harry-browne-permanent-portfolio

April 23, 2025

1 Does Harry Browne's permanent portfolio withstand the test of time?

1.1 Python Imports

[1]:
```
# Standard Library
import datetime
import io
import os
import random
import sys
import warnings
from pathlib import Path

# Data Handling
import numpy as np
import pandas as pd

# Data Visualization
import matplotlib.dates as mdates
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import seaborn as sns
from matplotlib.ticker import FormatStrFormatter, FuncFormatter, MultipleLocator

# Data Sources
import yfinance as yf

# Statistical Analysis
import statsmodels.api as sm

# Machine Learning
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

# Suppress warnings
warnings.filterwarnings("ignore")
```

1.2 Add Directories To Path

[2]:
```python
# Add the source subdirectory to the system path to allow import config from settings.py
current_directory = Path(os.getcwd())
website_base_directory = current_directory.parent.parent.parent
src_directory = website_base_directory / "src"
sys.path.append(str(src_directory)) if str(src_directory) not in sys.path else None

# Now you can import settings.py
from settings import config

# Get configured directories and add to path
SOURCE_DIR = config("SOURCE_DIR")
sys.path.append(str(Path(SOURCE_DIR))) if str(Path(SOURCE_DIR)) not in sys.path else None

QUANT_FINANCE_RESEARCH_BASE_DIR = config("QUANT_FINANCE_RESEARCH_BASE_DIR")
sys.path.append(str(Path(QUANT_FINANCE_RESEARCH_BASE_DIR))) if str(Path(QUANT_FINANCE_RESEARCH_BASE_DIR)) not in sys.path else None

QUANT_FINANCE_RESEARCH_SOURCE_DIR = config("QUANT_FINANCE_RESEARCH_SOURCE_DIR")
sys.path.append(str(Path(QUANT_FINANCE_RESEARCH_SOURCE_DIR))) if str(Path(QUANT_FINANCE_RESEARCH_SOURCE_DIR)) not in sys.path else None

# Print system path
for i, path in enumerate(sys.path):
    print(f"{i}: {path}")
```

```
0: /usr/lib/python313.zip
1: /usr/lib/python3.13
2: /usr/lib/python3.13/lib-dynload
3:
4: /home/jared/python-virtual-envs/general_313/lib/python3.13/site-packages
5: /home/jared/Cloud_Storage/Dropbox/Websites/jaredszajkowski.github.io/src
6: /home/jared/Cloud_Storage/Dropbox/Quant_Finance_Research
7: /home/jared/Cloud_Storage/Dropbox/Quant_Finance_Research/src
```

1.3 Import Functions

[3]:
```python
# Import functions from source directories
from export_track_md_deps import export_track_md_deps
from df_info_markdown import df_info_markdown
from pandas_set_decimal_places import pandas_set_decimal_places
from load_data import load_data
from df_info import df_info
```

1.4 Track Index Dependencies

[4]:
```
# Create file to track markdown dependencies
dep_file = Path("index_dep.txt")
dep_file.write_text("")
```

[4]: 0

1.5 Python Functions

1.5.1 bb_data_updater

[5]:
```
# This function takes an excel export from Bloomberg and
# removes all excess data leaving date and close columns

# Imports
import pandas as pd

# Function definition
def bb_data_updater(fund):

    # File name variable
    file = fund + ".xlsx"

    # Import data from file as a pandas dataframe
    df = pd.read_excel(file, sheet_name = 'Worksheet', engine='openpyxl')

    # Set the column headings from row 5 (which is physically row 6)
    df.columns = df.iloc[5]

    # Set the column heading for the index to be "None"
    df.rename_axis(None, axis=1, inplace = True)

    # Drop the first 6 rows, 0 - 5
    df.drop(df.index[0:6], inplace=True)

    # Set the date column as the index
    df.set_index('Date', inplace = True)

    # Drop the volume column
    try:
        df.drop(columns = {'PX_VOLUME'}, inplace = True)
    except KeyError:
        pass

    # Rename column
    df.rename(columns = {'PX_LAST':'Close'}, inplace = True)
```

```python
    # Sort by date
    df.sort_values(by=['Date'], inplace = True)

    # Export data to excel
    file = fund + "_Clean.xlsx"
    df.to_excel(file, sheet_name='data')

    # Output confirmation
    print(f"The last date of data for {fund} is: ")
    print(df[-1:])
    print(f"Bloomberg data conversion complete for {fund} data")
    return print(f"--------------------")
```

1.5.2 strategy

[6]:
```python
def strategy(
    fund_list,
    starting_cash,
    cash_contrib,
    close_prices_df,
    rebal_month,
    rebal_day,
    rebal_per_high,
    rebal_per_low
):

    """
    Execute the rebalance strategy based on specified criteria.

    Args:
        fund_list (str): List of funds for data to be combined from. Funds are␣
 ↪strings in the form "BTC-USD".
        starting_cash (int): Starting investment balance.
        cash_contrib (int): Cash contribution to be made daily.
        close_prices_df (pd.DataFrame): DataFrame containing date and close␣
 ↪prices for all funds to be included.
        rebal_month (int): Month for annual rebalance.
        rebal_day (int): Day for annual rebalance.
        rebal_per_high (float): High percentage for rebalance.
        rebal_per_low (float): Low percentage for rebalance.

    Returns:
        pd.DataFrame: DataFrame containing strategy data for all funds to be␣
 ↪included. Also dumps the df to excel for reference later.
    """

    num_funds = len(fund_list)
```

```python
    df = close_prices_df.copy()
    df.reset_index(inplace = True)

    # Date to be used for annual rebalance
    target_month = rebal_month
    target_day = rebal_day

    # Create a dataframe with dates from the specific month
    rebal_date = df[df['Date'].dt.month == target_month]

    # Specify the date or the next closest
    rebal_date = rebal_date[rebal_date['Date'].dt.day >= target_day]

    # Group by year and take the first entry for each year
    rebal_dates_by_year = rebal_date.groupby(rebal_date['Date'].dt.year).first().reset_index(drop=True)

    '''
    Column order for the dataframe:
    df[fund + "_BA_Shares"]
    df[fund + "_BA_$_Invested"]
    df[fund + "_BA_Port_%"]
    df['Total_BA_$_Invested']
    df['Contribution']
    df['Rebalance']
    df[fund + "_AA_Shares"]
    df[fund + "_AA_$_Invested"]
    df[fund + "_AA_Port_%"]
    df['Total_AA_$_Invested']
    '''

    # Calculate the columns and initial values for before action (BA) shares, $ invested, and port %
    for fund in fund_list:
        df[fund + "_BA_Shares"] = starting_cash / num_funds / df[fund + "_Close"]
        df[fund + "_BA_$_Invested"] = df[fund + "_BA_Shares"] * df[fund + "_Close"]
        df[fund + "_BA_Port_%"] = 0.25

    # Set column values initially
    df['Total_BA_$_Invested'] = starting_cash
    df['Contribution'] = 0
    # df['Contribution'] = cash_contrib
    df['Rebalance'] = "No"
```

```python
    # Set columns and values initially for after action (AA) shares, $␣
↪invested, and port %
    for fund in fund_list:
        df[fund + "_AA_Shares"] = starting_cash / num_funds / df[fund +␣
↪"_Close"]
        df[fund + "_AA_$_Invested"] = df[fund + "_AA_Shares"] * df[fund +␣
↪"_Close"]
        df[fund + "_AA_Port_%"] = 0.25

    # Set column value for after action (AA) total $ invested
    df['Total_AA_$_Invested'] = starting_cash

    # Iterate through the dataframe and execute the strategy
    for index, row in df.iterrows():

        # Ensure there's a previous row to reference by checking the index value
        if index > 0:

            # Initialize variable
            Total_BA_Invested = 0

            # Calculate before action (BA) shares and $ invested values
            for fund in fund_list:
                df.at[index, fund + "_BA_Shares"] = df.at[index - 1, fund +␣
↪"_AA_Shares"]
                df.at[index, fund + "_BA_$_Invested"] = df.at[index, fund +␣
↪"_BA_Shares"] * row[fund + "_Close"]

                # Sum the asset values to find the total
                Total_BA_Invested = Total_BA_Invested + df.at[index, fund +␣
↪"_BA_$_Invested"]

            # Calculate before action (BA) port % values
            for fund in fund_list:
                df.at[index, fund + "_BA_Port_%"] = df.at[index, fund +␣
↪"_BA_$_Invested"] / Total_BA_Invested

            # Set column for before action (BA) total $ invested
            df.at[index, 'Total_BA_$_Invested'] = Total_BA_Invested

            # Initialize variables
            rebalance = "No"
            date = row['Date']

            # Check for a specific date annually
```

```
            # Simple if statement to check if date_to_check is in␣
↪jan_28_or_after_each_year
            if date in rebal_dates_by_year['Date'].values:
                rebalance = "Yes"
            else:
                pass

            # Check to see if any asset has portfolio percentage of greater␣
↪than 35% or less than 15% and if so set variable
            for fund in fund_list:
                if df.at[index, fund + "_BA_Port_%"] > rebal_per_high or df.
↪at[index, fund + "_BA_Port_%"] < rebal_per_low:
                    rebalance = "Yes"
                else:
                    pass

            # If rebalance is required, rebalance back to 25% for each asset,␣
↪else just divide contribution evenly across assets
            if rebalance == "Yes":
                df.at[index, 'Rebalance'] = rebalance
                for fund in fund_list:
                        df.at[index, fund + "_AA_$_Invested"] =␣
↪(Total_BA_Invested + df.at[index, 'Contribution']) * 0.25
            else:
                df.at[index, 'Rebalance'] = rebalance
                for fund in fund_list:
                        df.at[index, fund + "_AA_$_Invested"] = df.at[index,␣
↪fund + "_BA_$_Invested"] + df.at[index, 'Contribution'] * 0.25

            # Initialize variable
            Total_AA_Invested = 0

            # Set column values for after action (AA) shares and port %
            for fund in fund_list:
                df.at[index, fund + "_AA_Shares"] = df.at[index, fund +␣
↪"_AA_$_Invested"] / row[fund + "_Close"]

                # Sum the asset values to find the total
                Total_AA_Invested = Total_AA_Invested + df.at[index, fund +␣
↪"_AA_$_Invested"]

            # Calculate after action (AA) port % values
            for fund in fund_list:
                df.at[index, fund + "_AA_Port_%"] = df.at[index, fund +␣
↪"_AA_$_Invested"] / Total_AA_Invested
```

```
            # Set column for after action (AA) total $ invested
            df.at[index, 'Total_AA_$_Invested'] = Total_AA_Invested

        # If this is the first row
        else:
            pass

    df['Return'] = df['Total_AA_$_Invested'].pct_change()
    df['Cumulative_Return'] = (1 + df['Return']).cumprod()

    plan_name = '_'.join(fund_list)
    file = plan_name + "_Strategy.xlsx"
    location = file
    df.to_excel(location, sheet_name="data")
    print(f"Strategy complete for {plan_name}.")
    return df
```

1.5.3 summary__stats

[7]:
```
# Stats for entire data set
def summary_stats(
    fund_list,
    df,
    period,
    excel_export
):

    """
    Calculate summary statistics for the given fund list and return data.

    Args:
        fund_list (str): List of funds for data to be combined from. Funds are␣
↪strings in the form "BTC-USD".
        df (df): Dataframe with return data.
        period (str): Period for which to calculate statistics. Options are␣
↪"Monthly", "Weekly", "Daily", "Hourly".
        excel_export (bool): If True, export to excel file.

    Returns:
        pd.DataFrame: DataFrame containing various portfolio statistics.
    """

    if period == "Monthly":
        timeframe = 12 # months
    elif period == "Weekly":
        timeframe = 52 # weeks
    elif period == "Daily":
```

```
        timeframe = 365 # days
    elif period == "Hourly":
        timeframe = 8760 # hours
    else:
        return print("Error, check inputs")

    df_stats = pd.DataFrame(df.mean(axis=0) * timeframe) # annualized
    # df_stats = pd.DataFrame((1 + df.mean(axis=0)) ** timeframe - 1) #␣
↪annualized, this is this true annualized return but we will simply use the␣
↪mean
    df_stats.columns = ['Annualized Mean']
    df_stats['Annualized Volatility'] = df.std() * np.sqrt(timeframe) #␣
↪annualized
    df_stats['Annualized Sharpe Ratio'] = df_stats['Annualized Mean'] /␣
↪df_stats['Annualized Volatility']

    df_cagr = (1 + df['Return']).cumprod()
    cagr = (df_cagr.iloc[-1] / 1) ** (1/(len(df_cagr) / timeframe)) - 1
    df_stats['CAGR'] = cagr

    df_stats[period + ' Max Return'] = df.max()
    df_stats[period + ' Max Return (Date)'] = df.idxmax().values[0]
    df_stats[period + ' Min Return'] = df.min()
    df_stats[period + ' Min Return (Date)'] = df.idxmin().values[0]

    wealth_index = 1000*(1+df).cumprod()
    previous_peaks = wealth_index.cummax()
    drawdowns = (wealth_index - previous_peaks)/previous_peaks

    df_stats['Max Drawdown'] = drawdowns.min()
    df_stats['Peak'] = [previous_peaks[col][:drawdowns[col].idxmin()].idxmax()␣
↪for col in previous_peaks.columns]
    df_stats['Bottom'] = drawdowns.idxmin()

    recovery_date = []
    for col in wealth_index.columns:
        prev_max = previous_peaks[col][:drawdowns[col].idxmin()].max()
        recovery_wealth = pd.DataFrame([wealth_index[col][drawdowns[col].
↪idxmin():]]).T
        recovery_date.append(recovery_wealth[recovery_wealth[col] >= prev_max].
↪index.min())
    df_stats['Recovery Date'] = recovery_date

    plan_name = '_'.join(fund_list)

    # Export to excel
```

```
    if excel_export == True:

        file = plan_name + "_Summary_Stats.xlsx"
        location = file
        # location = f"{base_directory}/{strategy_name}/{file_name}.xlsx"
        df_stats.to_excel(location, sheet_name="data")
    else:
        pass

    print(f"Summary stats complete for {plan_name}.")
    return df_stats
```

1.5.4 plot_cumulative_return

```
[8]: def plot_cumulative_return(strat_df):
    # Generate plot
    plt.figure(figsize=(10, 5), facecolor = '#F5F5F5')

    # Plotting data
    plt.plot(strat_df.index, strat_df['Cumulative_Return'], label = 'Strategy␣
↪Cumulative Return', linestyle='-', color='green', linewidth=1)

    # Set X axis
    # x_tick_spacing = 5  # Specify the interval for x-axis ticks
    # plt.gca().xaxis.set_major_locator(MultipleLocator(x_tick_spacing))
    plt.gca().xaxis.set_major_locator(mdates.YearLocator())
    plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
    plt.xlabel('Year', fontsize = 9)
    plt.xticks(rotation = 45, fontsize = 7)
    # plt.xlim(, )

    # Set Y axis
    y_tick_spacing = 0.5  # Specify the interval for y-axis ticks
    plt.gca().yaxis.set_major_locator(MultipleLocator(y_tick_spacing))
    plt.ylabel('Cumulative Return', fontsize = 9)
    plt.yticks(fontsize = 7)
    # plt.ylim(0, 7.5)

    # Set title, etc.
    plt.title('Cumulative Return', fontsize = 12)

    # Set the grid & legend
    plt.tight_layout()
    plt.grid(True)
    plt.legend(fontsize=8)

    # Save the figure
```

```
    plt.savefig('03_Cumulative_Return.png', dpi=300, bbox_inches='tight')

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

1.5.5 plot_values

```
[9]: def plot_values(strat_df):
    # Generate plot
    plt.figure(figsize=(10, 5), facecolor = '#F5F5F5')

    # Plotting data
    plt.plot(strat_df.index, strat_df['Total_AA_$_Invested'], label='Total␣
 ↪Portfolio Value', linestyle='-', color='black', linewidth=1)
    plt.plot(strat_df.index, strat_df['Stocks_AA_$_Invested'], label='Stocks␣
 ↪Position Value', linestyle='-', color='orange', linewidth=1)
    plt.plot(strat_df.index, strat_df['Bonds_AA_$_Invested'], label='Bond␣
 ↪Position Value', linestyle='-', color='yellow', linewidth=1)
    plt.plot(strat_df.index, strat_df['Gold_AA_$_Invested'], label='Gold␣
 ↪Position Value', linestyle='-', color='blue', linewidth=1)
    plt.plot(strat_df.index, strat_df['Cash_AA_$_Invested'], label='Cash␣
 ↪Position Value', linestyle='-', color='brown', linewidth=1)

    # Set X axis
    # x_tick_spacing = 5  # Specify the interval for x-axis ticks
    # plt.gca().xaxis.set_major_locator(MultipleLocator(x_tick_spacing))
    plt.gca().xaxis.set_major_locator(mdates.YearLocator())
    plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
    plt.xlabel('Year', fontsize = 9)
    plt.xticks(rotation = 45, fontsize = 7)
    # plt.xlim(, )

    # Set Y axis
    y_tick_spacing = 5000  # Specify the interval for y-axis ticks
    plt.gca().yaxis.set_major_locator(MultipleLocator(y_tick_spacing))
    plt.gca().yaxis.set_major_formatter(mtick.FuncFormatter(lambda x, pos: '{:,.
 ↪0f}'.format(x))) # Adding commas to y-axis labels
    plt.ylabel('Total Value ($)', fontsize = 9)
    plt.yticks(fontsize = 7)
    # plt.ylim(0, 75000)

    # Set title, etc.
    plt.title('Total Values For Stocks, Bonds, Gold, and Cash Positions and␣
 ↪Portfolio', fontsize = 12)

    # Set the grid & legend
```

```
    plt.tight_layout()
    plt.grid(True)
    plt.legend(fontsize=8)

    # Save the figure
    plt.savefig('04_Portfolio_Values.png', dpi=300, bbox_inches='tight')

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

1.5.6 plot_drawdown

[10]:
```
def plot_drawdown(strat_df):
    rolling_max = strat_df['Total_AA_$_Invested'].cummax()
    drawdown = (strat_df['Total_AA_$_Invested'] - rolling_max) / rolling_max *␣
↪100

    # Generate plot
    plt.figure(figsize=(10, 5), facecolor = '#F5F5F5')

    # Plotting data
    plt.plot(strat_df.index, drawdown, label='Drawdown', linestyle='-',␣
↪color='red', linewidth=1)

    # Set X axis
    # x_tick_spacing = 5  # Specify the interval for x-axis ticks
    # plt.gca().xaxis.set_major_locator(MultipleLocator(x_tick_spacing))
    plt.gca().xaxis.set_major_locator(mdates.YearLocator())
    plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
    plt.xlabel('Year', fontsize = 9)
    plt.xticks(rotation = 45, fontsize = 7)
    # plt.xlim(, )

    # Set Y axis
    y_tick_spacing = 1  # Specify the interval for y-axis ticks
    plt.gca().yaxis.set_major_locator(MultipleLocator(y_tick_spacing))
    # plt.gca().yaxis.set_major_formatter(mtick.FuncFormatter(lambda x, pos: '{:
↪,.0f}'.format(x))) # Adding commas to y-axis labels
    plt.gca().yaxis.set_major_formatter(mtick.FuncFormatter(lambda x, pos: '{:.
↪0f}'.format(x))) # Adding 0 decimal places to y-axis labels
    plt.ylabel('Drawdown (%)', fontsize = 9)
    plt.yticks(fontsize = 7)
    # plt.ylim(-20, 0)

    # Set title, etc.
    plt.title('Portfolio Drawdown', fontsize = 12)
```

```python
    # Set the grid & legend
    plt.tight_layout()
    plt.grid(True)
    plt.legend(fontsize=8)

    # Save the figure
    plt.savefig('05_Portfolio_Drawdown.png', dpi=300, bbox_inches='tight')

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

1.5.7 plot_asset_weights

[11]:
```python
def plot_asset_weights(strat_df):
    # Generate plot
    plt.figure(figsize=(10, 5), facecolor = '#F5F5F5')

    # Plotting data
    plt.plot(strat_df.index, strat_df['Stocks_AA_Port_%'] * 100, label='Stocks␣
↪Portfolio Weight', linestyle='-', color='orange', linewidth=1)
    plt.plot(strat_df.index, strat_df['Bonds_AA_Port_%'] * 100, label='Bonds␣
↪Portfolio Weight', linestyle='-', color='yellow', linewidth=1)
    plt.plot(strat_df.index, strat_df['Gold_AA_Port_%'] * 100, label='Gold␣
↪Portfolio Weight', linestyle='-', color='blue', linewidth=1)
    plt.plot(strat_df.index, strat_df['Cash_AA_Port_%'] * 100, label='Cash␣
↪Portfolio Weight', linestyle='-', color='brown', linewidth=1)

    # Set X axis
    # x_tick_spacing = 5  # Specify the interval for x-axis ticks
    # plt.gca().xaxis.set_major_locator(MultipleLocator(x_tick_spacing))
    plt.gca().xaxis.set_major_locator(mdates.YearLocator())
    plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
    plt.xlabel('Year', fontsize = 9)
    plt.xticks(rotation = 45, fontsize = 7)
    # plt.xlim(, )

    # Set Y axis
    y_tick_spacing = 1  # Specify the interval for y-axis ticks
    plt.gca().yaxis.set_major_locator(MultipleLocator(y_tick_spacing))
    # plt.gca().yaxis.set_major_formatter(mtick.FuncFormatter(lambda x, pos: '{:
↪,.0f}'.format(x))) # Adding commas to y-axis labels
    plt.ylabel('Asset Weight (%)', fontsize = 9)
    plt.yticks(fontsize = 7)
    # plt.ylim(14, 36)

    # Set title, etc.
```

```
    plt.title('Portfolio Asset Weights For Stocks, Bonds, Gold, and Cash␣
↪Positions', fontsize = 12)

    # Set the grid & legend
    plt.tight_layout()
    plt.grid(True)
    plt.legend(fontsize=8)

    # Save the figure
    plt.savefig('07_Portfolio_Weights.png', dpi=300, bbox_inches='tight')

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

1.5.8 plot_annual_returns

[12]:
```
def plot_annual_returns(return_df):
    # Generate plot
    plt.figure(figsize=(10, 5), facecolor = '#F5F5F5')

    # Plotting data
    plt.bar(return_df.index, return_df['Return'] * 100, label='Annual Returns',␣
↪width=0.5)  # width adjusted for better spacing

    # Set X axis
    x_tick_spacing = 1  # Specify the interval for x-axis ticks
    plt.gca().xaxis.set_major_locator(MultipleLocator(x_tick_spacing))
    # plt.gca().xaxis.set_major_locator(mdates.YearLocator())
    # plt.gca().xaxis.set_major_formatter(mdates.DateFormatter('%Y'))
    plt.xlabel('Year', fontsize = 9)
    plt.xticks(rotation = 45, fontsize = 7)
    # plt.xlim(, )

    # Set Y axis
    y_tick_spacing = 1  # Specify the interval for y-axis ticks
    plt.gca().yaxis.set_major_locator(MultipleLocator(y_tick_spacing))
    # plt.gca().yaxis.set_major_formatter(mtick.FuncFormatter(lambda x, pos: '{:
↪,.0f}'.format(x))) # Adding commas to y-axis labels
    plt.ylabel('Annual Return (%)', fontsize = 9)
    plt.yticks(fontsize = 7)
    # plt.ylim(-20, 20)

    # Set title, etc.
    plt.title('Portfolio Annual Returns', fontsize = 12)

    # Set the grid & legend
    plt.tight_layout()
```

```python
    plt.grid(True)
    plt.legend(fontsize=8)

    # Save the figure
    plt.savefig('08_Portfolio_Annual_Returns.png', dpi=300, bbox_inches='tight')

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

1.6 Import Data

[13]:
```python
# Bonds dataframe
bb_data_updater('SPBDU10T_S&P US Treasury Bond 7-10 Year Total Return Index')
bonds_data = load_data('SPBDU10T_S&P US Treasury Bond 7-10 Year Total Return␣
↪Index_Clean.xlsx')
bonds_data['Date'] = pd.to_datetime(bonds_data['Date'])
bonds_data.set_index('Date', inplace = True)
bonds_data = bonds_data[(bonds_data.index >= '1990-01-01') & (bonds_data.index␣
↪<= '2023-12-31')]
bonds_data.rename(columns={'Close':'Bonds_Close'}, inplace=True)
bonds_data['Bonds_Daily_Return'] = bonds_data['Bonds_Close'].pct_change()
bonds_data['Bonds_Total_Return'] = (1 + bonds_data['Bonds_Daily_Return']).
↪cumprod()
bonds_data
```

```
The last date of data for SPBDU10T_S&P US Treasury Bond 7-10 Year Total Return
Index is:
              Close
Date
2024-04-30  579.024
Bloomberg data conversion complete for SPBDU10T_S&P US Treasury Bond 7-10 Year
Total Return Index data
--------------------
```

[13]:

	Bonds_Close	Bonds_Daily_Return	Bonds_Total_Return
Date			
1990-01-02	99.972	NaN	NaN
1990-01-03	99.733	-0.002391	0.997609
1990-01-04	99.813	0.000802	0.998410
1990-01-05	99.769	-0.000441	0.997969
1990-01-08	99.681	-0.000882	0.997089
…	…	…	…
2023-12-22	604.166	-0.000681	6.043352
2023-12-26	604.555	0.000644	6.047243
2023-12-27	609.355	0.007940	6.095257
2023-12-28	606.828	-0.004147	6.069980
2023-12-29	606.185	-0.001060	6.063548

```
[8527 rows x 3 columns]
```

[14]:
```
# Stocks dataframe
bb_data_updater('SPXT_S&P 500 Total Return Index')
stocks_data = load_data('SPXT_S&P 500 Total Return Index_Clean.xlsx')
stocks_data['Date'] = pd.to_datetime(stocks_data['Date'])
stocks_data.set_index('Date', inplace = True)
stocks_data = stocks_data[(stocks_data.index >= '1990-01-01') & (stocks_data.
  ↪index <= '2023-12-31')]
stocks_data.rename(columns={'Close':'Stocks_Close'}, inplace=True)
stocks_data['Stocks_Daily_Return'] = stocks_data['Stocks_Close'].pct_change()
stocks_data['Stocks_Total_Return'] = (1 + stocks_data['Stocks_Daily_Return']).
  ↪cumprod()
stocks_data
```

```
The last date of data for SPXT_S&P 500 Total Return Index is:
               Close
Date
2024-04-30  10951.66
Bloomberg data conversion complete for SPXT_S&P 500 Total Return Index data
--------------------
```

[14]:
```
            Stocks_Close  Stocks_Daily_Return  Stocks_Total_Return
Date
1990-01-01           NaN                  NaN                  NaN
1990-01-02        386.16                  NaN                  NaN
1990-01-03        385.17            -0.002564             0.997436
1990-01-04        382.02            -0.008178             0.989279
1990-01-05        378.30            -0.009738             0.979646
…                    …                    …                    …
2023-12-22      10292.37             0.001661            26.653123
2023-12-26      10335.98             0.004237            26.766056
2023-12-27      10351.60             0.001511            26.806505
2023-12-28      10356.59             0.000482            26.819427
2023-12-29      10327.83            -0.002777            26.744950

[8584 rows x 3 columns]
```

[15]:
```
# Gold dataframe
bb_data_updater('XAU_Gold USD Spot')
gold_data = load_data('XAU_Gold USD Spot_Clean.xlsx')
gold_data['Date'] = pd.to_datetime(gold_data['Date'])
gold_data.set_index('Date', inplace = True)
gold_data = gold_data[(gold_data.index >= '1990-01-01') & (gold_data.index <=␣
  ↪'2023-12-31')]
gold_data.rename(columns={'Close':'Gold_Close'}, inplace=True)
```

```
gold_data['Gold_Daily_Return'] = gold_data['Gold_Close'].pct_change()
gold_data['Gold_Total_Return'] = (1 + gold_data['Gold_Daily_Return']).cumprod()
gold_data
```

```
The last date of data for XAU_Gold USD Spot is:
              Close
Date
2024-05-01  2299.31
Bloomberg data conversion complete for XAU_Gold USD Spot data
--------------------
```

[15]:

```
            Gold_Close  Gold_Daily_Return  Gold_Total_Return
Date
1990-01-02      399.00                NaN                NaN
1990-01-03      395.00          -0.010025           0.989975
1990-01-04      396.50           0.003797           0.993734
1990-01-05      405.00           0.021438           1.015038
1990-01-08      404.60          -0.000988           1.014035
…                  …                 …                  …
2023-12-22     2053.08           0.003485           5.145564
2023-12-26     2067.81           0.007175           5.182481
2023-12-27     2077.49           0.004681           5.206742
2023-12-28     2065.61          -0.005718           5.176967
2023-12-29     2062.98          -0.001273           5.170376

[8819 rows x 3 columns]
```

[16]:

```
# Merge the stock data and bond data into a single DataFrame using their␣
↪indices (dates)
perm_port = pd.merge(stocks_data['Stocks_Close'], bonds_data['Bonds_Close'],␣
↪left_index=True, right_index=True)

# Add gold data to the portfolio DataFrame by merging it with the existing data␣
↪on indices (dates)
perm_port = pd.merge(perm_port, gold_data['Gold_Close'], left_index=True,␣
↪right_index=True)

# Add a column for cash with a constant value of 1 (assumes the value of cash␣
↪remains constant at $1 over time)
perm_port['Cash_Close'] = 1

# Remove any rows with missing values (NaN) to ensure clean data for further␣
↪analysis
perm_port.dropna(inplace=True)

# Display the finalized portfolio DataFrame
perm_port
```

[16]:

```
            Stocks_Close  Bonds_Close  Gold_Close  Cash_Close
Date
1990-01-02        386.16       99.972      399.00           1
1990-01-03        385.17       99.733      395.00           1
1990-01-04        382.02       99.813      396.50           1
1990-01-05        378.30       99.769      405.00           1
1990-01-08        380.04       99.681      404.60           1
…                    …           …          …          …
2023-12-22      10292.37      604.166     2053.08           1
2023-12-26      10335.98      604.555     2067.81           1
2023-12-27      10351.60      609.355     2077.49           1
2023-12-28      10356.59      606.828     2065.61           1
2023-12-29      10327.83      606.185     2062.98           1

[8479 rows x 4 columns]
```

[17]:

```python
# Check for any missing values in each column
missing_values = perm_port.isnull().any()

# Display columns with missing values
print(missing_values)
```

```
Stocks_Close    False
Bonds_Close     False
Gold_Close      False
Cash_Close      False
dtype: bool
```

[18]:

```python
df_info(perm_port)
```

```
The columns, shape, and data types are:
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 8479 entries, 1990-01-02 to 2023-12-29
Data columns (total 4 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Stocks_Close  8479 non-null   float64
 1   Bonds_Close   8479 non-null   float64
 2   Gold_Close    8479 non-null   float64
 3   Cash_Close    8479 non-null   int64
dtypes: float64(3), int64(1)
memory usage: 331.2 KB
None
The first 5 rows are:

            Stocks_Close  Bonds_Close  Gold_Close  Cash_Close
Date
1990-01-02        386.16       99.972       399.0           1
1990-01-03        385.17       99.733       395.0           1
```

```
1990-01-04        382.02       99.813       396.5            1
1990-01-05        378.30       99.769       405.0            1
1990-01-08        380.04       99.681       404.6            1
```

The last 5 rows are:

```
            Stocks_Close  Bonds_Close  Gold_Close  Cash_Close
Date
2023-12-22      10292.37      604.166     2053.08           1
2023-12-26      10335.98      604.555     2067.81           1
2023-12-27      10351.60      609.355     2077.49           1
2023-12-28      10356.59      606.828     2065.61           1
2023-12-29      10327.83      606.185     2062.98           1
```

1.7 Execute Strategy

[19]:

```python
# List of funds to be used
fund_list = ['Stocks', 'Bonds', 'Gold', 'Cash']

# Starting cash contribution
starting_cash = 10000

# Monthly cash contribution
cash_contrib = 0

strat = strategy(
    fund_list=fund_list,
    starting_cash=starting_cash,
    cash_contrib=cash_contrib,
    close_prices_df=perm_port,
    rebal_month=1,
    rebal_day=1,
    rebal_per_high=0.35,
    rebal_per_low=0.15)

strat = strat.set_index('Date')

sum_stats = summary_stats(
    fund_list=fund_list,
    df=strat[['Return']],
    period="Daily",
    excel_export=False)

strat_pre_1999 = strat[strat.index < '2000-01-01']
sum_stats_pre_1999 = summary_stats(
    fund_list=fund_list,
    df=strat_pre_1999[['Return']],
    period="Daily",
```

```python
    excel_export=False)

strat_post_1999 = strat[strat.index >= '2000-01-01']
sum_stats_post_1999 = summary_stats(
    fund_list=fund_list,
    df=strat_post_1999[['Return']],
    period="Daily",
    excel_export=False)

strat_post_2009 = strat[strat.index >= '2010-01-01']
sum_stats_post_2009 = summary_stats(
    fund_list=fund_list,
    df=strat_post_2009[['Return']],
    period="Daily",
    excel_export=False)
```

```
Strategy complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
```

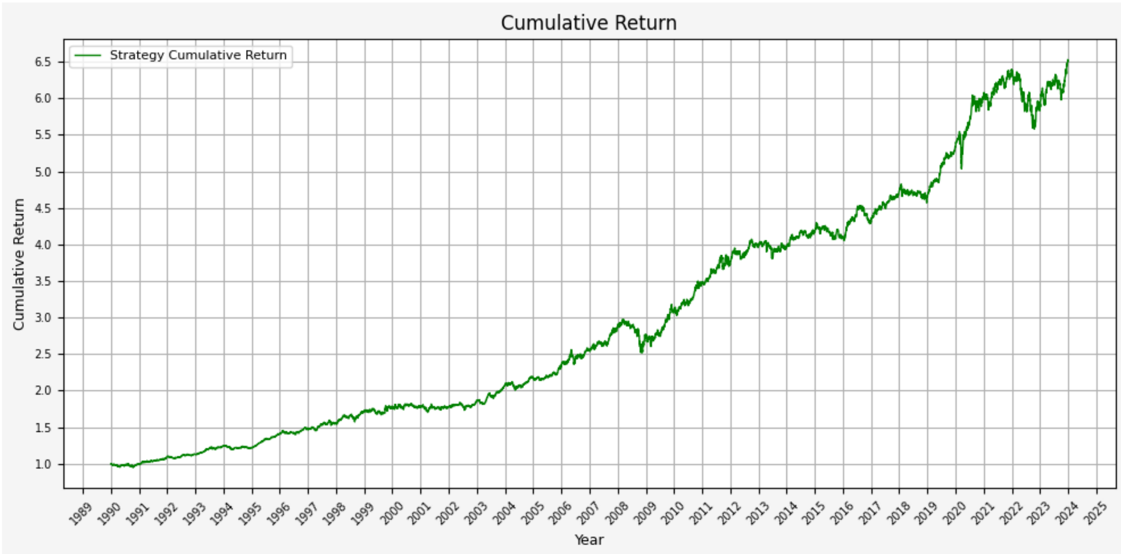
[20]:
```python
all_sum_stats = pd.concat([sum_stats])
all_sum_stats = all_sum_stats.rename(index={'Return': '1990 - 2023'})
all_sum_stats = pd.concat([all_sum_stats, sum_stats_pre_1999])
all_sum_stats = all_sum_stats.rename(index={'Return': 'Pre 1999'})
all_sum_stats = pd.concat([all_sum_stats, sum_stats_post_1999])
all_sum_stats = all_sum_stats.rename(index={'Return': 'Post 1999'})
all_sum_stats = pd.concat([all_sum_stats, sum_stats_post_2009])
all_sum_stats = all_sum_stats.rename(index={'Return': 'Post 2009'})
all_sum_stats
```

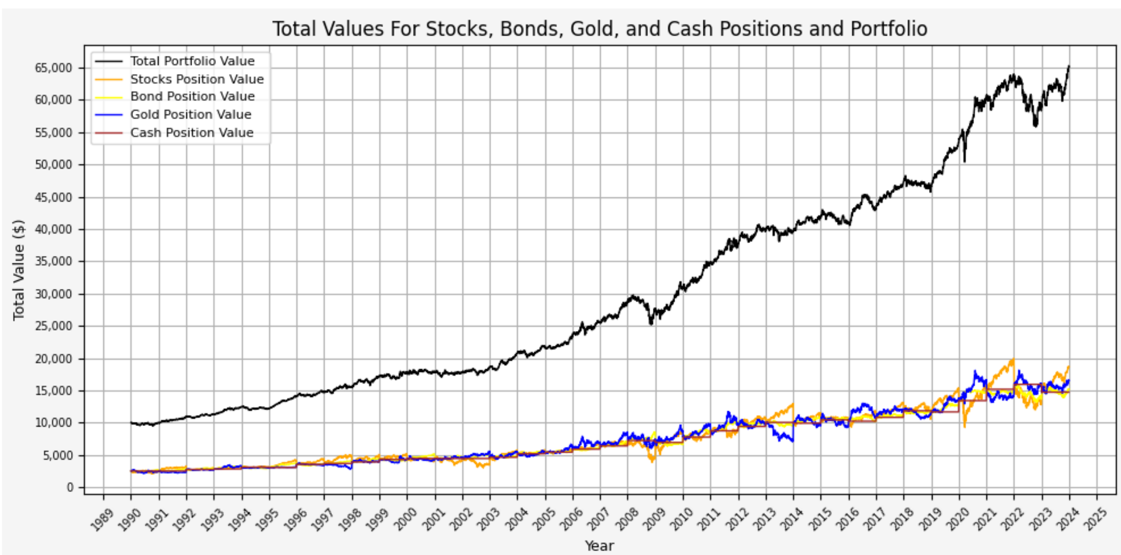
[20]:
```
             Annualized Mean  Annualized Volatility  Annualized Sharpe Ratio  \
1990 - 2023         0.083244               0.072251                 1.152142
Pre 1999            0.087544               0.060262                 1.452712
Post 1999           0.081473               0.076650                 1.062923
Post 2009           0.080996               0.072618                 1.115373

                 CAGR  Daily Max Return Daily Max Return (Date)  \
1990 - 2023  0.083953          0.028794              2020-03-24
Pre 1999     0.089462          0.021781              1999-09-28
Post 1999    0.081691          0.028794              2020-03-24
Post 2009    0.081501          0.028794              2020-03-24

             Daily Min Return Daily Min Return (Date)  Max Drawdown  \
1990 - 2023         -0.029852              2020-03-12     -0.153821
Pre 1999            -0.017880              1993-08-05     -0.062084
Post 1999           -0.029852              2020-03-12     -0.153821
```

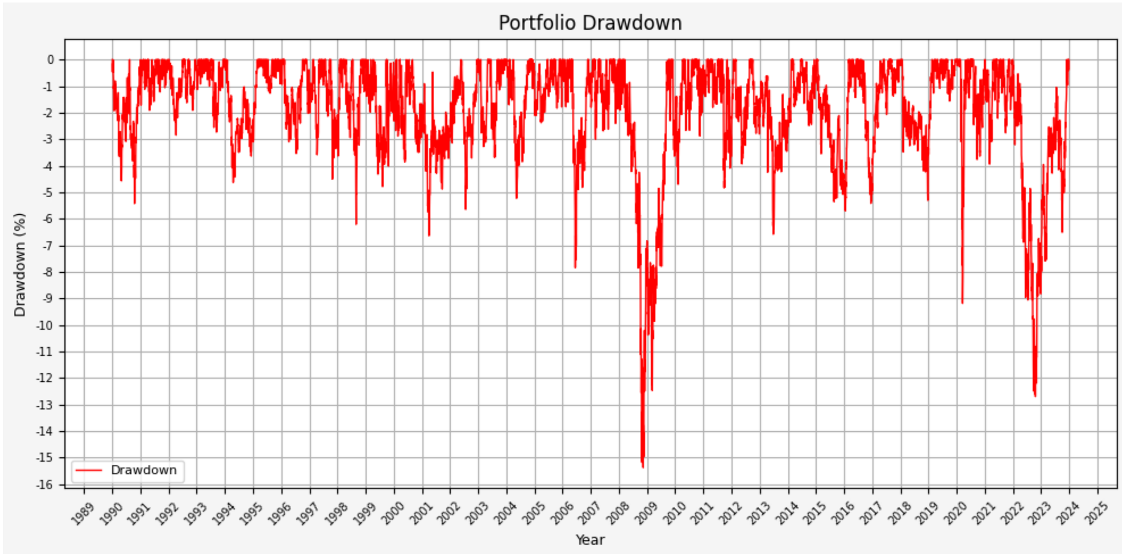
```
Post 2009          -0.029852            2020-03-12     -0.127055

                  Peak     Bottom Recovery Date
1990 - 2023 2008-03-18 2008-11-12    2009-10-06
Pre 1999    1998-07-20 1998-08-31    1998-11-05
Post 1999   2008-03-18 2008-11-12    2009-10-06
Post 2009   2021-12-27 2022-10-20    2023-12-01
```

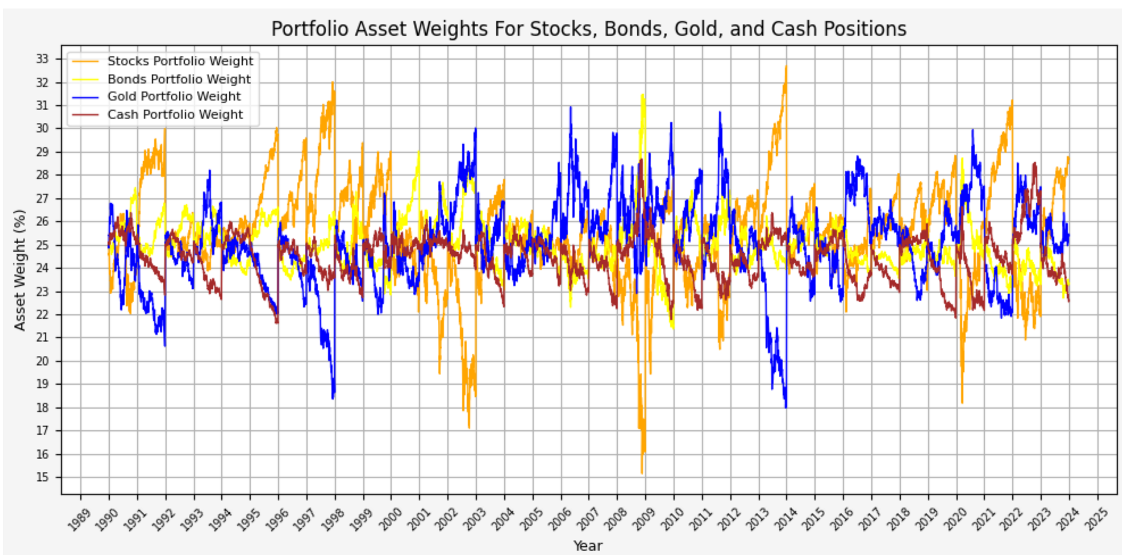
[21]:

```
plot_cumulative_return(strat)
plot_values(strat)
plot_drawdown(strat)
plot_asset_weights(strat)

# Create dataframe for the annual returns
strat_annual_returns = strat['Cumulative_Return'].resample('Y').last().
 ↪pct_change().dropna()
strat_annual_returns_df = strat_annual_returns.to_frame()
strat_annual_returns_df['Year'] = strat_annual_returns_df.index.year  # Add a␣
 ↪'Year' column with just the year
strat_annual_returns_df.reset_index(drop=True, inplace=True)  # Reset the index␣
 ↪to remove the datetime index

# Now the DataFrame will have 'Year' and 'Cumulative_Return' columns
strat_annual_returns_df = strat_annual_returns_df[['Year',␣
 ↪'Cumulative_Return']]  # Keep only 'Year' and 'Cumulative_Return' columns
strat_annual_returns_df.rename(columns = {'Cumulative_Return':'Return'},␣
 ↪inplace=True)
strat_annual_returns_df.set_index('Year', inplace=True)
display(strat_annual_returns_df)

plan_name = '_'.join(fund_list)
file = plan_name + "_Annual_Returns.xlsx"
location = file
strat_annual_returns_df.to_excel(location, sheet_name='data')

plot_annual_returns(strat_annual_returns_df)
```


Cumulative Return
Strategy Cumulative Return
Cumulative Return
Year

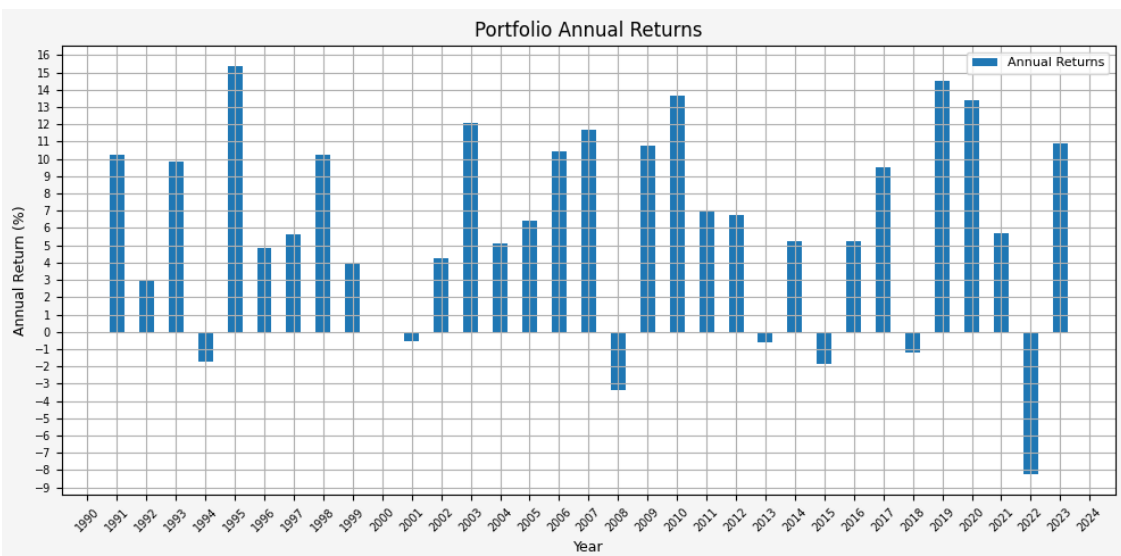

Total Values For Stocks, Bonds, Gold, and Cash Positions and Portfolio
Total Portfolio Value
Stocks Position Value
Bond Position Value
Gold Position Value
Cash Position Value
Total Value ($)
Year






```
        Return
Year
1991  0.102105
1992  0.030323
1993  0.098695
1994 -0.017222
1995  0.153473
1996  0.048529
1997  0.056127
1998  0.102107
```

```
1999  0.039196
2000  0.000025
2001 -0.005315
2002  0.042658
2003  0.120939
2004  0.051419
2005  0.064235
2006  0.104307
2007  0.117139
2008 -0.033383
2009  0.107354
2010  0.136550
2011  0.069683
2012  0.067507
2013 -0.006023
2014  0.052264
2015 -0.018332
2016  0.052463
2017  0.094968
2018 -0.011949
2019  0.145397
2020  0.133985
2021  0.056786
2022 -0.082424
2023  0.108761
```



1.8 Calculate stats for various rebalance dates

[22]:

```
# # List of funds to be used
# fund_list = ['Stocks', 'Bonds', 'Gold', 'Cash']

# # Starting cash contribution
# starting_cash = 10000

# # Monthly cash contribution
# cash_contrib = 0

# months = list(range(1, 13))
# days = list(range(1, 28))

# stats = pd.DataFrame(columns = ['Rebal_Month', 'Rebal_Day', 'Annualized␣
↪Mean', 'Annualized Volatility', 'Annualized Sharpe Ratio', 'CAGR',
#                                  'Daily Max Return', 'Daily Max Return␣
↪(Date)', 'Daily Min Return', 'Daily Min Return (Date)', 'Max Drawdown',
#                                  'Peak', 'Bottom', 'Recovery Date'])

# for month in months:
#     for day in days:
#         strat = strategy(fund_list, starting_cash, cash_contrib, perm_port,␣
↪month, day).set_index('Date')
#         sum_stats = summary_stats(fund_list, strat[['Return']], 'Daily')
#         stats = pd.concat([stats, sum_stats], ignore_index=True)
#         stats.loc[stats.index[-1], 'Rebal_Month'] = month
#         stats.loc[stats.index[-1], 'Rebal_Day'] = day
#         display(stats)

# plan_name = '_'.join(fund_list)
# file = plan_name + "_All_Summary_Stats.xlsx"
# location = file
# stats.to_excel(location, sheet_name='data')
# print(f"All summary stats complete for {plan_name}.")
```