

Carrie_Little_AAI_500_FinalProject

September 22, 2024

1 Risk Parity - Opportunity dataset

Carrie Little

1.0.1 Import Necessary Libraries

```
[1]: # Import necessary libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import scipy.stats as stats
import seaborn as sns
```

1.0.2 Load Opportunity Dataset

```
[2]: df = pd.read_csv('Opportunity_Set.csv', parse_dates=['Date'], index_col='Date')
print(df.head())
```

```

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

Date	AQR Diversified Arbitrage I (ADAIX)	iShares Gold Trust (IAU) \
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

Date	Bitcoin Market Price USD (^BTC) \
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

Date	AQR Risk-Balanced Commodities Strategy I (ARCIX) \
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

Date	AQR Long-Short Equity I (QLEIX) \
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

Date	AQR Style Premia Alternative I (QSPIX) \
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

Date	AQR Equity Market Neutral I (QMNIX) \
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]: # General information about the dataset
df.info()
```

```
<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
summary_stats = df.describe()
summary_stats
```

```
[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 (ZR0Z) \	
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
```

```
[5]: mean_stats = df.mean()  
     mean_stats
```

```
[5]: Vanguard LifeStrategy Income Fund (VASIX)          0.002883  
     Vanguard Total World Stock ETF (VT)                0.008376  
     PIMCO 25+ Year Zero Coupon US Trs ETF (ZROZ)       0.001381  
     AQR Diversified Arbitrage I (ADAIX)                 0.004370  
     iShares Gold Trust (IAU)                            0.007036  
     Bitcoin Market Price USD (~BTC)                    0.066718  
     AQR Risk-Balanced Commodities Strategy I (ARCIX)    0.005475  
     AQR Long-Short Equity I (QLEIX)                    0.008895  
     AQR Style Premia Alternative I (QSPIX)              0.005400  
     AQR Equity Market Neutral I (QMNIX)                 0.005330  
     AQR Macro Opportunities I (QGMIX)                   0.002896  
     AGF U.S. Market Neutral Anti-Beta (BTAL)           0.001880  
     AQR Managed Futures Strategy HV I (QMHIX)           0.003564  
     Invesco DB US Dollar Bullish (UUP)                  0.002768  
     ProShares VIX Mid-Term Futures (VIXM)               -0.008486  
     dtype: float64
```

```
[6]: median_stats = df.median()  
     median_stats
```

```
[6]: Vanguard LifeStrategy Income Fund (VASIX)          0.00470  
     Vanguard Total World Stock ETF (VT)                0.01225
```

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

dtype: float64

```
[7]: standard_dev = df.std()
      standard_dev
```

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

dtype: float64

```
[8]: from scipy.stats import skew, kurtosis
```

```
skewness = skew(df)
kurt = kurtosis(df)
print("Skewness:", skewness)
print("Kurtosis:", kurt)
```

```
Skewness: [-0.24060251 -0.42602365  0.37862641  0.08922212  0.37434495
 0.59998234  0.1050147   0.01608962  1.01559856  0.63732222  0.10293821 -0.3658655
 0.29453939 -0.07962696  2.86908603]
Kurtosis: [ 1.47266421  0.92861904  0.26255678  8.08371487 -0.11338543
 0.52693061
```



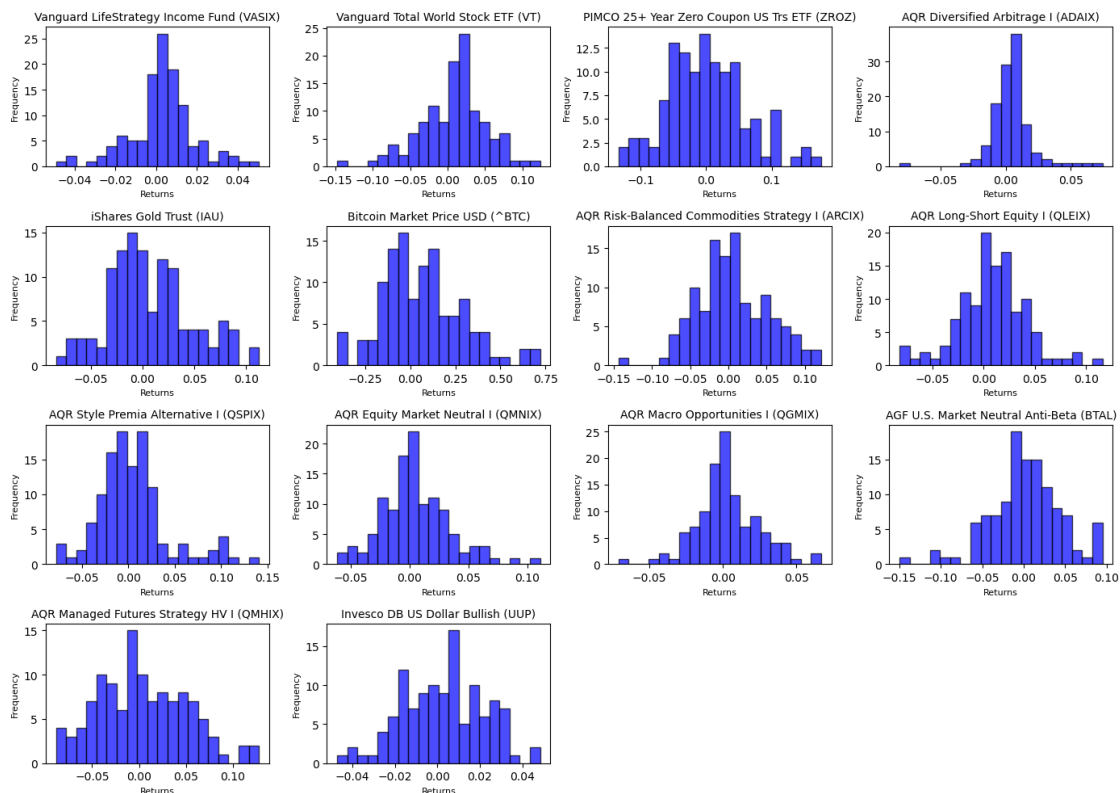
```
0.07823431 1.16242792 1.69763607 1.28244005 1.16948861 0.91320915
-0.30386081 -0.33754021 17.09732061]
```

1.0.5 Histogram

```
[9]: # Plot histograms for each fund to show their return distributions
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()
```

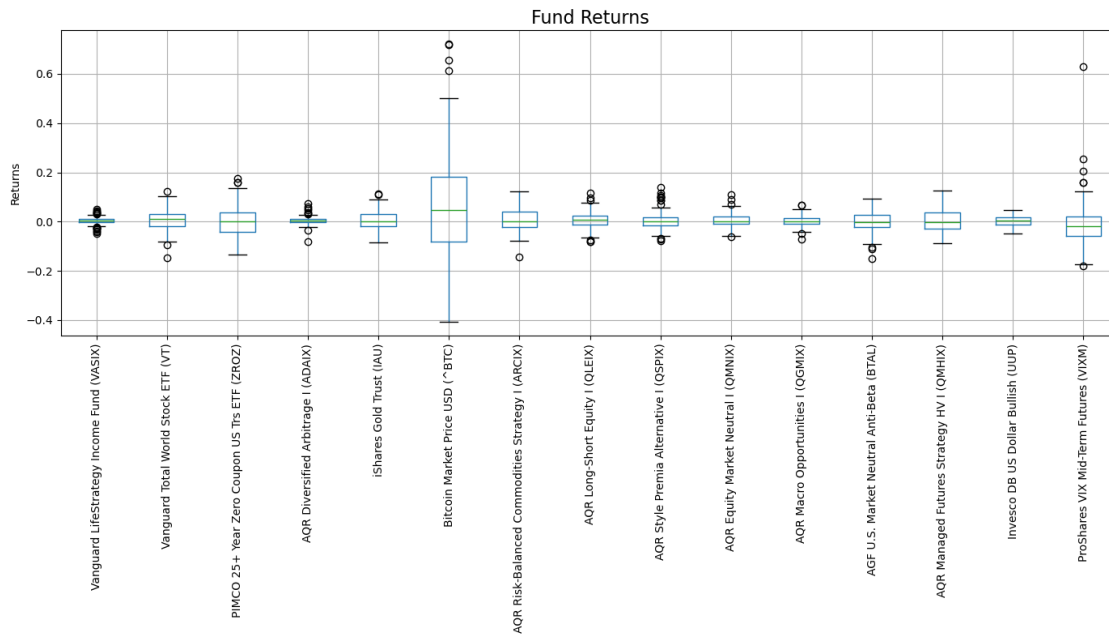


1.0.6 Boxplot

```
[10]: # Create a box plot
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()
```

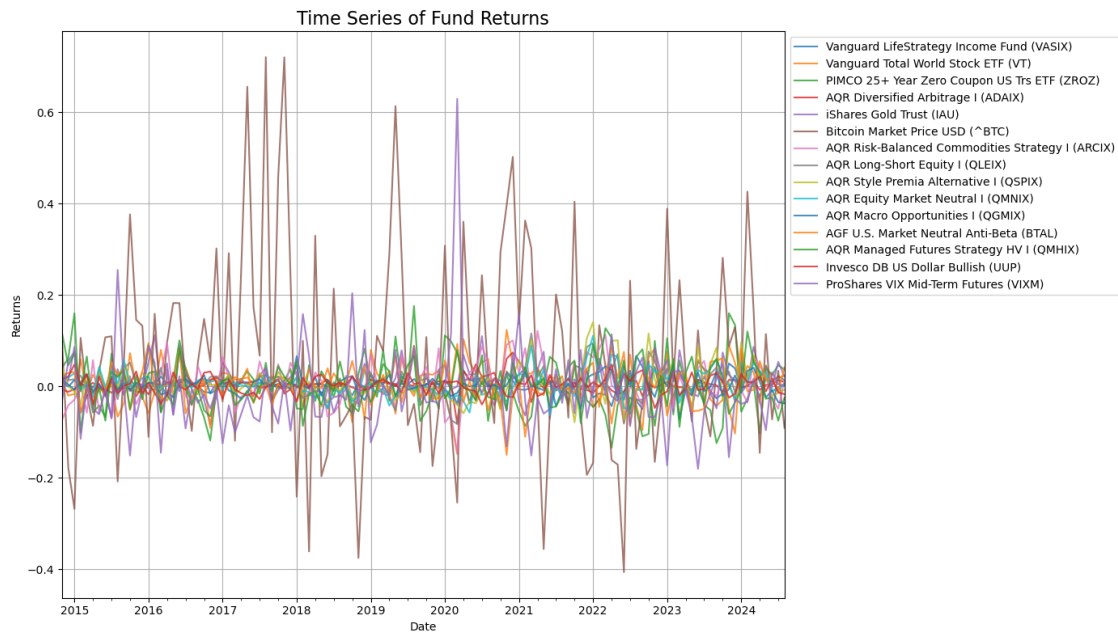


1.0.7 Time Series

```
[11]: # Plot time series for all funds
plt.figure(figsize=(14, 8))

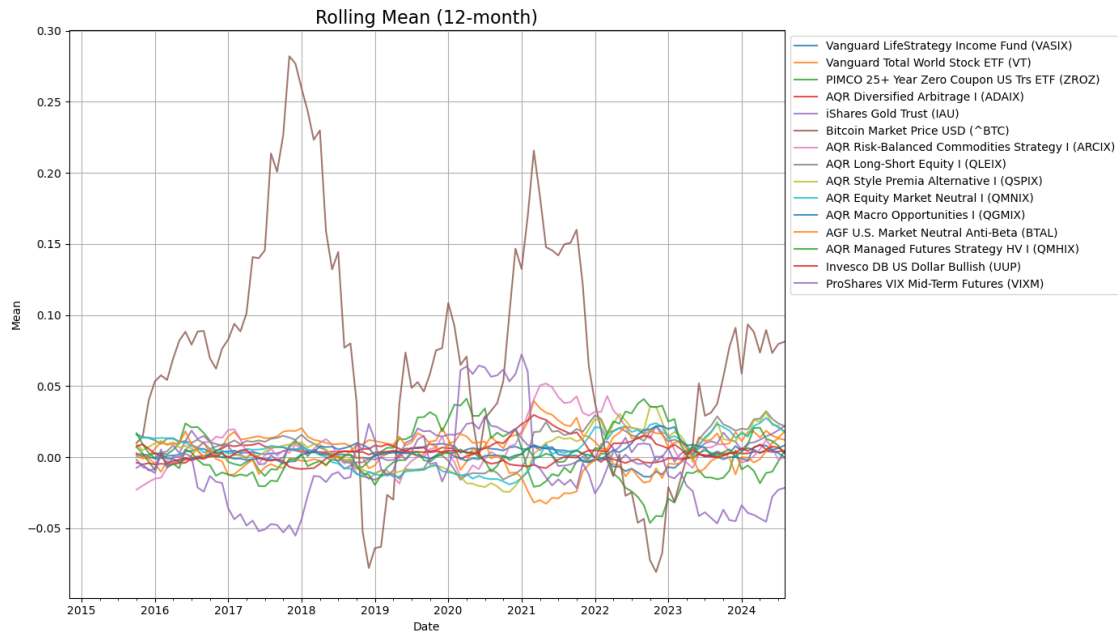
df.plot(ax=plt.gca(), legend=False, alpha=0.8)
plt.title('Time Series of Fund Returns', fontsize=16)
plt.xlabel('Date')
plt.ylabel('Returns')
plt.grid(True)
plt.legend(loc='upper left', bbox_to_anchor=(1, 1))
```

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



```
[12]: # 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()
```



1.0.8 Correlation Matrix

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

```
[13]:
```

	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

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

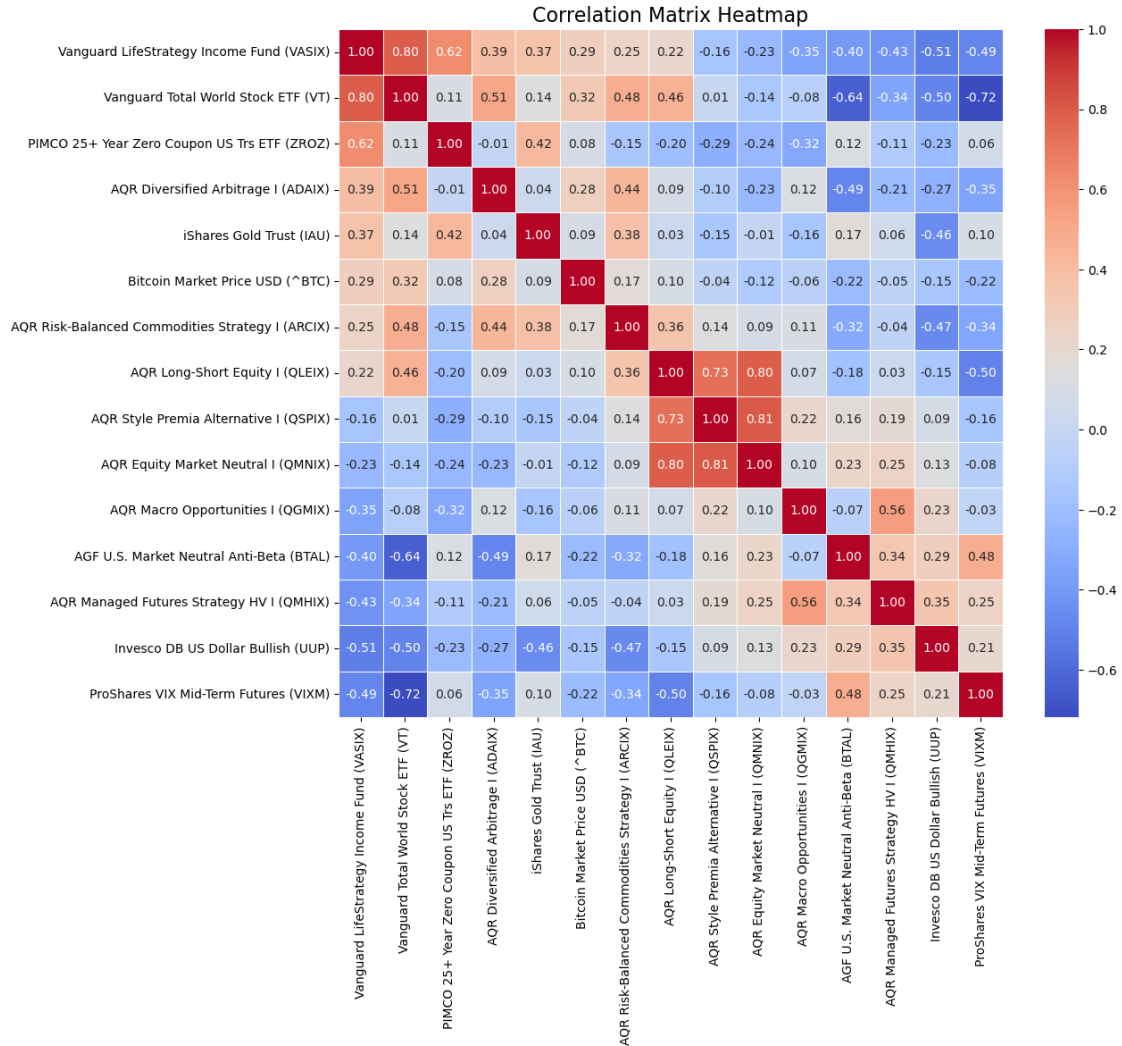
ProShares VIX Mid-Term Futures (VIXM)
0.206555

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)
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AQR Risk-Balanced Commodities Strategy I (ARCIX)
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AQR Long-Short Equity I (QLEIX)
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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

```
[14]: # 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()
```



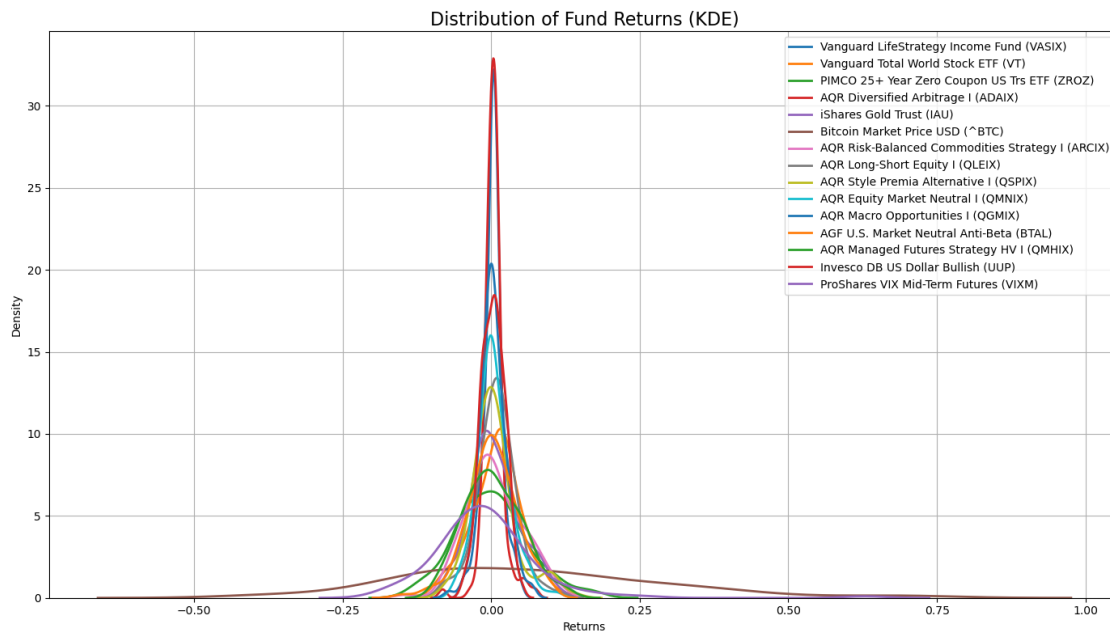
1.0.9 Kernel Density Estimate

```
[15]: # 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)

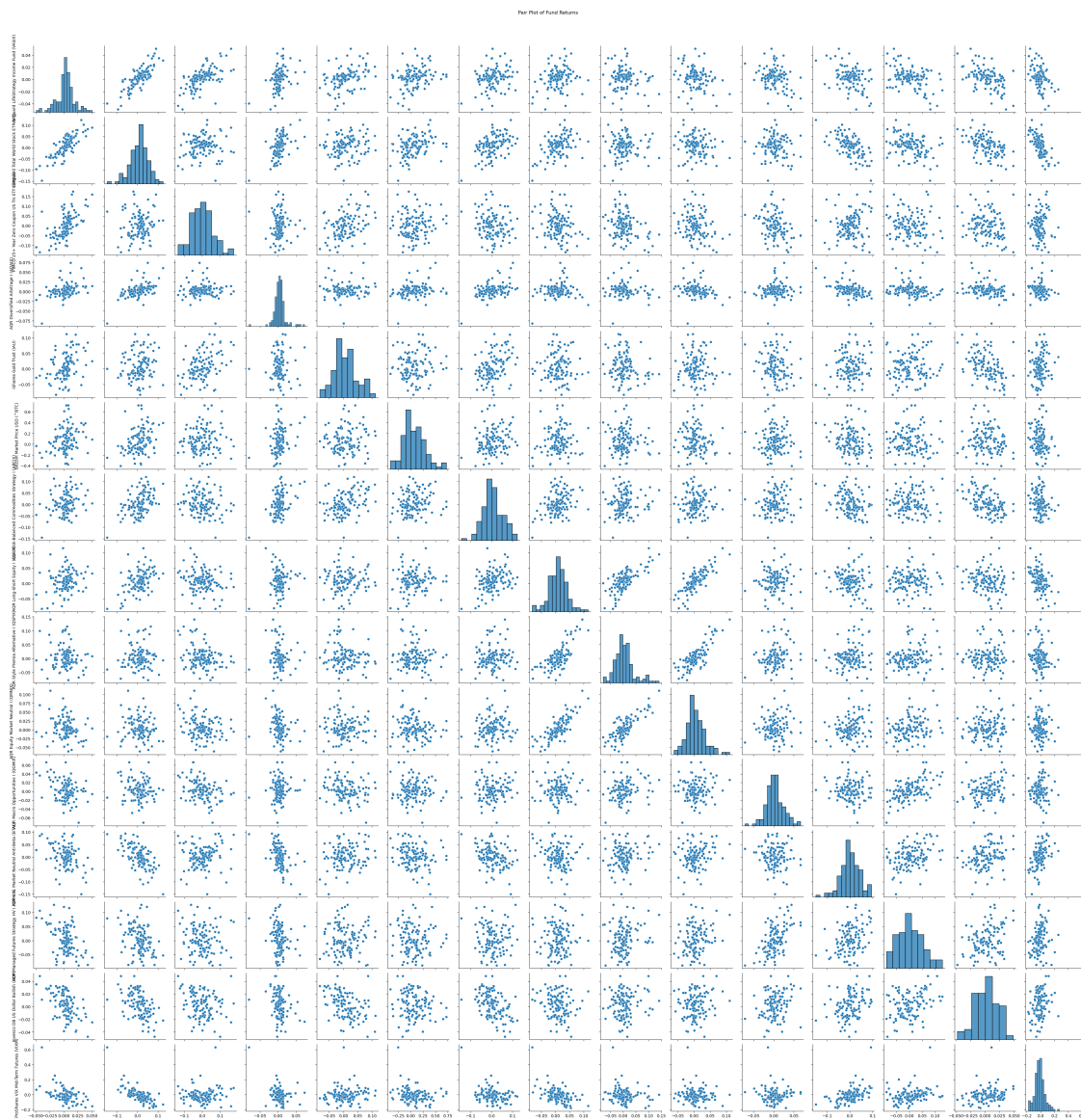
plt.title('Distribution of Fund Returns (KDE)', fontsize=16)
plt.xlabel('Returns')
plt.ylabel('Density')
plt.grid(True)
plt.legend(loc='upper right', bbox_to_anchor=(1, 1))
plt.tight_layout()
```

```
plt.show()
```



```
[16]: # 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()
```

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 distribution 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. 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.

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.

References

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

Opportunity Dataset - need link/website info