Bond Trading System

Kenneth Shinn

3 Parts

- **Business Cycles Indicator** (Inflation and GDP)
  - Aims to measure current location in a business cycle
- **Signal Generator** (one country and multiple countries)
  - Generates positions given the indicator
- **Returns Calculator** (one country and multiple countries)
  - Calculates daily returns given the positions

Business Cycles Indicator Desiderata

- Measure current location in a business cycle
  - High GDP and Inflation growth signify expanding economy
  - Expanding economy will lead to increases in the interest rate, decreasing value of bonds
- Quantify period GDP and Inflation growth as one easily interpretable and consistent number
  - The number should have a similar “impact” regardless of the date

Business Cycles Indicator Implementation

1. Calculate percent change of Real GDP and inflation
2. Calculate z-scores of RGDP and inflation growth using rolling means and SD
3. For each date, take a weighted average (RGDP 2, inflation 1) of the relevant z-scores.
4. Turn that weighted average of z's into a z-score with respect to all weighted average z's up until that date.

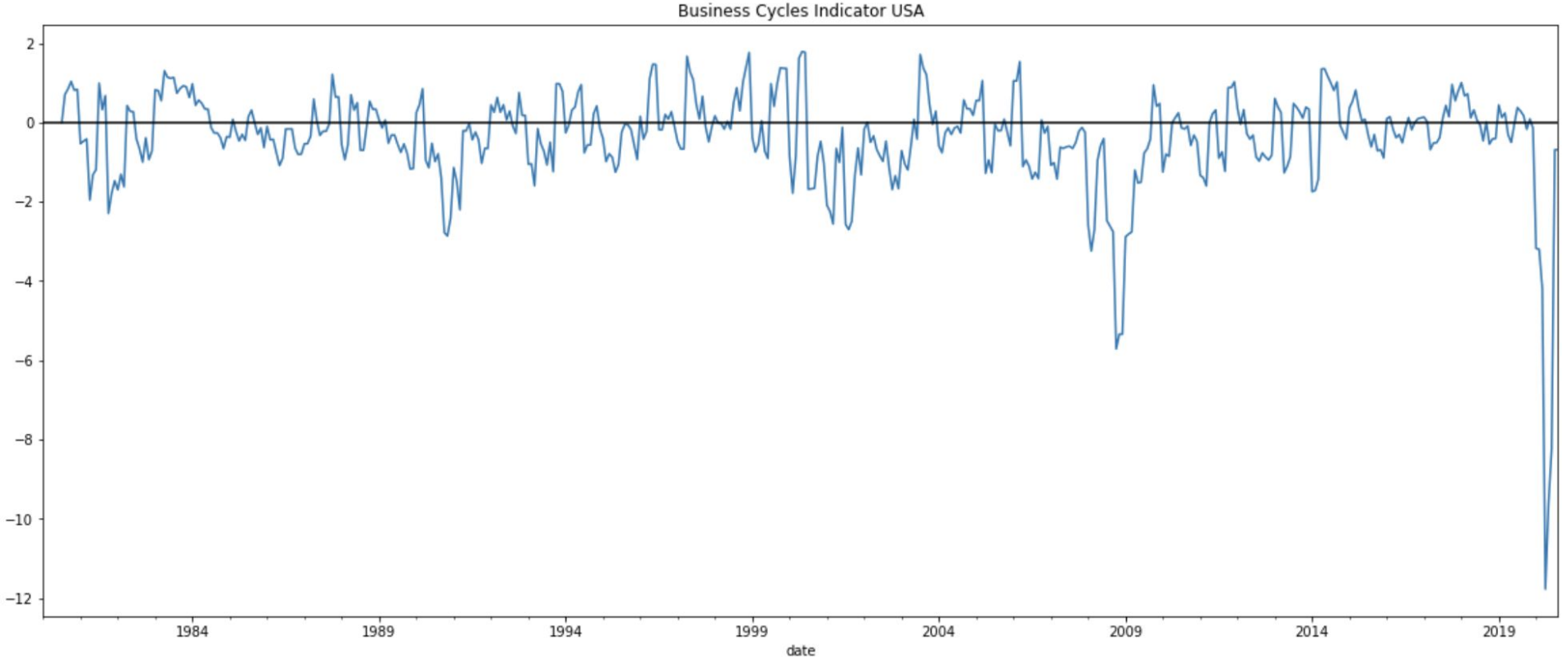
We are left with a data frame of values describing combined RGDP and inflation growth with respect to mean combined RGDP and inflation growth up until that date. This is our proxy for determining location in a business cycle. Positive values indicate to expansionary periods and negative values indicate recessionary periods.

Measurement Verification

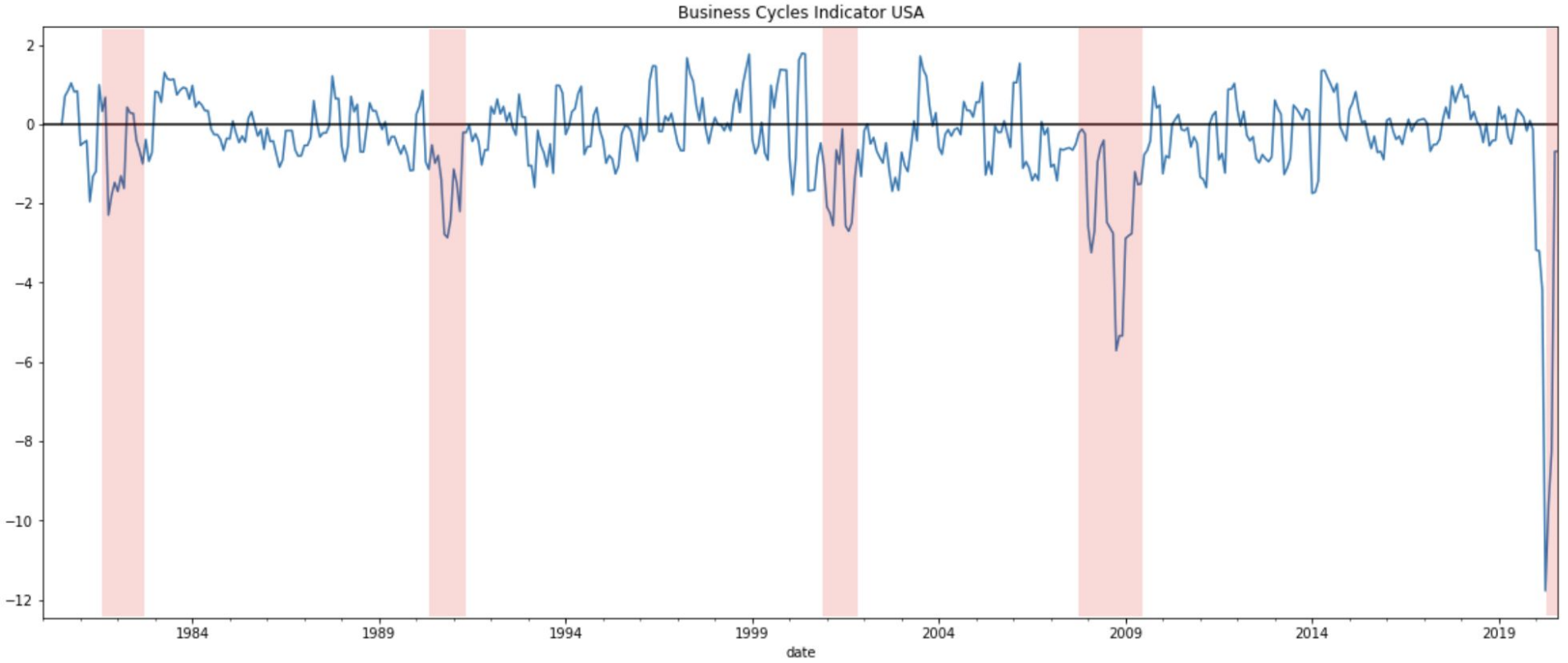
Does it actually measure what we want it to?

Let’s take a look at USA, CAN, and AUS.

Measurement Verification



Measurement Verification



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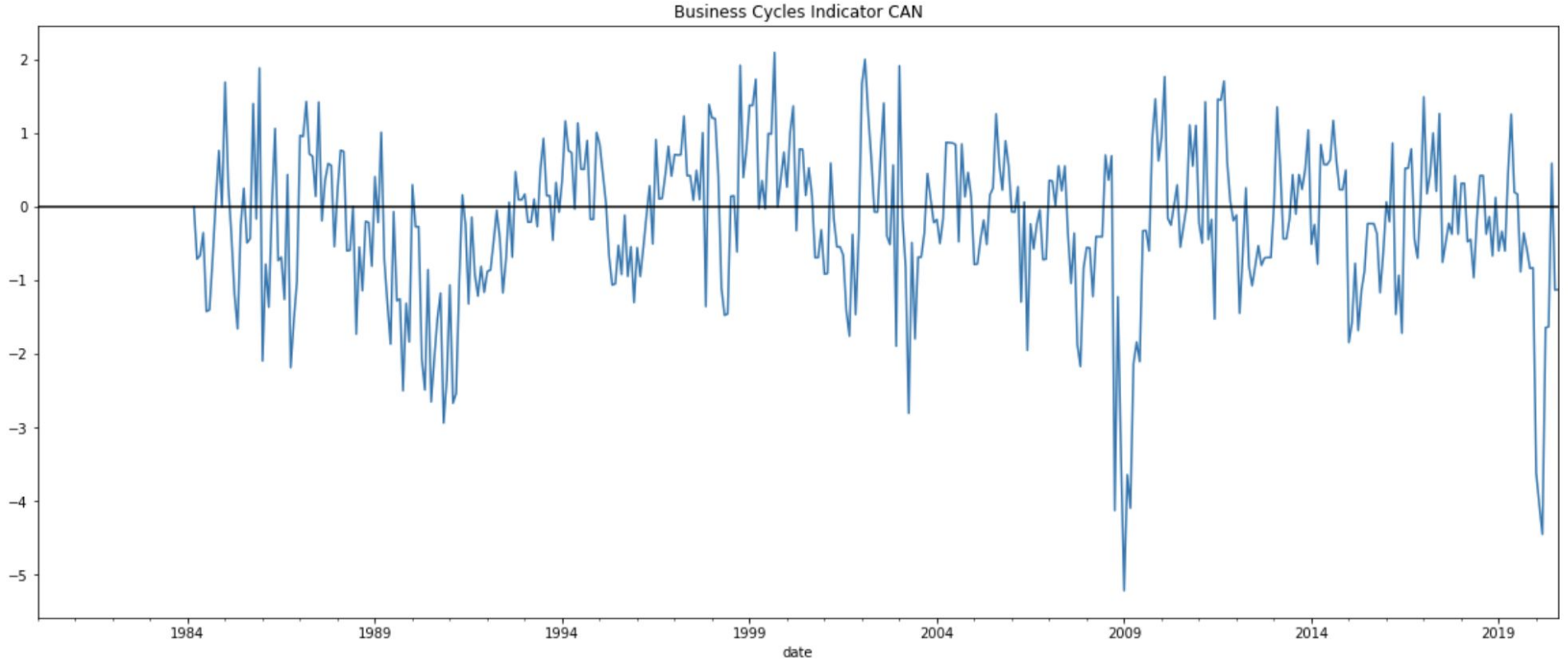

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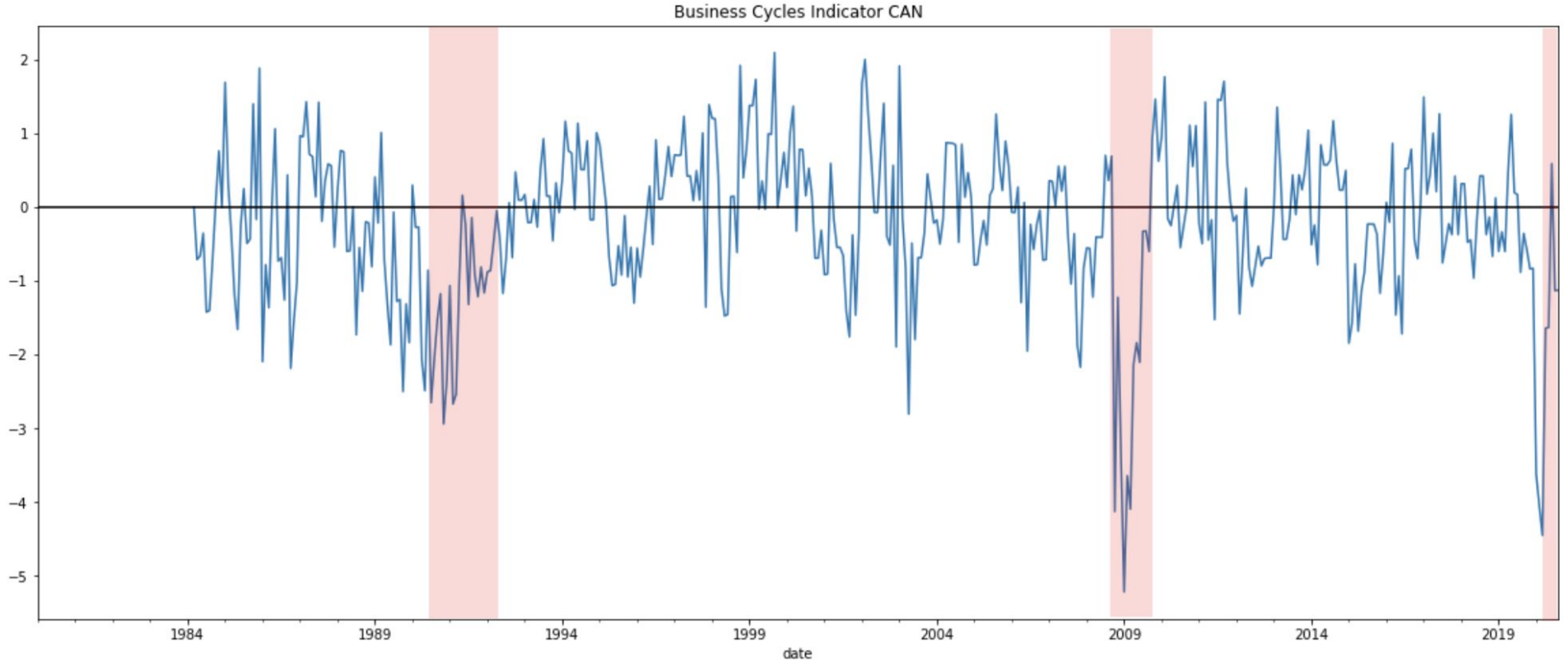

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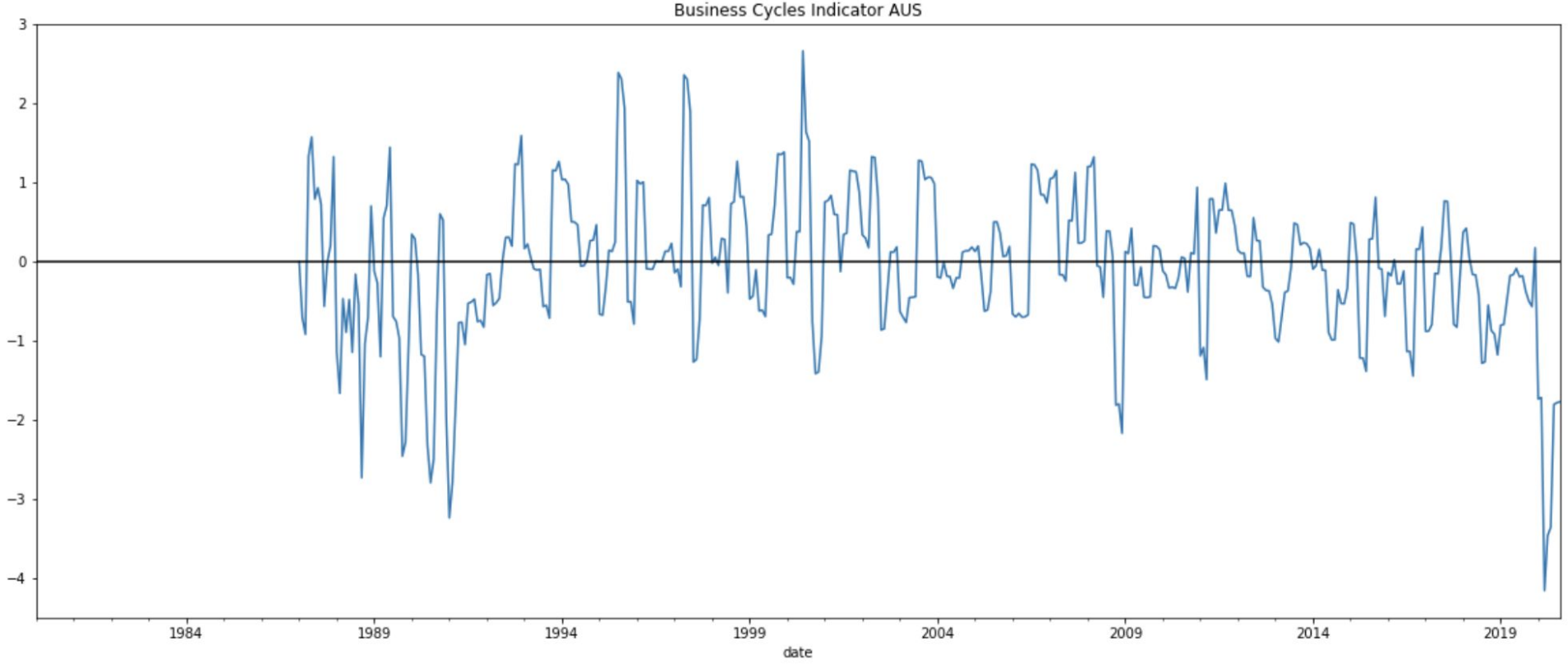

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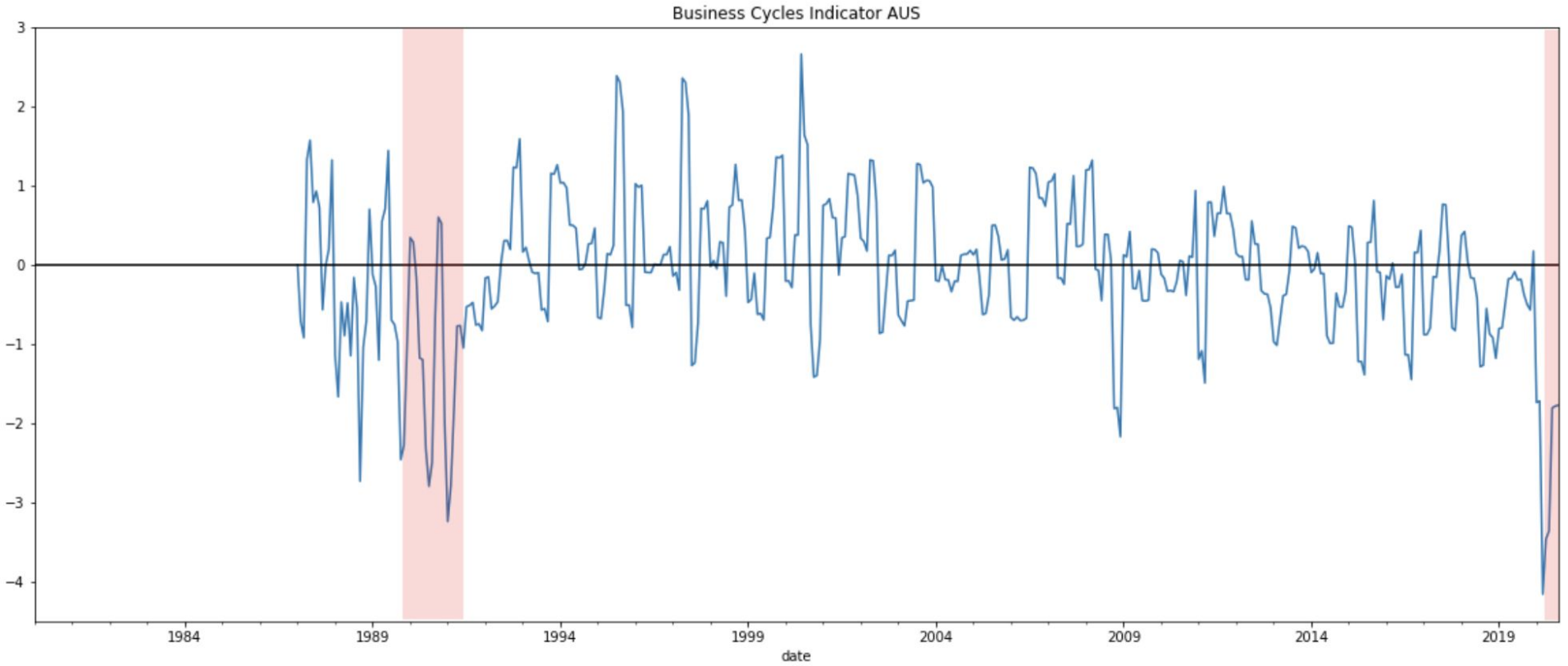
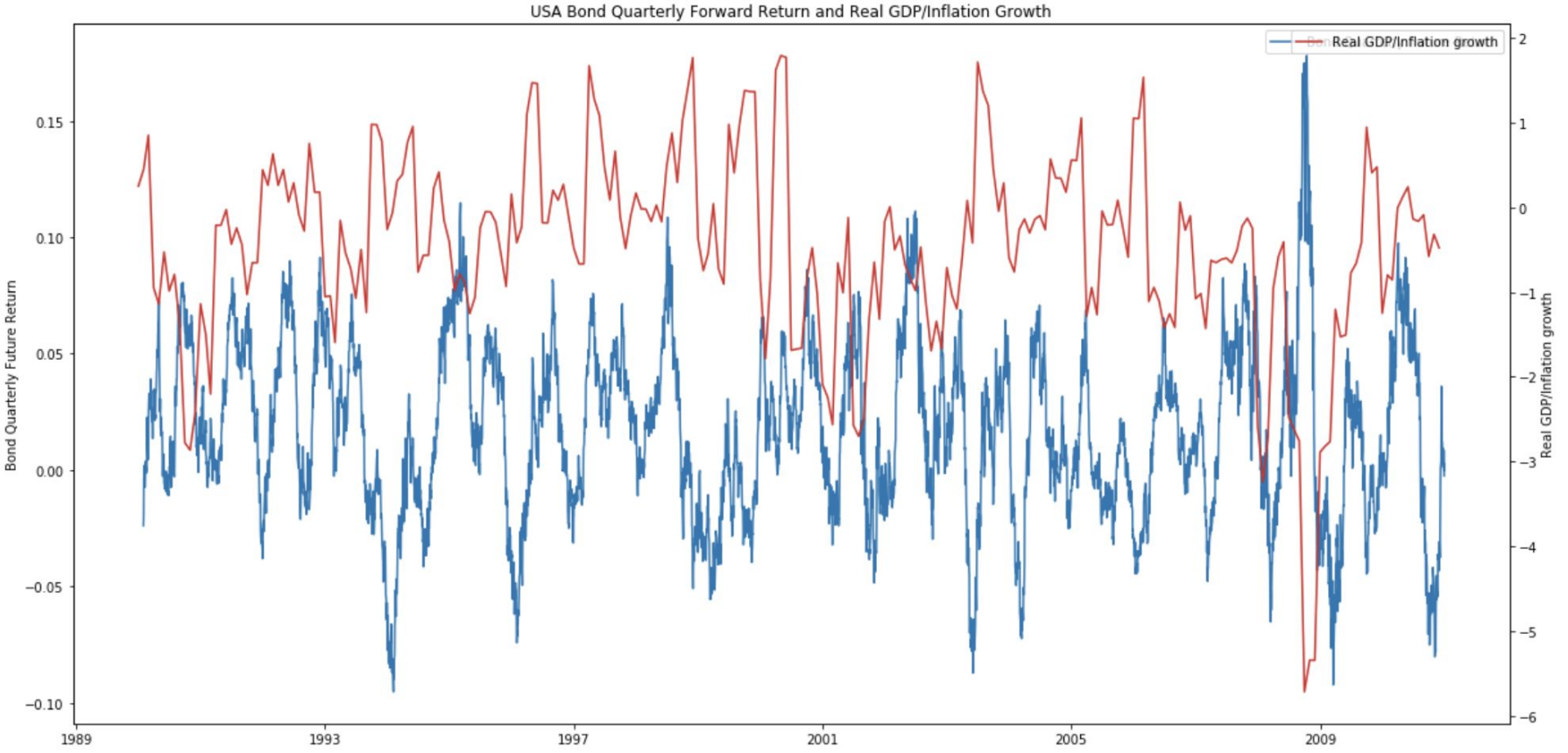


Potential?


USA Bond Quarterly Forward Return and Real GDP/Inflation Growth
Real GDP/Inflation growth
Bond Quarterly Future Return
Real GDP/Inflation growth
0.15
0.10
0.05
0.00
−0.05
−0.10
2
1
0
−1
−2
−3
−4
−5
−6
1989
1993
1997
2001
2005
2009

Signal Generator Desiderata

- Output position in [-1,1] for each date that we have an indicator
- For system signal generation, we want:
  - Positions corresponding to the relative indicator values for the countries
  - Global neutral positions

Signal Generator Implementation

Single country case:

1. If the indicator is > 0.5 or < -0.5, go fully short (-1) or long (1), respectively
2. Otherwise, our position is -1 * indicator / 0.5

Multiple country system case:

1. Calculate weighted sum of the indicators, call this α
2. Subtract α from each indicator to get the global neutral signals
3. Multiply by -1 to account for inverse relationship
4. Find signal with greatest absolute value, σ
5. Divide all signals by σ to normalize

Indicator to Signal Example (One Country)

date	
1990-01	0.249998
1990-02	0.448681
1990-03	0.850297
1990-04	-0.950047
1990-05	-1.141112
1990-06	-0.526637
1990-07	-0.987528

Indicator

date	
1990-01	-0.499997
1990-02	-0.897361
1990-03	-1.000000
1990-04	1.000000
1990-05	1.000000
1990-06	1.000000
1990-07	1.000000

Signal

Indicator to Signal Example (Multi-Country)

country	USA	CAN	AUS
date			
2020-04	-11.777663	-1.641014	-3.461253
2020-05	-9.627129	-1.628568	-3.356703
2020-06	-8.250509	0.594086	-1.803584
2020-07	-0.689559	-1.128130	-1.781613
2020-08	-0.686999	-1.123728	-1.768709

country	USA	CAN	AUS
date			
2020-04	1.000000	-0.647962	-0.352038
2020-05	1.000000	-0.681667	-0.318333
2020-06	1.000000	-0.735196	-0.264804
2020-07	-0.876879	-0.123121	1.000000
2020-08	-0.879392	-0.120608	1.000000

Equal Weights

country	USA	CAN	AUS
date			
2020-04	-11.777663	-1.641014	-3.461253
2020-05	-9.627129	-1.628568	-3.356703
2020-06	-8.250509	0.594086	-1.803584
2020-07	-0.689559	-1.128130	-1.781613
2020-08	-0.686999	-1.123728	-1.768709

country	USA	CAN	AUS
date			
2020-04	0.835224	-1.000000	-0.670449
2020-05	0.805009	-1.000000	-0.610018
2020-06	0.761270	-1.000000	-0.522540
2020-07	-0.539410	0.078820	1.000000
2020-08	-0.540677	0.081355	1.000000

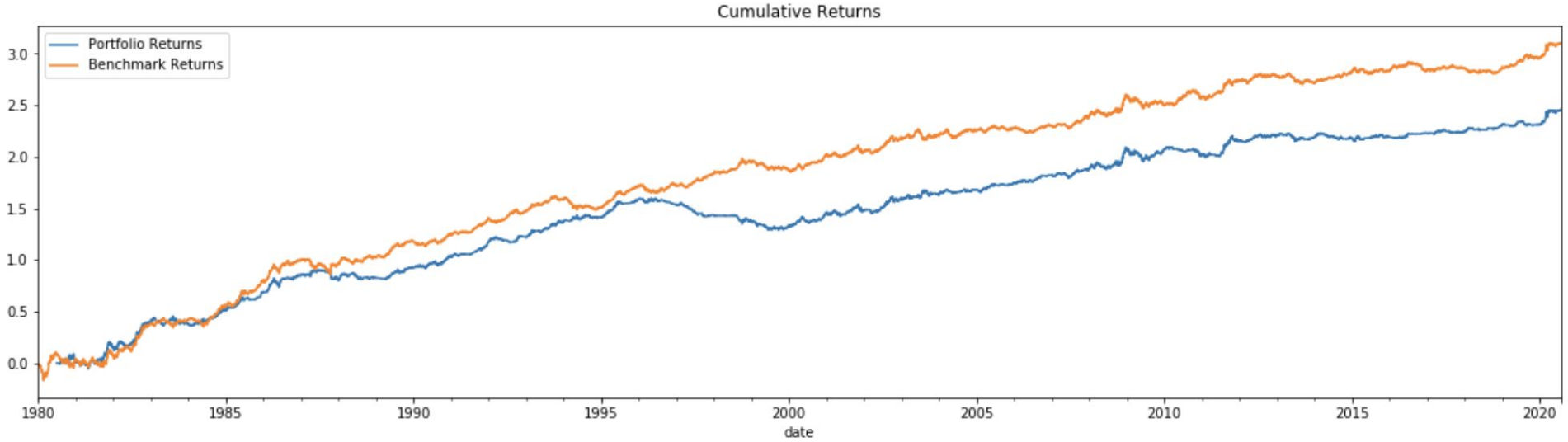
USA: 2, CAN: 1, AUS: 1

Returns Calculator

Calculates the sum of all countries’ weights*returns, where returns are position*lagged_returns for each country

USA Performance

Performance in US bond market



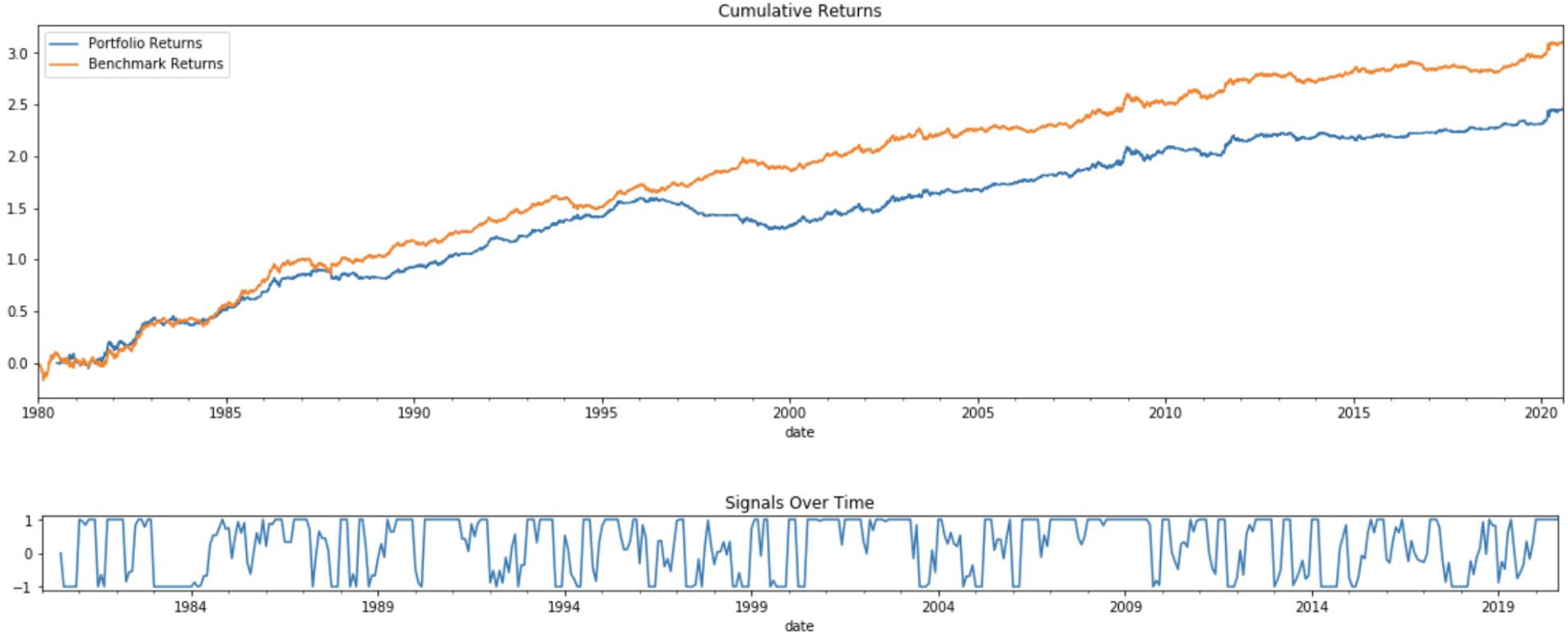

```
Portfolio Returns Mean, SD, and Sharpe Ratio
0.056329299811112045
0.08111919704155976
0.6944015950041132

Active Money Made: 2.4610426613722742
Passive Money Made: 3.1077267087451617
```

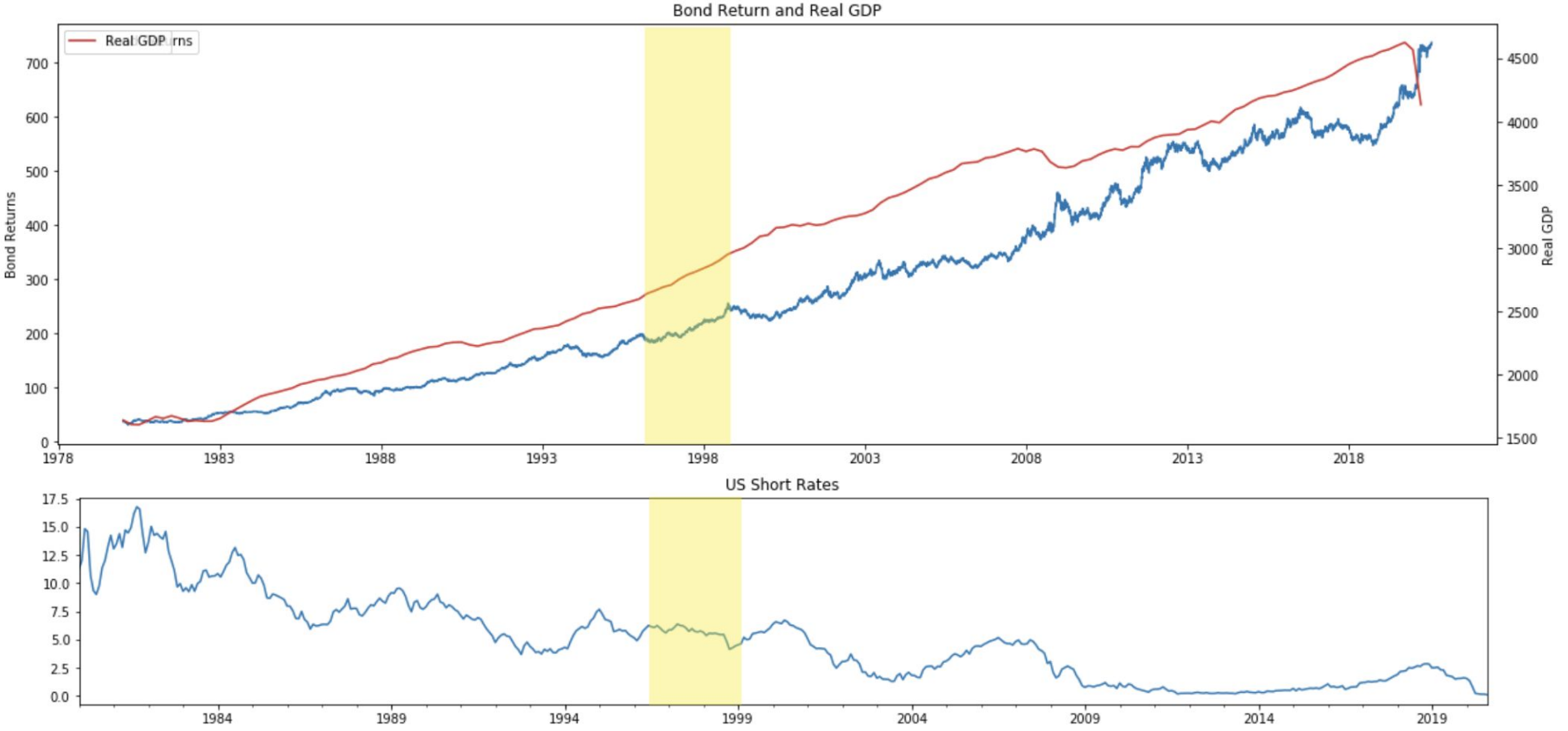
```
Long Returns Mean, SD, and Sharpe Ratio
0.07210208145435303
0.09083420174533659
0.793776794081363

Returns Correlation
0.3099274194204633
```

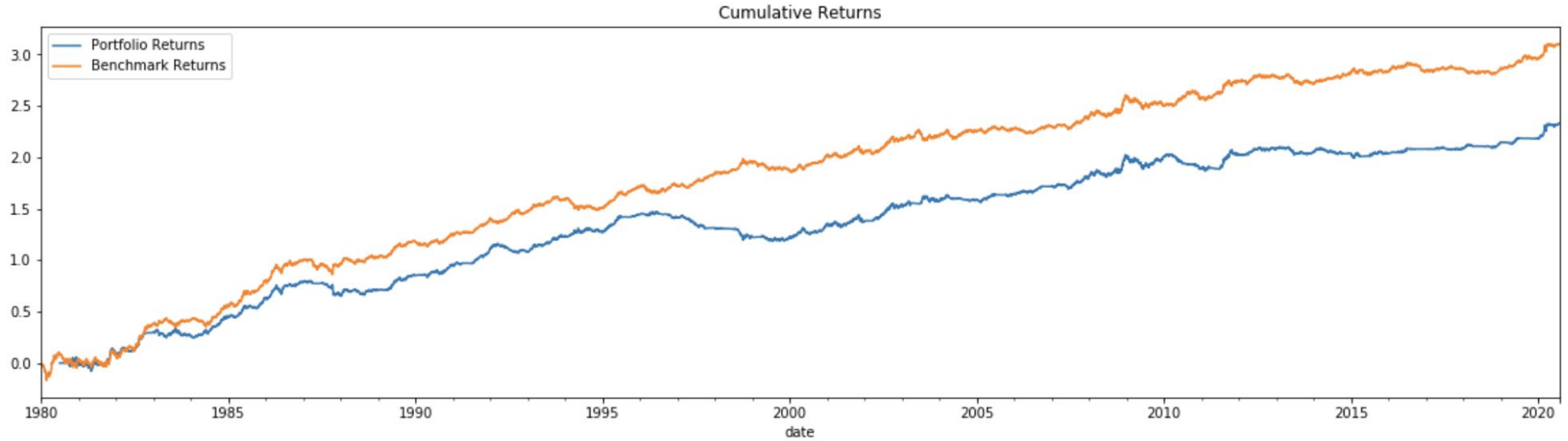
Signals in US bond market

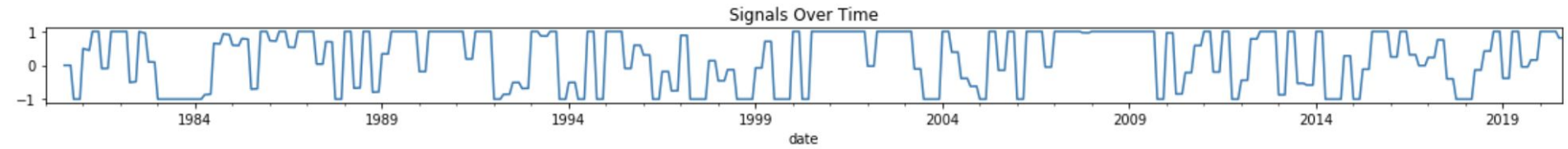


1996 - 1999 Bad Performance



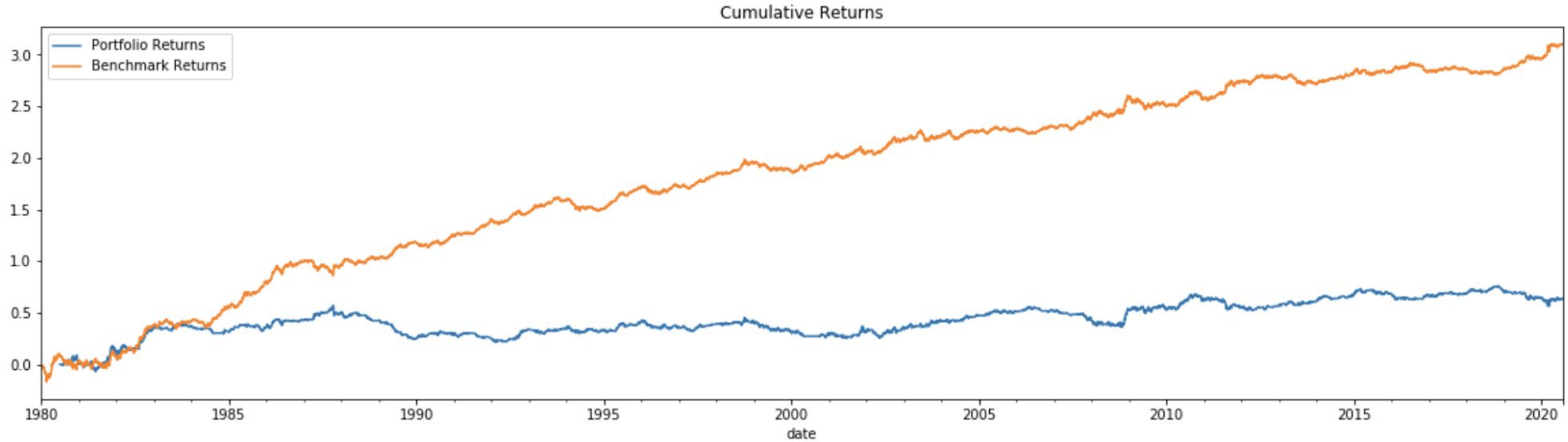
Comparing to GDP Only

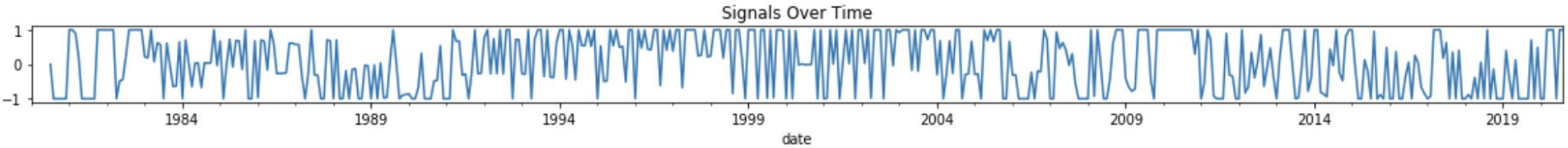





```
Active Money Made: 2.33012026757814
Passive Money Made: 3.1077267087451617
```

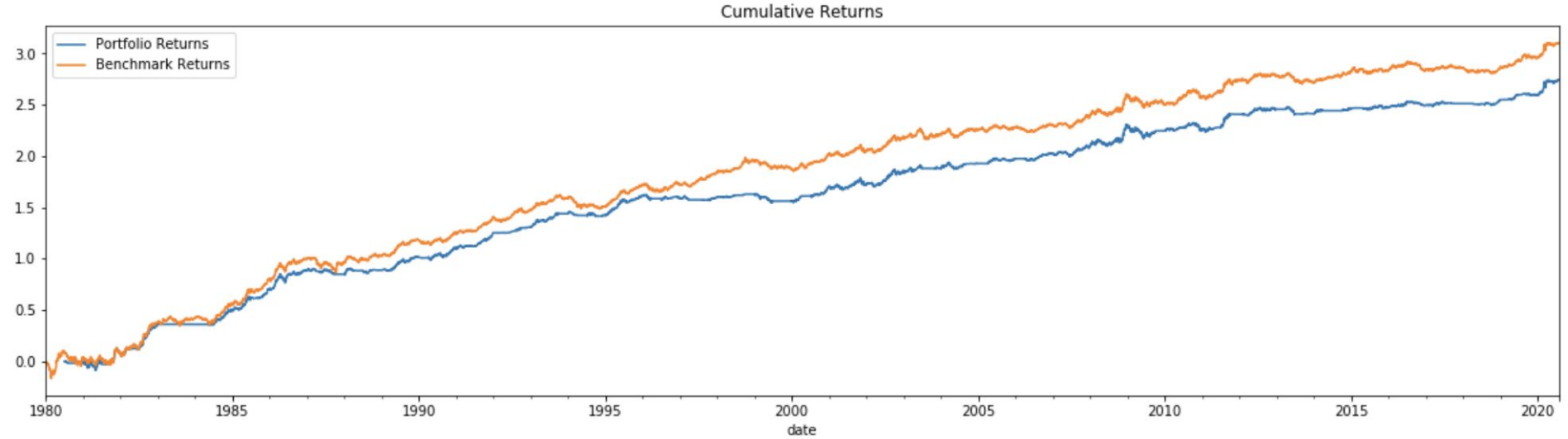
Comparing to Inflation Only






```
Active Money Made: 0.642947509702854
Passive Money Made: 3.1077267087451617
```

50% Fully Long and 50% Active Management

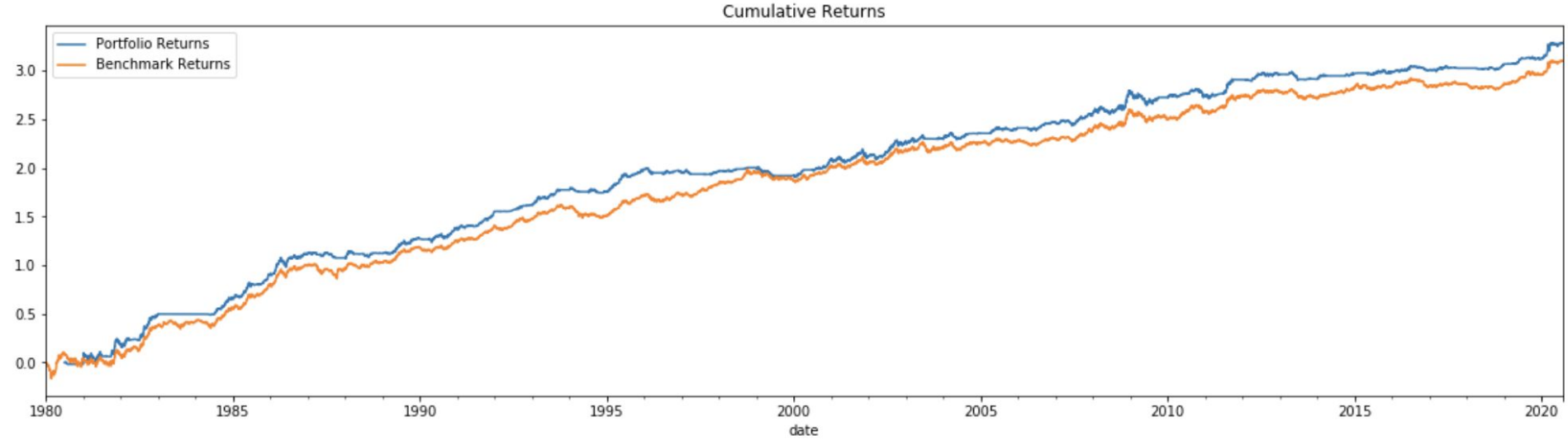


Combined Portfolio Returns Mean, SD, and Sharpe Ratio
0.06324909886977038
0.07988167499313319
0.7917848351979027

Long Returns Mean, SD, and Sharpe Ratio
0.07210208145435303
0.09083420174533659
0.793776794081363

Active Money Made: 2.744754422777288
Passive Money Made: 3.1077267087451617

Adjusting for Risk in Combined Portfolio



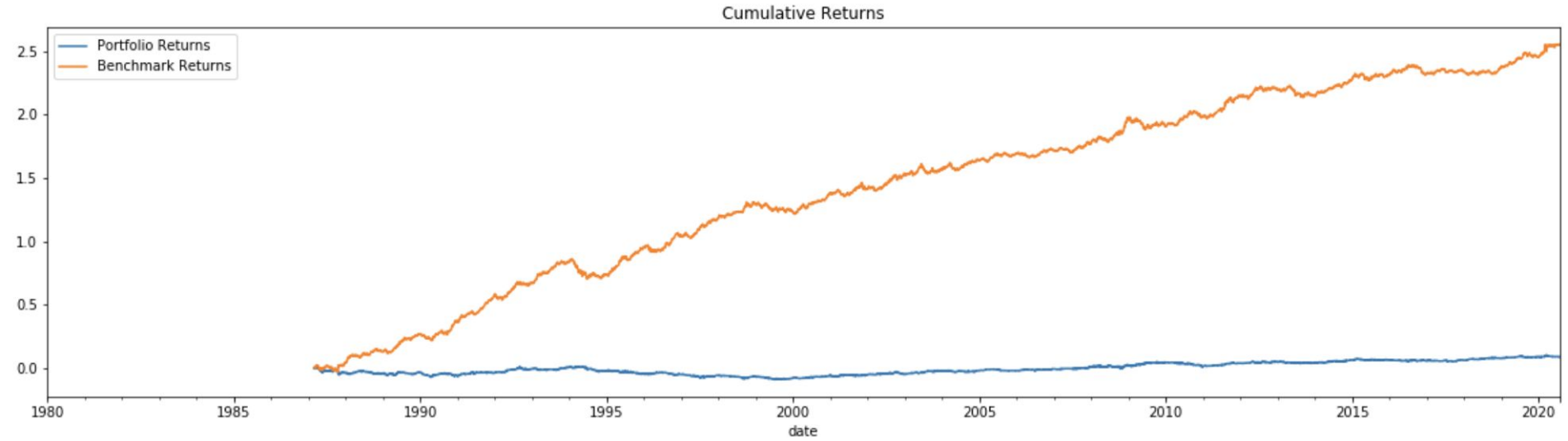

```
Risk Adjusted Returns Mean, SD, and Sharpe Ratio
0.07607189084986264
0.09442757580982067
0.805610969014742
```

```
Long Returns Mean, SD, and Sharpe Ratio
0.07210208145435303
0.09083420174533659
0.793776794081363
```

```
Active Money Made: 3.292684554041681
Passive Money Made: 3.1077267087451617
```

USA, CAN, AUS Performance

Performance in USA, CAN, AUS



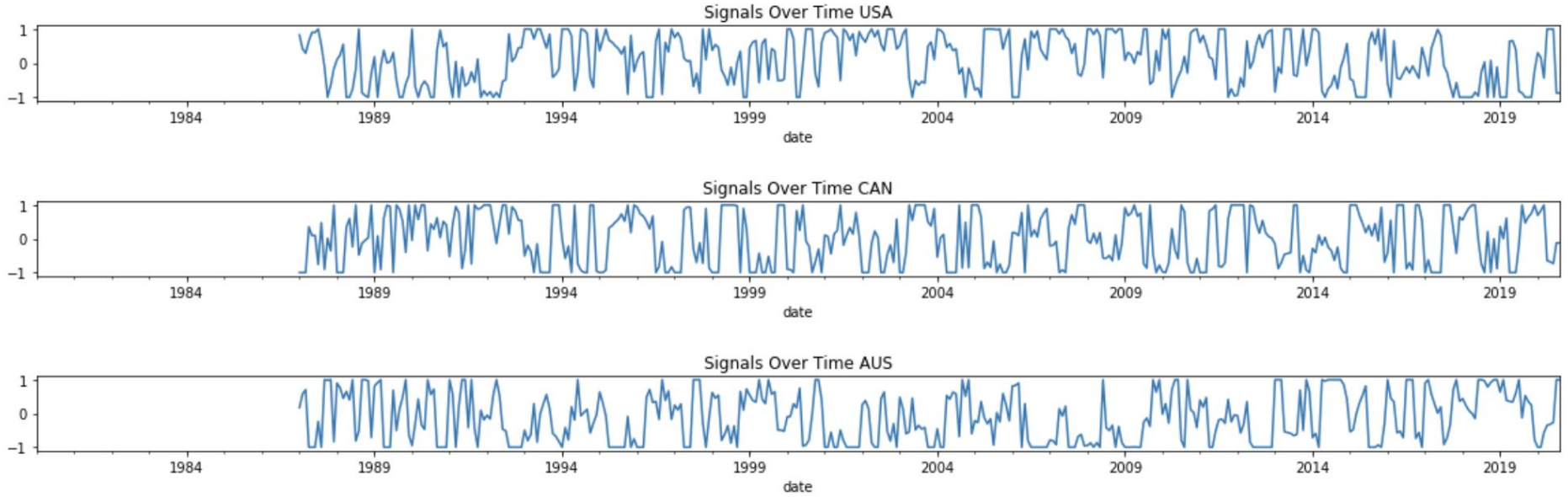
Portfolio Returns Mean, SD, and Sharpe Ratio
0.002652235341357021
0.017156852097767447
0.15458752725986055

Long Returns Mean, SD, and Sharpe Ratio
0.07201423984868398
0.07781630463530527
0.9254389576347359

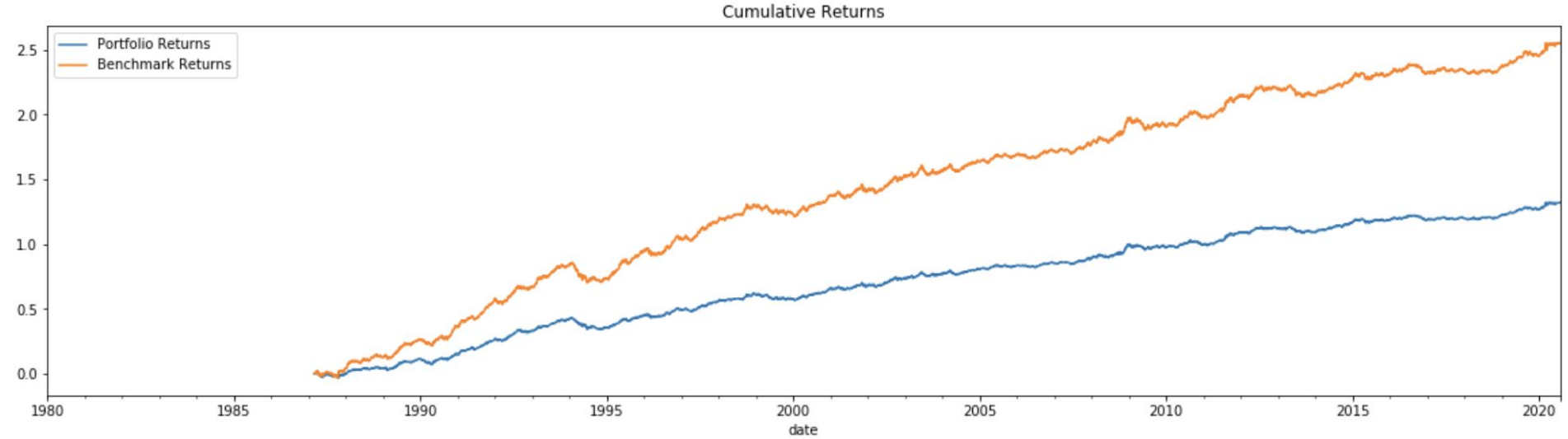
Active Money Made: 0.08894329001648807
Passive Money Made: 2.5554845417424823

Returns Correlation
0.02745736290119818

Signals in USA, CAN, AUS



50% Fully Long and 50% Global Neutral

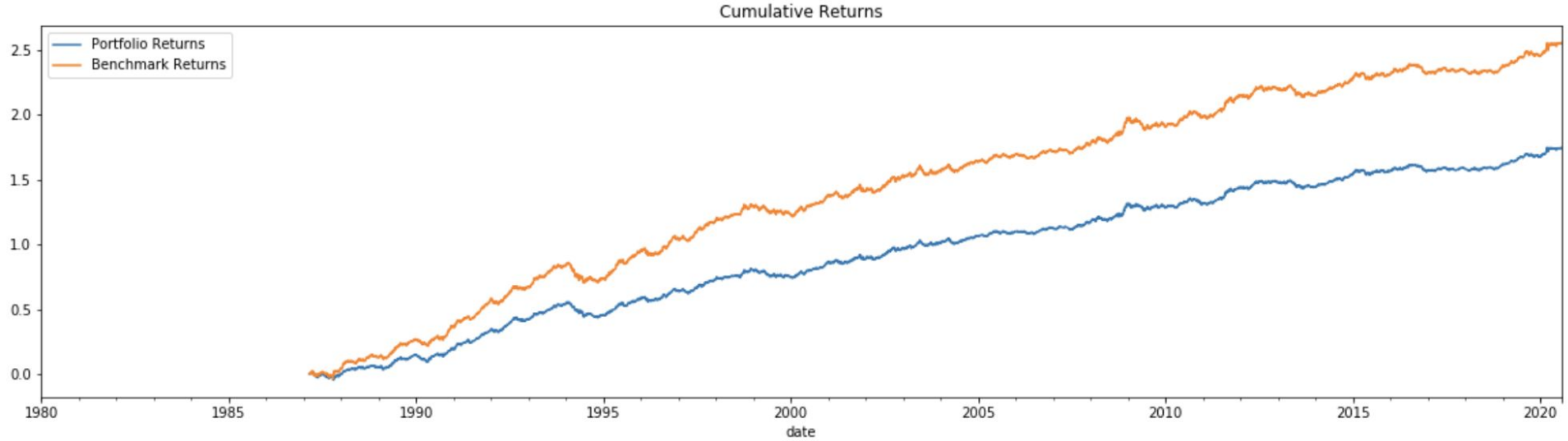


Combined Portfolio Returns Mean, SD, and Sharpe Ratio
0.0373332375950205
0.041427028439508455
0.9011806784436474

Long Returns Mean, SD, and Sharpe Ratio
0.07201423984868398
0.07781630463530527
0.9254389576347359

Active Money Made: 1.3222139158794899
Passive Money Made: 2.5554845417424823

Adjusting for Risk in Combined Portfolio




```
Risk Adjusted Returns Mean, SD, and Sharpe Ratio
0.049258037288359396
0.05480870277788834
0.8987265669829306
```

```
Long Returns Mean, SD, and Sharpe Ratio
0.07201423984868398
0.07781630463530527
0.9254389576347359
```

```
Active Money Made: 1.745678630373563
Passive Money Made: 2.5554845417424823
```

Points of Failure

- Linkage doesn’t always exist
  - Looking back at one country setting, GDP and Inflation can grow alongside bond returns for a variety of reasons
  - Improve by adding more factors to make business cycle estimation more accurate and building more indicators to fall back on when the business cycle indicator fails
- Low frequency of data
  - We’re essentially evaluating at the beginning of the month whether to go long/short for the whole month. Potentially, something detrimental could happen to the market on the second day of the month, and we’d be trading blindly for ~20 business days.
  - Improve by adding indicators that have a higher frequency of data
- Naive beginning
  - Z-scores are defined with respect to a mean and SD, and these estimates are less accurate closer to the start of the data (1980)
  - Improve by expanding the data’s history