harry-browne-permanent-portfolio

March 23, 2025

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

1.1 Python Imports

[1]:
```
import os
import pandas as pd
import numpy as np
import datetime
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import matplotlib.dates as mdates
from matplotlib.ticker import FuncFormatter
from matplotlib.ticker import FormatStrFormatter
from matplotlib.ticker import MultipleLocator
import warnings
import seaborn as sns
import statsmodels.api as sm
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler
import random
warnings.filterwarnings("ignore")
```

1.2 Python Functions

1.2.1 bb_data_updater

[2]:
```
# 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"--------------------")
```

1.2.2 dp

[3]:
```
# 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)
```

1.2.3 df_info

[4]:
```
# 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())
```

1.2.4 load_data

[5]:
```
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
```

1.2.5 strategy

[6]:
```
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
```

1.2.6 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
```

1.2.7 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()
```

1.2.8 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()
```

1.2.9 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)

    # 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()
```

1.2.10 plot_asset_weights

[11]:
```
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()
```

1.2.11 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()
    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()
```

1.3 Import Data

[13]:
```
# 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]:

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]

[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 10951.660
Bloomberg data conversion complete for SPXT_S&P 500 Total Return Index data
--------------------
```

[14]:

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]
```

[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 2299.310
Bloomberg data conversion complete for XAU_Gold USD Spot data
--------------------
```

[15]:

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]

[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]:

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]

[17]:
```
# 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]:
```
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

1.4 Execute Strategy

[19]:
```
# 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)
```

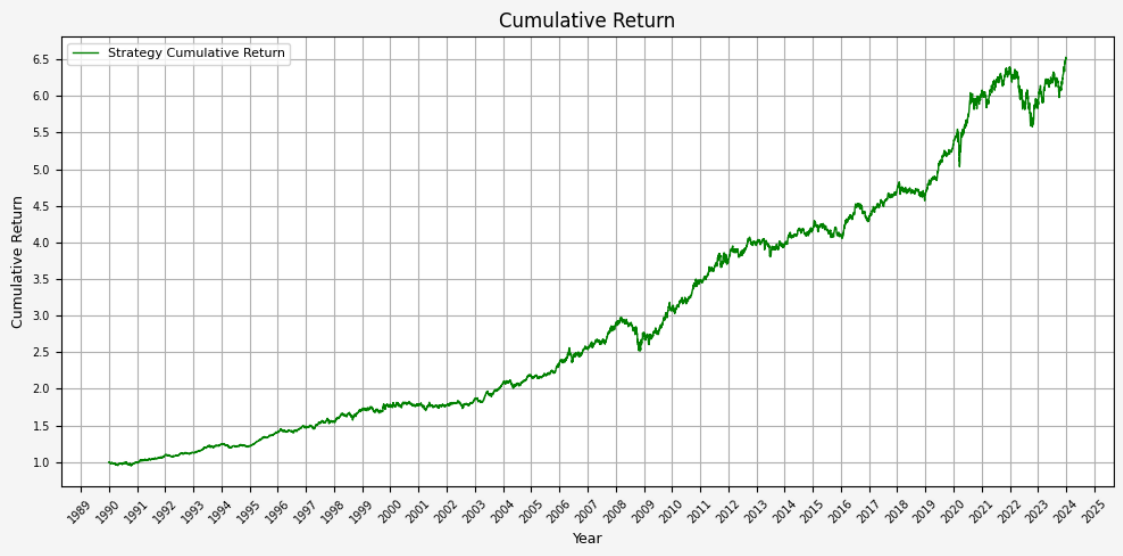
```
Strategy complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
Summary stats complete for Stocks_Bonds_Gold_Cash.
```

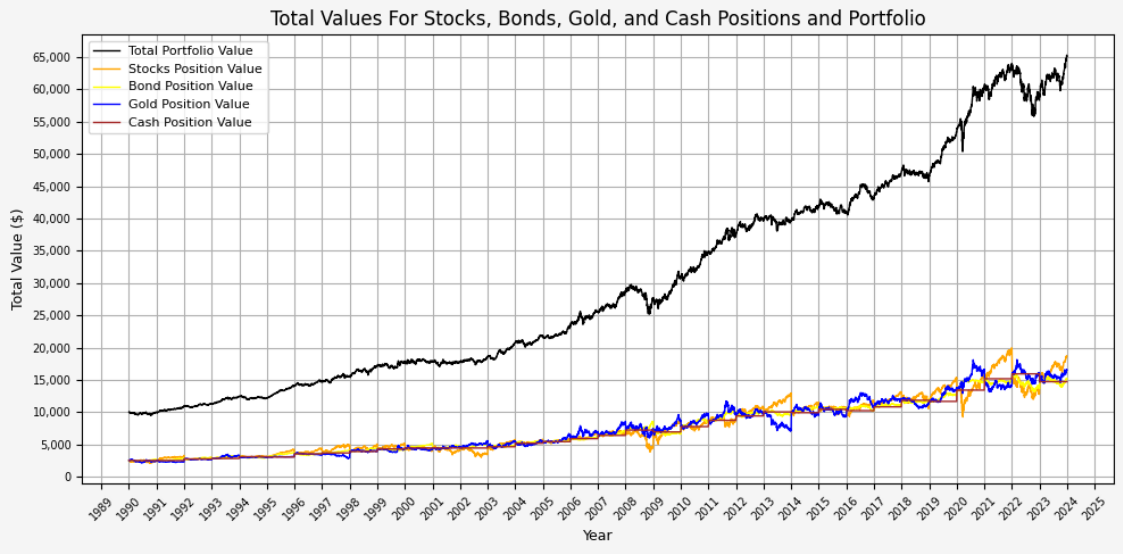
[20]:
```
all_sum_stats = pd.concat([sum_stats])
all_sum_stats = all_sum_stats.rename(index={'Return': '1990 - 2023'})
all_sum_stats = pd.concat([all_sum_stats, sum_stats_pre_1999])
all_sum_stats = all_sum_stats.rename(index={'Return': 'Pre 1999'})
all_sum_stats = pd.concat([all_sum_stats, sum_stats_post_1999])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

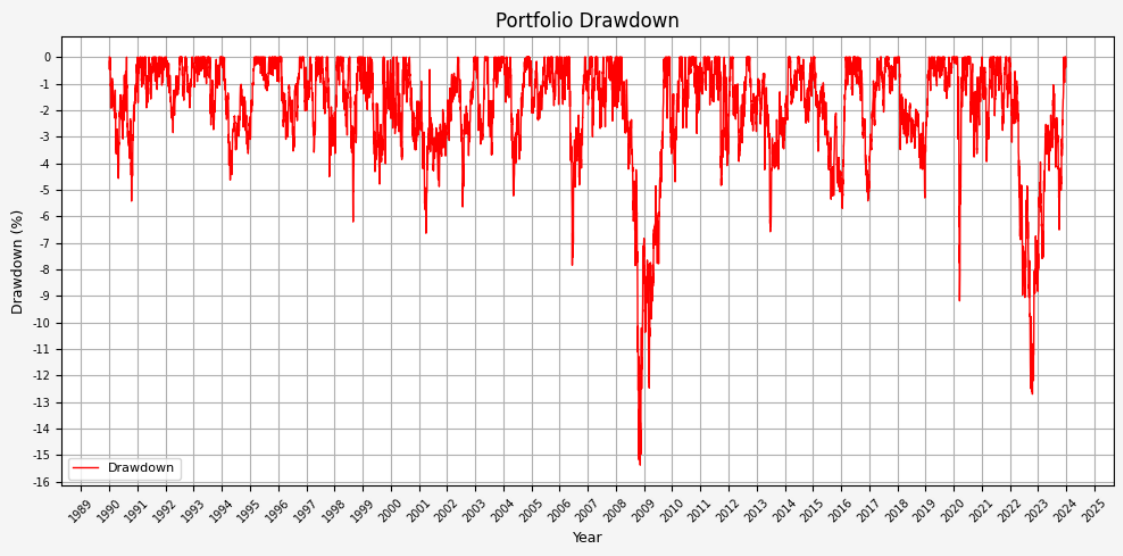
[20]:
```
             Annualized Mean  Annualized Volatility  Annualized Sharpe Ratio  \
1990 - 2023            0.083                  0.072                    1.152
Pre 1999               0.088                  0.060                    1.453
Post 1999              0.081                  0.077                    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
```

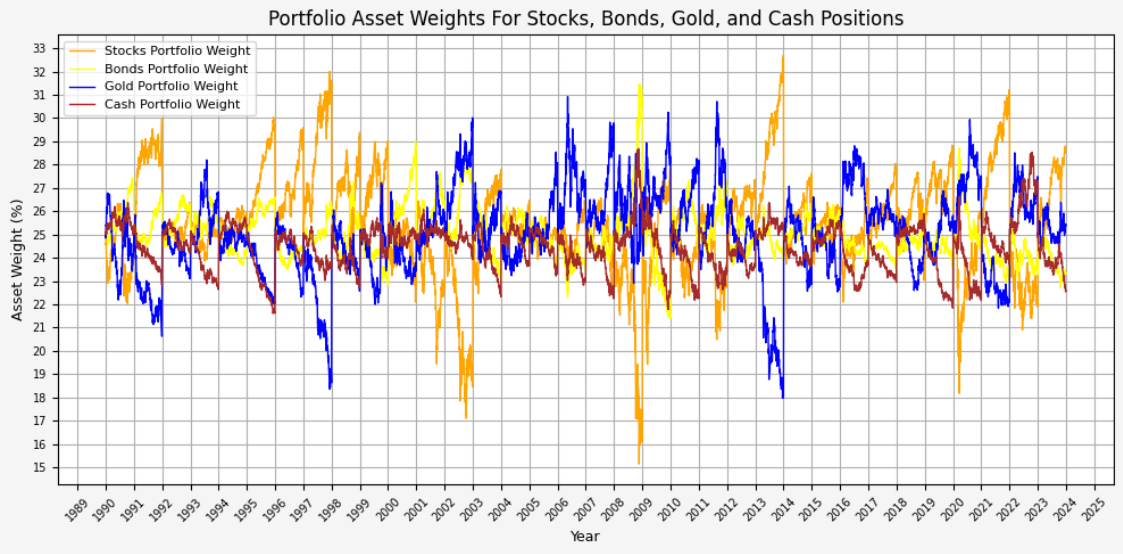
[21]:
```
plot_cumulative_return(strat)
plot_values(strat)
plot_drawdown(strat)
plot_asset_weights(strat)

# 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)
```



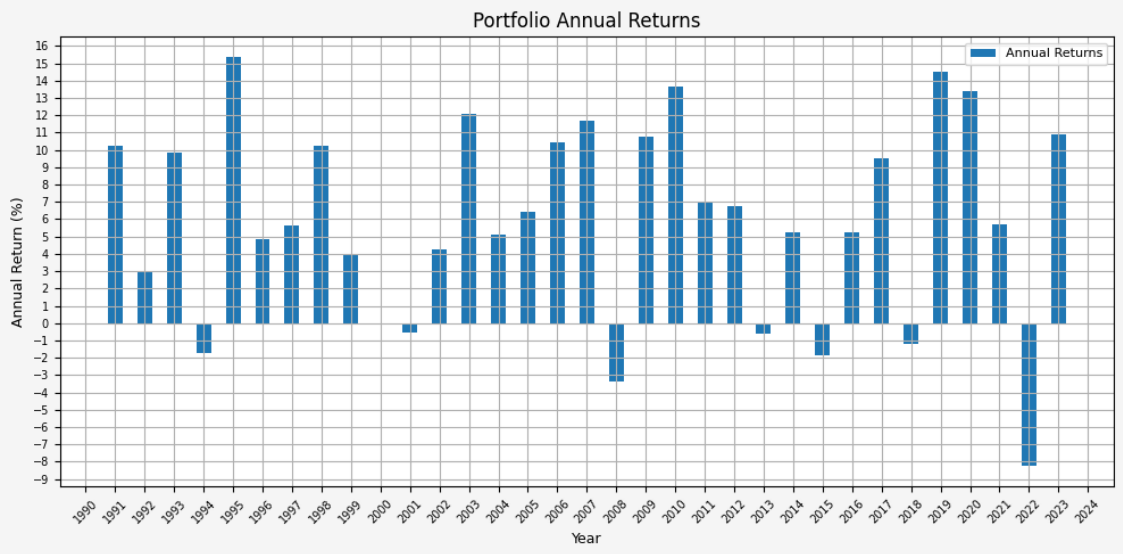






Year	Return
1991	0.102
1992	0.030
1993	0.099
1994	-0.017
1995	0.153
1996	0.049
1997	0.056
1998	0.102

```
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
```



1.5 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}.")
```