harry-browne-permanent-portfolio

April 15, 2025

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

1.1 Python Imports

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

# Data Handling
import pandas as pd
import numpy as np

# Data Visualization
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import matplotlib.dates as mdates
import seaborn as sns
# import dataframe_image as dfi

from matplotlib.ticker import FuncFormatter, FormatStrFormatter, MultipleLocator

# Data Sources
import yfinance as yf

# Statistical Analysis
import statsmodels.api as sm
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

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

1.2 Set Base Directory

[2]:
```
# Add the base directory to the system path
base_directory = "/home/jared/Cloud_Storage/Dropbox/Quant_Finance_Research"
sys.path.append(base_directory)
```

1.3 Python Functions

1.3.1 bb_data_updater

[3]:
```
# 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)

    # 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"---------------------")
```

1.3.2 dp

[4]:
```
# Set number of decimal places in pandas

def dp(decimal_places):
    pd.set_option('display.float_format', lambda x: f'%.{decimal_places}f' % x)

dp(3)
```

1.3.3 df_info

[5]:
```
# The `df_info` function returns some useful information about
# a dataframe, such as the columns, data types, and size.

def df_info(df):
    print('The columns, shape, and data types are:')
    print(df.info())
    print('The first 5 rows are:')
    display(df.head())
    print('The last 5 rows are:')
    display(df.tail())
```

1.3.4 load_data

[6]:
```
def load_data(file):
    # Import CSV
    try:
        df = pd.read_csv(file)
    except:
        pass

    # Import excel
    try:
        df = pd.read_excel(file, sheet_name='data', engine='openpyxl')
    except:
        pass
```

```
    return df
```

1.3.5 strategy

[7]:
```
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)

    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"

    # 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
```

1.3.6 summary_stats

[8]:
```
# 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
```

1.3.7 plot_cumulative_return

[9]:
```
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()
```

1.3.8 plot_values

[10]:
```
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()
```

1.3.9 plot_drawdown

[11]:
```
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)

    # 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()
```

1.3.10 plot_asset_weights

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

1.3.11 plot_annual_returns

[13]:
```
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()
    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()
```

1.4 Import Data

[14]:
```
# 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
```

```
/home/jared/python-virtual-envs/general_313/lib/python3.13/site-
packages/pandas/core/indexes/base.py:7588: FutureWarning: Dtype inference on a
pandas object (Series, Index, ExtensionArray) is deprecated. The Index
constructor will keep the original dtype in the future. Call `infer_objects` on
the result to get the old behavior.
  return Index(sequences[0], name=names)
```

```
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
--------------------
```

[14]:

Date	Bonds_Close	Bonds_Daily_Return	Bonds_Total_Return
1990-01-02	99.972	NaN	NaN
1990-01-03	99.733	-0.002	0.998
1990-01-04	99.813	0.001	0.998
1990-01-05	99.769	-0.000	0.998
1990-01-08	99.681	-0.001	0.997
…	…	…	…
2023-12-22	604.166	-0.001	6.043
2023-12-26	604.555	0.001	6.047
2023-12-27	609.355	0.008	6.095
2023-12-28	606.828	-0.004	6.070
2023-12-29	606.185	-0.001	6.064

[8527 rows x 3 columns]

[15]:
```
# 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
```

```
/home/jared/python-virtual-envs/general_313/lib/python3.13/site-
packages/pandas/core/indexes/base.py:7588: FutureWarning: Dtype inference on a
pandas object (Series, Index, ExtensionArray) is deprecated. The Index
constructor will keep the original dtype in the future. Call `infer_objects` on
the result to get the old behavior.
  return Index(sequences[0], name=names)
```

```
The last date of data for SPXT_S&P 500 Total Return Index is:
               Close
Date
2024-04-30 10951.660
Bloomberg data conversion complete for SPXT_S&P 500 Total Return Index data
--------------------
```

```
/tmp/ipykernel_11017/1682549453.py:8: FutureWarning: The default
fill_method='pad' in Series.pct_change is deprecated and will be removed in a
future version. Either fill in any non-leading NA values prior to calling
pct_change or specify 'fill_method=None' to not fill NA values.
  stocks_data['Stocks_Daily_Return'] = stocks_data['Stocks_Close'].pct_change()
```

[15]:

Date	Stocks_Close	Stocks_Daily_Return	Stocks_Total_Return
1990-01-01	NaN	NaN	NaN
1990-01-02	386.160	NaN	NaN
1990-01-03	385.170	-0.003	0.997
1990-01-04	382.020	-0.008	0.989
1990-01-05	378.300	-0.010	0.980
…	…	…	…
2023-12-22	10292.370	0.002	26.653
2023-12-26	10335.980	0.004	26.766
2023-12-27	10351.600	0.002	26.807
2023-12-28	10356.590	0.000	26.819
2023-12-29	10327.830	-0.003	26.745

[8584 rows x 3 columns]

[16]:
```
# 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
```

```
/home/jared/python-virtual-envs/general_313/lib/python3.13/site-
packages/pandas/core/indexes/base.py:7588: FutureWarning: Dtype inference on a
pandas object (Series, Index, ExtensionArray) is deprecated. The Index
constructor will keep the original dtype in the future. Call `infer_objects` on
the result to get the old behavior.
  return Index(sequences[0], name=names)
The last date of data for XAU_Gold USD Spot is:
             Close
Date
2024-05-01 2299.310
Bloomberg data conversion complete for XAU_Gold USD Spot data
--------------------
```

[16]:

Date	Gold_Close	Gold_Daily_Return	Gold_Total_Return
1990-01-02	399.000	NaN	NaN
1990-01-03	395.000	-0.010	0.990
1990-01-04	396.500	0.004	0.994
1990-01-05	405.000	0.021	1.015
1990-01-08	404.600	-0.001	1.014
…	…	…	…
2023-12-22	2053.080	0.003	5.146
2023-12-26	2067.810	0.007	5.182
2023-12-27	2077.490	0.005	5.207
2023-12-28	2065.610	-0.006	5.177
2023-12-29	2062.980	-0.001	5.170

[8819 rows x 3 columns]

[17]:
```
# 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
```

[17]:

Date	Stocks_Close	Bonds_Close	Gold_Close	Cash_Close
1990-01-02	386.160	99.972	399.000	1
1990-01-03	385.170	99.733	395.000	1
1990-01-04	382.020	99.813	396.500	1
1990-01-05	378.300	99.769	405.000	1
1990-01-08	380.040	99.681	404.600	1
…	…	…	…	…
2023-12-22	10292.370	604.166	2053.080	1
2023-12-26	10335.980	604.555	2067.810	1
2023-12-27	10351.600	609.355	2077.490	1
2023-12-28	10356.590	606.828	2065.610	1
2023-12-29	10327.830	606.185	2062.980	1

[8479 rows x 4 columns]

[18]:
```
# 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
```

[19]:
```
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:
```

Date	Stocks_Close	Bonds_Close	Gold_Close	Cash_Close
1990-01-02	386.160	99.972	399.000	1
1990-01-03	385.170	99.733	395.000	1
1990-01-04	382.020	99.813	396.500	1
1990-01-05	378.300	99.769	405.000	1
1990-01-08	380.040	99.681	404.600	1

```
The last 5 rows are:
```

Date	Stocks_Close	Bonds_Close	Gold_Close	Cash_Close
2023-12-22	10292.370	604.166	2053.080	1
2023-12-26	10335.980	604.555	2067.810	1
2023-12-27	10351.600	609.355	2077.490	1
2023-12-28	10356.590	606.828	2065.610	1
2023-12-29	10327.830	606.185	2062.980	1

1.5 Execute Strategy

[20]:
```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",
    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)
```

```
/tmp/ipykernel_11017/15022227.py:104: FutureWarning: Setting an item of
incompatible dtype is deprecated and will raise an error in a future version of
pandas. Value '9962.55140947963' has dtype incompatible with int64, please
explicitly cast to a compatible dtype first.
  df.at[index, 'Total_BA_$_Invested'] = Total_BA_Invested
/tmp/ipykernel_11017/15022227.py:149: FutureWarning: Setting an item of
incompatible dtype is deprecated and will raise an error in a future version of
pandas. Value '9962.55140947963' has dtype incompatible with int64, please
explicitly cast to a compatible dtype first.
  df.at[index, 'Total_AA_$_Invested'] = Total_AA_Invested

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.
```

[21]:
```
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
```

[21]:

	Annualized Mean	Annualized Volatility	Annualized Sharpe Ratio	\
1990 - 2023	0.083	0.072	1.152	
Pre 1999	0.088	0.060	1.453	
Post 1999	0.081	0.077	1.063	
Post 2009	0.081	0.073	1.115	

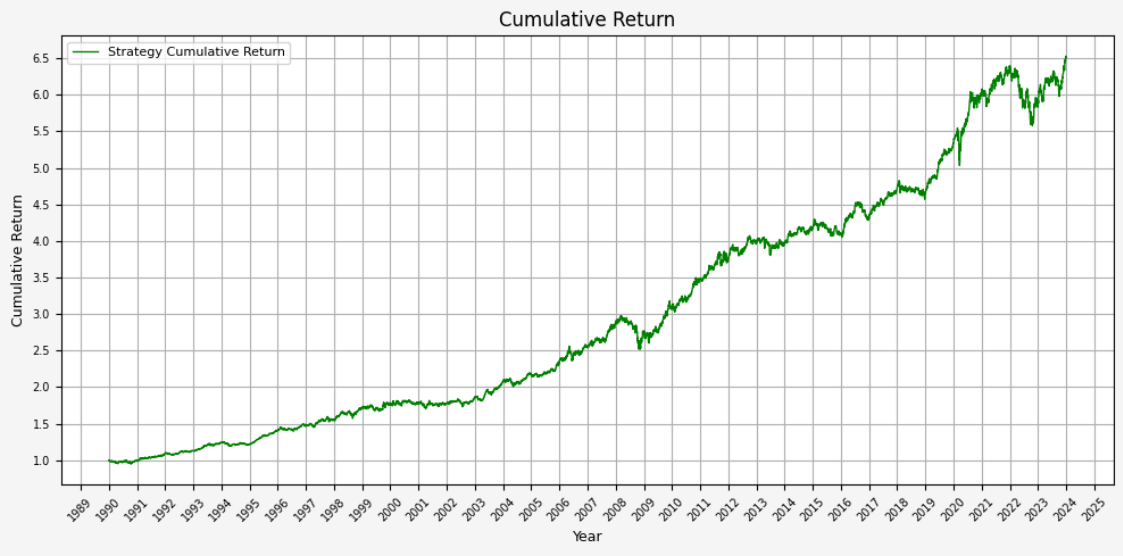
	CAGR	Daily Max Return	Daily Max Return (Date)	Daily Min Return	\
1990 - 2023	0.084	0.029	2020-03-24	-0.030	
Pre 1999	0.089	0.022	1999-09-28	-0.018	
Post 1999	0.082	0.029	2020-03-24	-0.030	
Post 2009	0.082	0.029	2020-03-24	-0.030	

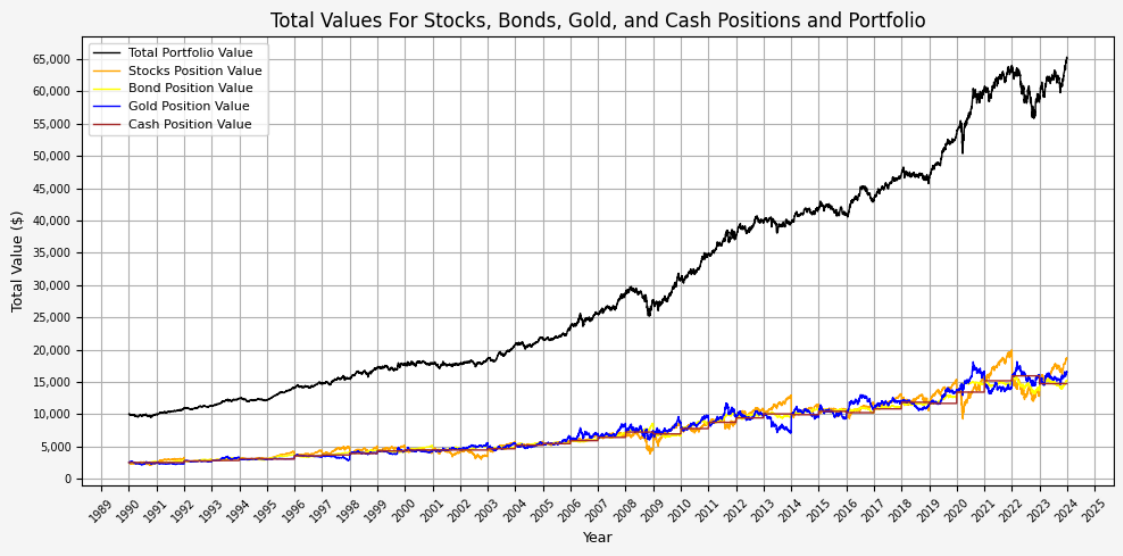
	Daily Min Return (Date)	Max Drawdown	Peak	Bottom	\
1990 - 2023	2020-03-12	-0.154	2008-03-18	2008-11-12	
Pre 1999	1993-08-05	-0.062	1998-07-20	1998-08-31	
Post 1999	2020-03-12	-0.154	2008-03-18	2008-11-12	
Post 2009	2020-03-12	-0.127	2021-12-27	2022-10-20	

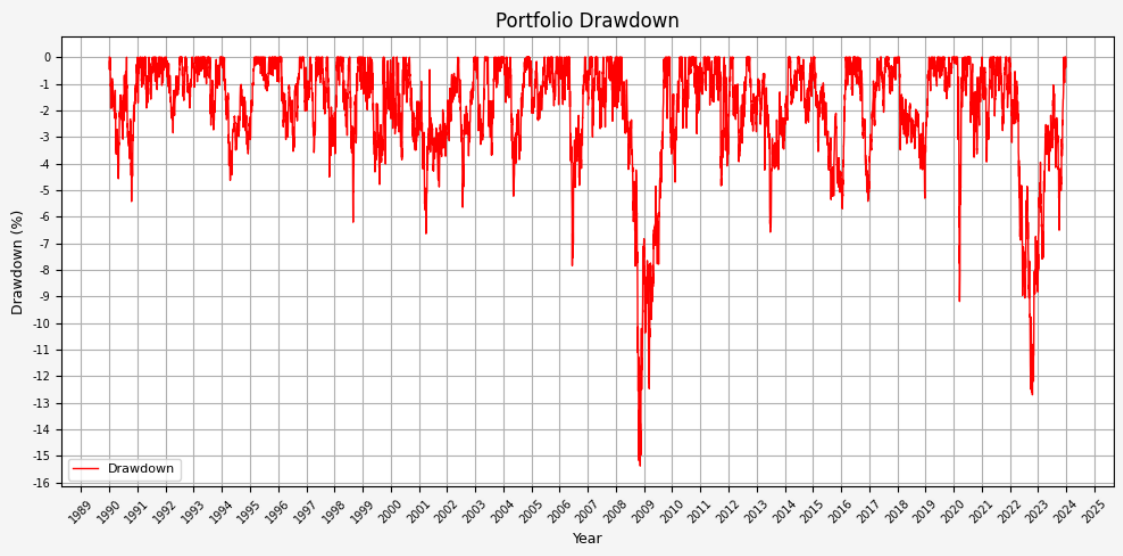
	Recovery Date
1990 - 2023	2009-10-06
Pre 1999	1998-11-05
Post 1999	2009-10-06
Post 2009	2023-12-01

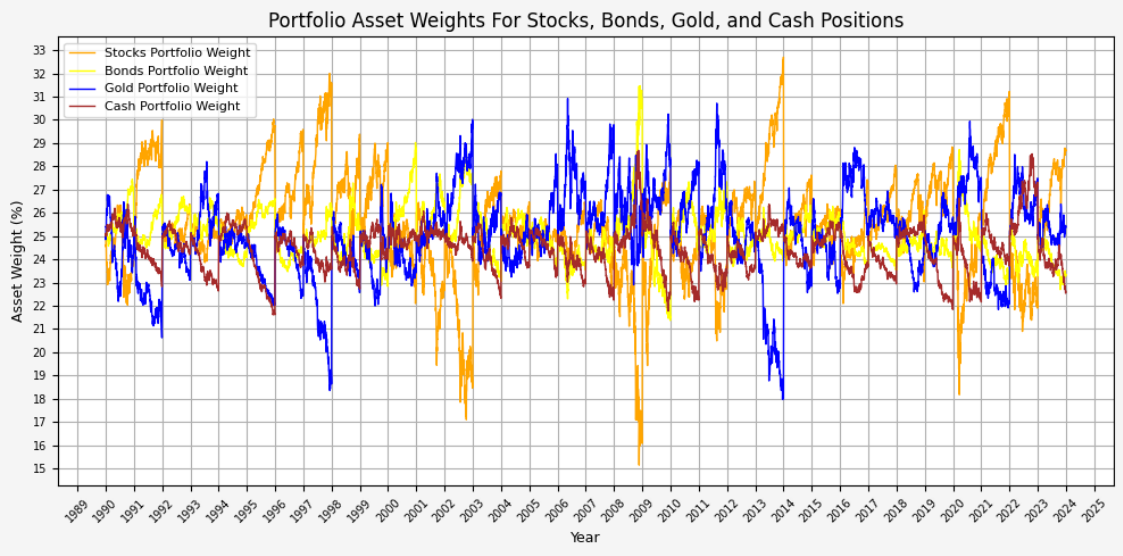
[22]:
```
plot_cumulative_return(strat)
plot_values(strat)
plot_drawdown(strat)
plot_asset_weights(strat)

# 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)
```




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

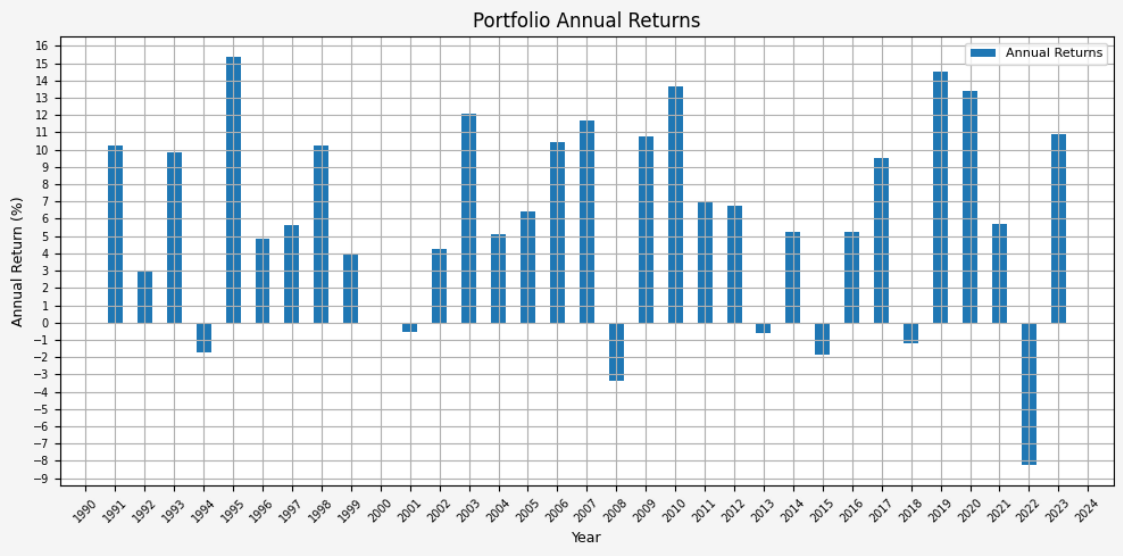

Portfolio Drawdown
Drawdown
Drawdown (%)
Year




```
/tmp/ipykernel_11017/2757918626.py:7: FutureWarning: 'Y' is deprecated and will
be removed in a future version, please use 'YE' instead.
  strat_annual_returns =
strat['Cumulative_Return'].resample('Y').last().pct_change().dropna()
```

Year	Return
1991	0.102
1992	0.030
1993	0.099
1994	-0.017
1995	0.153
1996	0.049
1997	0.056
1998	0.102
1999	0.039
2000	0.000
2001	-0.005
2002	0.043
2003	0.121
2004	0.051
2005	0.064
2006	0.104
2007	0.117
2008	-0.033
2009	0.107
2010	0.137
2011	0.070
2012	0.068

```
2013  -0.006
2014   0.052
2015  -0.018
2016   0.052
2017   0.095
2018  -0.012
2019   0.145
2020   0.134
2021   0.057
2022  -0.082
2023   0.109
```



1.6 Calculate stats for various rebalance dates

[23]:
```
# # 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}.")
```