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 Track Index Dependencies

[3]:
```
# Define the dependency tracker
dep_file = Path("index_dep.txt")
Path("index_dep.txt").write_text("")

def export_and_track(md_filename: str, content: str):
    """Export markdown and append to index_dependencies.txt"""
    Path(md_filename).write_text(content)
    with dep_file.open("a") as f:
        f.write(md_filename + "\n")
    print(f"  Exported and tracked: {md_filename}")
```

1.4 Import Functions

[4]:
```
# TBD
```

2 Begin Index.md Here

2.1 Python Functions

2.1.1 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)

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

2.1.2 dp

[6]:
```
# 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)
```

2.1.3 df_info

[7]:
```
# 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())
```

2.1.4 load_data

[8]:
```
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
```

2.1.5 strategy

[9]:
```
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
```

2.1.6 summary_stats

[10]:
```
# 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
```

2.1.7 plot_cumulative_return

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

2.1.8 plot_values

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

2.1.9 plot_drawdown

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

2.1.10 plot_asset_weights

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

2.1.11 plot_annual_returns

[15]:
```
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()
```

2.2 Import Data

[16]:
```
# 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
--------------------
```

[16]:

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]

[17]:
```
# 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_16625/1682549453.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()
```

[17]:

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]

[18]:
```
# 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
--------------------
```

[18]:

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]
```

[19]:
```
# 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
```

[19]:
```
            Stocks_Close  Bonds_Close  Gold_Close  Cash_Close
Date
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]
```

[20]:
```
# 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
```

[21]:
```
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       386.160       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:

            Stocks_Close  Bonds_Close  Gold_Close  Cash_Close
Date
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
```

2.3 Execute Strategy

[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

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_16625/15022227.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_$_Invested'] = Total_BA_Invested
/tmp/ipykernel_16625/15022227.py:149: FutureWarning: Setting an item of
incompatible dtype is deprecated and will raise an error in a future version of
pandas. Value '9962.55140947963' has dtype incompatible with int64, please
explicitly cast to a compatible dtype first.
  df.at[index, 'Total_AA_$_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.
```

[23]:
```
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
```

[23]:

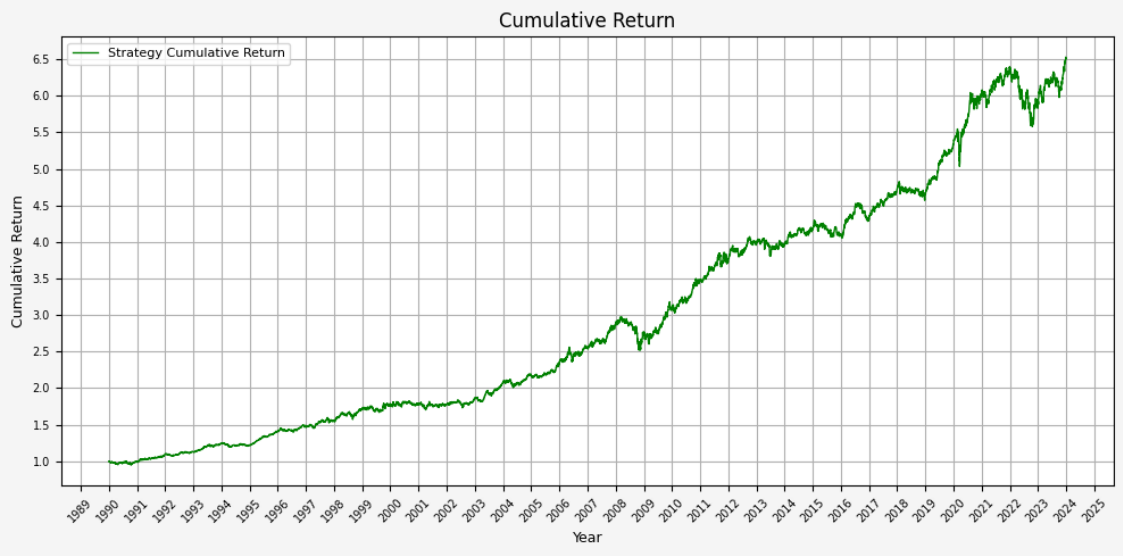
	Annualized Mean	Annualized Volatility	Annualized Sharpe Ratio	\
1990 - 2023	0.083	0.072	1.152	
Pre 1999	0.088	0.060	1.453	
Post 1999	0.081	0.077	1.063	
Post 2009	0.081	0.073	1.115	

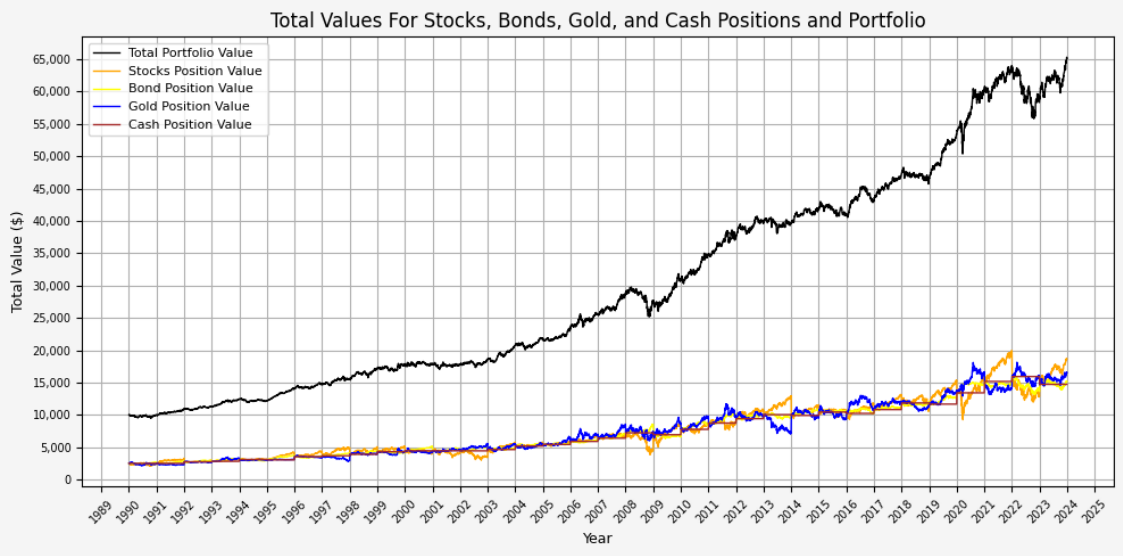
	CAGR	Daily Max Return	Daily Max Return (Date)	Daily Min Return	\
1990 - 2023	0.084	0.029	2020-03-24	-0.030	
Pre 1999	0.089	0.022	1999-09-28	-0.018	
Post 1999	0.082	0.029	2020-03-24	-0.030	
Post 2009	0.082	0.029	2020-03-24	-0.030	

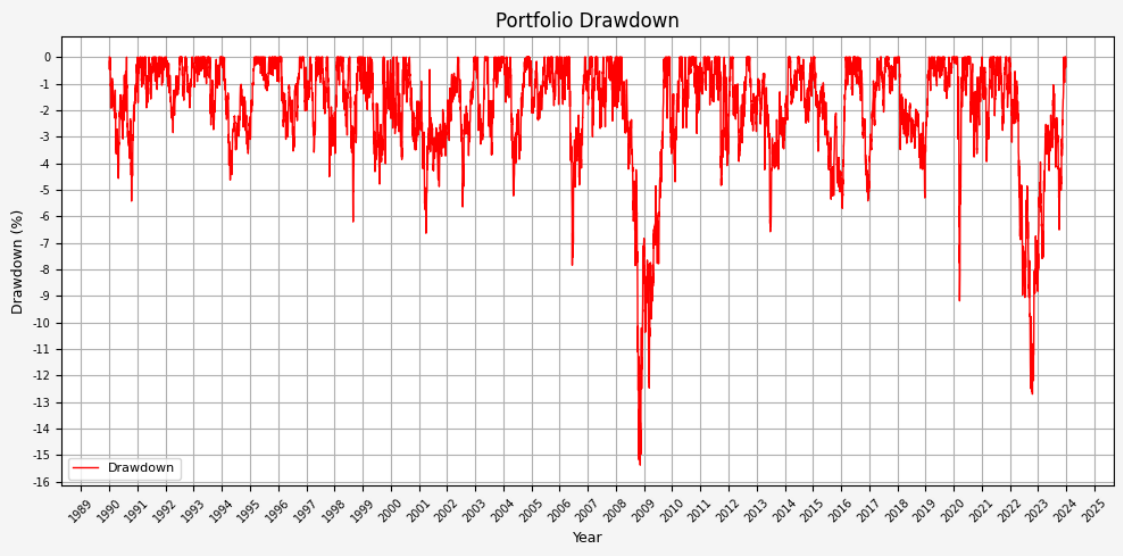
	Daily Min Return (Date)	Max Drawdown	Peak	Bottom	\
1990 - 2023	2020-03-12	-0.154	2008-03-18	2008-11-12	
Pre 1999	1993-08-05	-0.062	1998-07-20	1998-08-31	
Post 1999	2020-03-12	-0.154	2008-03-18	2008-11-12	
Post 2009	2020-03-12	-0.127	2021-12-27	2022-10-20	

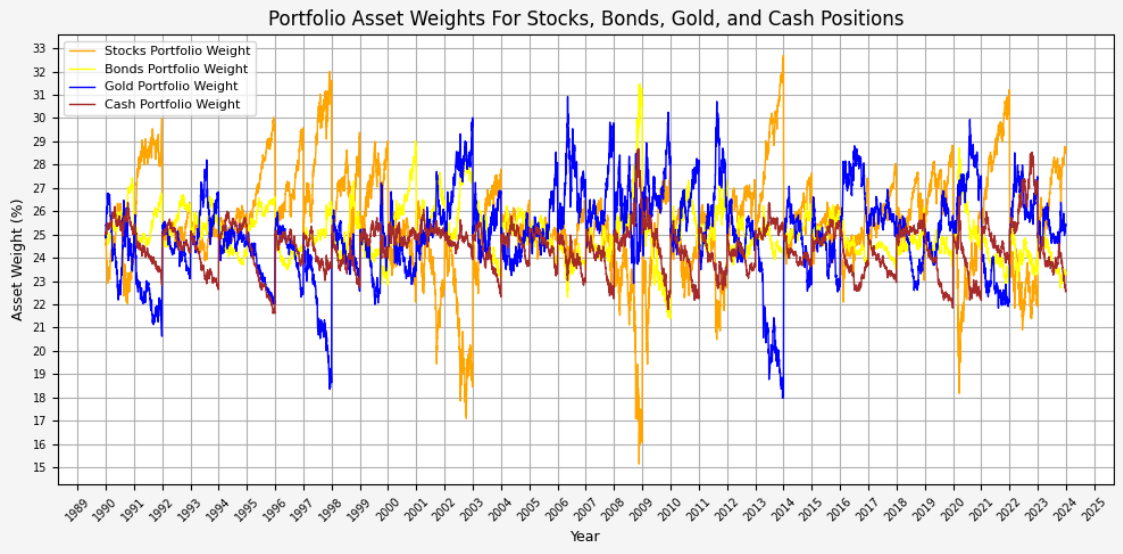
```
             Recovery Date
1990 - 2023    2009-10-06
Pre 1999       1998-11-05
Post 1999      2009-10-06
Post 2009      2023-12-01
```

[24]:
```
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

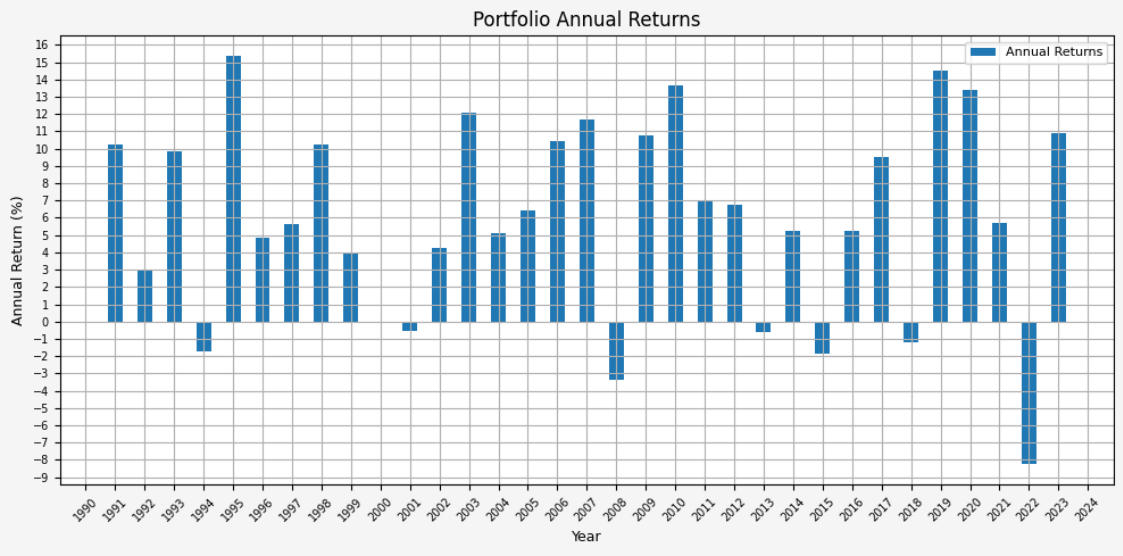





```
/tmp/ipykernel_16625/2757918626.py:7: FutureWarning: 'Y' is deprecated and will
be removed in a future version, please use 'YE' instead.
  strat_annual_returns =
strat['Cumulative_Return'].resample('Y').last().pct_change().dropna()
```

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
```



2.4 Calculate stats for various rebalance dates

[25]:
```
# # 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}.")
```