)
0.380276
Bitcoin Market Price USD (^BTC)
0.168327
AQR Risk-Balanced Commodities Strategy I (ARCIX)
1.000000
AQR Long-Short Equity I (QLEIX)
0.358372
AQR Style Premia Alternative I (QSPIX)
0.140950
AQR Equity Market Neutral I (QMNIX)
0.086284
AQR Macro Opportunities I (QGMIX)
0.107711
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.319044

16

AQR Managed Futures Strategy HV I (QMHIX)
-0.040040
Invesco DB US Dollar Bullish (UUP)
-0.468701
ProShares VIX Mid-Term Futures (VIXM)
-0.341527

                                        AQR Long-Short Equity I
(QLEIX) \
Vanguard LifeStrategy Income Fund (VASIX)
0.219485
Vanguard Total World Stock ETF (VT)
0.460751
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.202543
AQR Diversified Arbitrage I (ADAIX)
0.085852
iShares Gold Trust (IAU)
0.033452
Bitcoin Market Price USD (^BTC)
0.097437
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.358372
AQR Long-Short Equity I (QLEIX)
1.000000
AQR Style Premia Alternative I (QSPIX)
0.729026
AQR Equity Market Neutral I (QMNIX)
0.798438
AQR Macro Opportunities I (QGMIX)
0.070964
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.181864
AQR Managed Futures Strategy HV I (QMHIX)
0.031753
Invesco DB US Dollar Bullish (UUP)
-0.146403
ProShares VIX Mid-Term Futures (VIXM)
-0.497014

                                        AQR Style Premia Alternative I
(QSPIX) \
Vanguard LifeStrategy Income Fund (VASIX)
-0.156694
Vanguard Total World Stock ETF (VT)
0.007711
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)

-0.287704
AQR Diversified Arbitrage I (ADAIX)
-0.100675
iShares Gold Trust (IAU)
-0.152538
Bitcoin Market Price USD (^BTC)
-0.037460
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.140950
AQR Long-Short Equity I (QLEIX)
0.729026
AQR Style Premia Alternative I (QSPIX)
1.000000
AQR Equity Market Neutral I (QMNIX)
0.806121
AQR Macro Opportunities I (QGMIX)
0.215109
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.158212
AQR Managed Futures Strategy HV I (QMHIX)
0.189893
Invesco DB US Dollar Bullish (UUP)
0.091452
ProShares VIX Mid-Term Futures (VIXM)
-0.157005

                                                 AQR Equity Market Neutral I
(QMNIX) \
Vanguard LifeStrategy Income Fund (VASIX)
-0.231995
Vanguard Total World Stock ETF (VT)
-0.139991
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.238885
AQR Diversified Arbitrage I (ADAIX)
-0.231412
iShares Gold Trust (IAU)
-0.013239
Bitcoin Market Price USD (^BTC)
-0.116087
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.086284
AQR Long-Short Equity I (QLEIX)
0.798438
AQR Style Premia Alternative I (QSPIX)
0.806121
AQR Equity Market Neutral I (QMNIX)

```
1.000000
AQR Macro Opportunities I (QGMIX)
0.097228
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.231500
AQR Managed Futures Strategy HV I (QMHIX)
0.251190
Invesco DB US Dollar Bullish (UUP)
0.129102
ProShares VIX Mid-Term Futures (VIXM)
-0.082435


                                             AQR Macro Opportunities I
(QGMIX)   \
Vanguard LifeStrategy Income Fund (VASIX)
-0.353287
Vanguard Total World Stock ETF (VT)
-0.080182
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.322309
AQR Diversified Arbitrage I (ADAIX)
0.115521
iShares Gold Trust (IAU)
-0.158983
Bitcoin Market Price USD (^BTC)
-0.062044
AQR Risk-Balanced Commodities Strategy I (ARCIX)
0.107711
AQR Long-Short Equity I (QLEIX)
0.070964
AQR Style Premia Alternative I (QSPIX)
0.215109
AQR Equity Market Neutral I (QMNIX)
0.097228
AQR Macro Opportunities I (QGMIX)
1.000000
AGF U.S. Market Neutral Anti-Beta (BTAL)
-0.067689
AQR Managed Futures Strategy HV I (QMHIX)
0.556294
Invesco DB US Dollar Bullish (UUP)
0.226025
ProShares VIX Mid-Term Futures (VIXM)
-0.029806


                                             AGF U.S. Market Neutral Anti-
Beta (BTAL)   \
```

Vanguard LifeStrategy Income Fund (VASIX)
-0.396115
Vanguard Total World Stock ETF (VT)
-0.640102
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
0.119725
AQR Diversified Arbitrage I (ADAIX)
-0.489470
iShares Gold Trust (IAU)
0.165409
Bitcoin Market Price USD (^BTC)
-0.223792
AQR Risk-Balanced Commodities Strategy I (ARCIX)
-0.319044
AQR Long-Short Equity I (QLEIX)
-0.181864
AQR Style Premia Alternative I (QSPIX)
0.158212
AQR Equity Market Neutral I (QMNIX)
0.231500
AQR Macro Opportunities I (QGMIX)
-0.067689
AGF U.S. Market Neutral Anti-Beta (BTAL)
1.000000
AQR Managed Futures Strategy HV I (QMHIX)
0.341463
Invesco DB US Dollar Bullish (UUP)
0.288372
ProShares VIX Mid-Term Futures (VIXM)
0.481303

                                        AQR Managed Futures Strategy
HV I (QMHIX) \
Vanguard LifeStrategy Income Fund (VASIX)
-0.431737
Vanguard Total World Stock ETF (VT)
-0.343223
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.114056
AQR Diversified Arbitrage I (ADAIX)
-0.214968
iShares Gold Trust (IAU)
0.058928
Bitcoin Market Price USD (^BTC)
-0.047346
AQR Risk-Balanced Commodities Strategy I (ARCIX)
-0.040040

AQR Long-Short Equity I (QLEIX)
0.031753
AQR Style Premia Alternative I (QSPIX)
0.189893
AQR Equity Market Neutral I (QMNIX)
0.251190
AQR Macro Opportunities I (QGMIX)
0.556294
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.341463
AQR Managed Futures Strategy HV I (QMHIX)
1.000000
Invesco DB US Dollar Bullish (UUP)
0.347456
ProShares VIX Mid-Term Futures (VIXM)
0.254549

                                              Invesco DB US Dollar Bullish
(UUP) \
Vanguard LifeStrategy Income Fund (VASIX)
-0.511921
Vanguard Total World Stock ETF (VT)
-0.495324
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
-0.225970
AQR Diversified Arbitrage I (ADAIX)
-0.274885
iShares Gold Trust (IAU)
-0.458180
Bitcoin Market Price USD (^BTC)
-0.153065
AQR Risk-Balanced Commodities Strategy I (ARCIX)
-0.468701
AQR Long-Short Equity I (QLEIX)
-0.146403
AQR Style Premia Alternative I (QSPIX)
0.091452
AQR Equity Market Neutral I (QMNIX)
0.129102
AQR Macro Opportunities I (QGMIX)
0.226025
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.288372
AQR Managed Futures Strategy HV I (QMHIX)
0.347456
Invesco DB US Dollar Bullish (UUP)
1.000000

ProShares VIX Mid-Term Futures (VIXM)
0.206555

ProShares VIX Mid-Term Futures
(VIXM)
Vanguard LifeStrategy Income Fund (VASIX)
-0.485680
Vanguard Total World Stock ETF (VT)
-0.718278
PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)
0.064462
AQR Diversified Arbitrage I (ADAIX)
-0.345754
iShares Gold Trust (IAU)
0.099998
Bitcoin Market Price USD (^BTC)
-0.217431
AQR Risk-Balanced Commodities Strategy I (ARCIX)
-0.341527
AQR Long-Short Equity I (QLEIX)
-0.497014
AQR Style Premia Alternative I (QSPIX)
-0.157005
AQR Equity Market Neutral I (QMNIX)
-0.082435
AQR Macro Opportunities I (QGMIX)
-0.029806
AGF U.S. Market Neutral Anti-Beta (BTAL)
0.481303
AQR Managed Futures Strategy HV I (QMHIX)
0.254549
Invesco DB US Dollar Bullish (UUP)
0.206555
ProShares VIX Mid-Term Futures (VIXM)
1.000000

```
[11]:  # Visualize the correlation matrix using a heatmap
       import matplotlib.pyplot as plt
       import seaborn as sns

       plt.figure(figsize=(12, 10))
       sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt='.2f',␣
         ↪linewidths=0.5)
       plt.title('Correlation Matrix Heatmap', fontsize=16)
       plt.show()
```

Correlation Matrix Heatmap
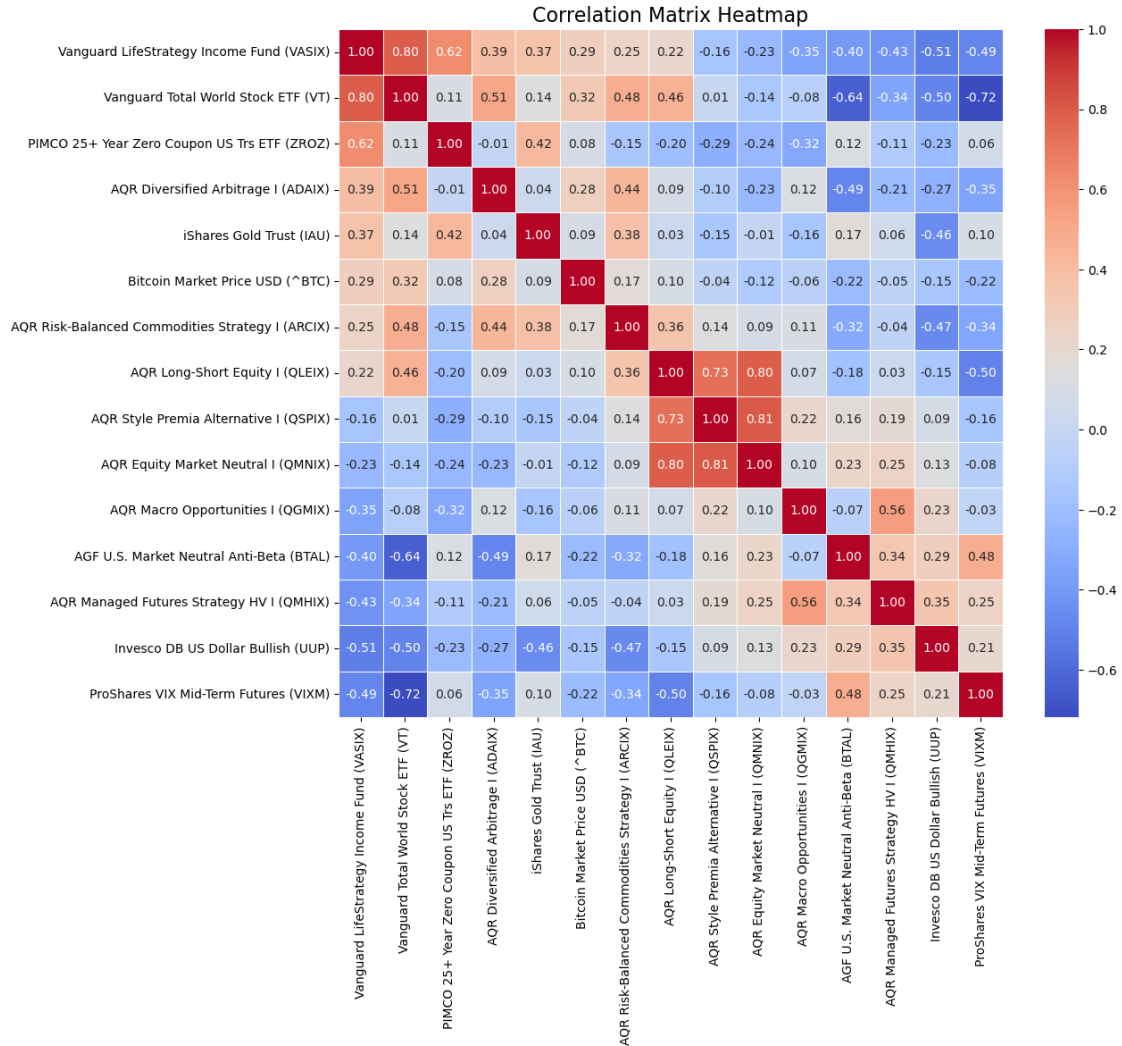
1.0.9 Kernel Density Estimate

```
[12]:  # Plot the# Plot the Kernel Density Estimate for each fund
       plt.figure(figsize=(14, 8))

       for column in df.columns:
           sns.kdeplot(df[column], label=column, linewidth=2)

       plt.title('Distribution of Fund Returns (KDE)', fontsize=16)
       plt.xlabel('Returns')
       plt.ylabel('Density')
       plt.grid(True)
       plt.legend(loc='upper right', bbox_to_anchor=(1, 1))
       plt.tight_layout()
```
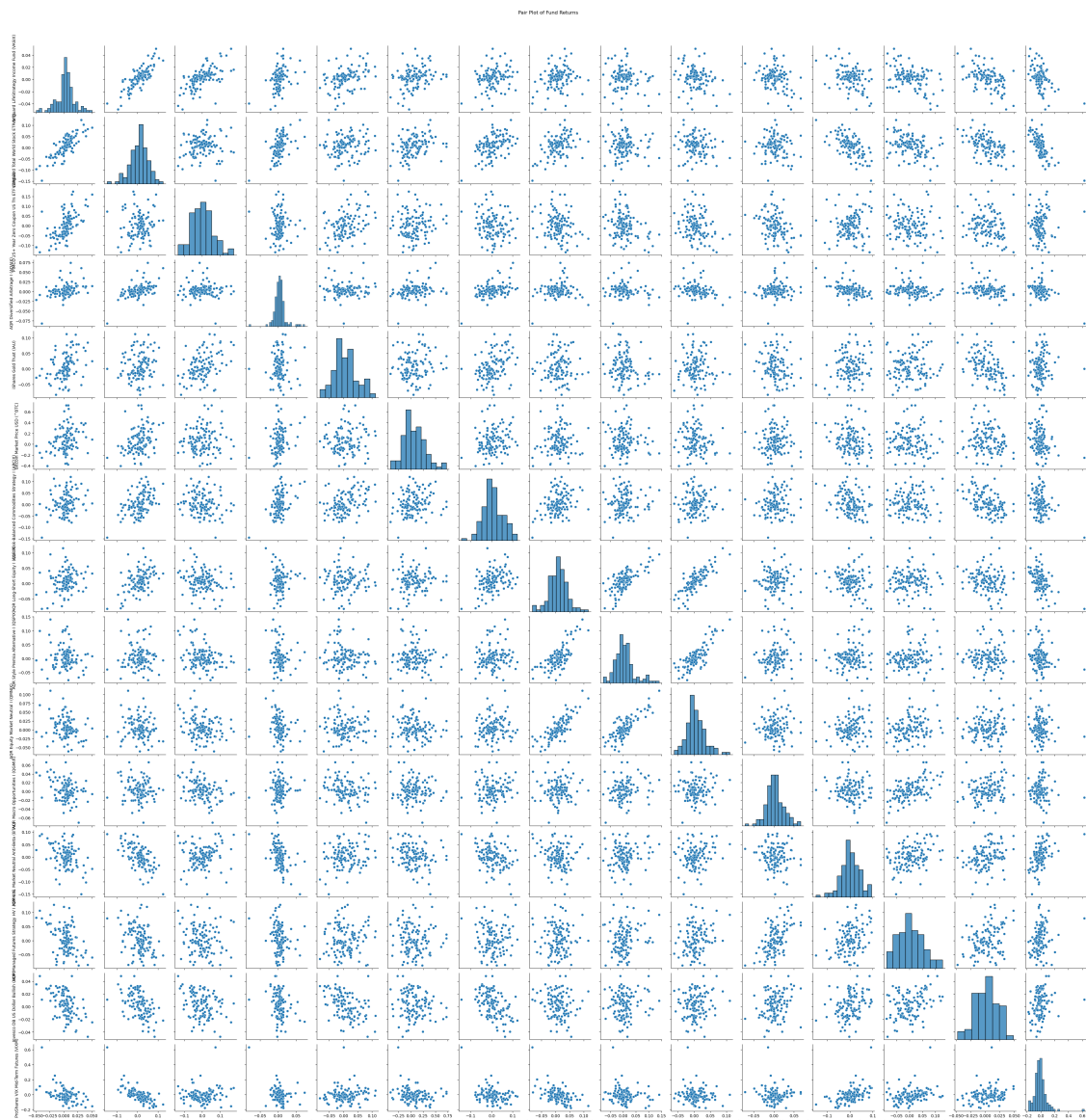
```
plt.show()
```


Distribution of Fund Returns (KDE)
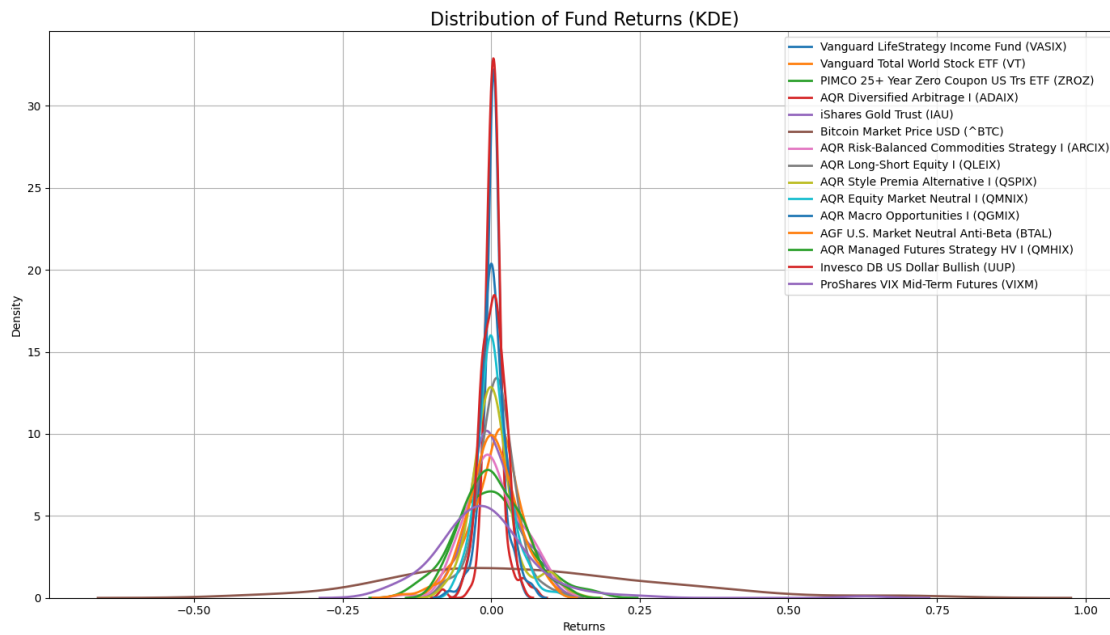
[13]:
```
# Create a pair plot for the dataset to visualize relationships between funds
import seaborn as sns
pairplot_df = df
sns.pairplot(pairplot_df)
plt.suptitle("Pair Plot of Fund Returns", y=1.02)
plt.show()
```

Pair Plot of Fund Returns

From ChatGPT

1.0.10 How to Read Pair Plot

Key Elements of a Pair Plot: Scatter Plots (Off-Diagonal): Each scatter plot shows the relationship between two different funds. Each point represents an observation (a time point) with the return of one fund on the x-axis and the return of another fund on the y-axis.

Linear Relationships: A clear upward or downward trend indicates a positive or negative correlation, respectively, between the returns of two funds. No Pattern: If the points are scattered without any clear direction, this implies little or no correlation between the two funds. Clusters: Visible clusters or groupings of points may indicate different regimes or types of behavior in the data (e.g., periods of high/low returns). Histograms (Diagonal): The diagonal plots show the dis-

tribution of returns for each fund individually. These are histograms (or sometimes density plots), allowing you to assess the shape of the distribution.

Normal Distribution: If the histogram is bell-shaped, the returns of the fund are approximately normally distributed. Skewness: If the histogram leans to the left or right, the returns are skewed. Spread: The width of the histogram indicates the variability or volatility of the returns. A wide histogram suggests higher variability (volatility) in returns.

1.0.11 Interpreting Scatter Plots

Positive Correlation: If the points in the scatter plot form an upward-sloping line, it indicates that when the return of one fund increases, the return of the other tends to increase as well. The stronger the correlation, the tighter the points will cluster along the line.

Example: If two funds are positively correlated, investing in both may not diversify risk because their performance moves together.

Negative Correlation: A downward-sloping line means the two funds are negatively correlated, where one increases while the other decreases. This can be a sign that the two funds might hedge each other.

Example: If one fund tends to gain when another loses, holding both may reduce portfolio risk.

No Correlation: A random scatter of points with no discernible pattern suggests no relationship between the two funds.

1.0.12 Interpreting Histograms (Diagonal):

Symmetry: Symmetrical histograms show that the returns are balanced around the mean (close to normal distribution). #### Skewness: **Right Skewed (Positive Skew):** Most of the returns are concentrated on the left side, with a long tail on the right. This indicates occasional large gains. **Left Skewed (Negative Skew):** Most returns are concentrated on the right side, with a long tail on the left, indicating occasional large losses. **Kurtosis (Fat Tails):** If the histogram has high peaks and fat tails, it suggests the presence of extreme values, meaning the fund might experience rare but large fluctuations in returns.

1.0.13 Models

Risk Parity

```
[14]: # Load Opportunity Dataset
      data = pd.read_csv('Opportunity_Set.csv')      # Load Dataset as Dataframe
      data.head()                                                                  ␣
       ↪       # Diaplay 1st 5 in Dataframe
```

```
[14]:        Date  Vanguard LifeStrategy Income Fund (VASIX)  \
      0  11/30/2014                                   0.0094
      1  12/31/2014                                  -0.0005
      2   1/31/2015                                   0.0141
      3   2/28/2015                                   0.0033
      4   3/31/2015                                   0.0018
```

```
    Vanguard Total World Stock ETF (VT)  \
0                            0.0126
1                           -0.0199
2                           -0.0163
3                            0.0595
4                           -0.0121


   PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)  \
0                                       0.0414
1                                       0.0612
2                                       0.1600
3                                      -0.1007
4                                       0.0117


   AQR Diversified Arbitrage I (ADAIX)  iShares Gold Trust (IAU)  \
0                              -0.0066                   -0.0053
1                              -0.0117                    0.0133
2                              -0.0059                    0.0865
3                               0.0069                   -0.0579
4                               0.0000                   -0.0222


   Bitcoin Market Price USD (^BTC)  \
0                           0.0969
1                          -0.1777
2                          -0.2677
3                           0.1062
4                          -0.0150


   AQR Risk-Balanced Commodities Strategy I (ARCIX)  \
0                                           -0.0726
1                                           -0.0412
2                                           -0.0287
3                                            0.0044
4                                           -0.0573


   AQR Long-Short Equity I (QLEIX)  AQR Style Premia Alternative I (QSPIX)  \
0                           0.0248                                  0.0412
1                           0.0140                                  0.0002
2                           0.0156                                 -0.0112
3                           0.0236                                 -0.0390
4                          -0.0027                                  0.0256


   AQR Equity Market Neutral I (QMNIX)  AQR Macro Opportunities I (QGMIX)  \
0                               0.0257                             0.0154
1                               0.0195                             0.0039
2                               0.0290                            -0.0070
3                              -0.0078                             0.0091
```

```
4                              0.0049                              0.0261

    AGF U.S. Market Neutral Anti-Beta (BTAL)  \
0                                   0.0235
1                                   0.0294
2                                   0.0320
3                                  -0.0568
4                                   0.0000

    AQR Managed Futures Strategy HV I (QMHIX)  \
0                                   0.1159
1                                   0.0461
2                                   0.0721
3                                  -0.0108
4                                   0.0655

    Invesco DB US Dollar Bullish (UUP)  ProShares VIX Mid-Term Futures (VIXM)
0                               0.0165                                -0.0298
1                               0.0213                                 0.0553
2                               0.0484                                 0.0762
3                               0.0028                                -0.1145
4                               0.0278                                 0.0033
```

```python
[15]:  # Extract the returns data (excluding the Date column)
       returns = data.iloc[:, 1:]

       # Calculate the covariance matrix of asset returns
       cov_matrix = returns.cov()

       # Number of assets
       n_assets = cov_matrix.shape[0]

       # Define the variables for the optimization (portfolio weights)
       weights = cp.Variable(n_assets)

       # Define the objective (minimize portfolio variance)
       portfolio_variance = cp.quad_form(weights, cov_matrix.values)

       # Constraints (weights sum to 1 and are non-negative)
       constraints = [cp.sum(weights) == 1, weights >= 0]
       # the constraints don't seem to work with negative optimal weight below...???

       # Optimization problem (minimize variance)
       problem = cp.Problem(cp.Minimize(portfolio_variance), constraints)
       problem.solve()

       # Optimal portfolio weights
```

```
optimal_weights = weights.value

# Compute Marginal Risk Contribution (MRC)
mrc = 2 * np.dot(cov_matrix.values, optimal_weights)

# Creating a dataframe to display the results
mrc_df = pd.DataFrame({
    'Asset': returns.columns,
    'Optimal Weights': optimal_weights,
    'Marginal Risk Contribution': mrc
})

# Display the results
mrc_df
```

[15]:
	Asset	Optimal Weights
0	Vanguard LifeStrategy Income Fund (VASIX)	3.932301e-01
1	Vanguard Total World Stock ETF (VT)	-2.099375e-18
2	PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)	-5.248749e-18
3	AQR Diversified Arbitrage I (ADAIX)	1.133455e-01
4	iShares Gold Trust (IAU)	-2.448059e-18
5	Bitcoin Market Price USD (^BTC)	1.844191e-18
6	AQR Risk-Balanced Commodities Strategy I (ARCIX)	2.807962e-02
7	AQR Long-Short Equity I (QLEIX)	-5.006550e-19
8	AQR Style Premia Alternative I (QSPIX)	4.818605e-19
9	AQR Equity Market Neutral I (QMNIX)	7.008853e-02
10	AQR Macro Opportunities I (QGMIX)	1.092522e-01
11	AGF U.S. Market Neutral Anti-Beta (BTAL)	3.719750e-02
12	AQR Managed Futures Strategy HV I (QMHIX)	-9.423550e-19
13	Invesco DB US Dollar Bullish (UUP)	2.149796e-01
14	ProShares VIX Mid-Term Futures (VIXM)	3.382701e-02

	Marginal Risk Contribution
0	0.000061
1	0.000079
2	0.000239
3	0.000061
4	0.000098
5	0.000238
6	0.000061
7	0.000089
8	0.000098
9	0.000061
10	0.000061
11	0.000061
12	0.000131
13	0.000061

```
14                    0.000061
```

```
[16]:  # Assuming equal weights for simplicity in this example, but you can replace␣
       ↪with any other weighting strategy
       n_assets = len(returns.columns)
       equal_weights = np.array([1/n_assets] * n_assets)

       # Calculate the portfolio variance
       portfolio_variance_equal_weight = equal_weights.T @ cov_matrix @ equal_weights

       # Portfolio variance result
       portfolio_variance_equal_weight
```

```
[16]:  0.0003504452730310492
```

```
[17]:  # Calculate the mean returns (expected returns) of each asset
       expected_returns = returns.mean()

       # Calculate the portfolio's expected return using equal weights
       portfolio_expected_return_equal = np.dot(equal_weights, expected_returns)

       # Portfolio expected return result
       portfolio_expected_return_equal
```

```
[17]:  0.007898983050847456
```

```
[18]:  # Calculate the mean returns (expected returns) of each asset
       expected_returns = returns.mean()

       # Calculate the portfolio's expected return using optimal weights
       portfolio_expected_return_optimal = np.dot(optimal_weights, expected_returns)

       # Portfolio optimal return result
       portfolio_expected_return_optimal
```

```
[18]:  0.0028506210338368025
```

```
[19]:  # Assume risk-free rate is 0 for simplicity, you can adjust as necessary
       risk_free_rate = 0.0

       # Portfolio variance and standard deviation
       portfolio_variance_optimal = np.dot(optimal_weights.T, np.dot(cov_matrix,␣
        ↪optimal_weights))
       portfolio_std = np.sqrt(portfolio_variance_optimal)

       # Sharpe ratio calculation
```

```python
portfolio_sharpe_ratio = (portfolio_expected_return_optimal - risk_free_rate) /␣
  ↪portfolio_std

# Display the Sharpe ratio
print(f"Portfolio Sharpe Ratio: {portfolio_sharpe_ratio:.4f}")
```

Portfolio Sharpe Ratio: 0.5141

```python
[20]: print("Equal Weighted Portfolio")
print(f"The Portfolio Variance is {portfolio_variance_equal_weight:.4f}")
print(f"The Expected Return is {portfolio_expected_return_equal:.4f}")
print()
print("Optimal Weighted Portfolio")
print(f"The Portfolio Variance is {portfolio_variance_optimal:.4f}")
print(f"The Expected Return is {portfolio_expected_return_optimal:.4f}")
print(f"The Portfolio Sharpe Ratio is {portfolio_sharpe_ratio:.4f}")
```

Equal Weighted Portfolio
The Portfolio Variance is 0.0004
The Expected Return is 0.0079

Optimal Weighted Portfolio
The Portfolio Variance is 0.0000
The Expected Return is 0.0029
The Portfolio Sharpe Ratio is 0.5141

The constraints used to prevent a negative optimal weight do not work in this model (Input 3)

Fama-French Factor Model

```python
[21]: # http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
fama_french_factors = pd.read_csv('F-F_Research_Data_Factors.csv',␣
  ↪parse_dates=['Date'])      # Load Dataset as Dataframe
fama_french_factors.head()                                              ␣
  ↪             # Diaplay 1st 5 inDataframe
```

```
[21]:         Date  Mkt-RF   SMB   HML   RF
     0 2014-11-30    2.55 -2.06 -3.10  0.0
     1 2014-12-31   -0.06  2.49  2.27  0.0
     2 2015-01-31   -3.11 -0.56 -3.59  0.0
     3 2015-02-28    6.13  0.63 -1.86  0.0
     4 2015-03-31   -1.12  3.04 -0.38  0.0
```

```python
[22]: df = pd.read_csv('Opportunity_Set.csv', parse_dates=['Date'])       # Load␣
  ↪Dataset as Dataframe
df.head()
```

```
[22]:         Date  Vanguard LifeStrategy Income Fund (VASIX)  \
      0 2014-11-30                                      0.0094
      1 2014-12-31                                     -0.0005
      2 2015-01-31                                      0.0141
      3 2015-02-28                                      0.0033
      4 2015-03-31                                      0.0018

         Vanguard Total World Stock ETF (VT)  \
      0                              0.0126
      1                             -0.0199
      2                             -0.0163
      3                              0.0595
      4                             -0.0121

         PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)  \
      0                                        0.0414
      1                                        0.0612
      2                                        0.1600
      3                                       -0.1007
      4                                        0.0117

         AQR Diversified Arbitrage I (ADAIX)  iShares Gold Trust (IAU)  \
      0                             -0.0066                   -0.0053
      1                             -0.0117                    0.0133
      2                             -0.0059                    0.0865
      3                              0.0069                   -0.0579
      4                              0.0000                   -0.0222

         Bitcoin Market Price USD (^BTC)  \
      0                          0.0969
      1                         -0.1777
      2                         -0.2677
      3                          0.1062
      4                         -0.0150

         AQR Risk-Balanced Commodities Strategy I (ARCIX)  \
      0                                          -0.0726
      1                                          -0.0412
      2                                          -0.0287
      3                                           0.0044
      4                                          -0.0573

         AQR Long-Short Equity I (QLEIX)  AQR Style Premia Alternative I (QSPIX)  \
      0                          0.0248                                  0.0412
      1                          0.0140                                  0.0002
      2                          0.0156                                 -0.0112
      3                          0.0236                                 -0.0390
```

```
4                       -0.0027                                    0.0256

     AQR Equity Market Neutral I (QMNIX)  AQR Macro Opportunities I (QGMIX)  \
0                              0.0257                              0.0154
1                              0.0195                              0.0039
2                              0.0290                             -0.0070
3                             -0.0078                              0.0091
4                              0.0049                              0.0261

     AGF U.S. Market Neutral Anti-Beta (BTAL)  \
0                              0.0235
1                              0.0294
2                              0.0320
3                             -0.0568
4                              0.0000

     AQR Managed Futures Strategy HV I (QMHIX)  \
0                              0.1159
1                              0.0461
2                              0.0721
3                             -0.0108
4                              0.0655

     Invesco DB US Dollar Bullish (UUP)  ProShares VIX Mid-Term Futures (VIXM)
0                              0.0165                             -0.0298
1                              0.0213                              0.0553
2                              0.0484                              0.0762
3                              0.0028                             -0.1145
4                              0.0278                              0.0033
```

```python
[23]: import pandas as pd
      import statsmodels.api as sm

      asset_return = df['Vanguard LifeStrategy Income Fund (VASIX)']  # Replace with␣
       ↪your asset's returns

      # Step 3: Prepare the factors and align with asset returns by date
      factor_returns = fama_french_factors[['Mkt-RF', 'SMB', 'HML']] # Ensure both␣
       ↪asset returns and factors are aligned by date
      factor_returns_RF = fama_french_factors['RF']  # Risk-free rate
      excess_asset_returns = asset_return - factor_returns_RF # Calculate excess␣
       ↪returns over risk-free rate

      # Add a constant (alpha) to the model
      X = sm.add_constant(factor_returns[['Mkt-RF', 'SMB', 'HML']])
      y = excess_asset_returns
```

```
# Fit the model
model = sm.OLS(y, X).fit()

# Display the summary of the regression
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.025
Model:                            OLS   Adj. R-squared:                 -0.001
Method:                 Least Squares   F-statistic:                    0.9667
Date:                Sun, 06 Oct 2024   Prob (F-statistic):              0.411
Time:                        12:08:36   Log-Likelihood:                 57.434
No. Observations:                 118   AIC:                            -106.9
Df Residuals:                     114   BIC:                            -95.78
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.1267      0.014     -8.839      0.000      -0.155      -0.098
Mkt-RF         0.0016      0.003      0.518      0.605      -0.005       0.008
SMB            0.0066      0.005      1.260      0.210      -0.004       0.017
HML            0.0020      0.004      0.532      0.596      -0.005       0.009
==============================================================================
Omnibus:                       18.265   Durbin-Watson:                   0.069
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               22.950
Skew:                          -1.080   Prob(JB):                     1.04e-05
Kurtosis:                       2.930   Cond. No.                         4.91
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[24]:
```
# Merge the two datasets on the 'Date' column
merged_df = pd.merge(df, fama_french_factors, on='Date')

# Set the index to 'Date' for easier handling
merged_df.set_index('Date', inplace=True)

# Prepare the assets for regression (list of asset columns)
asset_columns = [
    'Vanguard LifeStrategy Income Fund (VASIX)',
    'Vanguard Total World Stock ETF (VT)',
    'PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)',
    'AQR Diversified Arbitrage I (ADAIX)',
```

```python
    'iShares Gold Trust (IAU)',
    'Bitcoin Market Price USD (^BTC)'
]

# We need to calculate excess returns for the assets (subtracting the risk-free↵
 ↪rate RF)
for asset in asset_columns:
    merged_df[asset] = merged_df[asset] - (merged_df['RF'] / 100)  # Converting↵
 ↪RF to percentage

# Prepare the factor data for the regression (convert from percentage to↵
 ↪decimal)
factor_columns = ['Mkt-RF', 'SMB', 'HML']
merged_df[factor_columns] = merged_df[factor_columns] / 100

# Perform Fama-French 3-factor regression for each asset
import statsmodels.api as sm

betas = pd.DataFrame()

for asset in asset_columns:
    X = sm.add_constant(merged_df[factor_columns])  # Add constant (alpha)
    y = merged_df[asset]  # Asset's excess returns
    model = sm.OLS(y, X).fit()  # Fit OLS regression

    # Collect the coefficients (betas) for each asset
    betas[asset] = model.params[1:]  # Ignore the intercept (alpha), take only↵
 ↪factor betas

# Rename the index for factors
betas.index = factor_columns
betas

# Now we can visualize the beta exposures for all assets
betas.T.plot(kind='bar', figsize=(12, 6))
plt.title('Fama-French Factor Exposures for Multiple Assets')
plt.xlabel('Assets')
plt.ylabel('Beta Coefficients (Exposure)')
plt.xticks(rotation=45)
plt.legend(title='Factors')

# Display the plot
plt.show()
```

Fama-French Factor Exposures for Multiple Assets
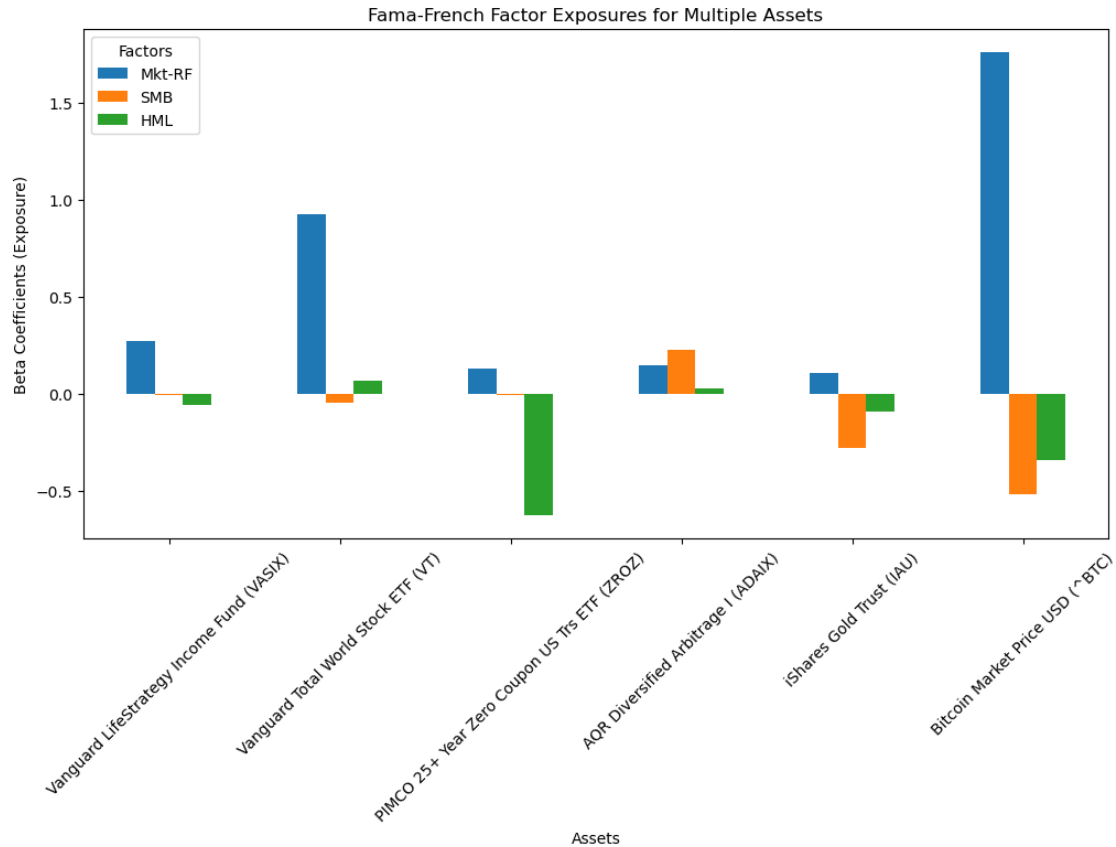

```
[25]:  # Let's extend the analysis to include all assets in the opportunity dataset.

       # Extract all asset columns (ignoring the factor columns)
       all_asset_columns = merged_df.columns.difference(factor_columns + ['RF']).
        ↪tolist()

       # Initialize an empty DataFrame to store the betas for all assets
       all_betas = pd.DataFrame()

       # Perform Fama-French 3-factor regression for each asset
       for asset in all_asset_columns:
           X = sm.add_constant(merged_df[factor_columns])  # Add constant (alpha)
           y = merged_df[asset]  # Asset's excess returns
           model = sm.OLS(y, X).fit()  # Fit OLS regression

           # Collect the coefficients (betas) for each asset
           all_betas[asset] = model.params[1:]  # Ignore the intercept (alpha), take␣
        ↪only factor betas

       # Rename the index for factors
```
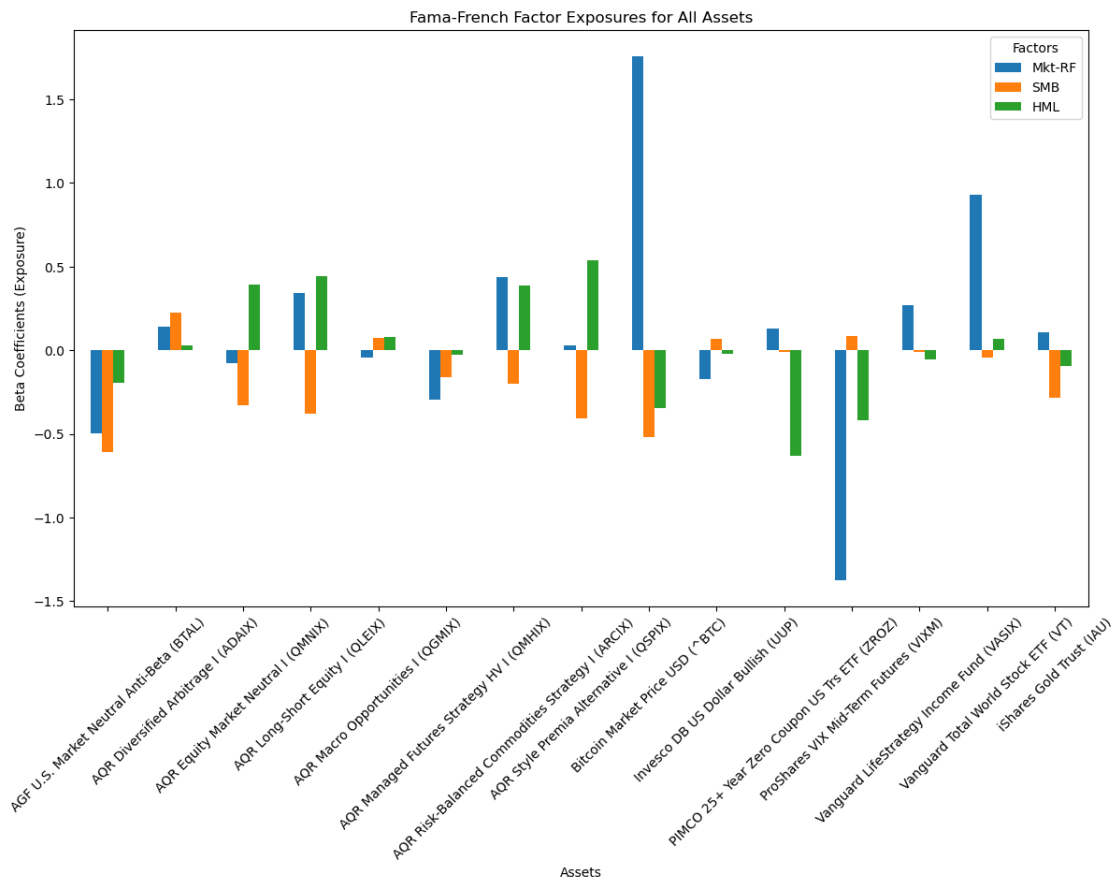
```
all_betas.index = factor_columns

all_betas

# Visualize the beta exposures for all assets
all_betas.T.plot(kind='bar', figsize=(14, 8))
plt.title('Fama-French Factor Exposures for All Assets')
plt.xlabel('Assets')
plt.ylabel('Beta Coefficients (Exposure)')
plt.xticks(rotation=45)
plt.legend(title='Factors')

# Display the plot
plt.show()
```


Fama-French Factor Exposures for All Assets

Betas (1, 2, 3) : These represent the asset's sensitivity to each factor.

A high 1 (market) means the asset is strongly correlated with market movements. A positive 2 (SMB) means the asset has small-cap exposure. A positive 3 (HML) means the asset has exposure to value stocks.

References

Agresti, Alan, and Maria Kateri. Foundations of Statistics for Data Scientists: With R and Python. CRC Press, Taylor & Francis Group, 2022.

Agresti, Alan, and Maria Kateri. (2022) Appendix B2. Chapter 2: Python for Probability Distributions. In Foundations of Statistics for Data Scientists: With R and Python (p. 385-389). CRC Press, Taylor & Francis Group, 2022.

ChatGPT, (2024) GPT-4o version, OpenAI. [Large language model]. https://chatgpt.com/

Opportuinty Dataset - need link/website info

F-F_Reasearch_Data_Factors.CSV Kenneth French's website. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html