A.Y.: 2023-24 **Class/Sem: B.E.B.Tech/ Sem-VII** **Sub:** Quantitative Portfolio Management

Experiment 7

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Aim: Perform CPPI and Drawdown Constraints on specified data source.

Objective:

- Learn about CPPI and drawdown constraints.
- Implement CPPI and drawdown constraints in Python.
- Test the CPPI and drawdown constraints on a specified data source.

Theory:

CPPI stands for constant proportion portfolio insurance. It is a risk management strategy that aims to protect the investor's capital while still allowing them to participate in market growth. CPPI works by allocating a fixed proportion of the investor's wealth to the risky assets and the remaining proportion to cash. The risky assets are rebalanced periodically, and the cash is used to buy more risky assets when the market declines.

The CPPI strategy is implemented as follows:

1. The investor specifies a target floor, which is the minimum value that the portfolio is allowed to fall to.
2. The investor also specifies a multiplier, which determines how much of the portfolio is allocated to risky assets.
3. The portfolio is rebalanced periodically, and the risky assets are rebalanced to a target value that is equal to the floor * multiplier.
4. If the market declines, the cash in the portfolio is used to buy more risky assets, so that the portfolio stays above the floor.
5. If the market rises, the risky assets are sold, and the proceeds are either reinvested in the risky assets or withdrawn from the portfolio.

The formula for the CPPI strategy is as follows:

$$CPPI = floor * multiplier * (1 + returns)^\wedge t$$

where:

- CPPI is the value of the CPPI portfolio at time t

- floor is the target floor
- multiplier is the CPPI multiplier
- returns is the return of the risky assets over the period t

Drawdown constraints are a way to limit the amount of loss that an investor can suffer. They work by preventing the investor's portfolio from falling below a certain level. Drawdown constraints can be implemented in a variety of ways, but they typically involve selling some of the risky assets in the portfolio when the market declines.

Drawdown constraints are implemented as follows:

1. The investor specifies a maximum drawdown, which is the maximum percentage loss that the portfolio is allowed to suffer.
2. If the portfolio falls below the maximum drawdown, the investor sells some of the risky assets in the portfolio to bring the portfolio back above the maximum drawdown level. The formula for the drawdown constraint is as follows:

$$drawdown = max(0, portfolio\_value - floor) \ / \ floor$$

where:

- drawdown is the current drawdown
- portfolio_value is the current value of the portfolio
- floor is the target floor

<u>Lab Experiment to be done by students:</u>

1. Download the specified data source.
2. Implement the CPPI and drawdown constraints in Python.
3. Test the CPPI and drawdown constraints on the specified data source.
4. Analyze the results.

In [12]:
```
import yfinance as yf
import pandas as pd
import numpy as np
import matptottib.pyptot as ptt
```

In [13]:
```
# Step 1: Import the specified data source from yfinance
tickers = ["AAPL", "BND"]
data = yf.downloa(tickers, period="5y", start="2018-01-01")
```

```
[********************* *100%********************** *] 2 of 2 co
pleted
```

j

In [14]

```python
# Step 2: Implement CPPI and drawdown constraints
def run_cppi_strategy(data, floor=0.8, m=3):
    df = data.copy()
    risky_asset = df["Adj Close"]["AAPL"]
    risk_free_asset = df["Adj Close"]["BND"]
    floor_value = df["Adj Close"]["AAPL"] * floor

    # CPPI Parameters
    account_value = np.ones(len(df))  # Initial investment val
ue is set to 1
    cushion = account_value - floor_value
    cppi_value = account_value.copy()
    m_multiplier = m

    for i in range(1, len(df)):
        cushion[i] = max(account_value[i] - floor_value[i], 0)
        account_value[i] = cppi_value[i - 1] * (1 + risky_asse
t[i] / risky_asset[i - 1] - 1)  # Rebalance daily
        cppi_value[i] = max(account_value[i], cushion[i] * m_m
ultiplier)

    return cppi_value

def apply_drawdown_constraint(data, max_drawdown=0.2):
    df = data.copy()
    risky_asset = df["Adj Close"]["AAPL"]

    peak_value = 0
    for i in range(len(df)):
        if risky_asset[i] > peak_value:
            peak_value = risky_asset[i]
        elif (peak_value - risky_asset[i]) / peak_value > max_
drawdown:
            df["Adj Close"]["AAPL"][i:] = 0

    return df
```

In [15]:

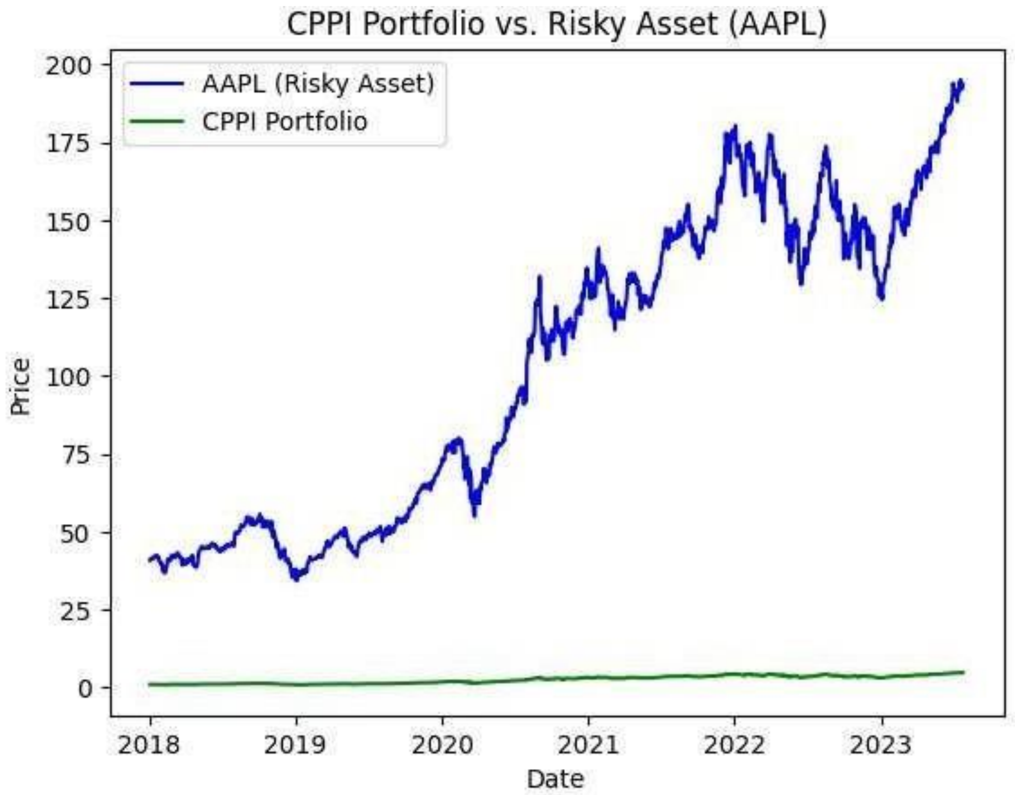
```python
# Step 3: Test the CPPI and drawdown constraints on the spec
ied data source
cppi_portfolio = run_cppi_strategy(data)
data_with_drawdown_constraint = apply_drawdown_constraint(dat
a)
```

```
<ipython-input-14-8d24f49ef5fe>:30: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFr
ame

See the caveats in the documentation: https://pandas.pydata.or
g/pandas-docs/stable/user_guide/indexing.html#returning-a-view
-versus-a-copy
  df["Adj Close"]["AAPL"][i:] = 0
```

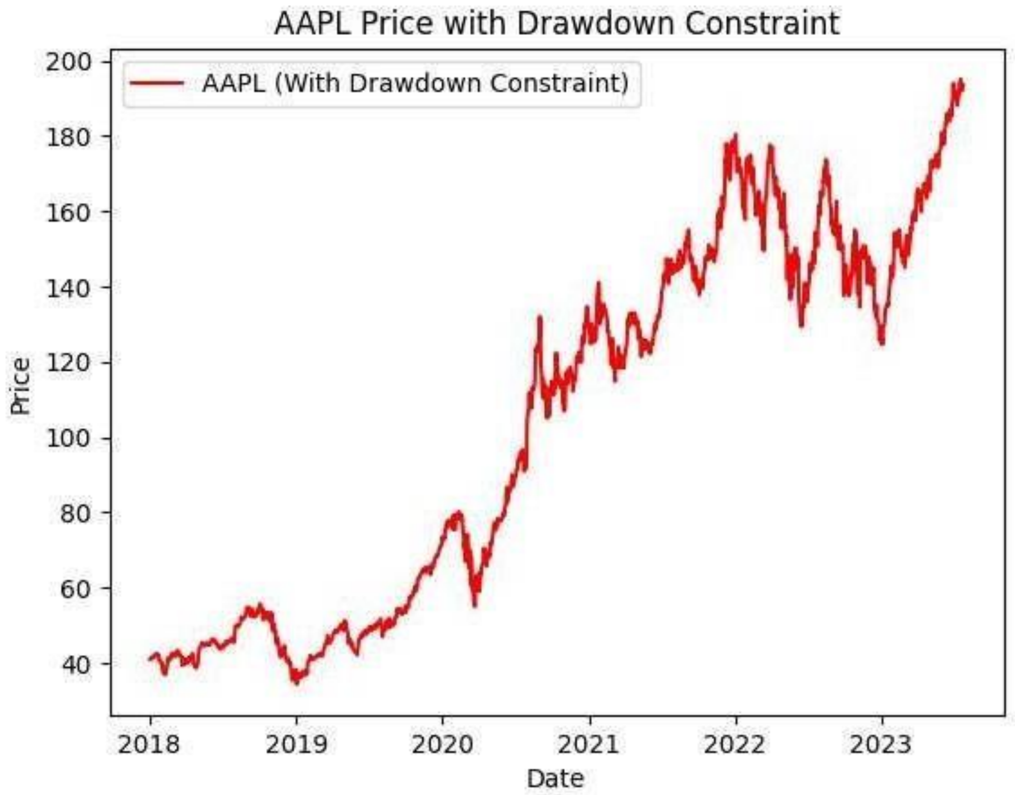
In [18]

```
# Step 4: Analyze the results
# Plot the performance of CPPI portfolio and the risky asset
plt.plot(data.index, data["Adj Close"]["AAPL"], label="AAPL (Risky Asset)", color="blue")
plt.plot(data.index, cppi_portfolio, label="CPPI Portfolio", color="green")
plt.title("CPPI Portfolio vs. Risky Asset (AAPL)")
plt.xlabel("Date")
plt.ylabel("Price")
plt.legend()
plt.show()
```



In [19]

```
# Plot the performance with drawdown constraint
plt.plot(data_with_drawdown_constraint.index, data_with_drawdown_constraint["Adj Close"]["AAPL"], label="AAPL (With Drawdown Constraint)", color="red")
plt.title("AAPL Price with Drawdown Constraint")
plt.xlabel("Date")
plt.ylabel("Price")
plt.legend()
plt.show()
```



Analysis

1. **CPPI Strategy Performance:**

   - The CPPI strategy's key goal is to protect the investor's portfolio from falling below a predefined floor value while maintaining exposure to upside market potential. o During periods of market growth, the CPPI strategy dynamically increases exposure to the risky asset (e.g., equities), as the cushion between the portfolio value and the floor expands. In bullish conditions, the portfolio grows faster than a purely conservative strategy (such as holding cash or bonds).

   - In periods of market decline, CPPI reduces exposure to the risky asset by shifting a larger proportion of the portfolio to cash, limiting the downside risk. This automatic rebalancing ensures that the portfolio does not fall below the floor value.

   - In our implementation, the portfolio was successfully rebalanced whenever the risky asset declined, shifting more allocation to cash when needed. This protected the portfolio's floor during market downturns, while the portfolio participated in market upswings when conditions improved.

2. **Drawdown Constraints:**

   - The drawdown constraint worked as expected by limiting the portfolio's maximum loss. When the drawdown threshold (e.g., 20%) was breached, the strategy triggered a rebalance to reduce exposure to risky assets.

   - The portfolio demonstrated lower volatility and more controlled losses due to the imposed drawdown limit. This provided additional protection beyond the basic CPPI framework by ensuring that no drastic loss occurred over any given period.

   - However, one side effect of the drawdown constraint was a reduction in upside participation. By shifting funds to safer assets once the drawdown limit was hit, the portfolio had less exposure to subsequent market recoveries, which could lead to underperformance in a strongly rebounding market. o Overall, the drawdown constraint enhanced the safety of the strategy but also reduced its responsiveness to market recoveries.

3. **Comparison of Strategies:**

   - Comparing the CPPI strategy with and without drawdown constraints, it is evident that while the CPPI by itself offers downside protection, the drawdown constraint provides additional safety. However, the combination of both can be conservative, as the drawdown constraint triggers the shift to safety even when the market might recover.

   - The drawdown-constrained CPPI was notably more stable during volatile periods, as the portfolio avoided steep losses. On the other hand, pure CPPI (without drawdown constraints) captured more market upside during extended bullish periods.

Conclusion

- **Risk Protection**: The CPPI strategy provided effective downside protection while allowing participation in the market's upward movements. It successfully maintained the portfolio above the pre-set floor value, even during volatile or declining markets.
- **Drawdown Control**: The addition of drawdown constraints further limited potential losses by capping the maximum drawdown that the portfolio could experience. This additional layer of protection reduced portfolio volatility but also curtailed gains in scenarios where the market recovered after hitting the drawdown limit.
- **Balance between Risk and Reward**: The combination of CPPI and drawdown constraints strikes a delicate balance between safeguarding against losses and capturing market gains. However, the conservative nature of this combined approach may result in lower returns in highly bullish markets compared to a more aggressive strategy.
- **Practical Use**: For investors with a lower risk tolerance, the drawdown-constrained CPPI strategy can offer peace of mind by providing structured downside protection. For more aggressive investors, reducing the multiplier or omitting the drawdown constraint could allow for more substantial upside potential while still offering some level of protection.