Anish Ketha - Project 3 - Create a Stock-Picking Strategy

Project 3 Report

Project Overview

Built and evaluated the performance of several renowned factor investing strategies:

1. Momentum
2. Value
3. Quality
4. Defensive (Low Risk)

```
library(zoo)
```

```
Attaching package: 'zoo'

The following objects are masked from 'package:base':

    as.Date, as.Date.numeric
```

```
library(xts)
library(quantmod)
```

```
Loading required package: TTR

Registered S3 method overwritten by 'quantmod':
  method            from
  as.zoo.data.frame zoo
```

```
# Remember to change his directory to your local folder
datalink <- "Stock Picking Data/Stock Picking Data/Stock Data "
```

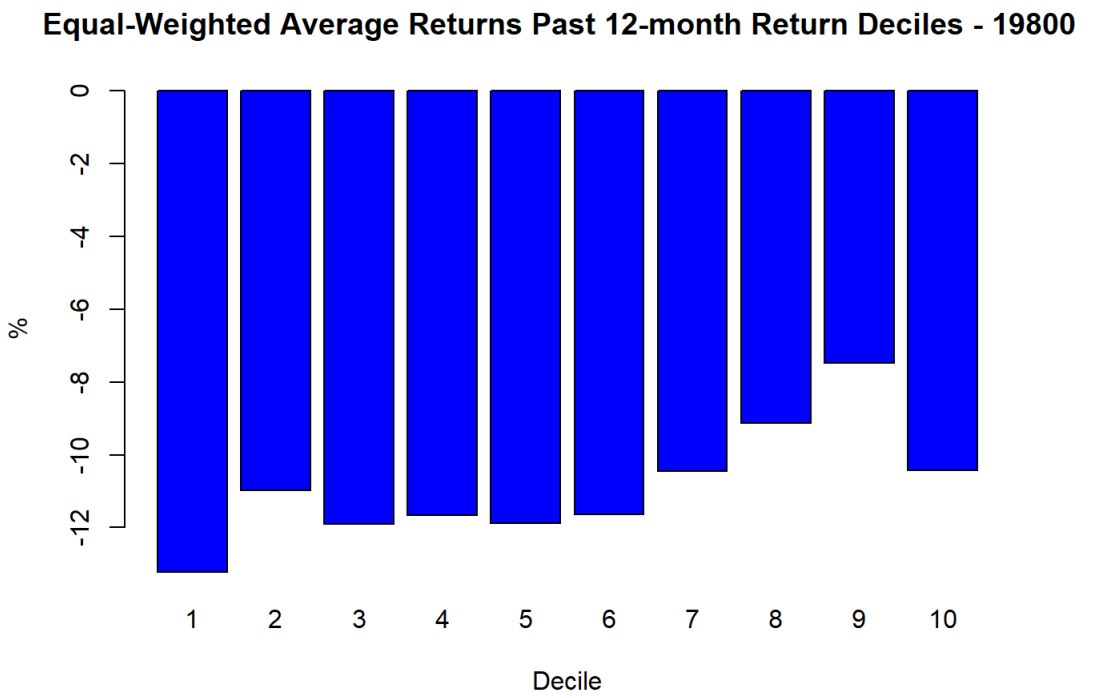
Momentum Investing

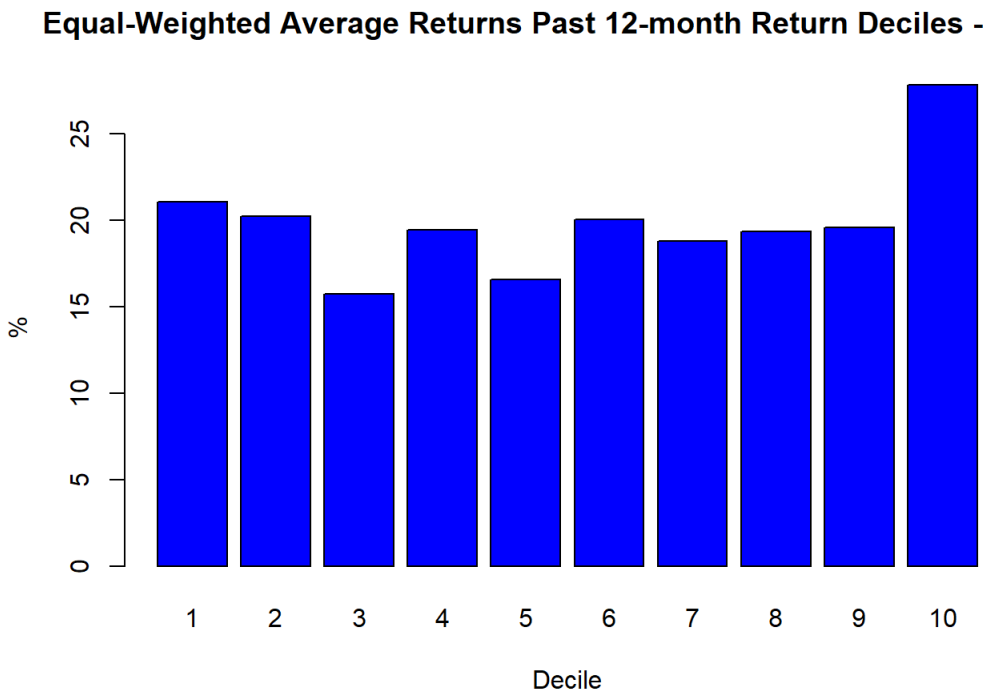
```
signal <- "ret_12_1"
description <- "Past 12-month Return"

# Define the range of years and quarters
years <- 1980:2022
quarters <- 1:4

# Generate all combinations of years and quarters
decile_df <- expand.grid(year = years, quarter = quarters)
decile_df[, paste0("Decile ", 1:10)] <- NaN
```

```
decile_sorts <- function(data, signal, description, plot = TRUE){
    df_test <- data[, c("yearq","ticker","sp500","r1000","r2000","ret","market_equity")]
    df_test$signal <- data[[signal]]

    df_test <- na.omit(df_test)

    # Sort the data by market_equity from low to high
    df_test <- df_test[order(df_test$signal, na.last = TRUE), ]
```

```
    # Assign rankings to the sorted data
    df_test$rank <- rank(df_test$signal, ties.method = "first")

    # Create decile rankings based on market_equity
    df_test$decile <- cut(df_test$rank,
                          breaks = 10,
                          include.lowest = TRUE, labels = 1:10)

    # Calculate average returns for each decile
    equal_weighted_decile_returns <- tapply(df_test$ret, df_test$decile, mean, na.rm = TRUE)

    if (plot == TRUE) {
        barplot(equal_weighted_decile_returns * 100, names.arg = 1:10,
                main = paste("Equal-Weighted Average Returns", description, "Deciles -", yearq),
                xlab = "Decile", ylab = "%", col = "blue")
    }
    return(equal_weighted_decile_returns)
}
```

```
# Loop over each year and calculate decile sorted portfolio returns
for (year in years) {
  for (quarter in quarters){
    yearq <- year*100 + quarter
    # Load the dataset for the current year
    data <- read.csv(paste(datalink, as.character(yearq), ".csv", sep = ""))

    # Calculate decile returns for the current year
    decile_returns <- decile_sorts(data = data, signal = signal, description = description)

    # Store the results in the matrix
    decile_df[decile_df$year == year & decile_df$quarter == quarter, paste0("Decile ", 1:10)] <- as.numeric(decile_
  }
}
```




Equal-Weighted Average Returns Past 12-month Return Deciles - 19800
%
0
5
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15
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25
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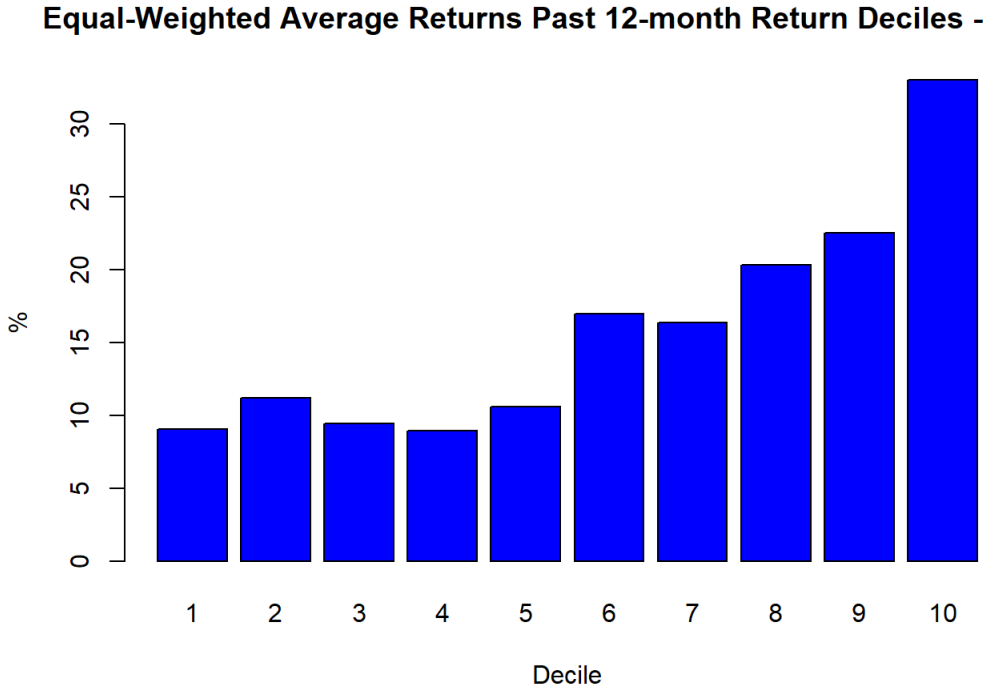
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19800
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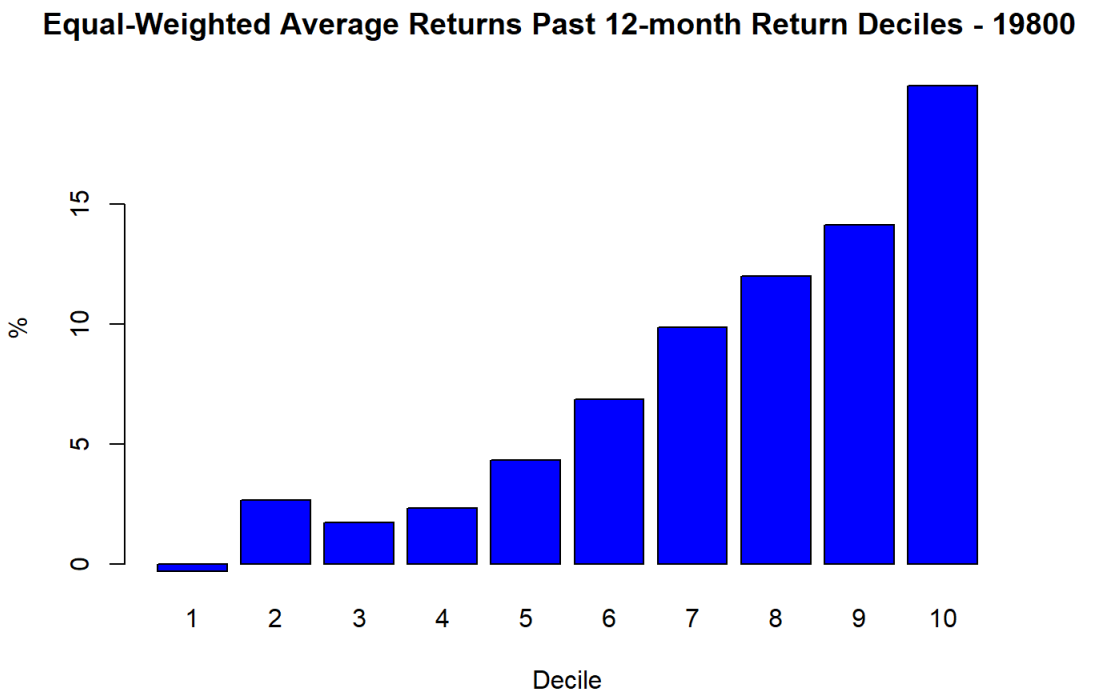
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19800
%
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7
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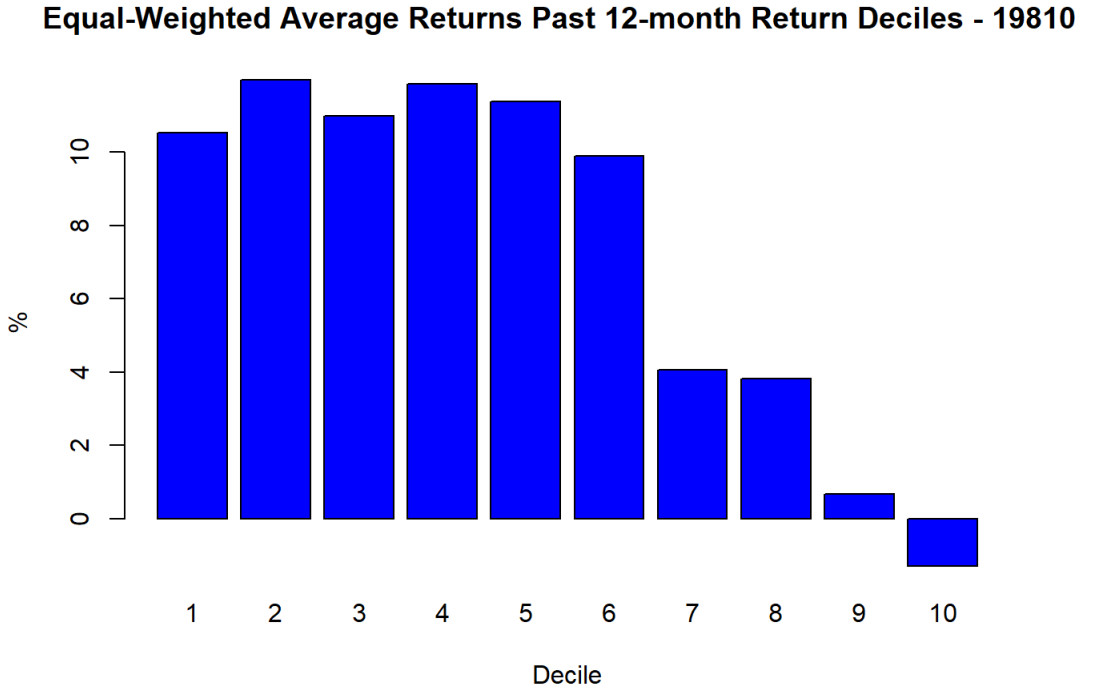
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19810
%
0
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8
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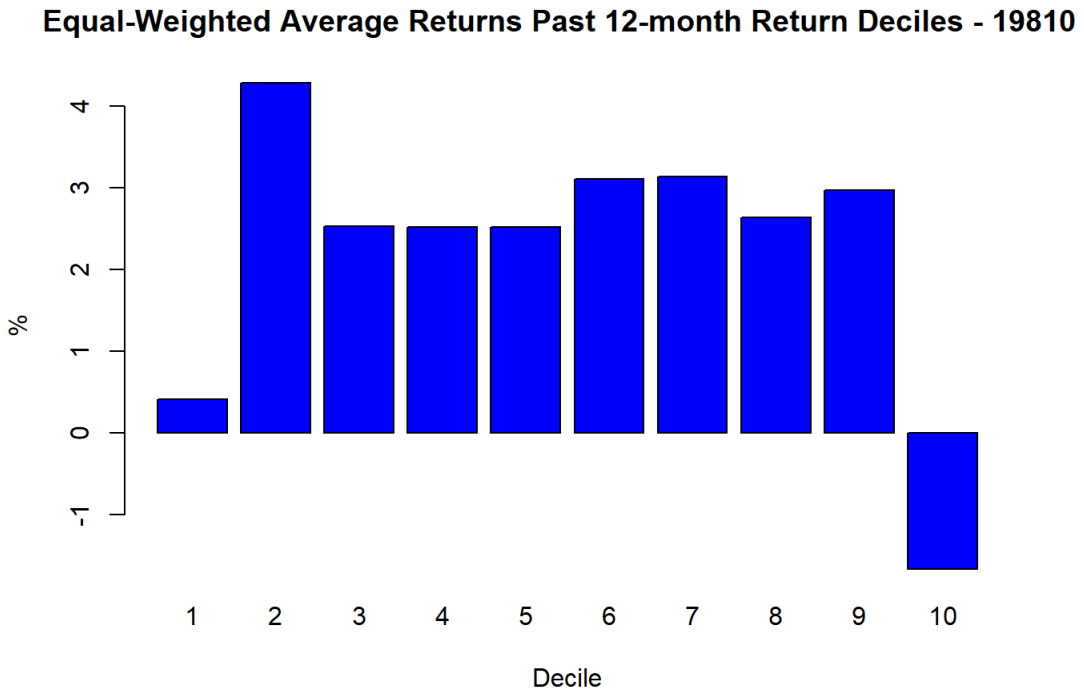
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19810
%
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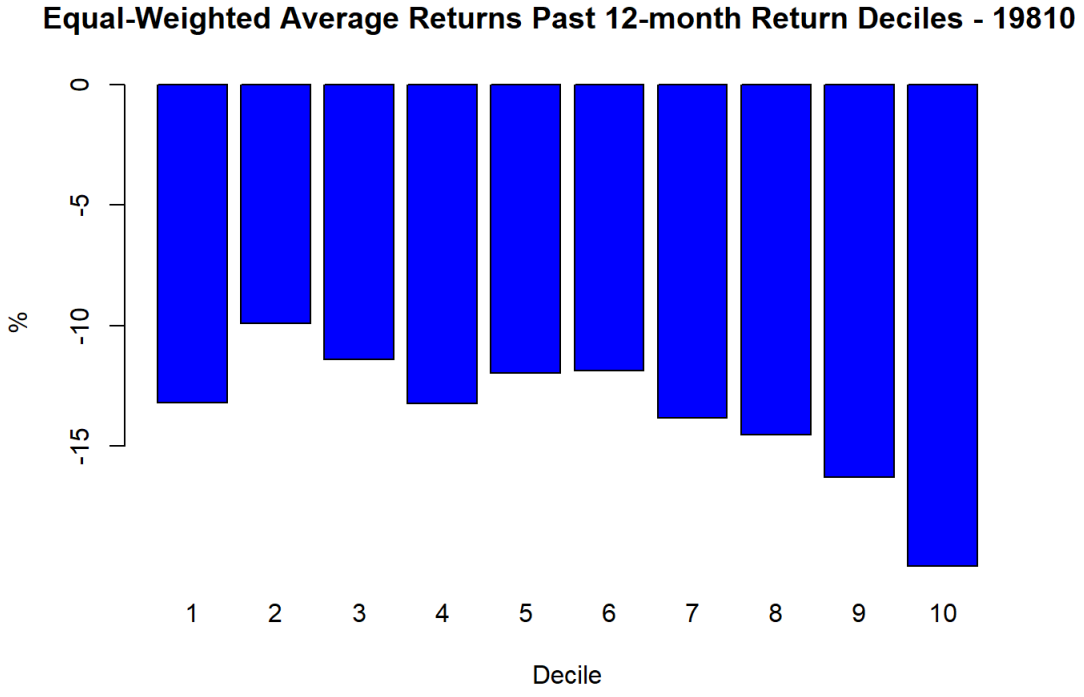
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19810
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-15
-10
-5
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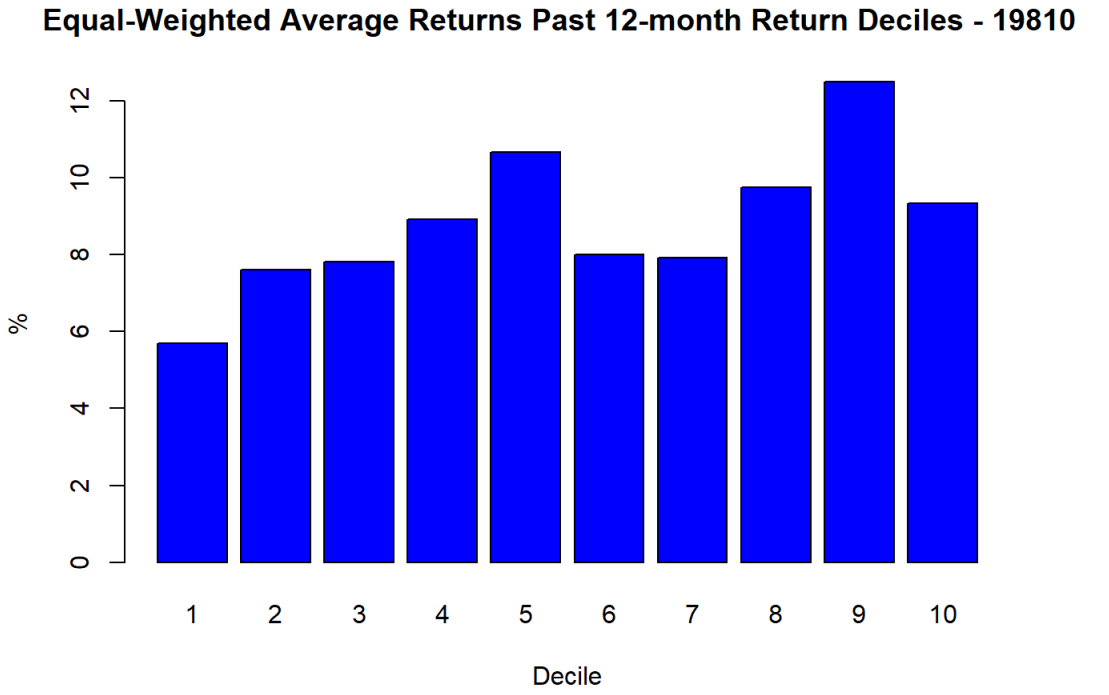
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19810
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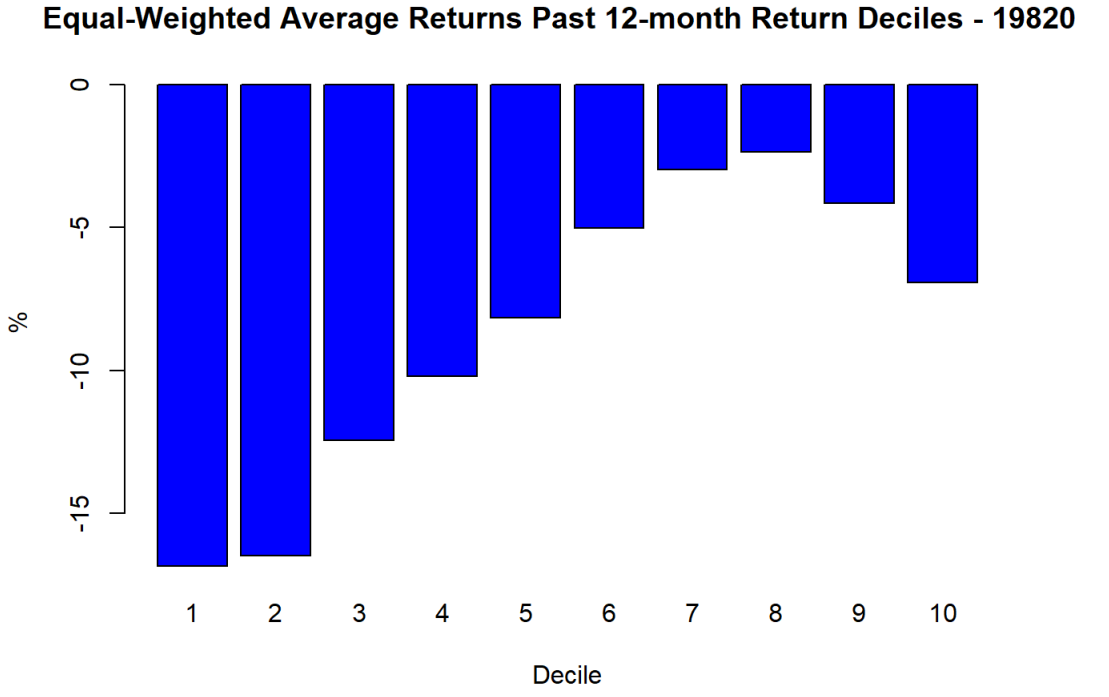
Decile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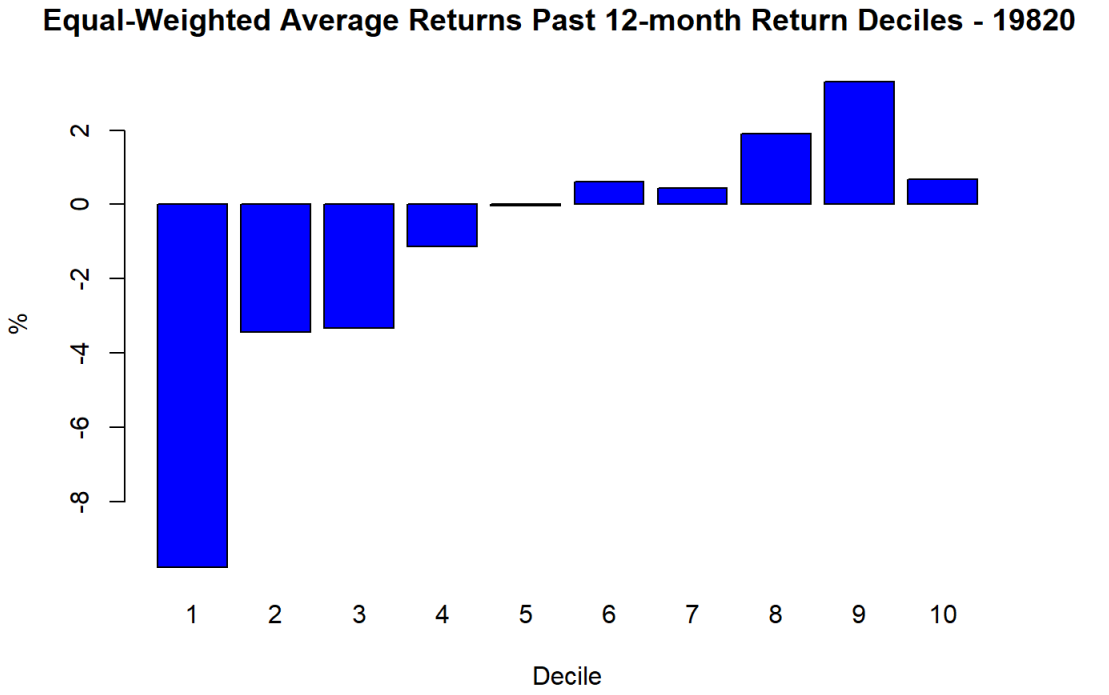
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19820
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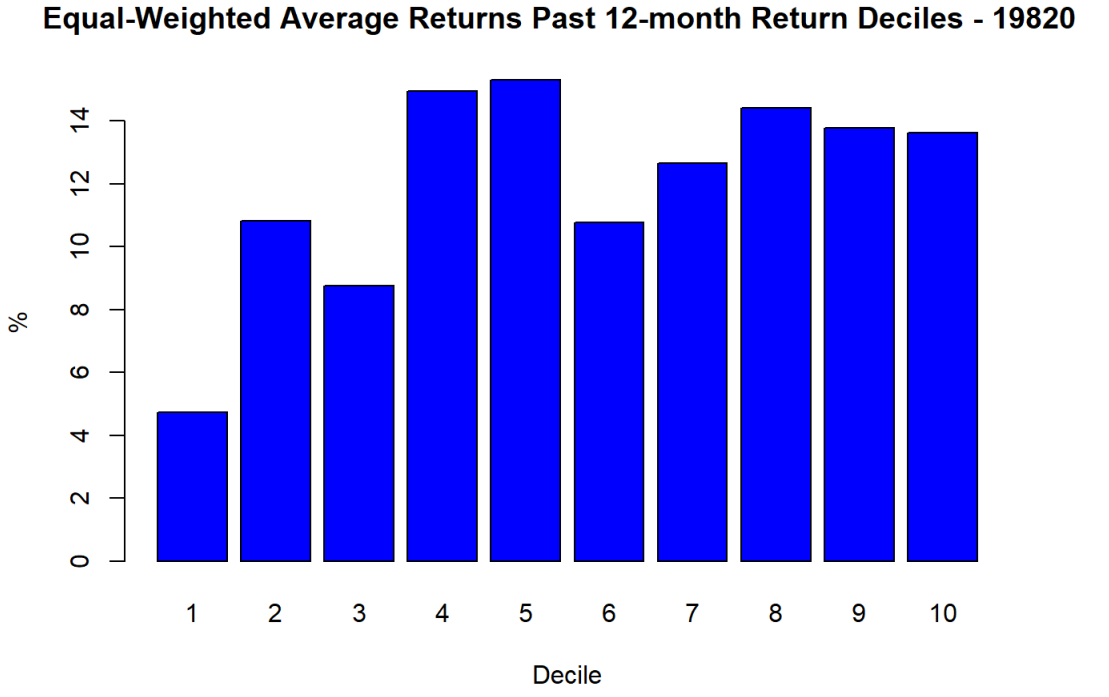
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19820
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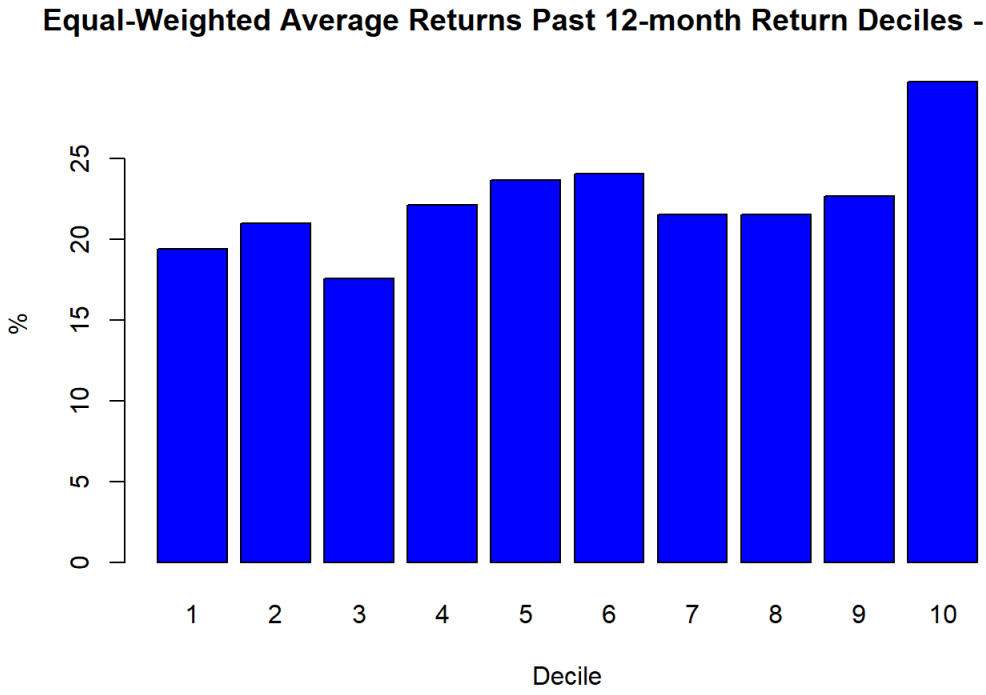
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19820
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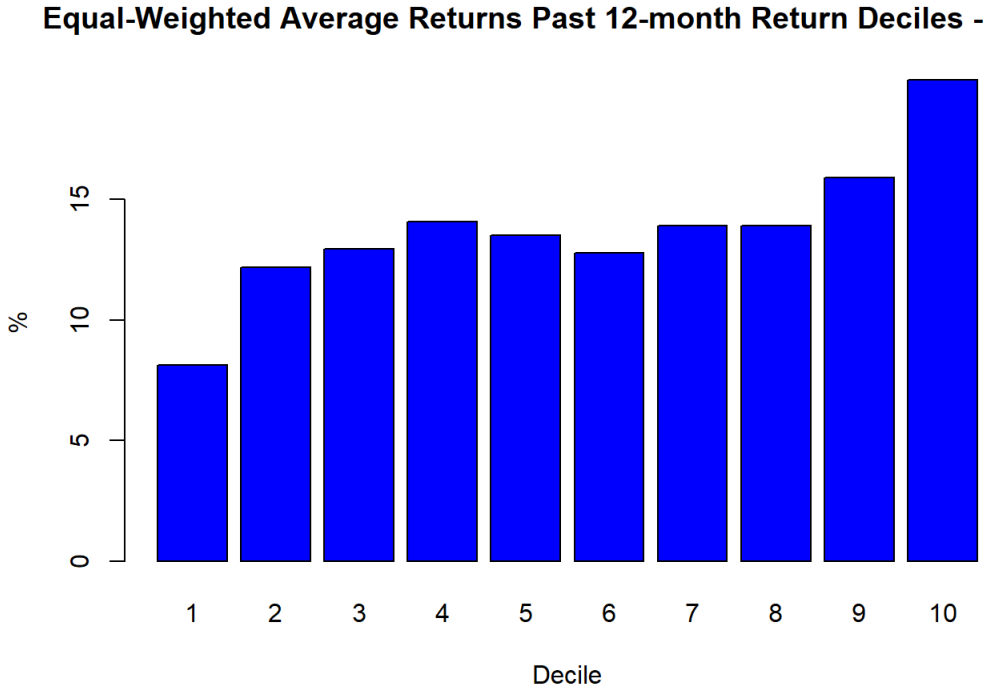
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19830
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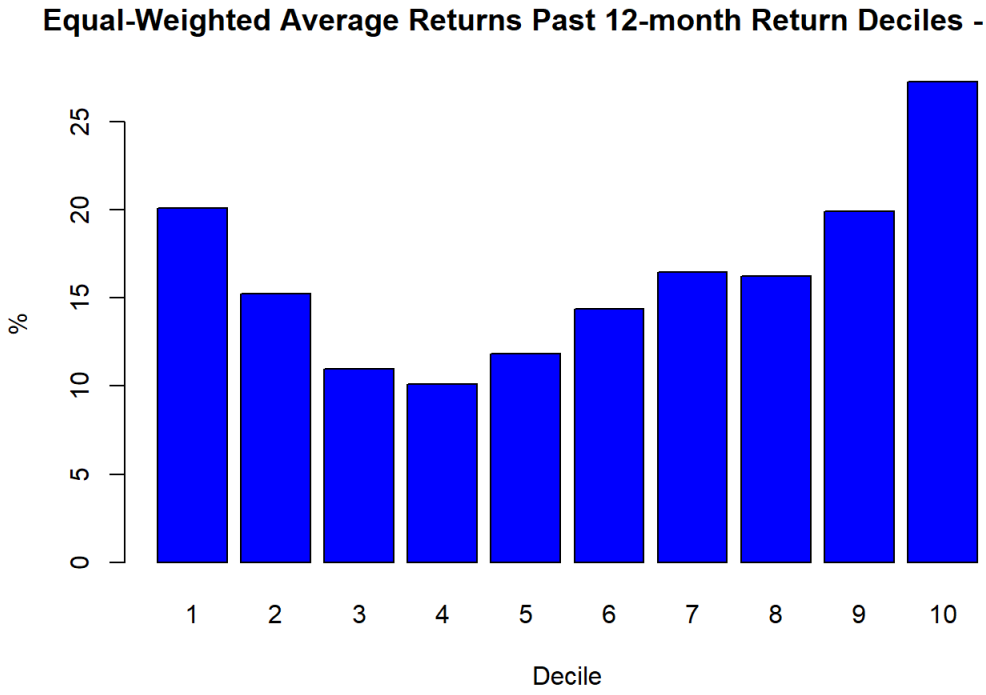
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19830
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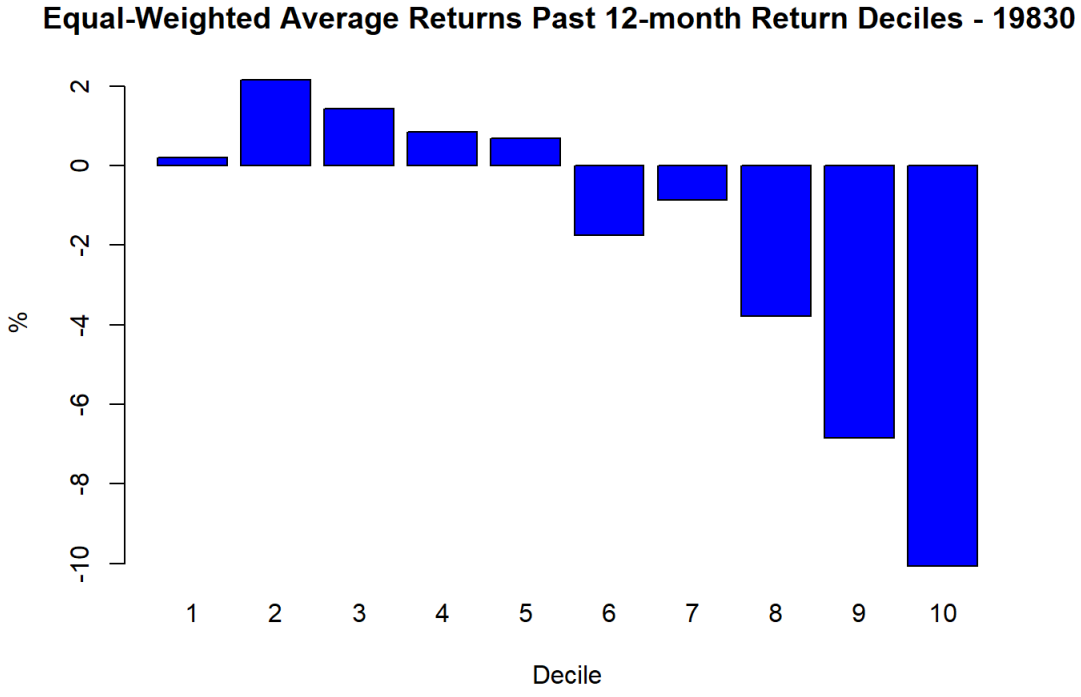
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19830
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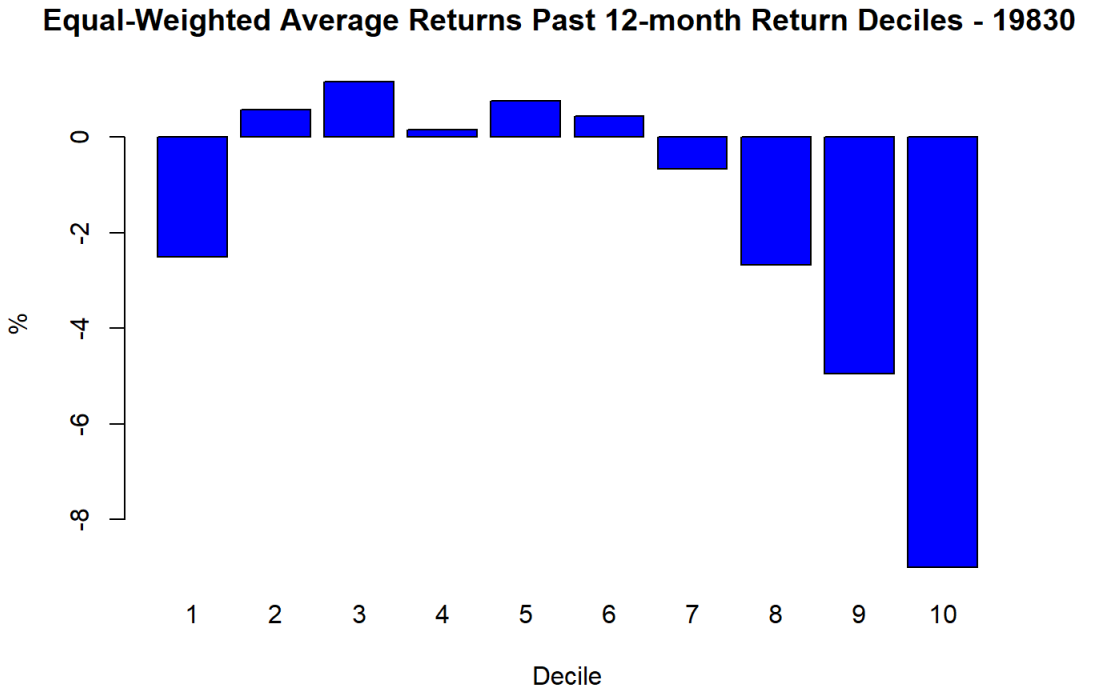
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19830
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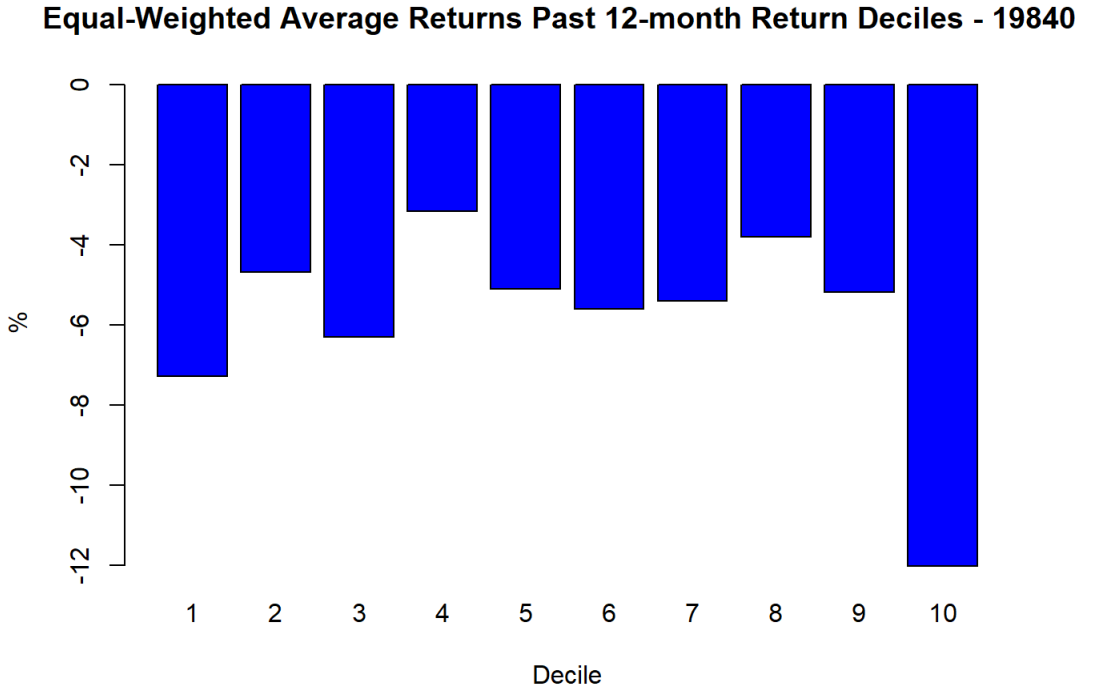
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19840
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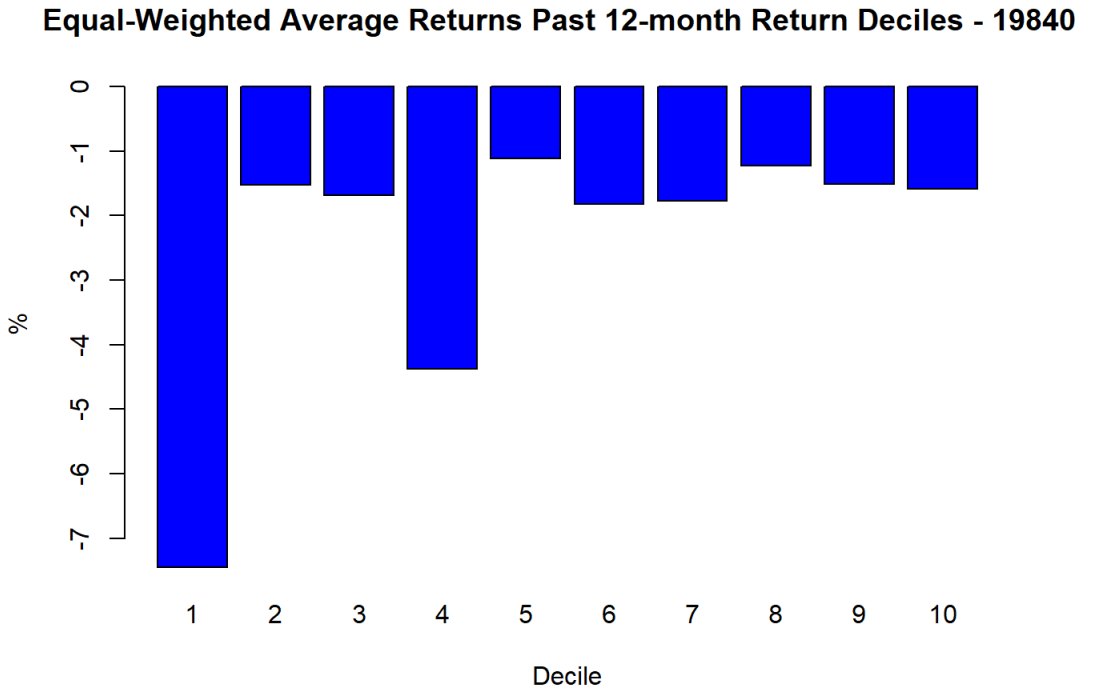
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19840
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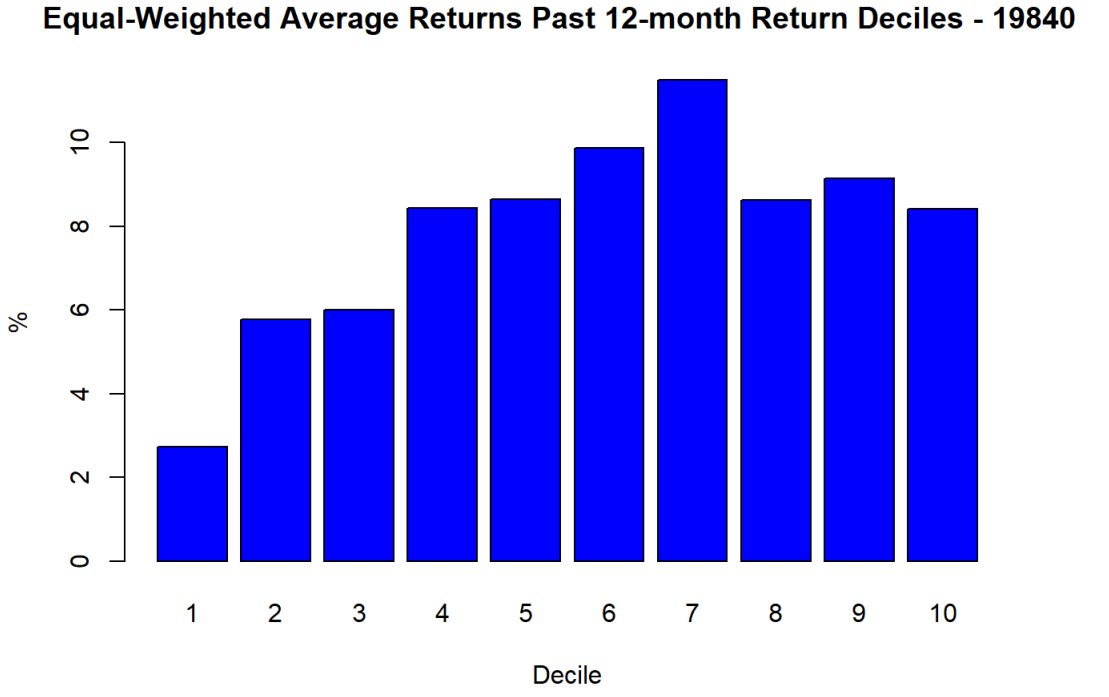
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19840
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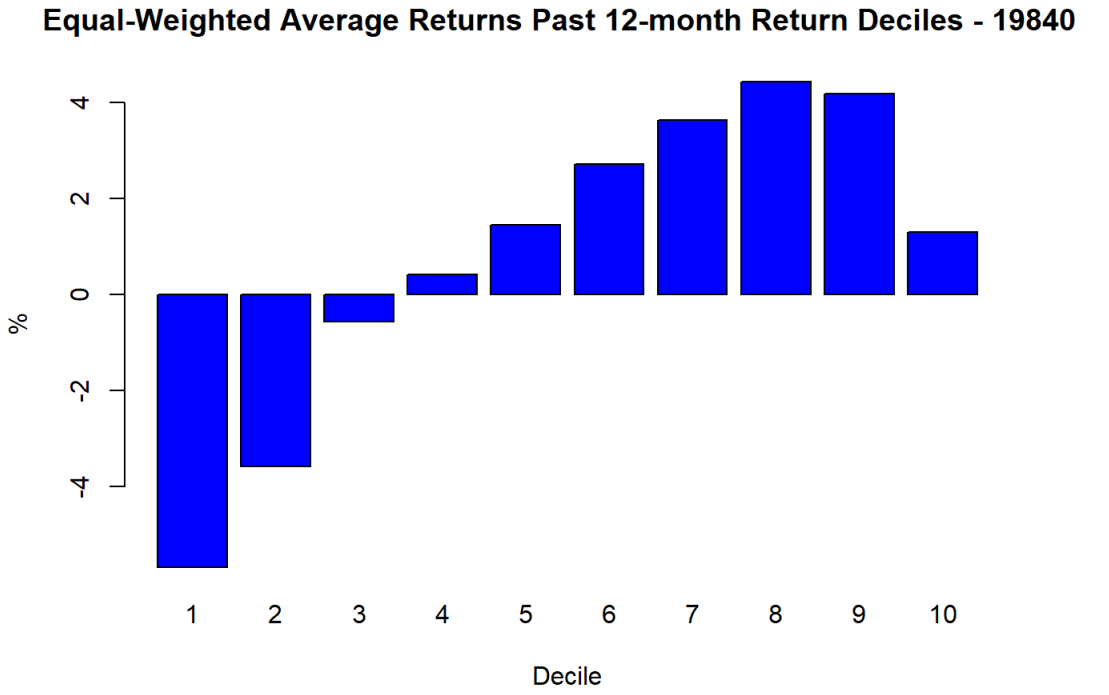
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19840
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4
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-2
-4
1
2
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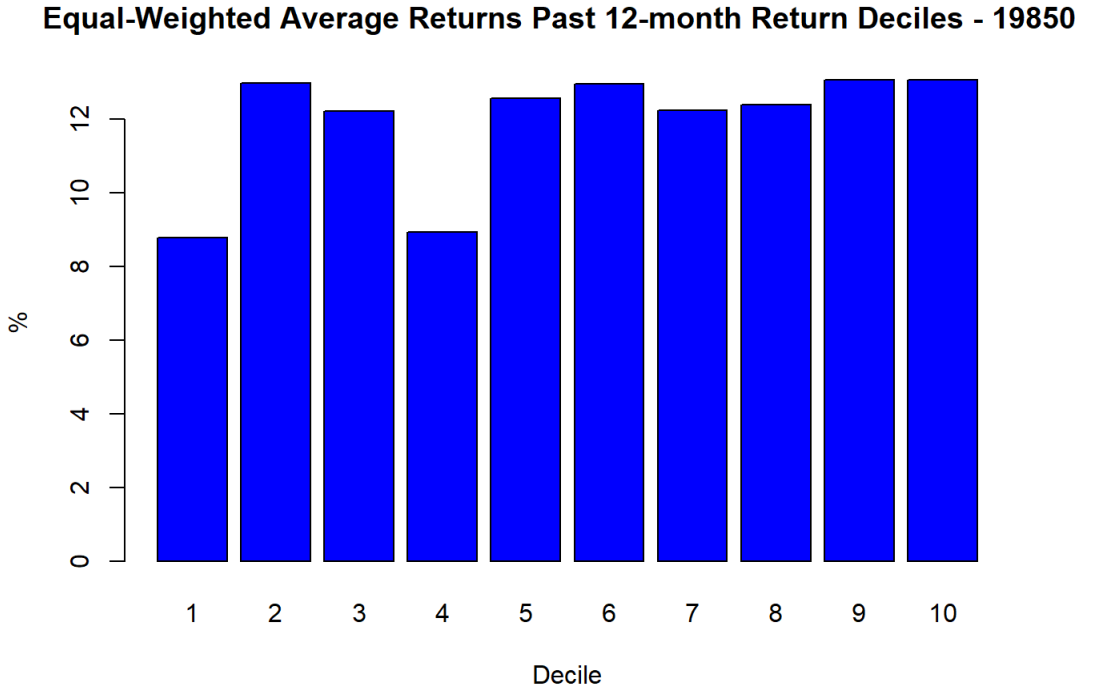
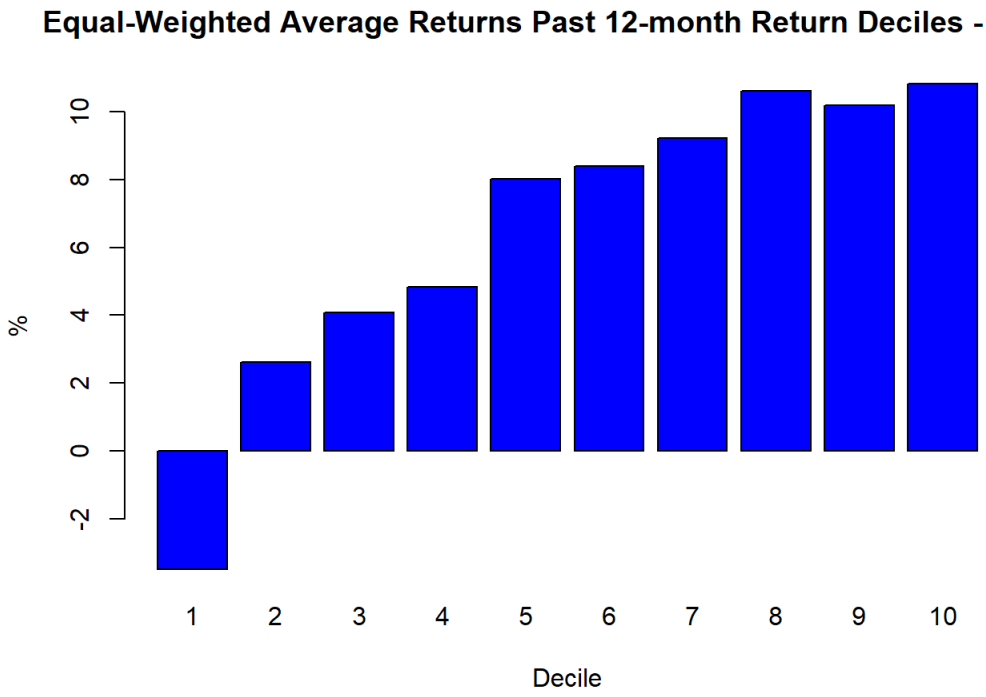
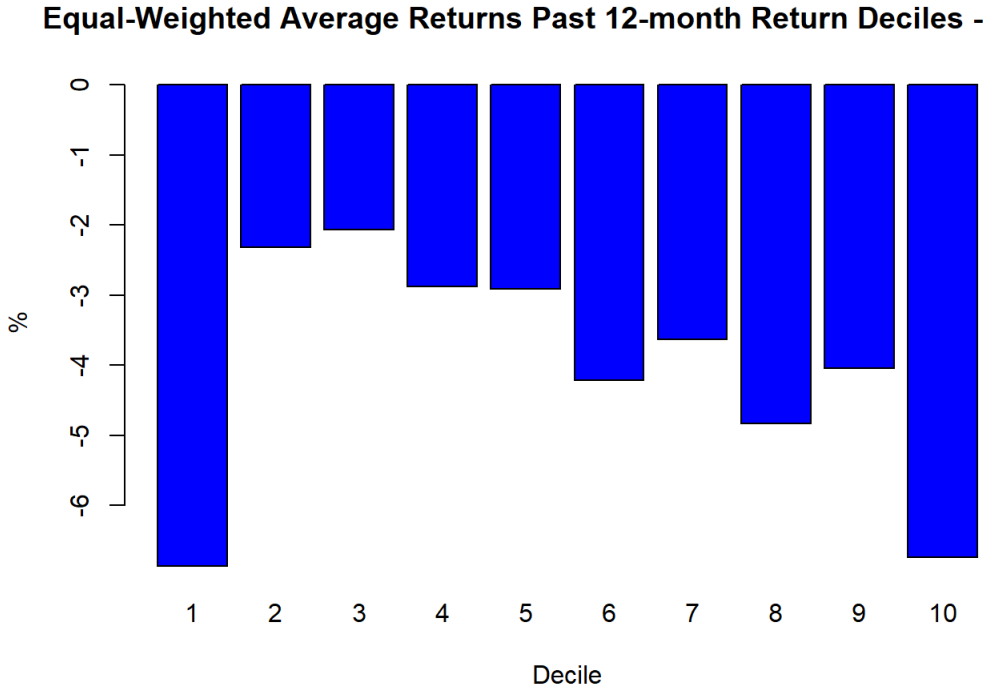
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19850
%
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19850
%
-2
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19850
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-6
-5
-4
-3
-2
-1
0
1
2
3
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5
6
7
8
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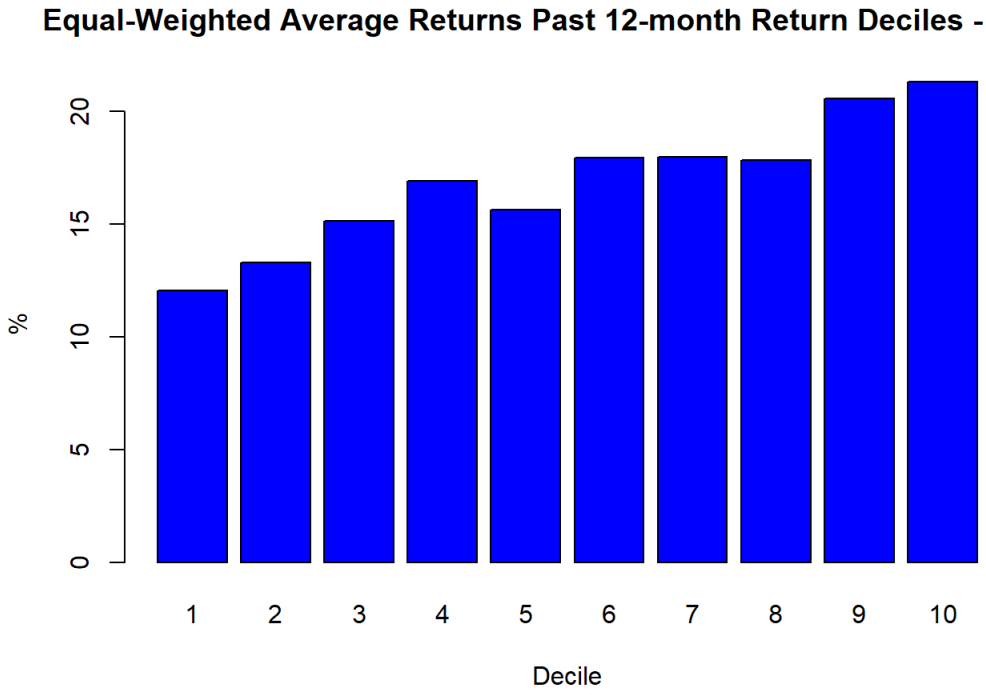
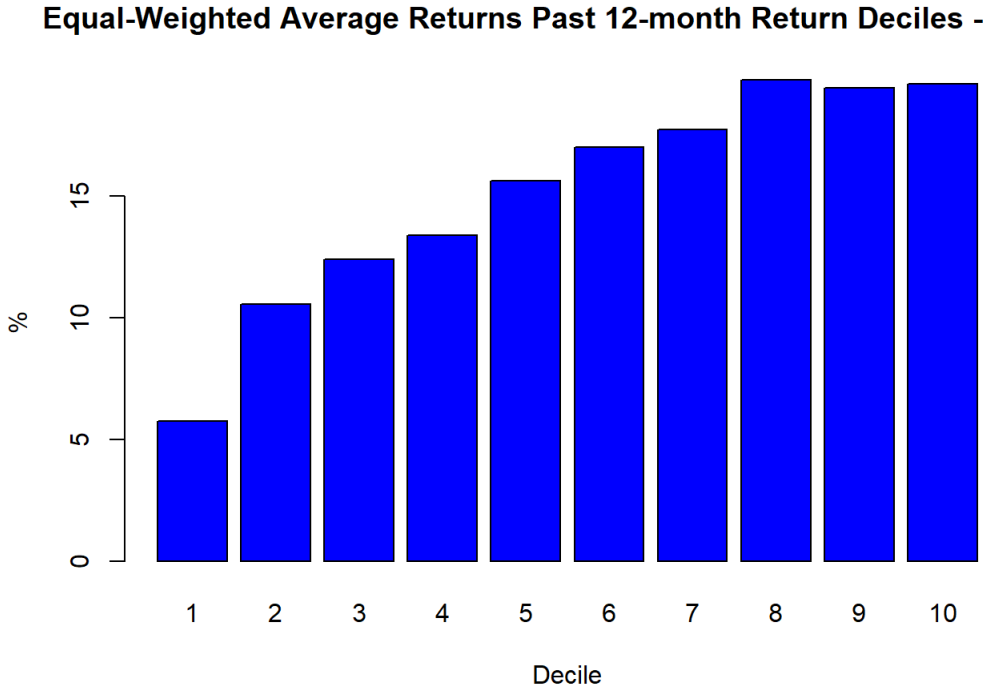
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19850
%
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19860
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0
5
10
15
1
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3
4
5
6
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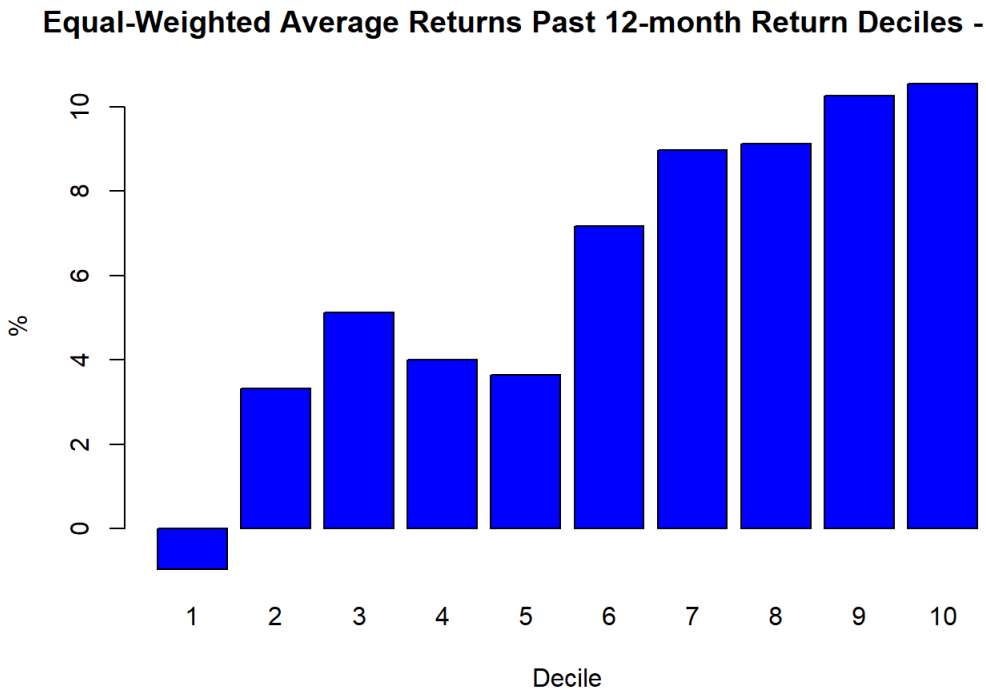
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19860
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0
2
4
6
8
10
1
2
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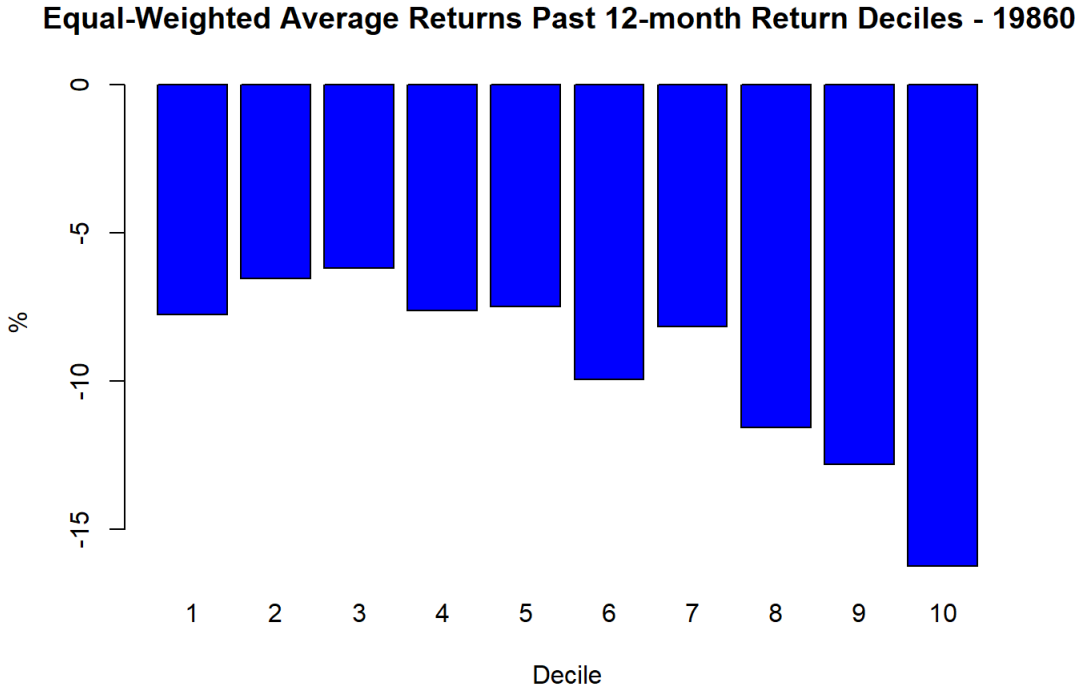
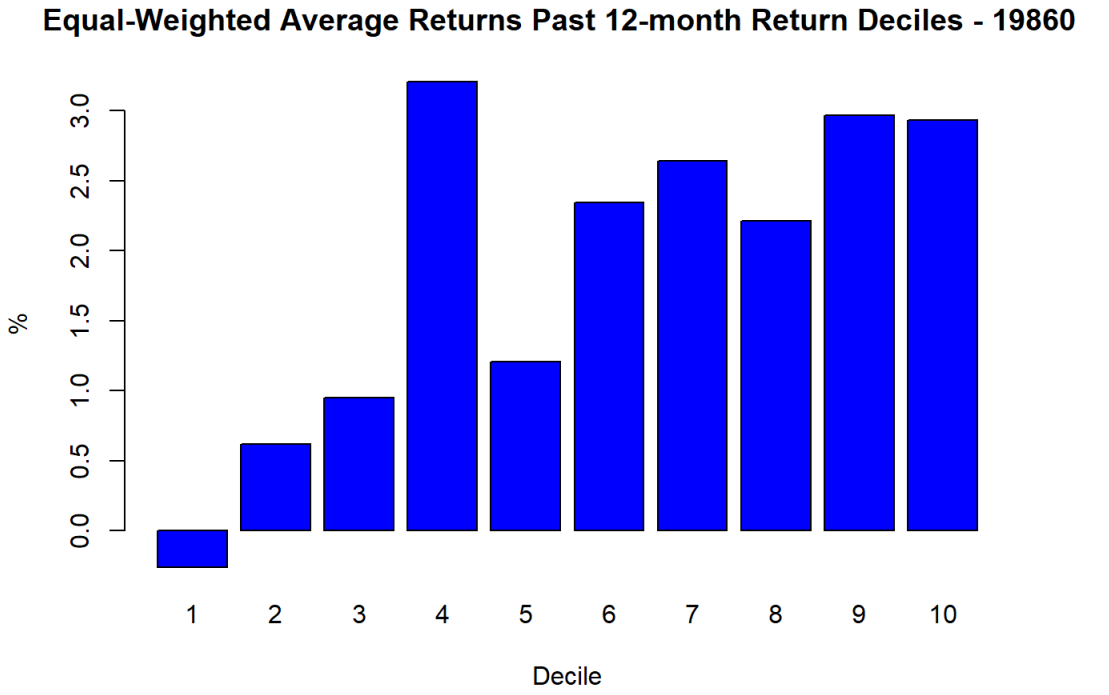
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19860
%
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19860
%
0.0
0.5
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1.5
2.0
2.5
3.0
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2
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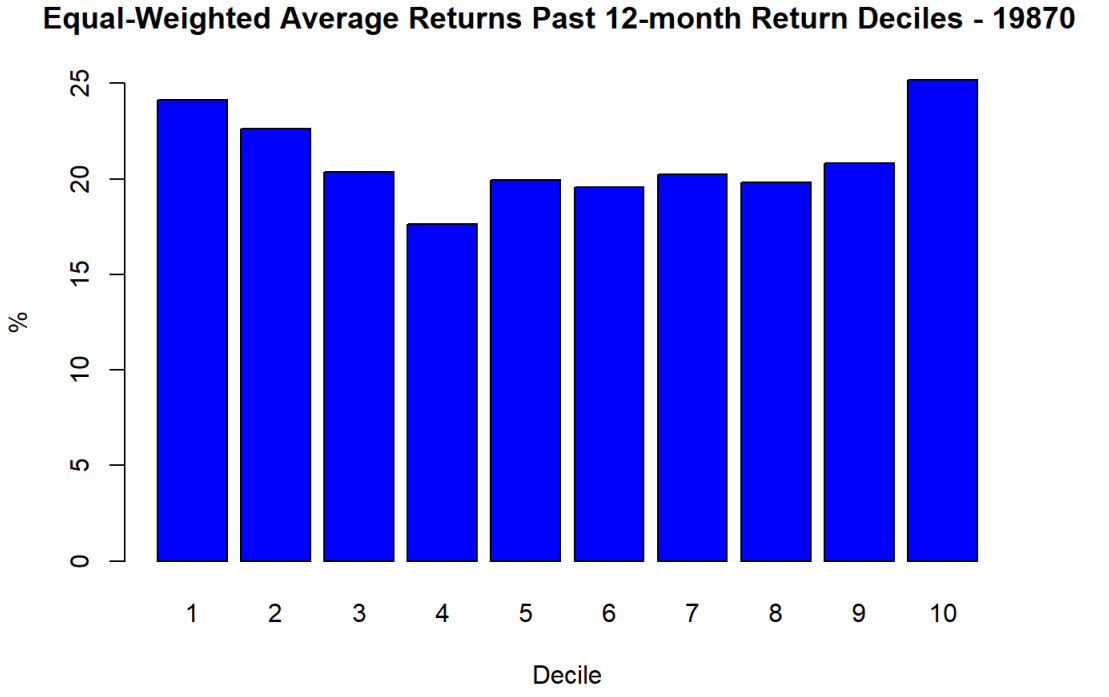
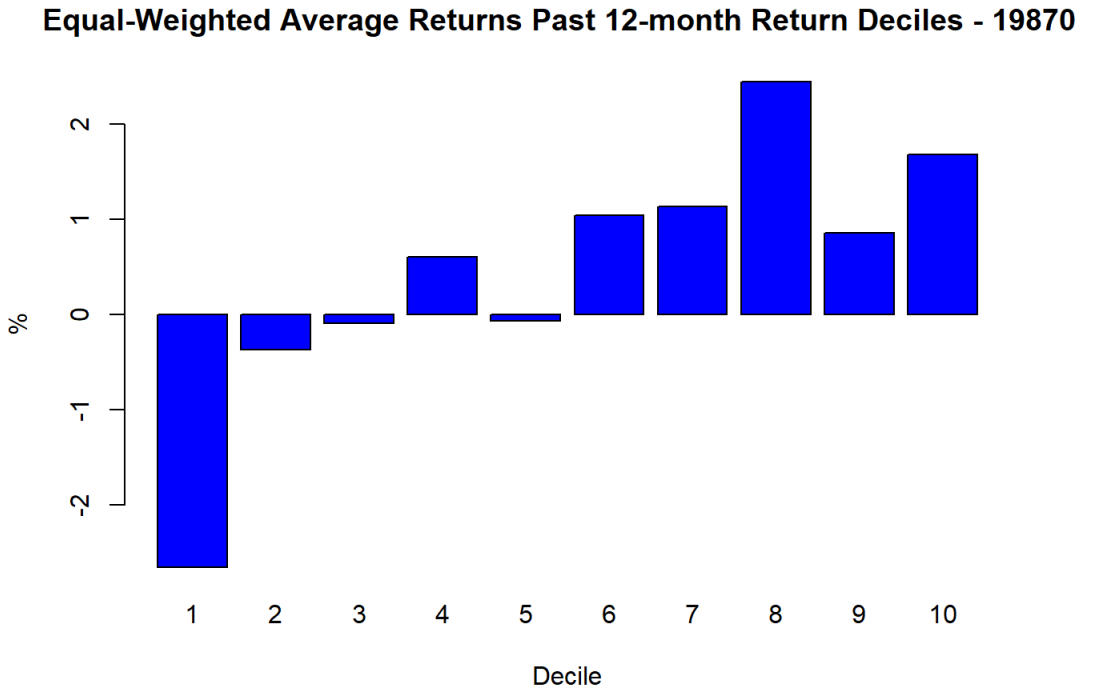
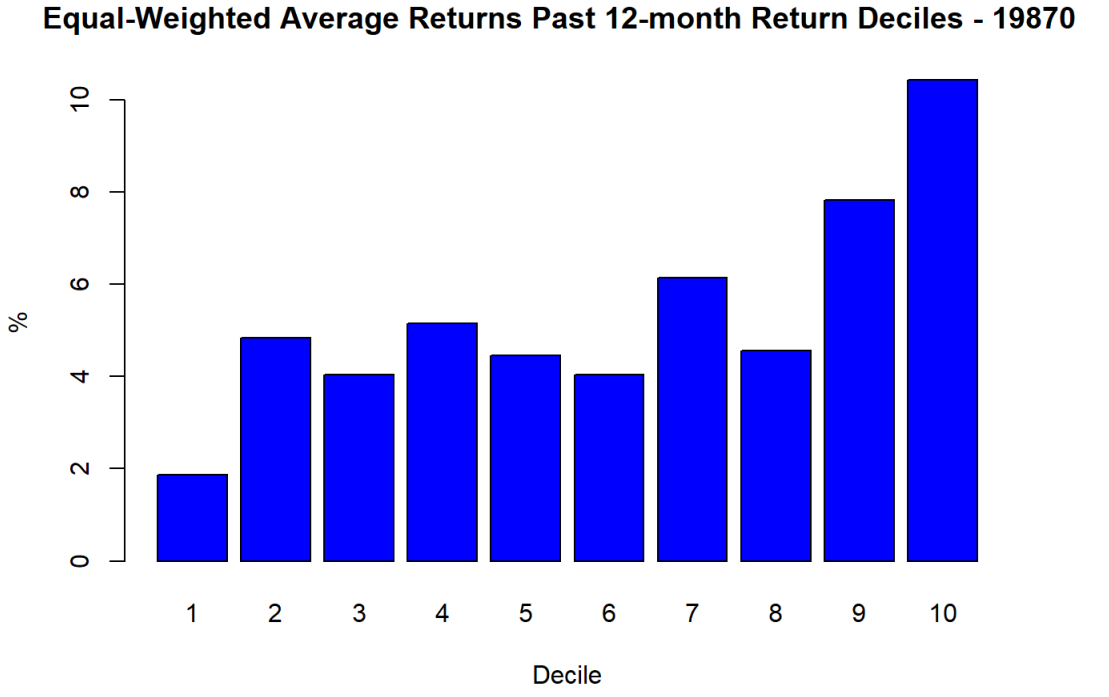
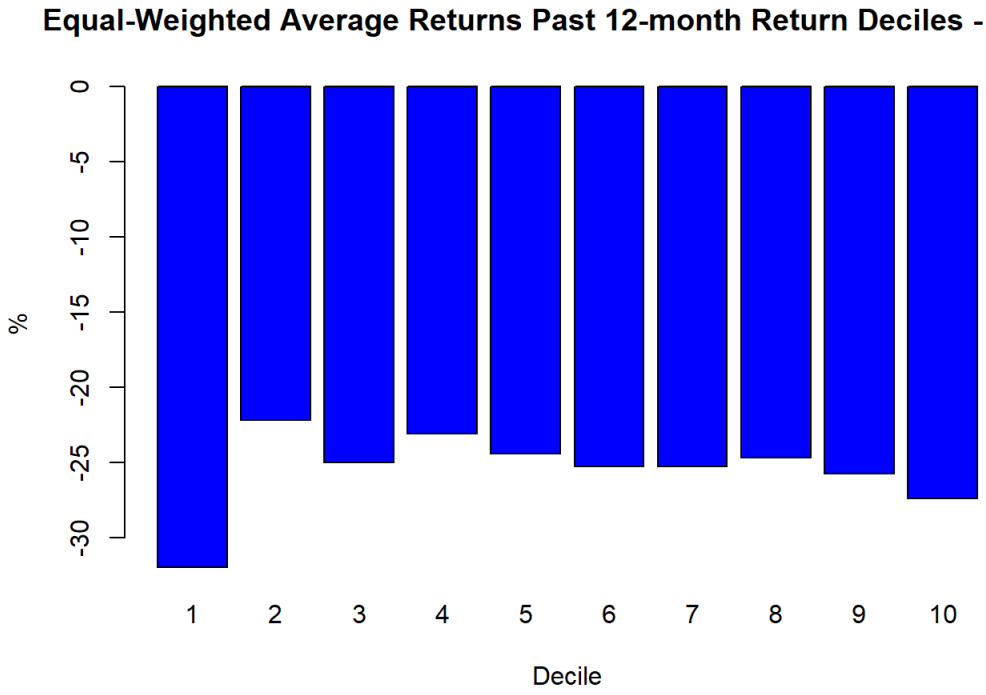
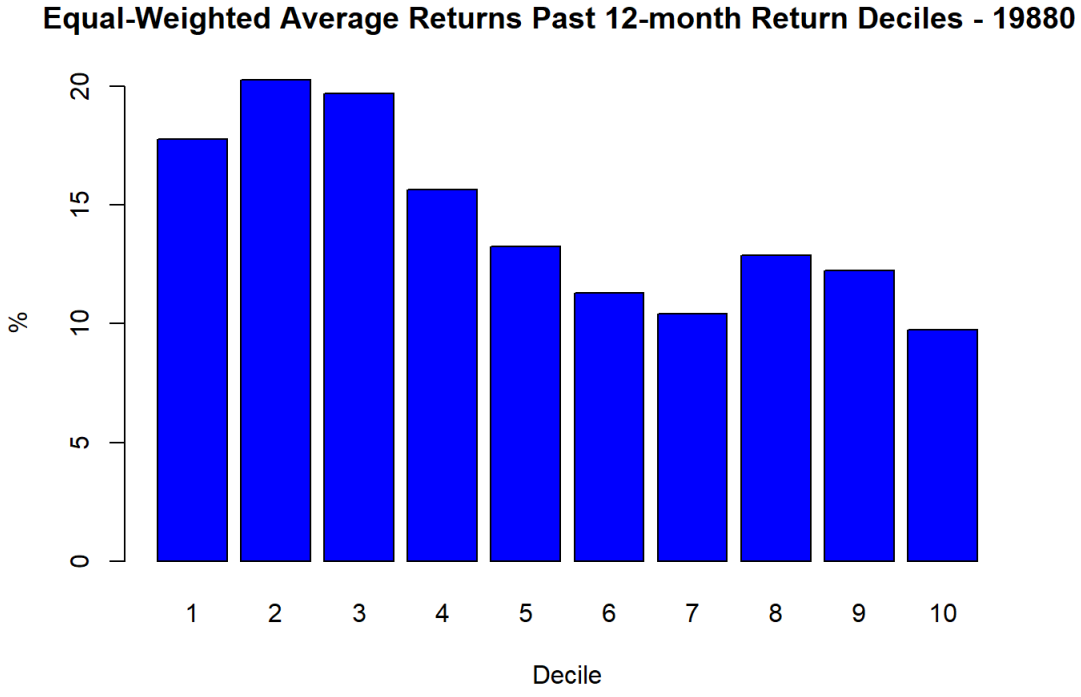
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19870
%
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19870
%
2
1
0
-1
-2
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19870
%
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19870
%
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19880
%
0
5
10
15
20
1
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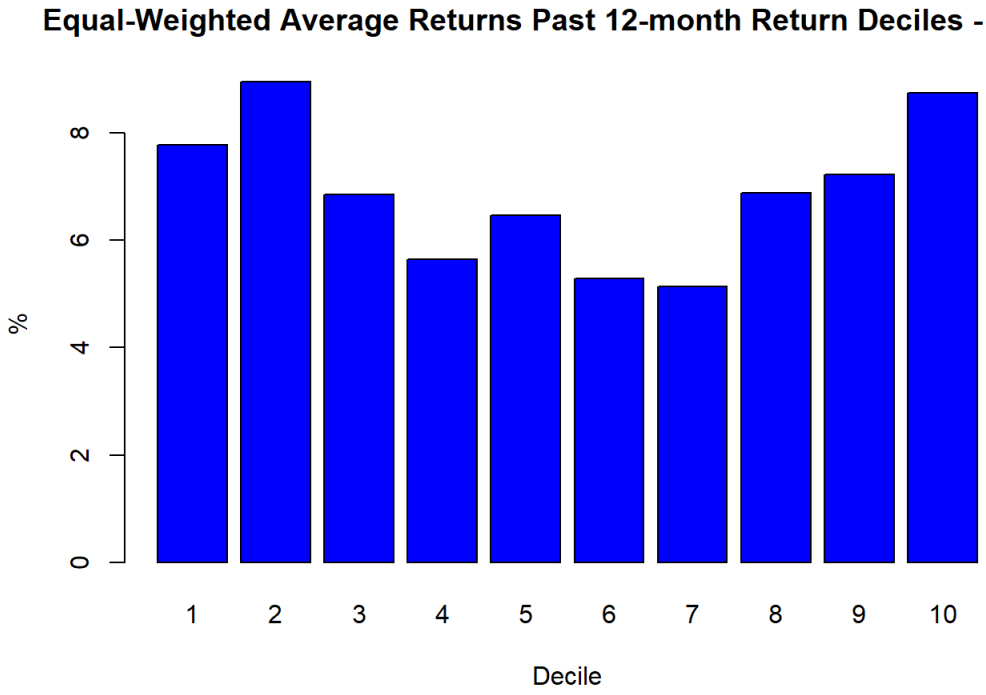
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19880
%
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4
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2
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5
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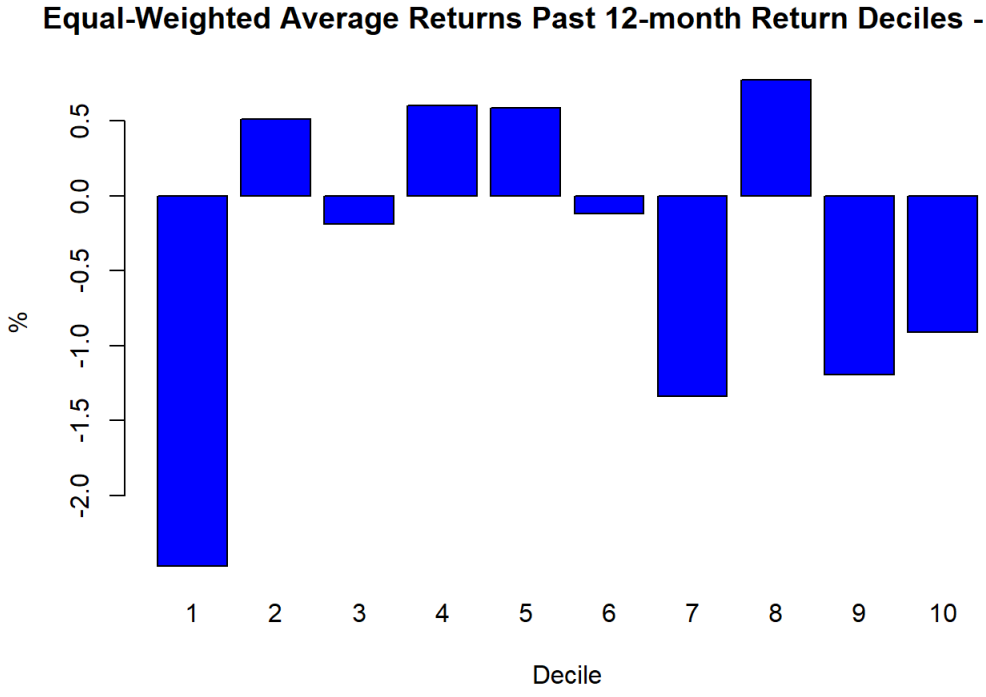
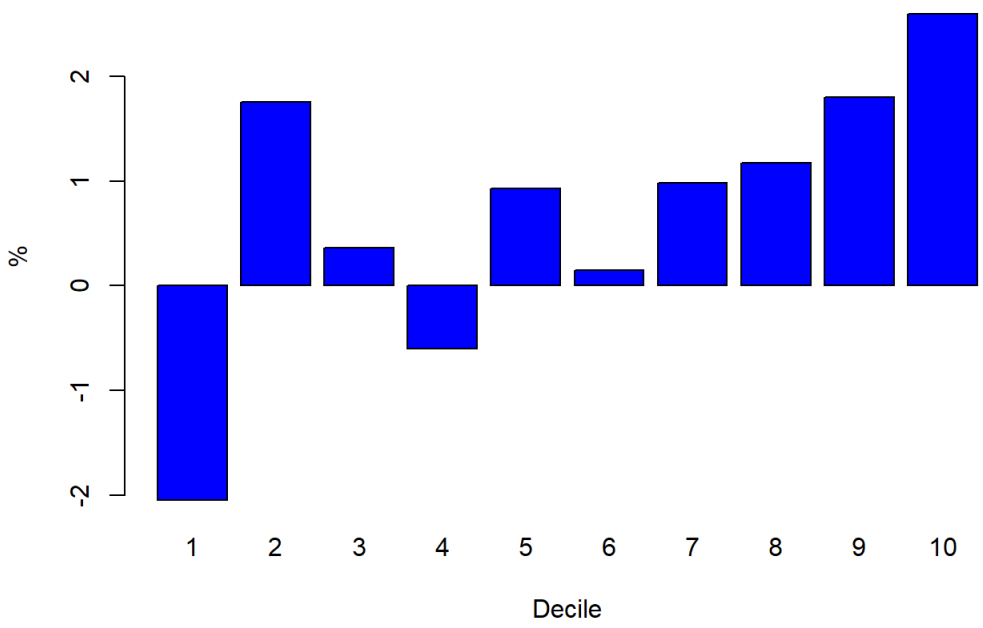
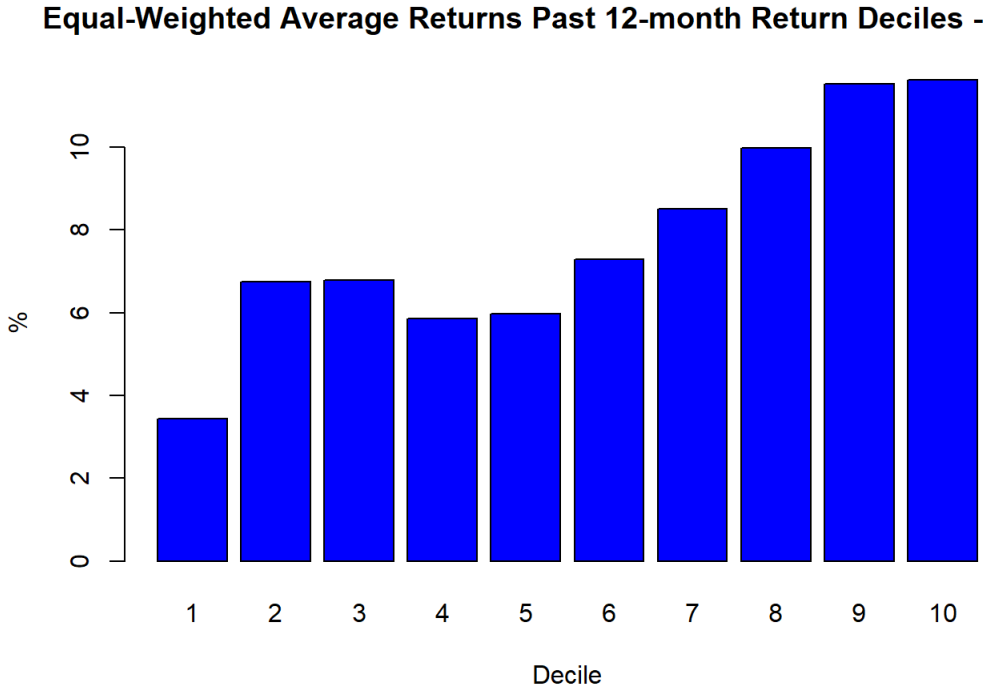
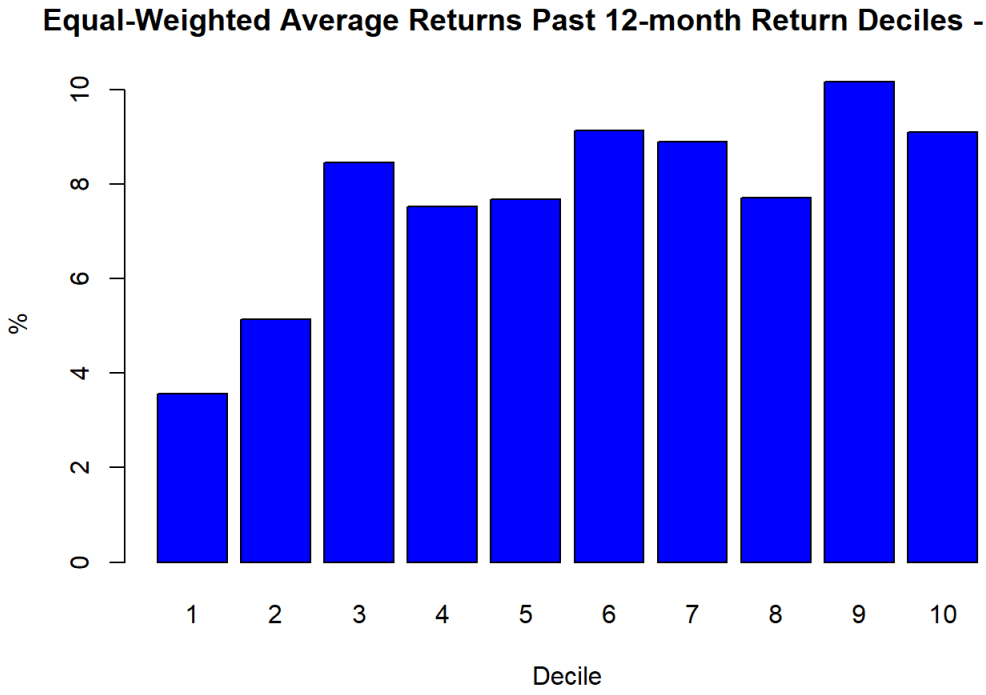
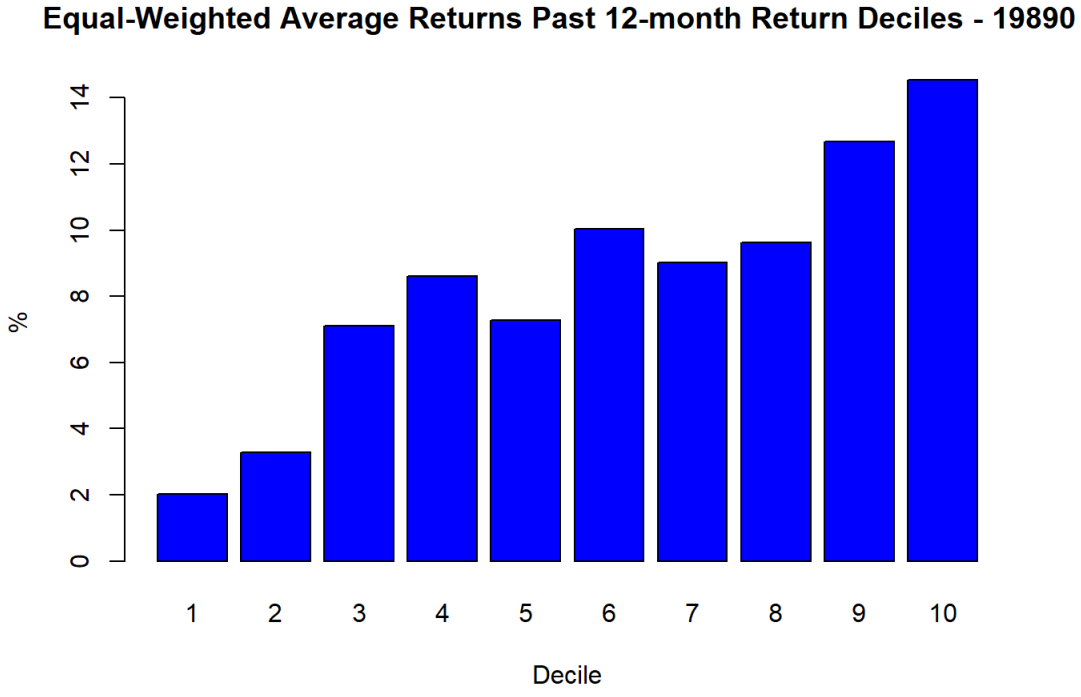
7
8
9
10
Decile

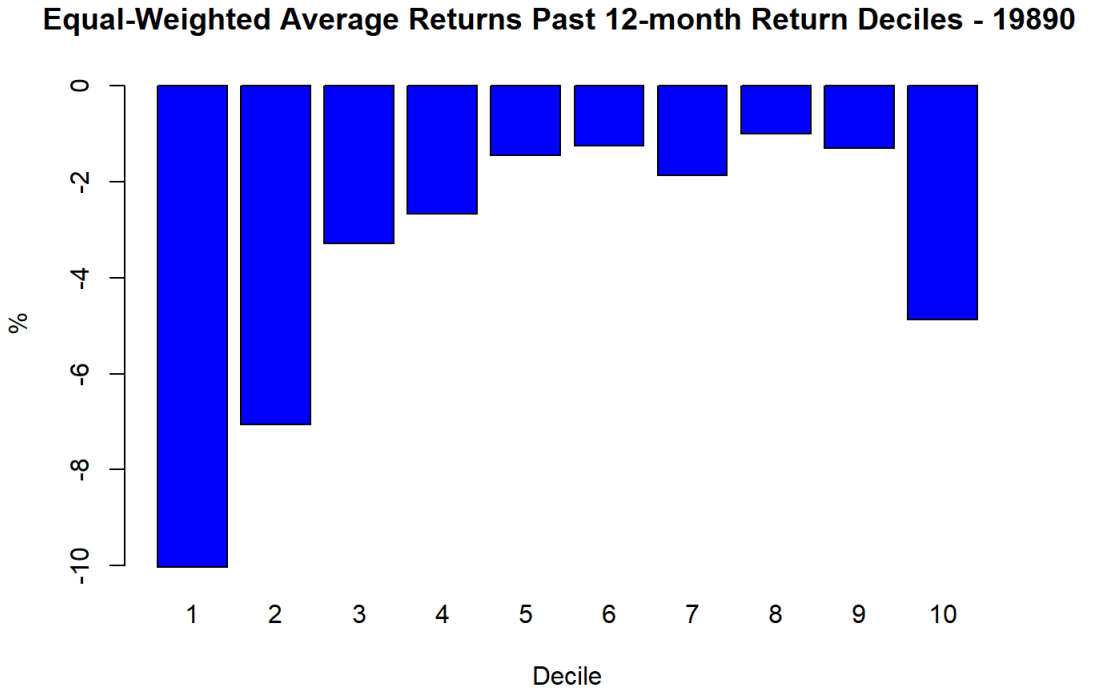

Equal-Weighted Average Returns Past 12-month Return Deciles - 19880
%
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1
2
3
4
5
6
7
8
9
10
Decile

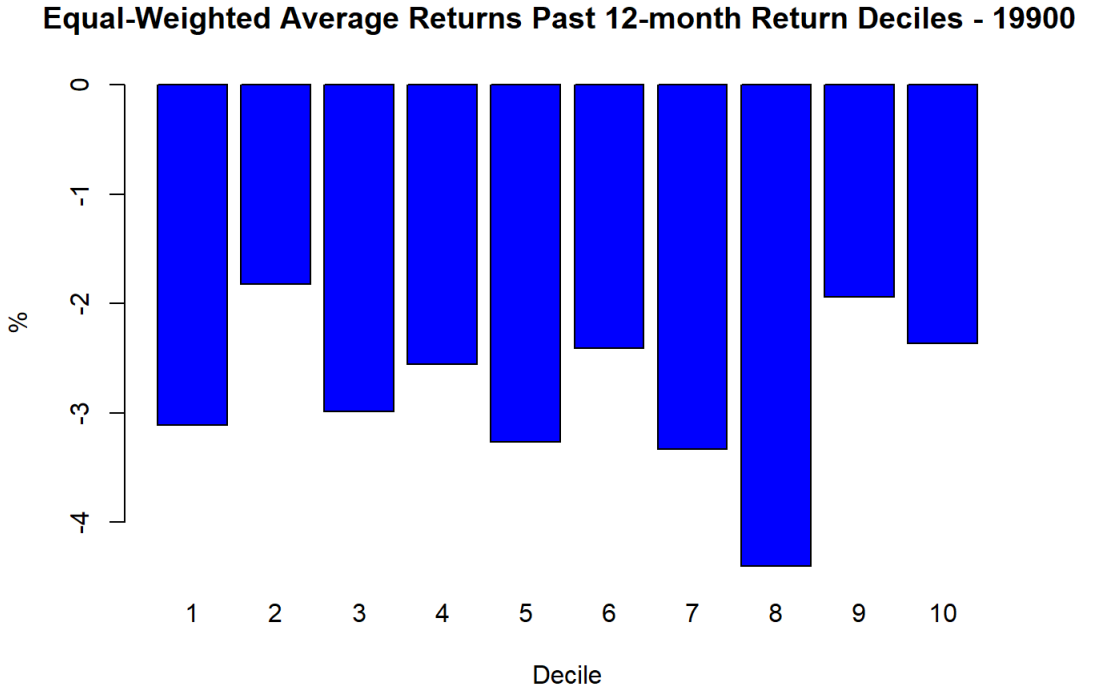

Equal-Weighted Average Returns Past 12-month Return Deciles - 19880
%
2
1
0
-1
-2
1
2
3
4
5
6
7
8
9
10
Decile

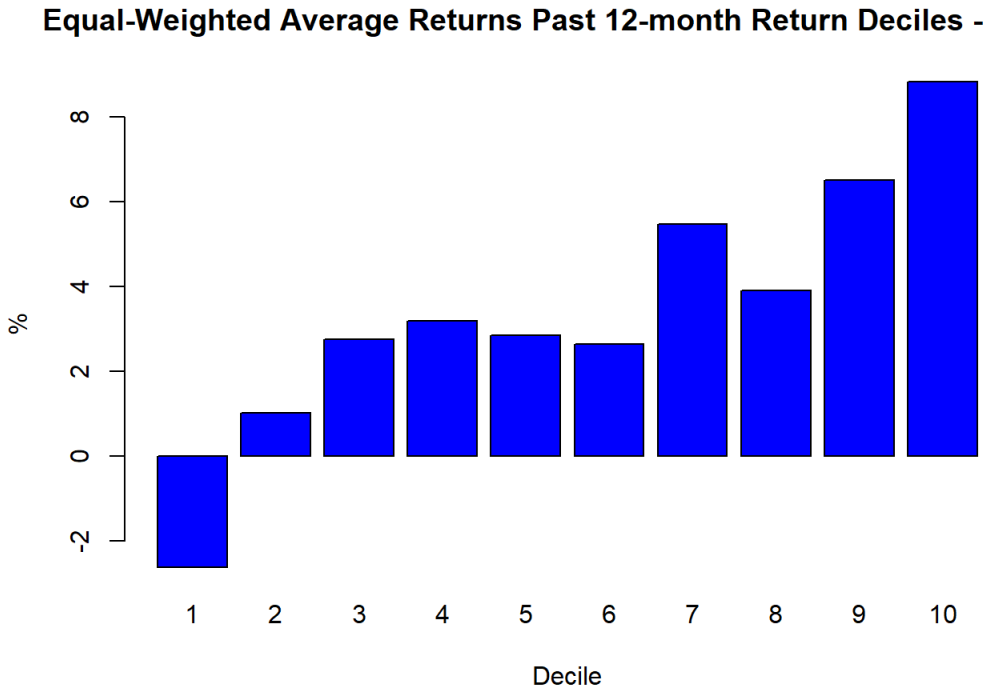

Equal-Weighted Average Returns Past 12-month Return Deciles - 19890
%
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Decile

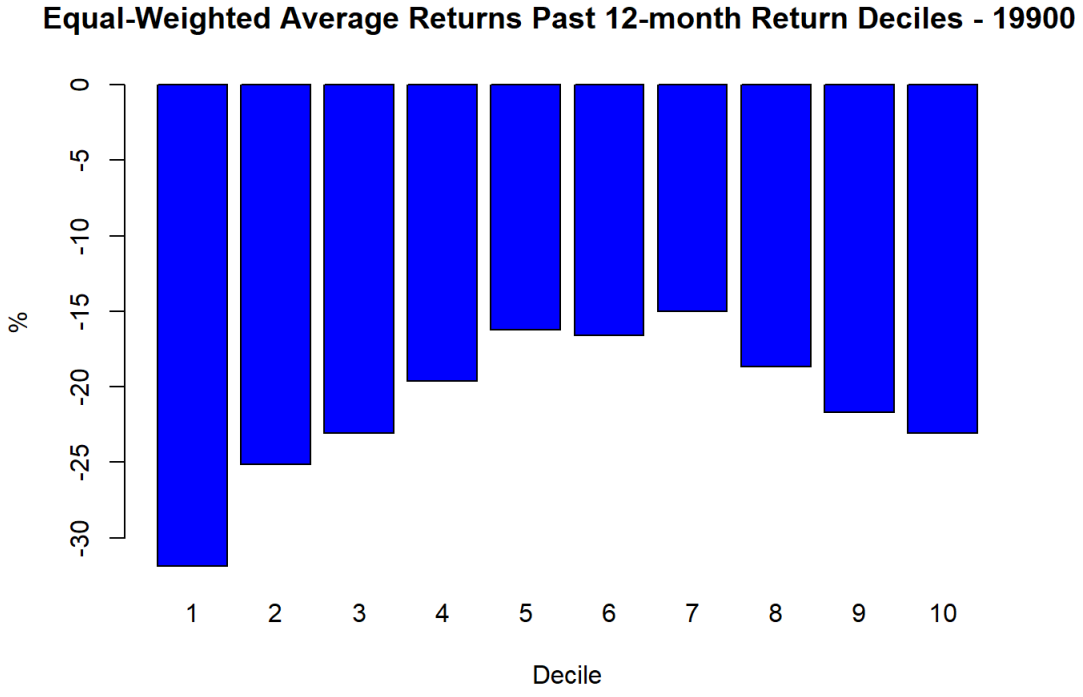

Equal-Weighted Average Returns Past 12-month Return Deciles - 19890
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

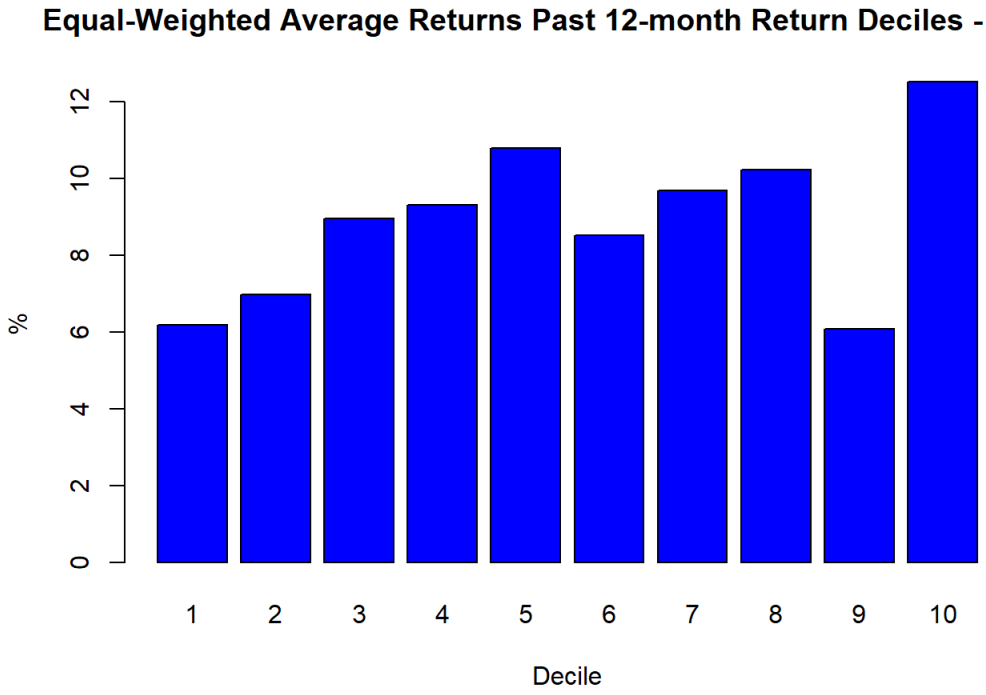

Equal-Weighted Average Returns Past 12-month Return Deciles - 19890
%
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
Decile

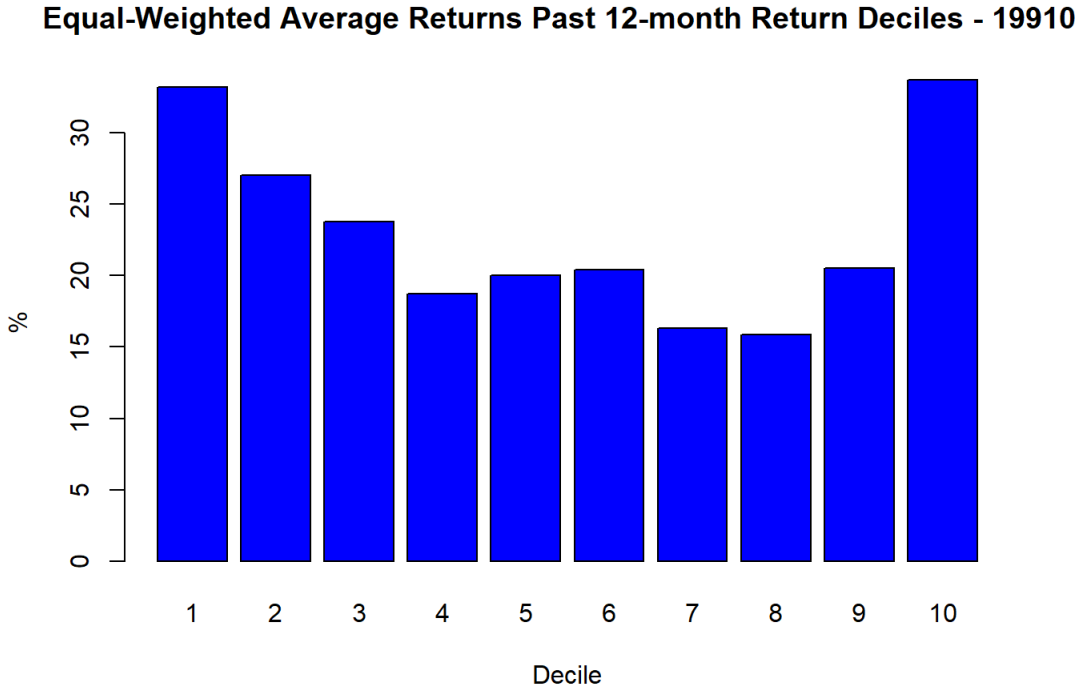

Equal-Weighted Average Returns Past 12-month Return Deciles - 19890
%
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
Decile

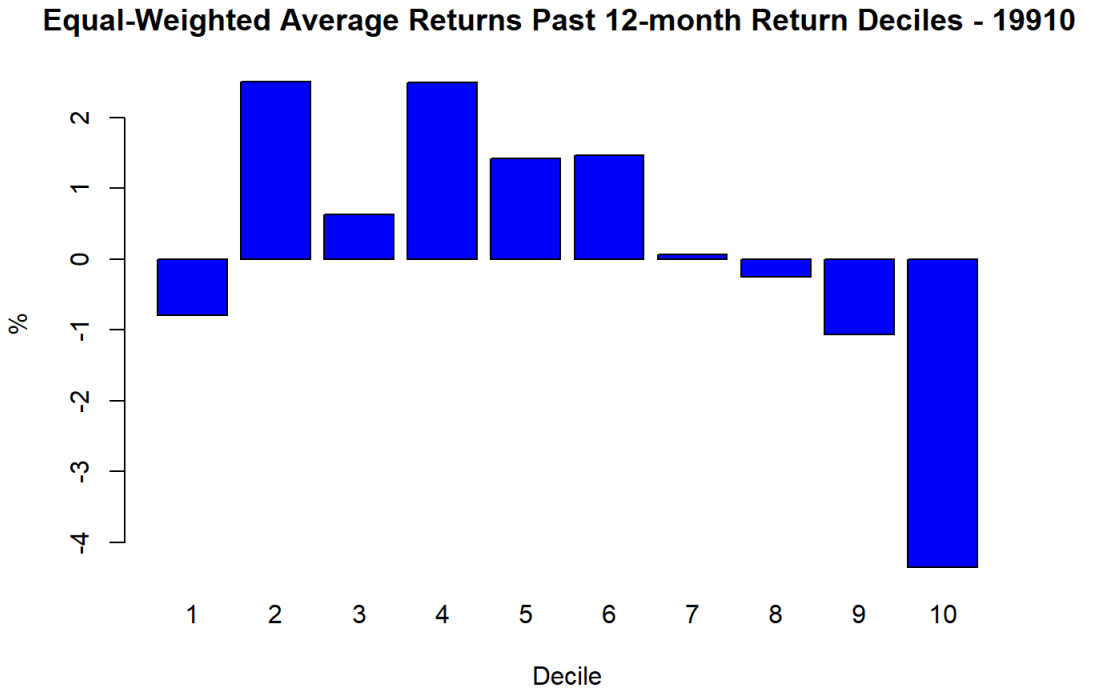

Equal-Weighted Average Returns Past 12-month Return Deciles - 19900
%
0
-1
-2
-3
-4
1
2
3
4
5
6
7
8
9
10
Decile

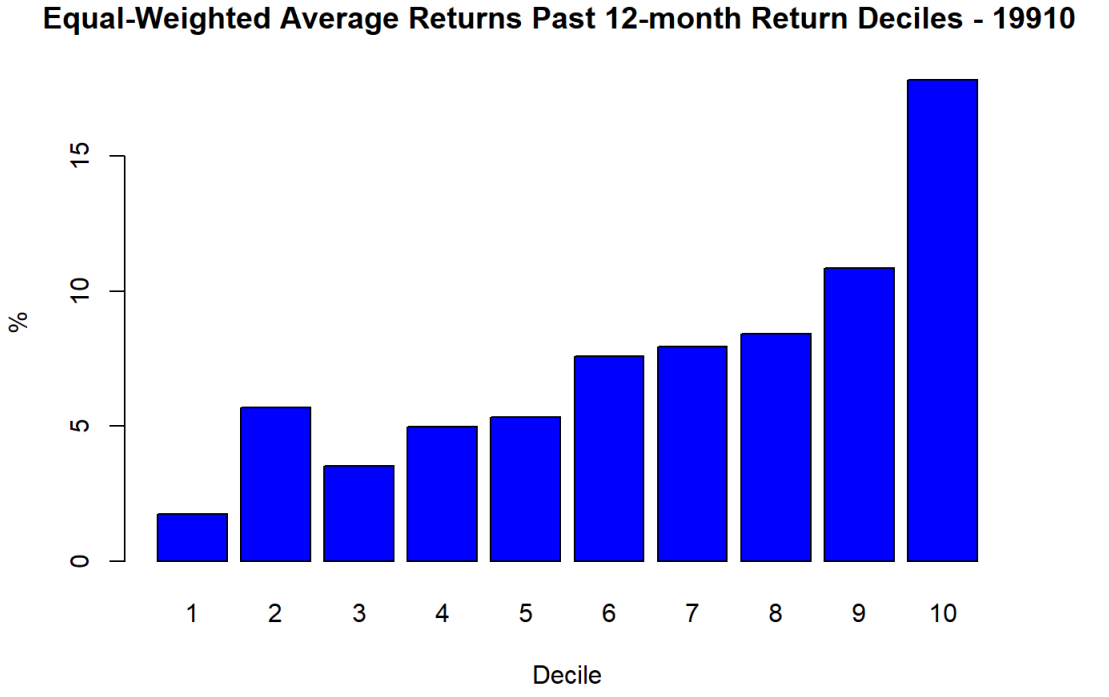

Equal-Weighted Average Returns Past 12-month Return Deciles - 19900
%
-2
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

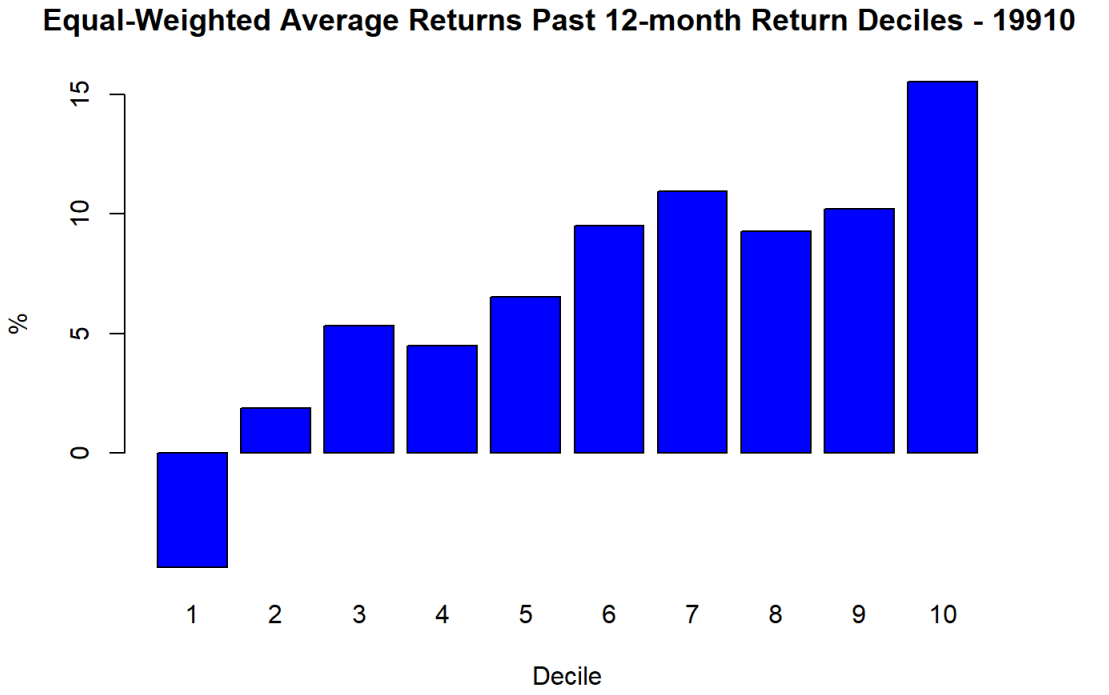

Equal-Weighted Average Returns Past 12-month Return Deciles - 19900
%
-30
-25
-20
-15
-10
-5
0
1
2
3
4
5
6
7
8
9
10
Decile

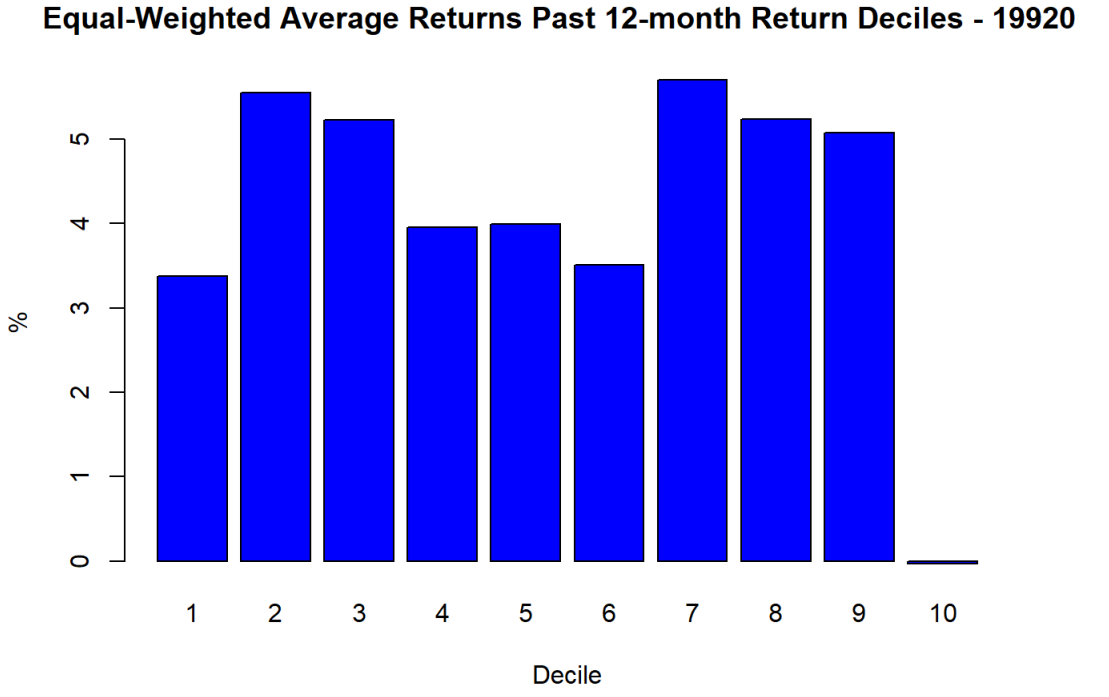

Equal-Weighted Average Returns Past 12-month Return Deciles - 19900
%
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
Decile

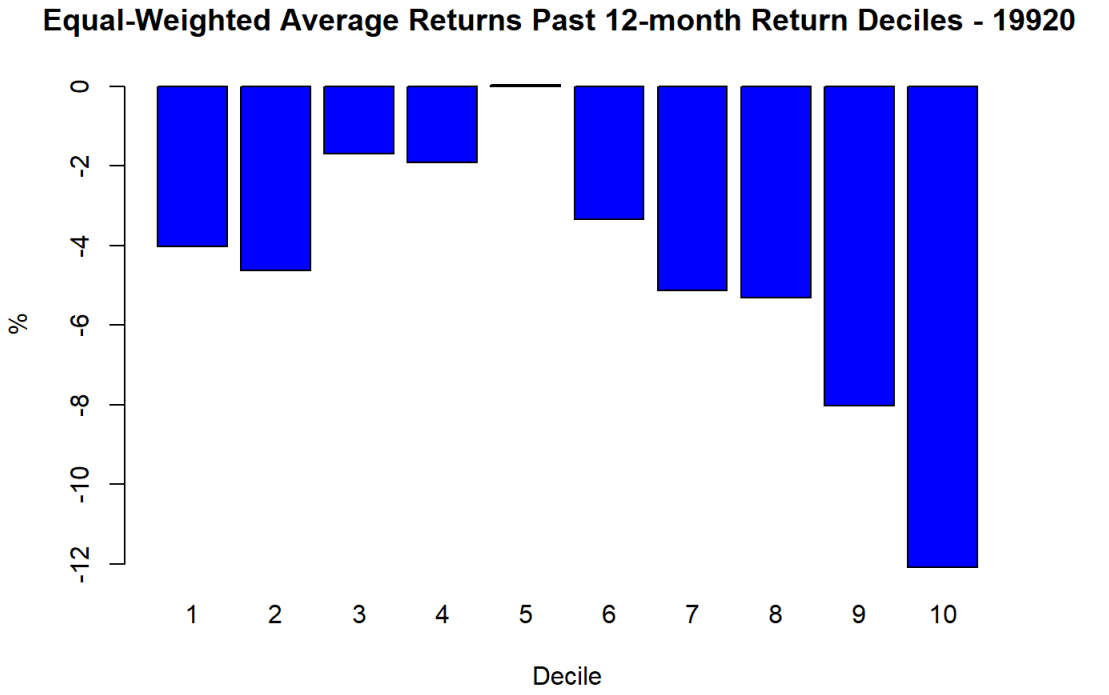

Equal-Weighted Average Returns Past 12-month Return Deciles - 19910
%
0
5
10
15
20
25
30
1
2
3
4
5
6
7
8
9
10
Decile

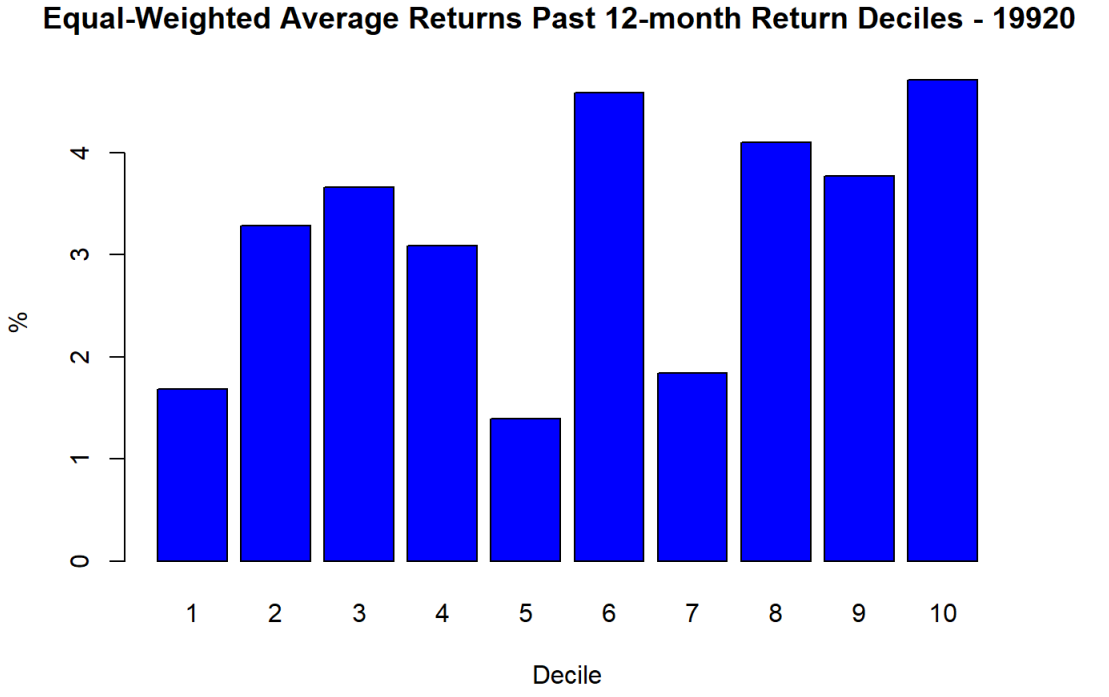

Equal-Weighted Average Returns Past 12-month Return Deciles - 19910
%
2
1
0
-1
-2
-3
-4
1
2
3
4
5
6
7
8
9
10
Decile

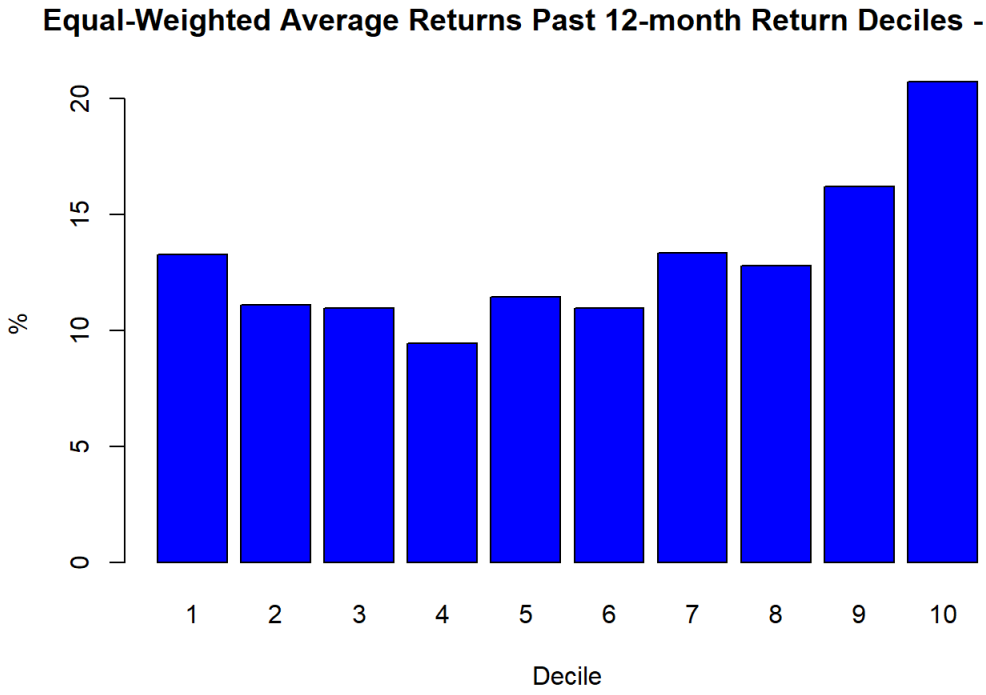

Equal-Weighted Average Returns Past 12-month Return Deciles - 19910
%
15
10
5
0
1
2
3
4
5
6
7
8
9
10
Decile

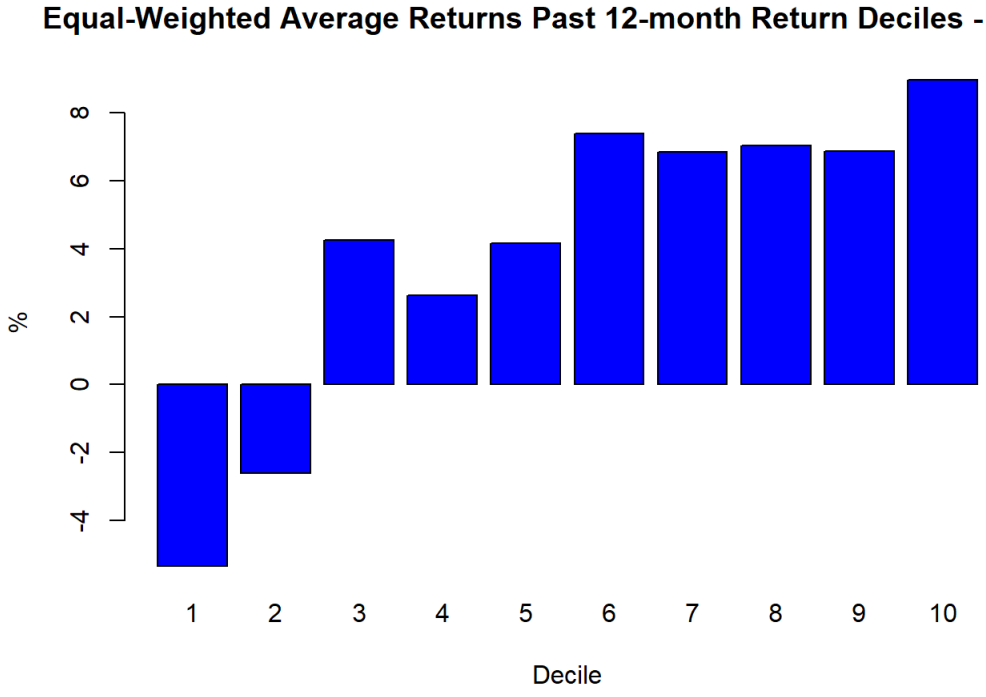

Equal-Weighted Average Returns Past 12-month Return Deciles - 19910
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

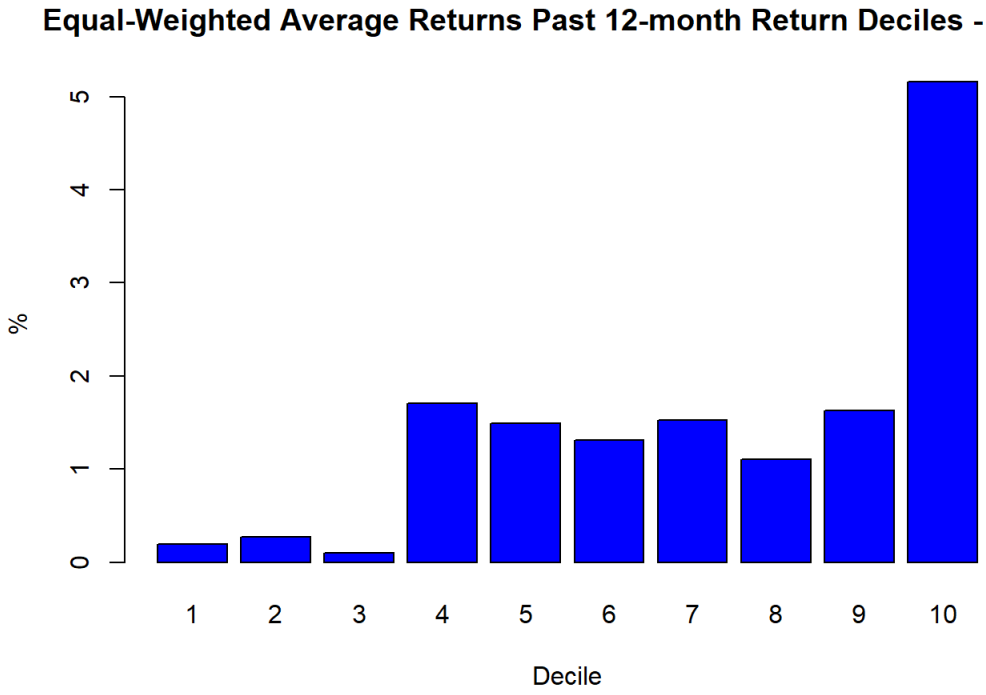

Equal-Weighted Average Returns Past 12-month Return Deciles - 19920
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

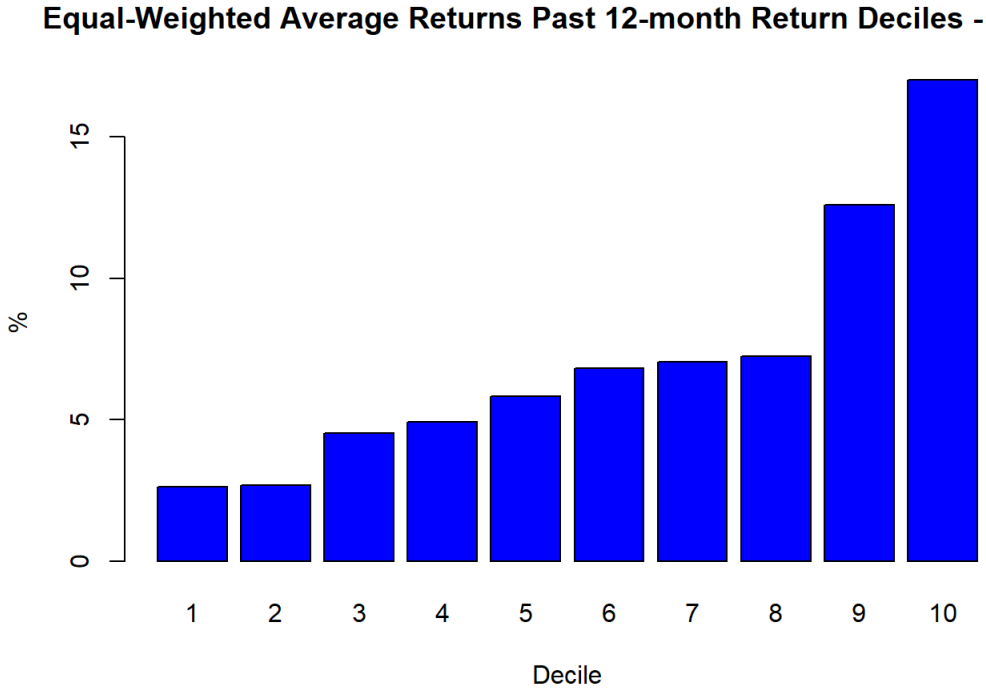

Equal-Weighted Average Returns Past 12-month Return Deciles - 19920
%
0
-2
-4
-6
-8
-10
-12
1
2
3
4
5
6
7
8
9
10
Decile

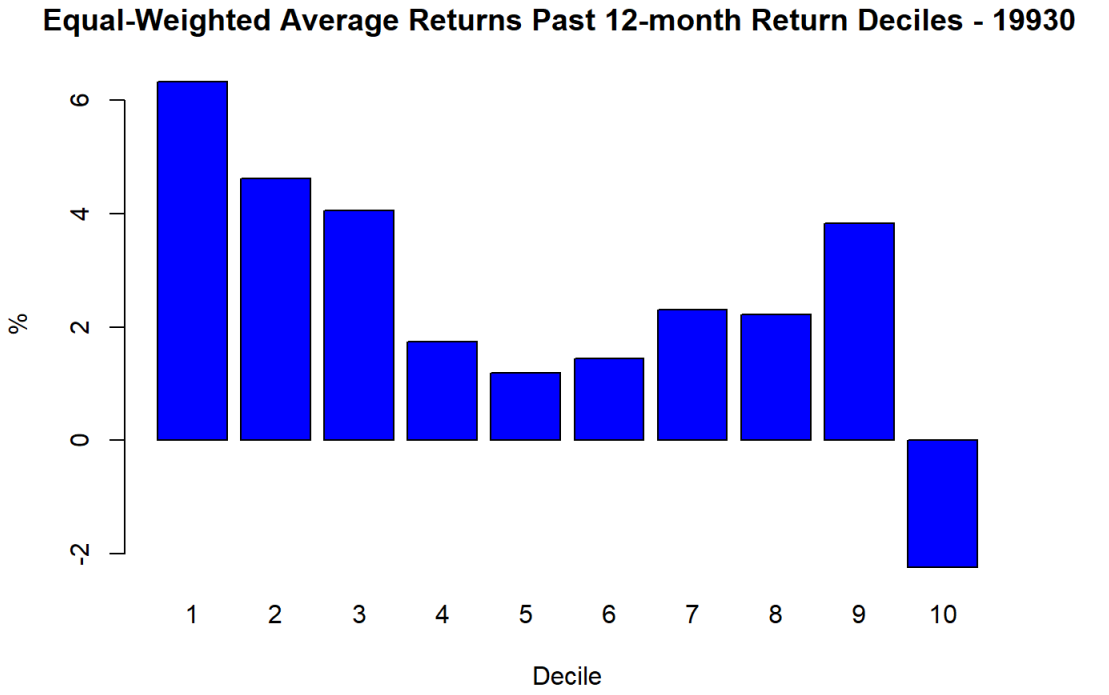

Equal-Weighted Average Returns Past 12-month Return Deciles - 19920
%
0
1
2
3
4
1
2
3
4
5
6
7
8
9
10
Decile

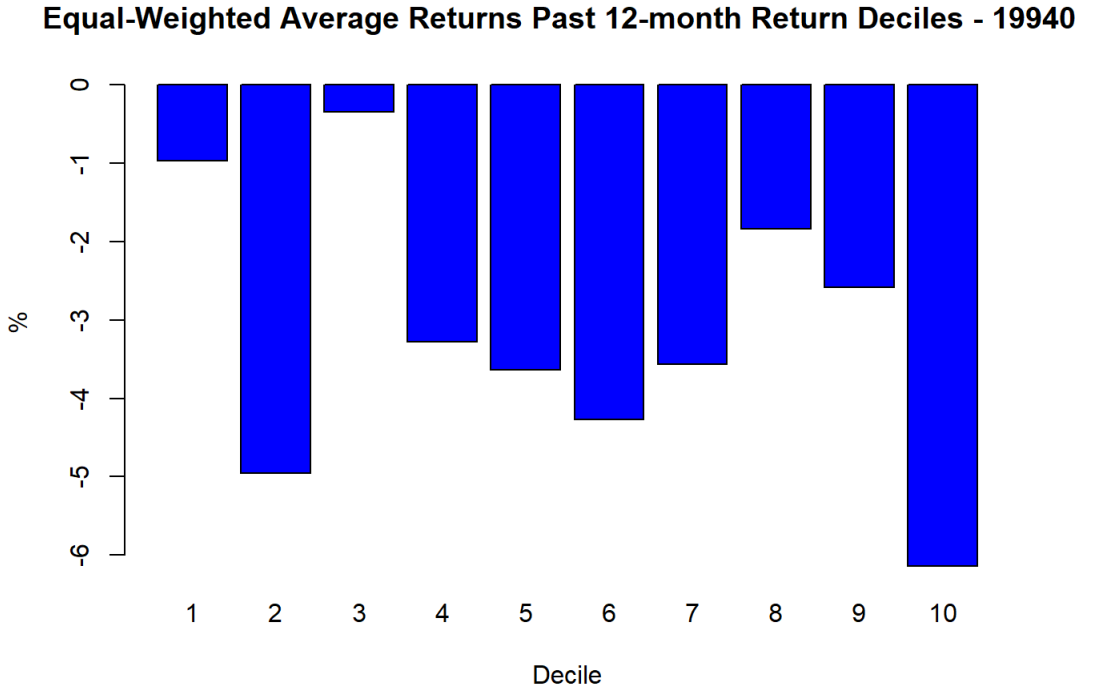

Equal-Weighted Average Returns Past 12-month Return Deciles - 19920
%
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
Decile

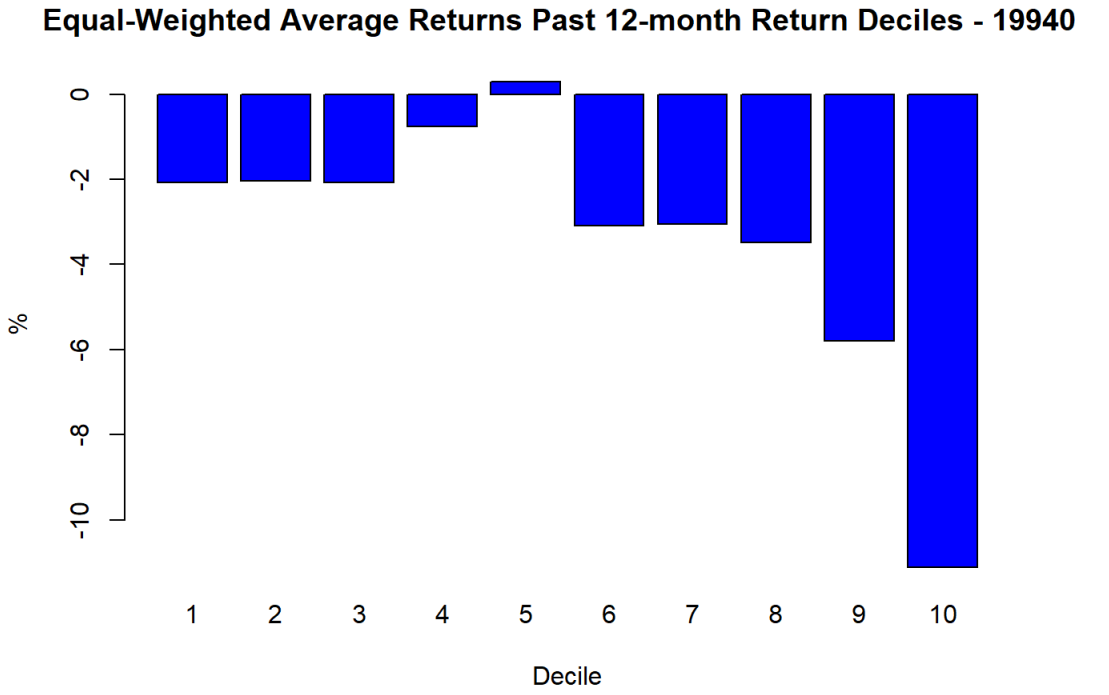

Equal-Weighted Average Returns Past 12-month Return Deciles - 19930
%
-4
-2
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

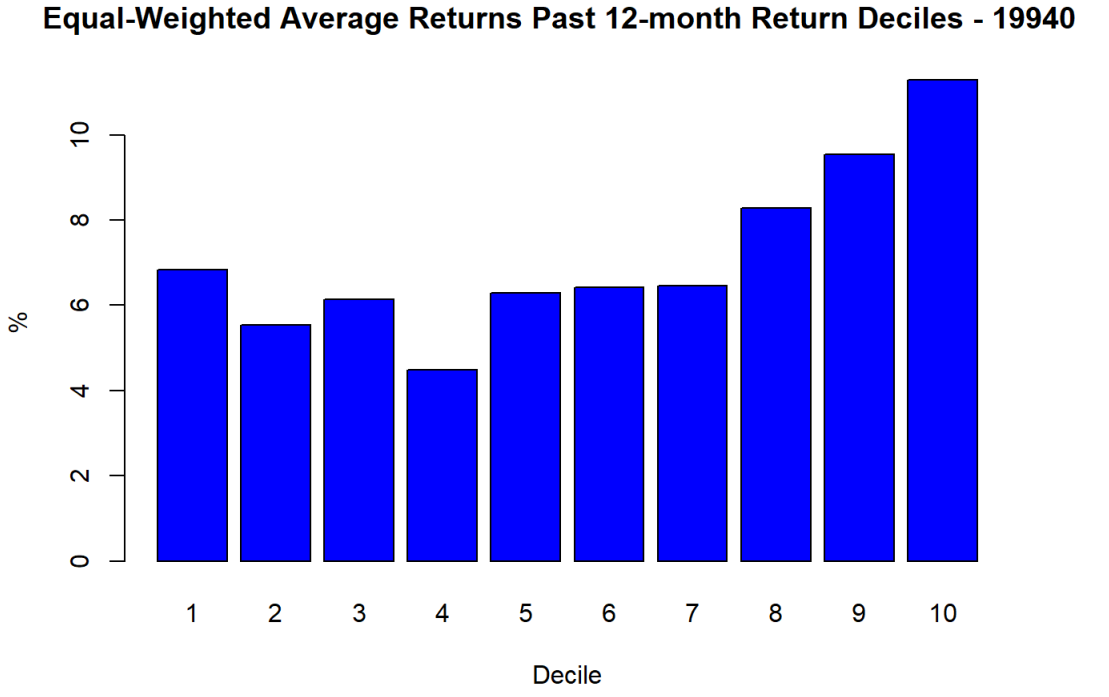

Equal-Weighted Average Returns Past 12-month Return Deciles - 19930
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

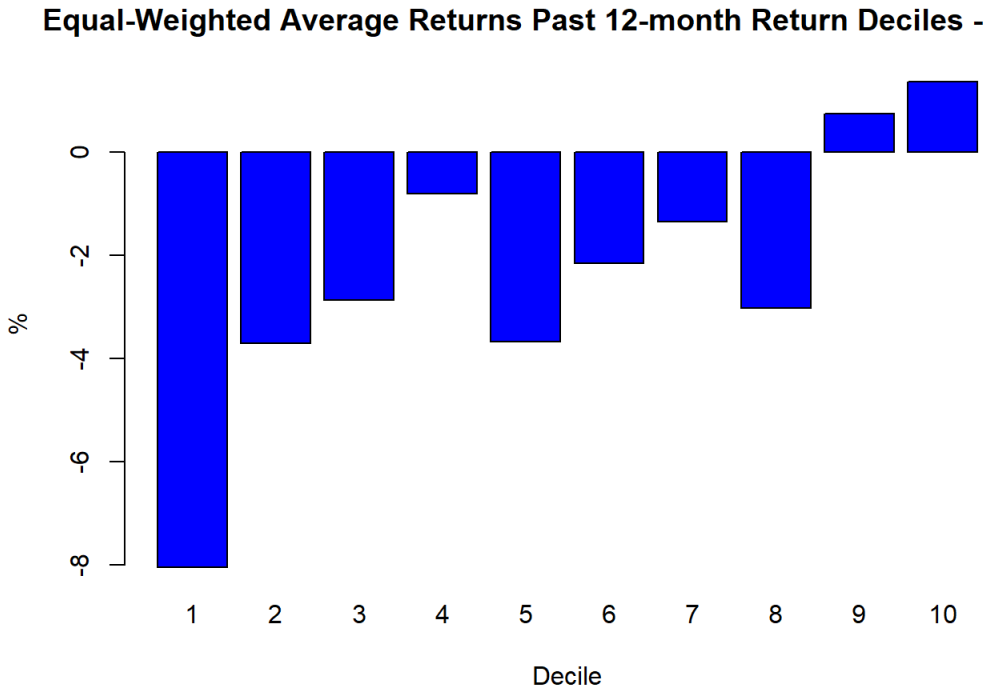

Equal-Weighted Average Returns Past 12-month Return Deciles - 19930
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

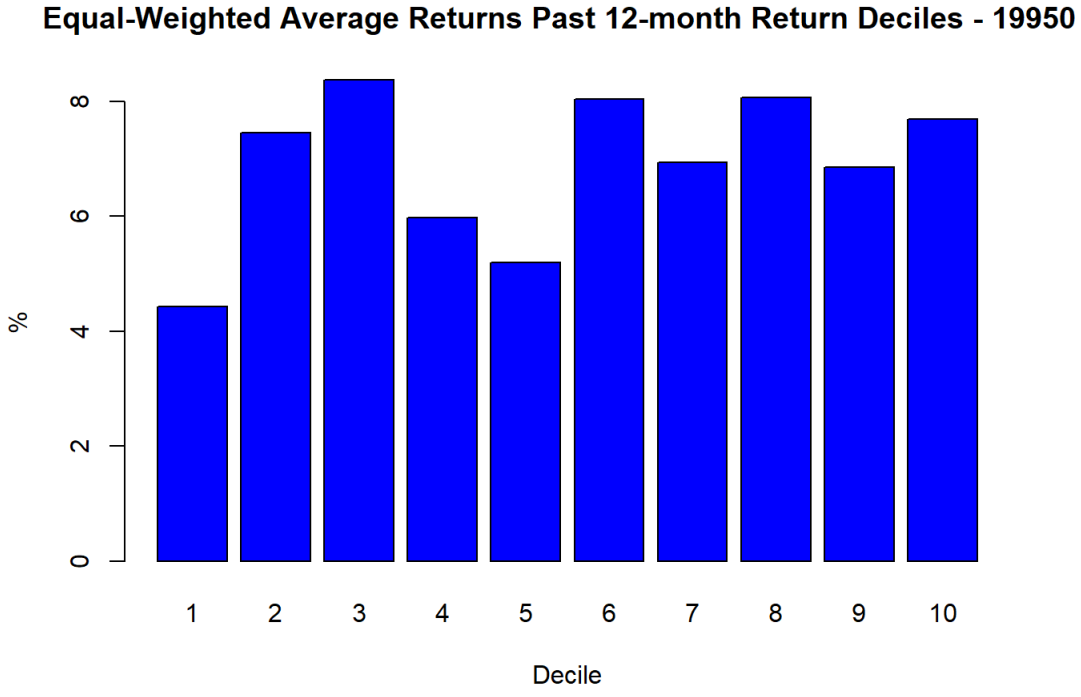

Equal-Weighted Average Returns Past 12-month Return Deciles - 19930
%
6
4
2
0
-2
1
2
3
4
5
6
7
8
9
10
Decile

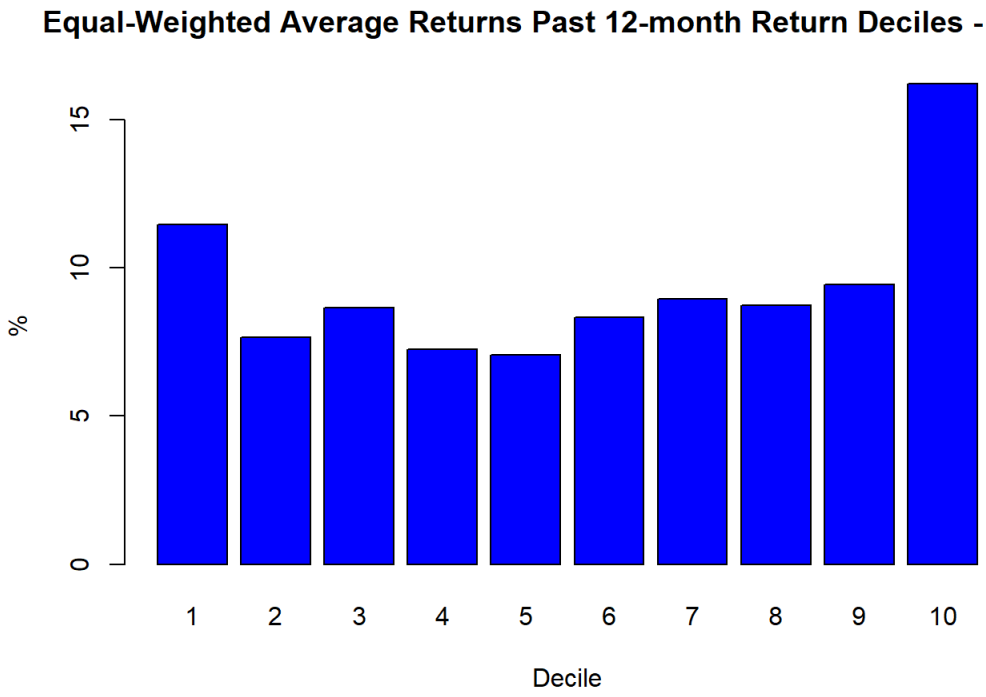

Equal-Weighted Average Returns Past 12-month Return Deciles - 19940
%
0
-1
-2
-3
-4
-5
-6
1
2
3
4
5
6
7
8
9
10
Decile

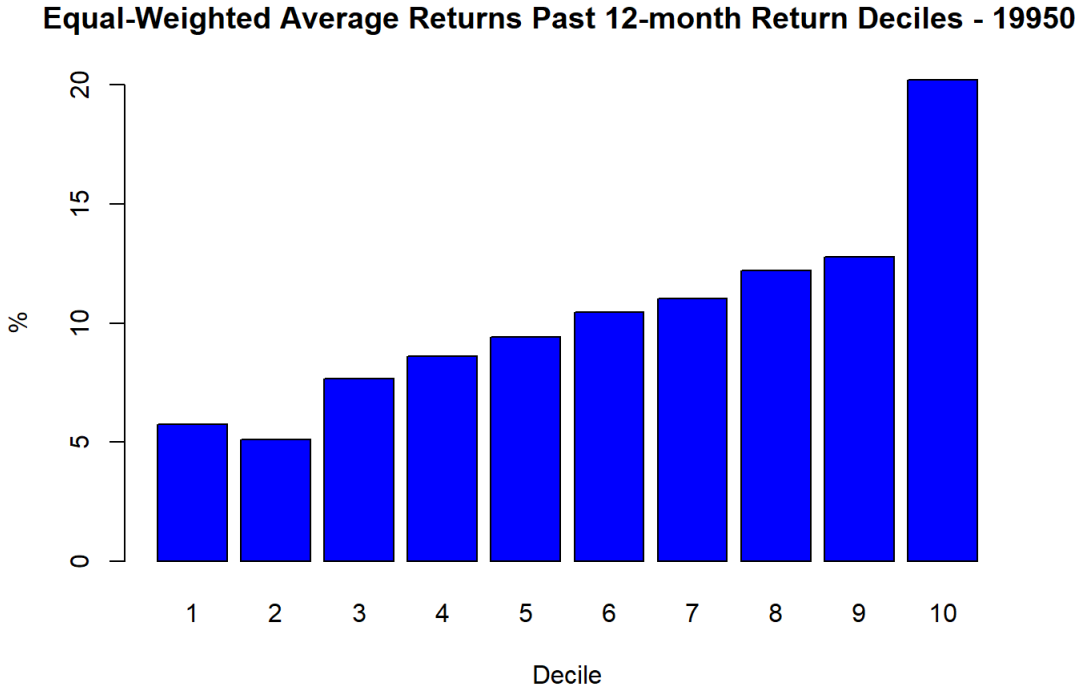

Equal-Weighted Average Returns Past 12-month Return Deciles - 19940
%
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
Decile

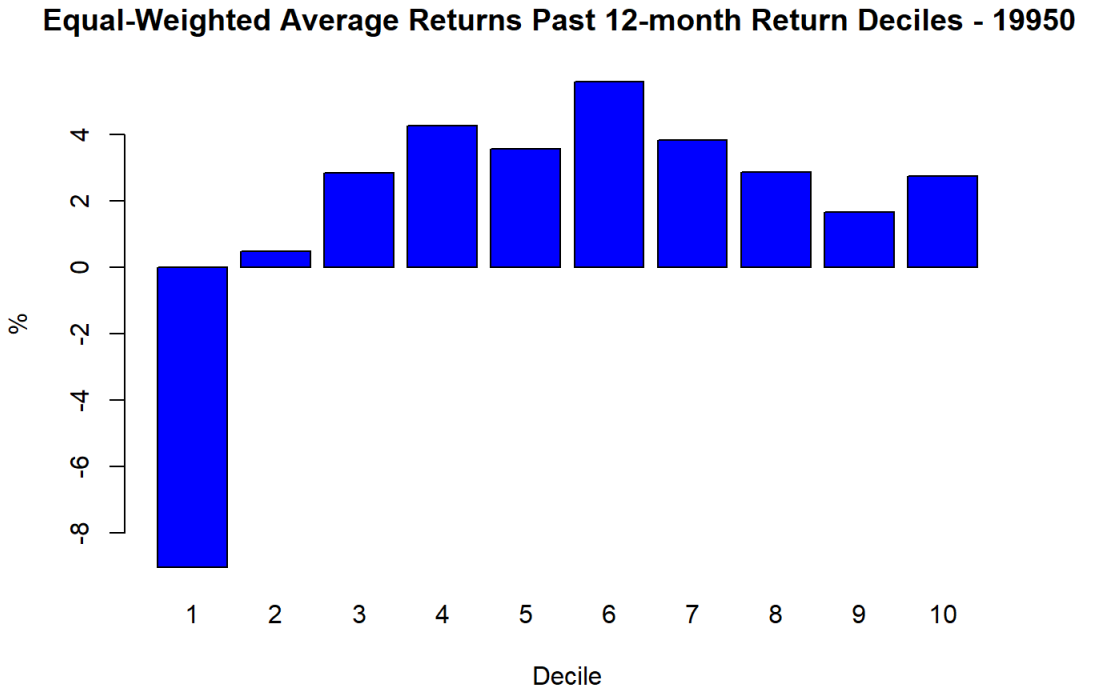

Equal-Weighted Average Returns Past 12-month Return Deciles - 19940
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

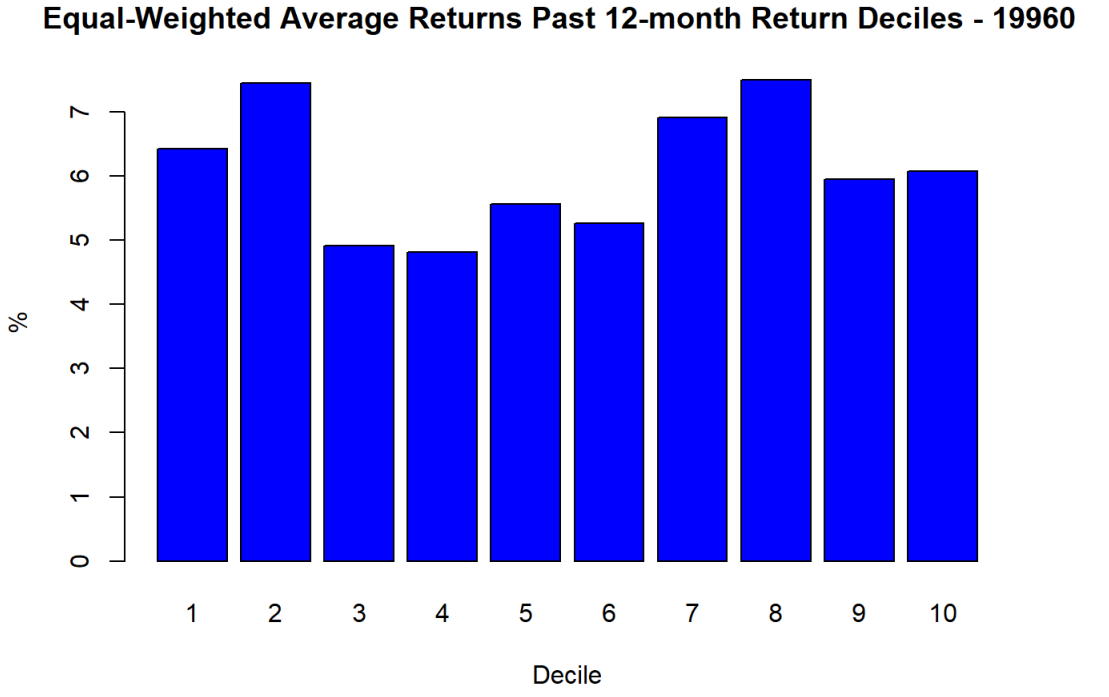

Equal-Weighted Average Returns Past 12-month Return Deciles - 19940
%
0
-2
-4
-6
-8
1
2
3
4
5
6
7
8
9
10
Decile

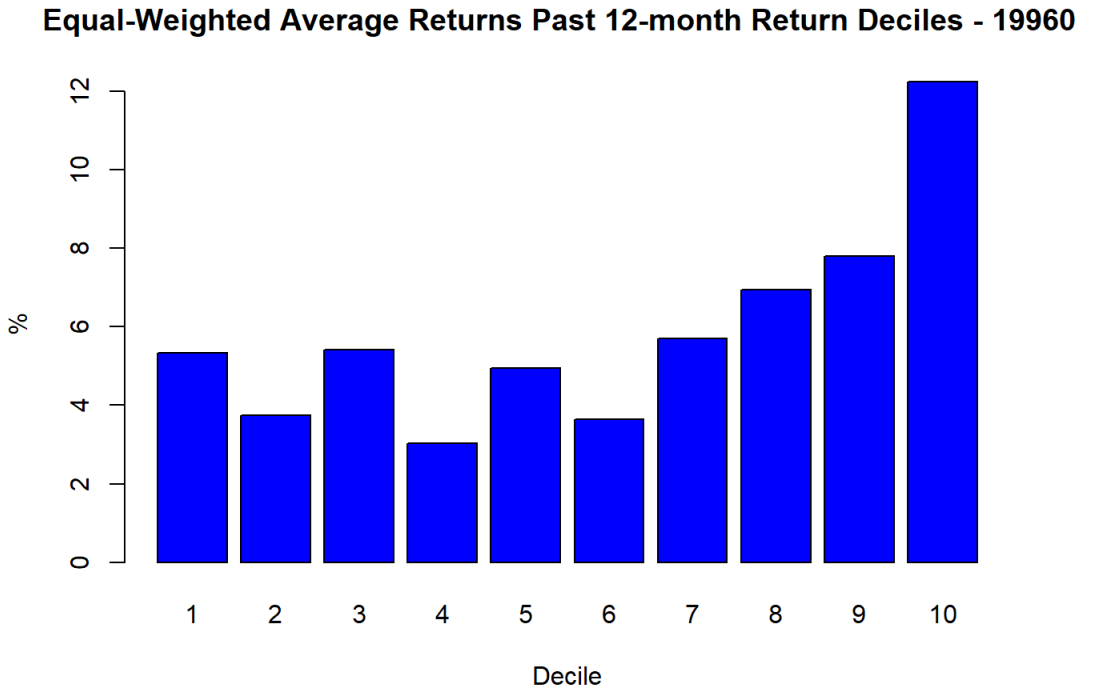

Equal-Weighted Average Returns Past 12-month Return Deciles - 19950
%
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

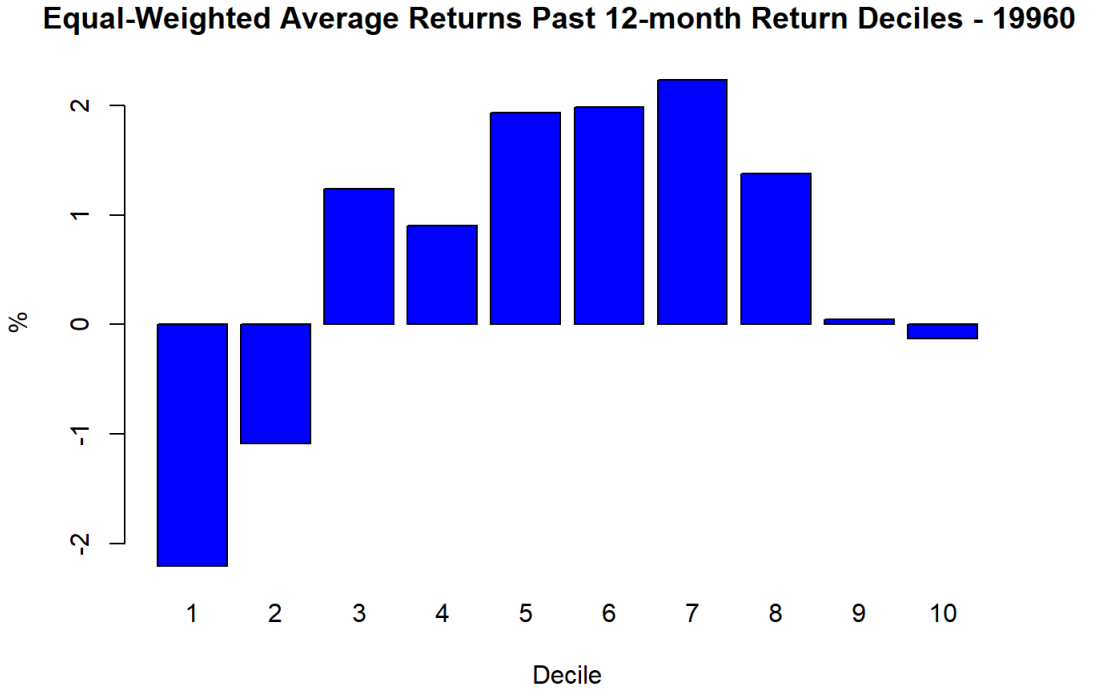

Equal-Weighted Average Returns Past 12-month Return Deciles - 19950
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

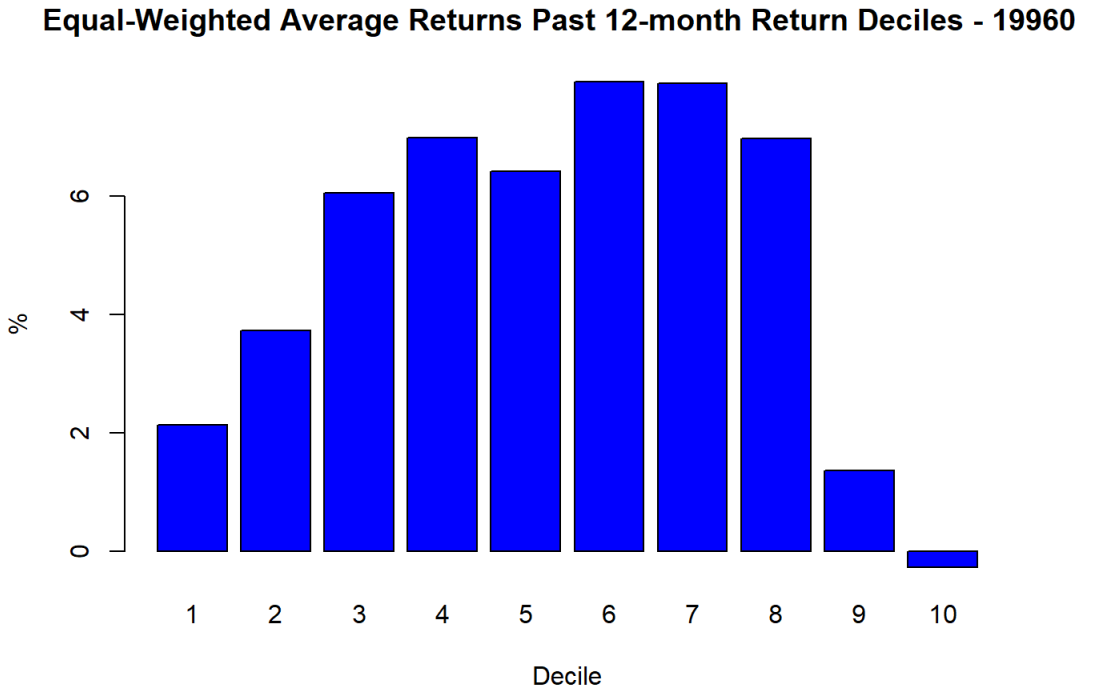

Equal-Weighted Average Returns Past 12-month Return Deciles - 19950
%
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
Decile

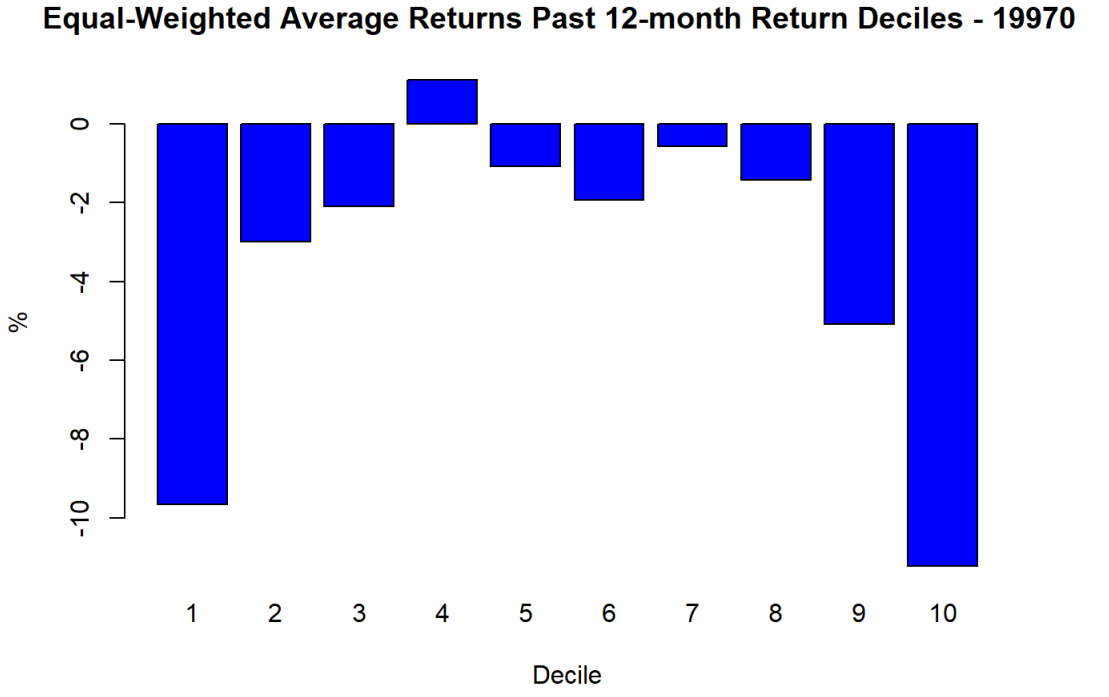

Equal-Weighted Average Returns Past 12-month Return Deciles - 19950
%
-8
-6
-4
-2
0
2
4
1
2
3
4
5
6
7
8
9
10
Decile

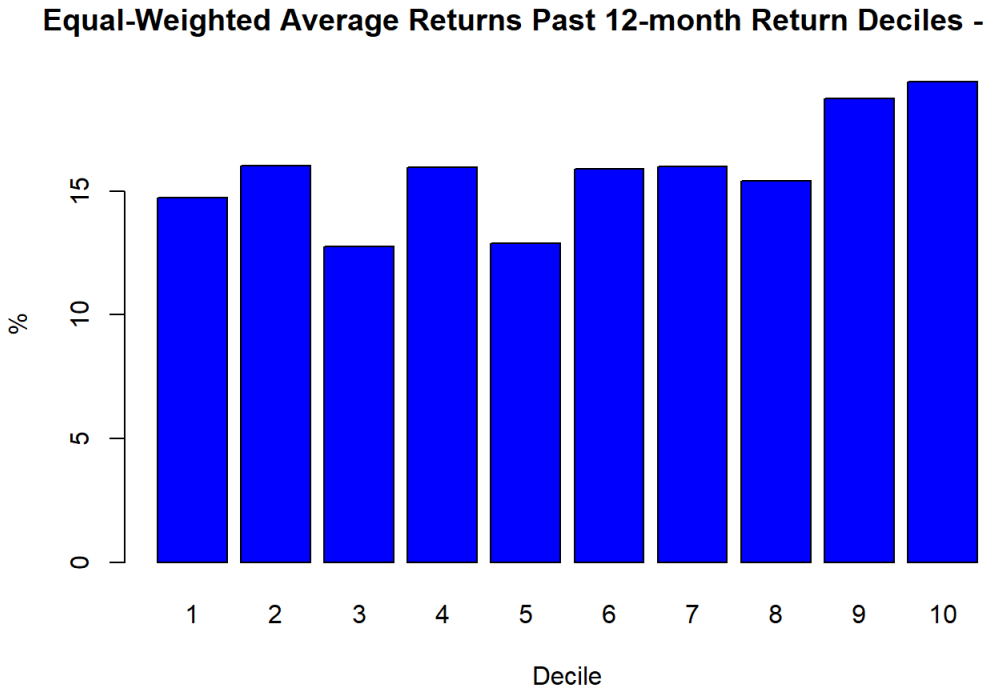

Equal-Weighted Average Returns Past 12-month Return Deciles - 19960
%
0
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9
10
Decile

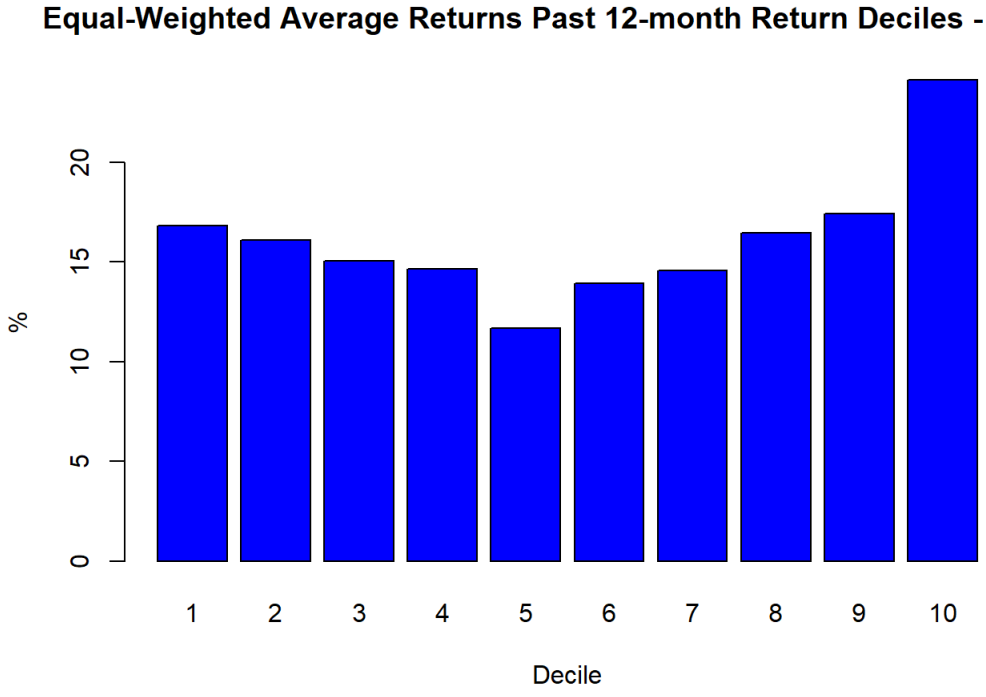

Equal-Weighted Average Returns Past 12-month Return Deciles - 19960
%
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
Decile

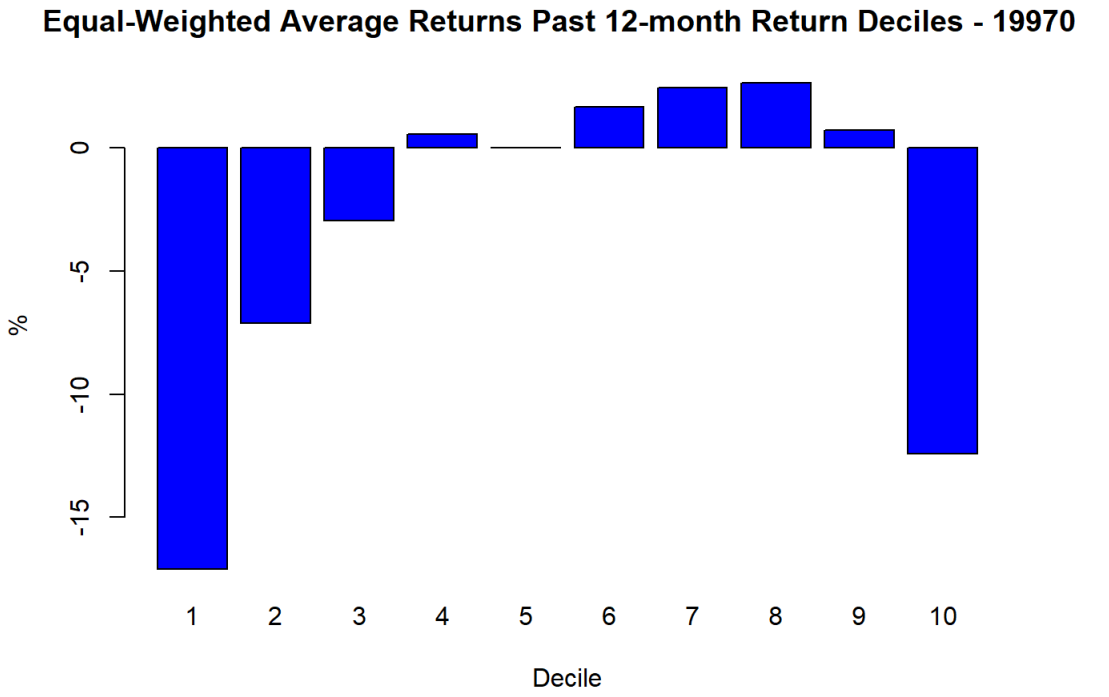

Equal-Weighted Average Returns Past 12-month Return Deciles - 19960
%
-2
-1
0
1
2
1
2
3
4
5
6
7
8
9
10
Decile

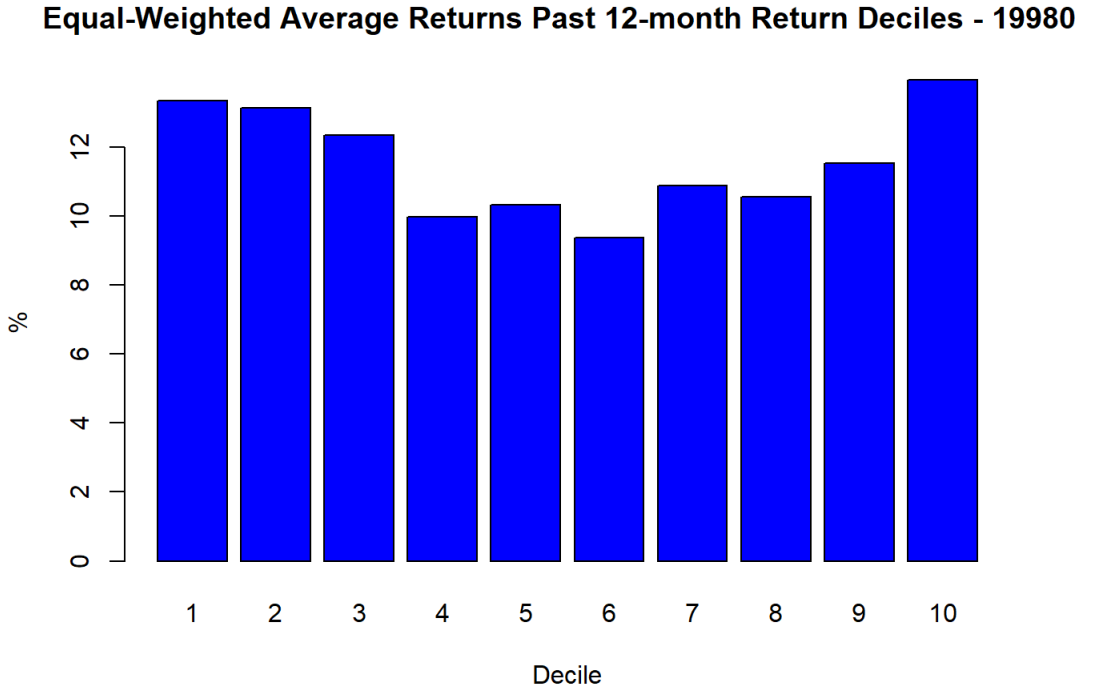

Equal-Weighted Average Returns Past 12-month Return Deciles - 19960
%
0
2
4
6
1
2
3
4
5
6
7
8
9
10
Decile

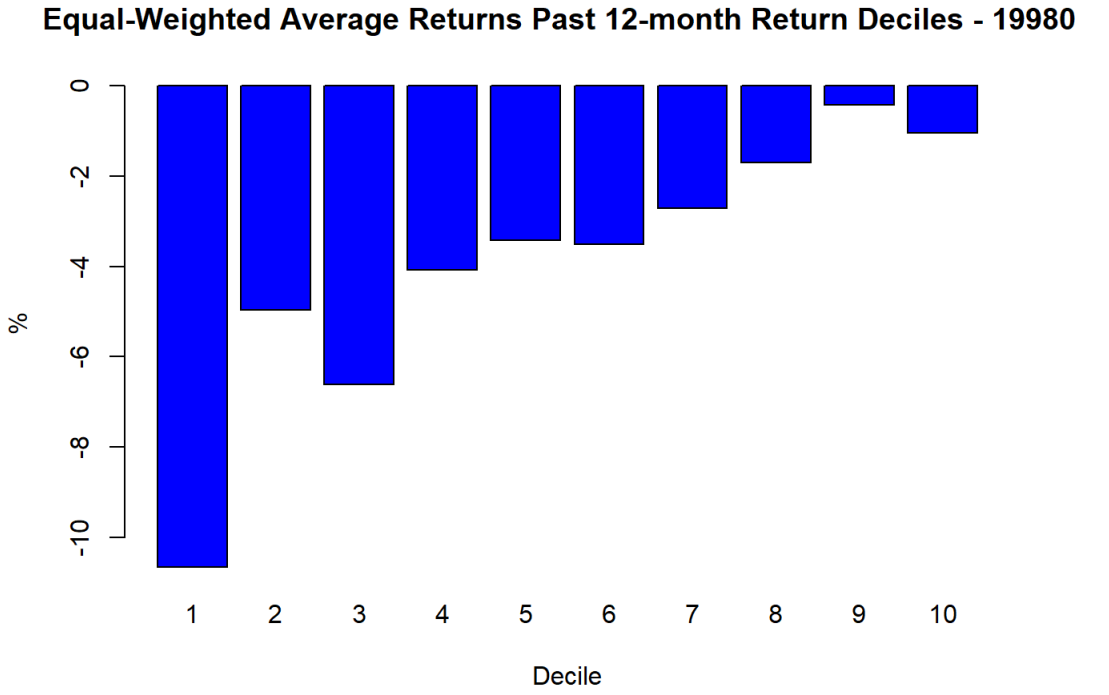

Equal-Weighted Average Returns Past 12-month Return Deciles - 19970
%
-10
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

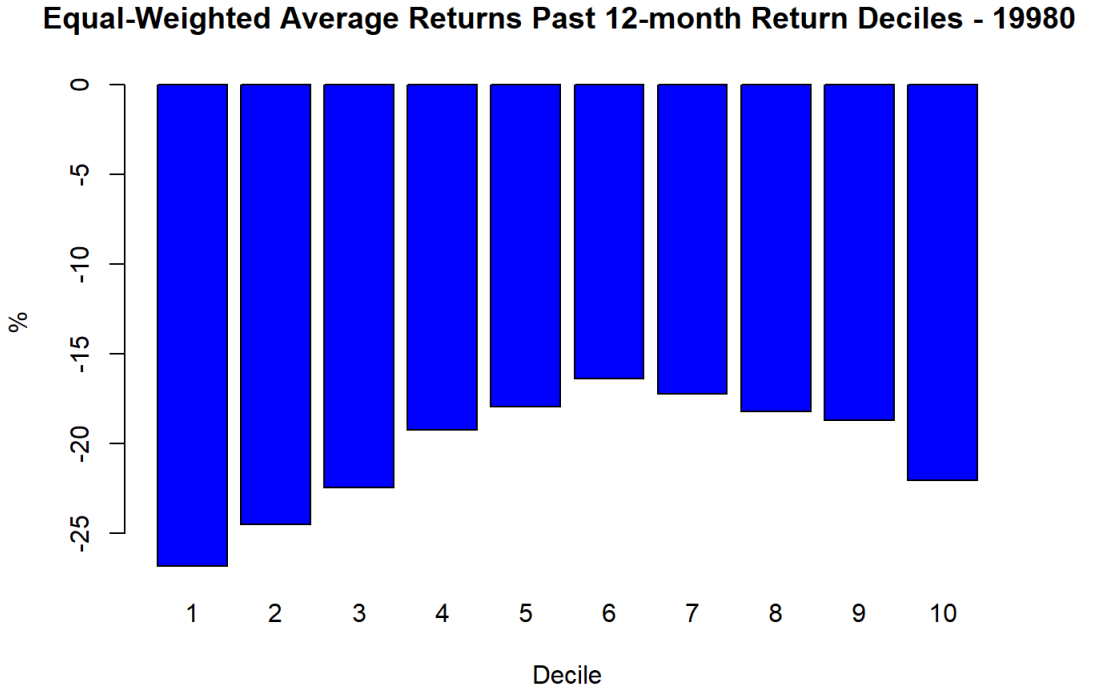

Equal-Weighted Average Returns Past 12-month Return Deciles - 19970
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

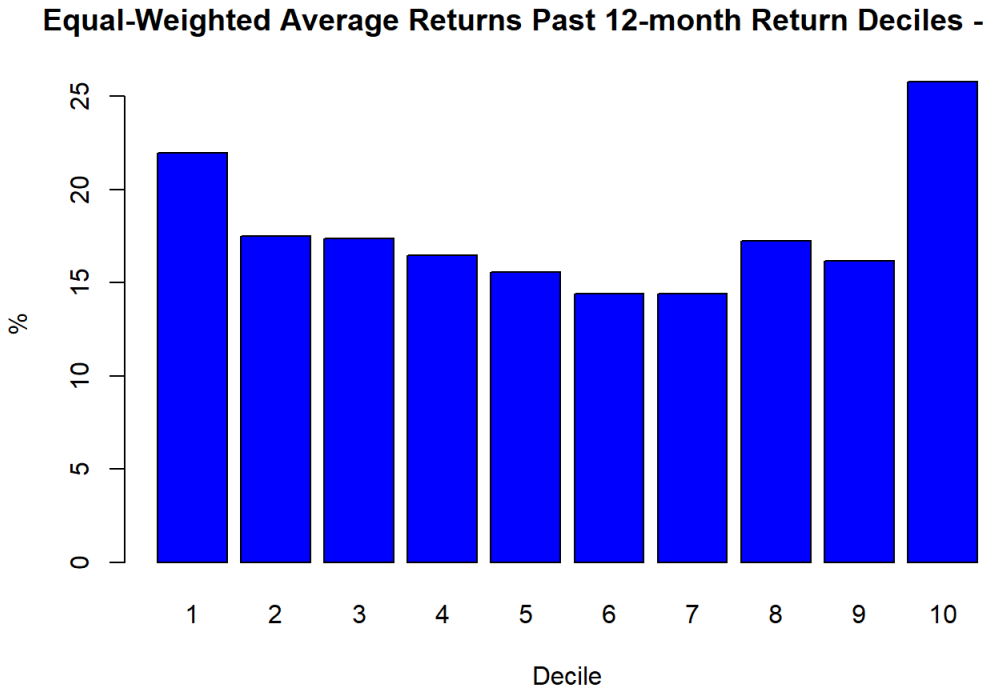

Equal-Weighted Average Returns Past 12-month Return Deciles - 19970
%
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
Decile

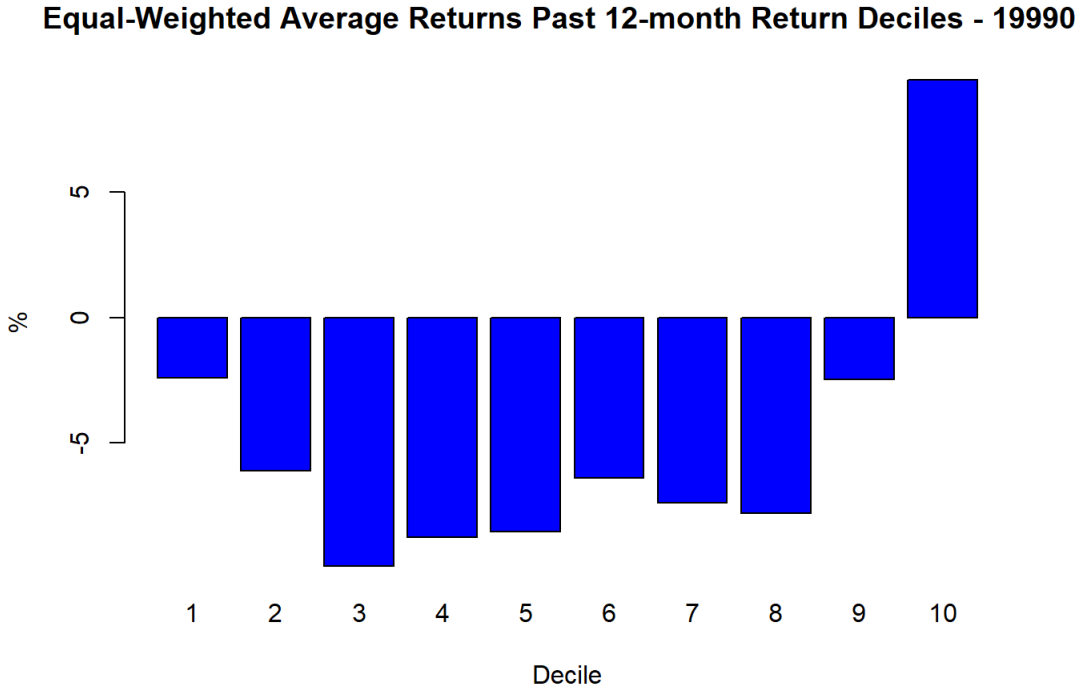

Equal-Weighted Average Returns Past 12-month Return Deciles - 19970
0
-5
-10
-15
%
1
2
3
4
5
6
7
8
9
10
Decile

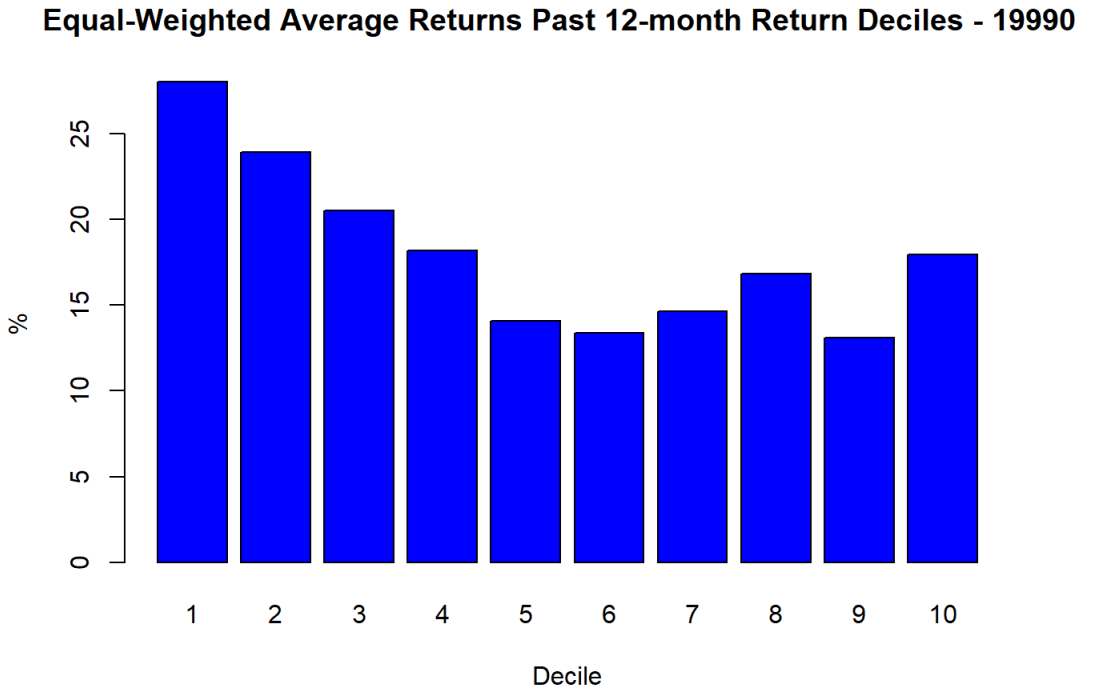

Equal-Weighted Average Returns Past 12-month Return Deciles - 19980
0
2
4
6
8
10
12
%
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19980
%
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19980
%
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19980
%
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19990
%
-5
0
5
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19990
%
0
5
10
15
20
25
1
2
3
4
5
6
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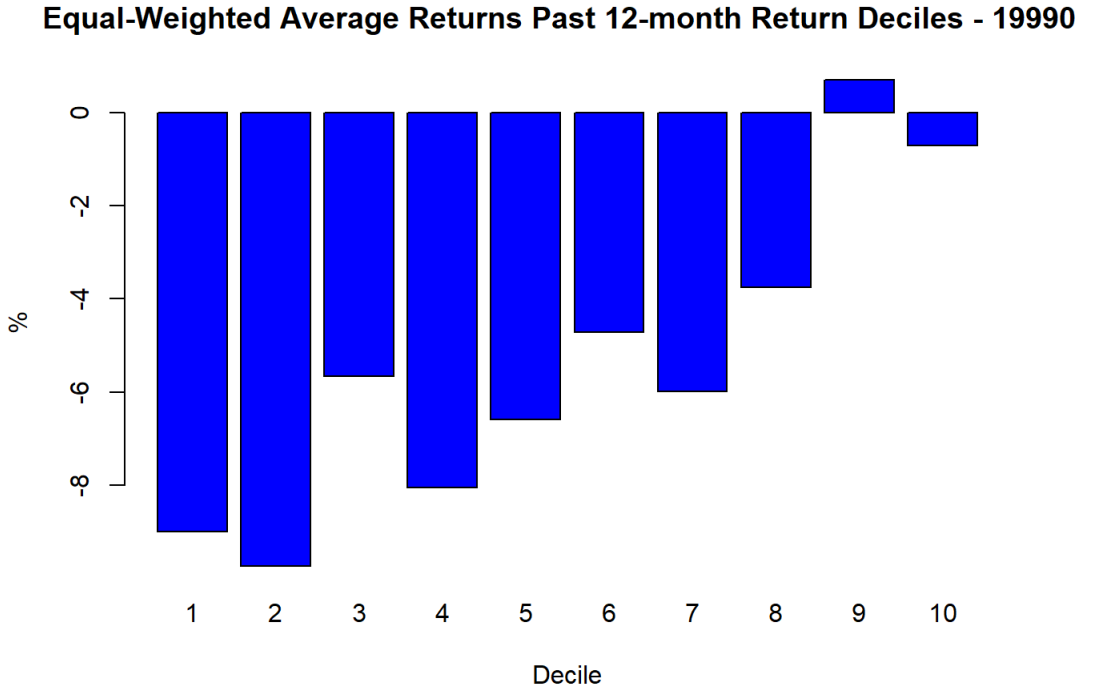
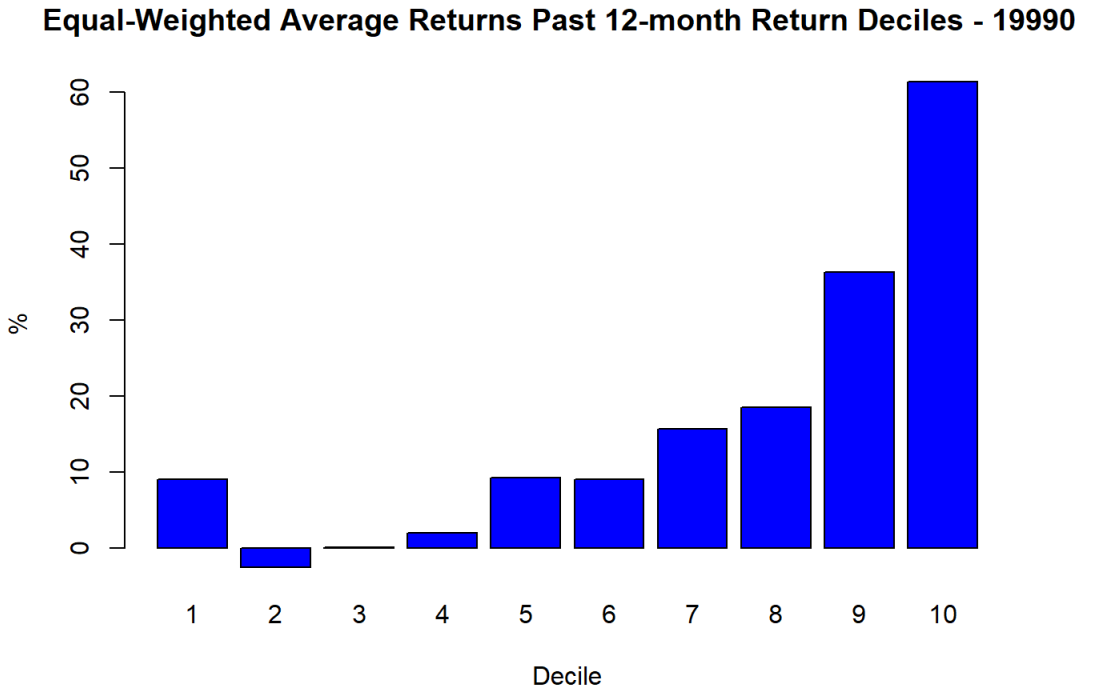
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19990
%
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 19990
%
0
10
20
30
40
50
60
1
2
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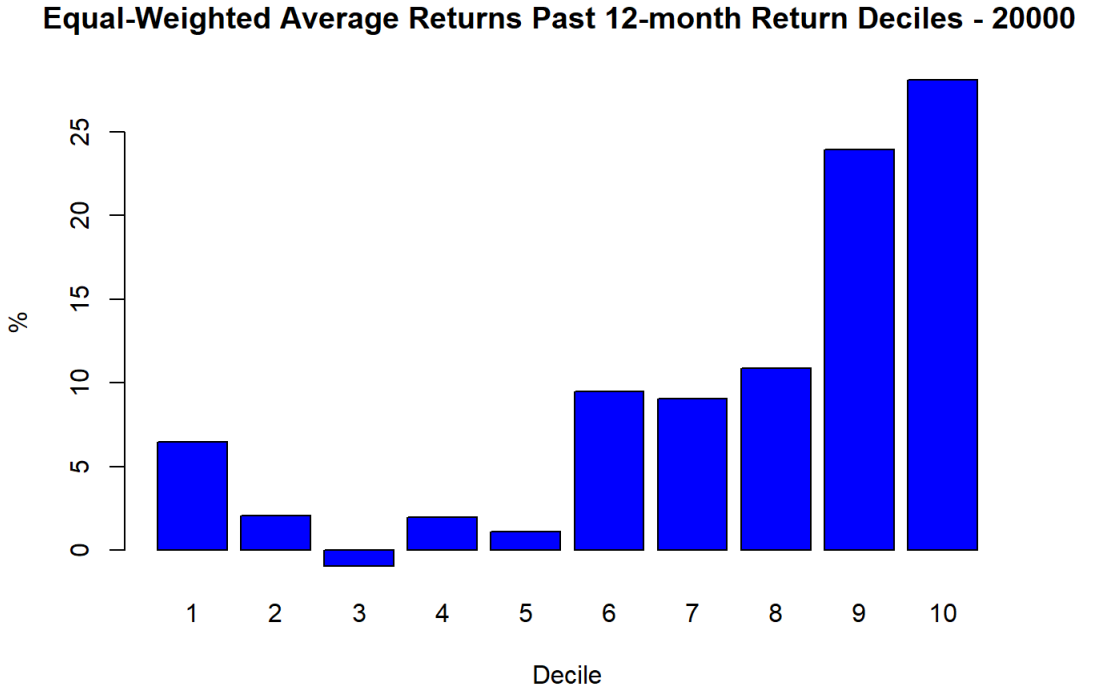
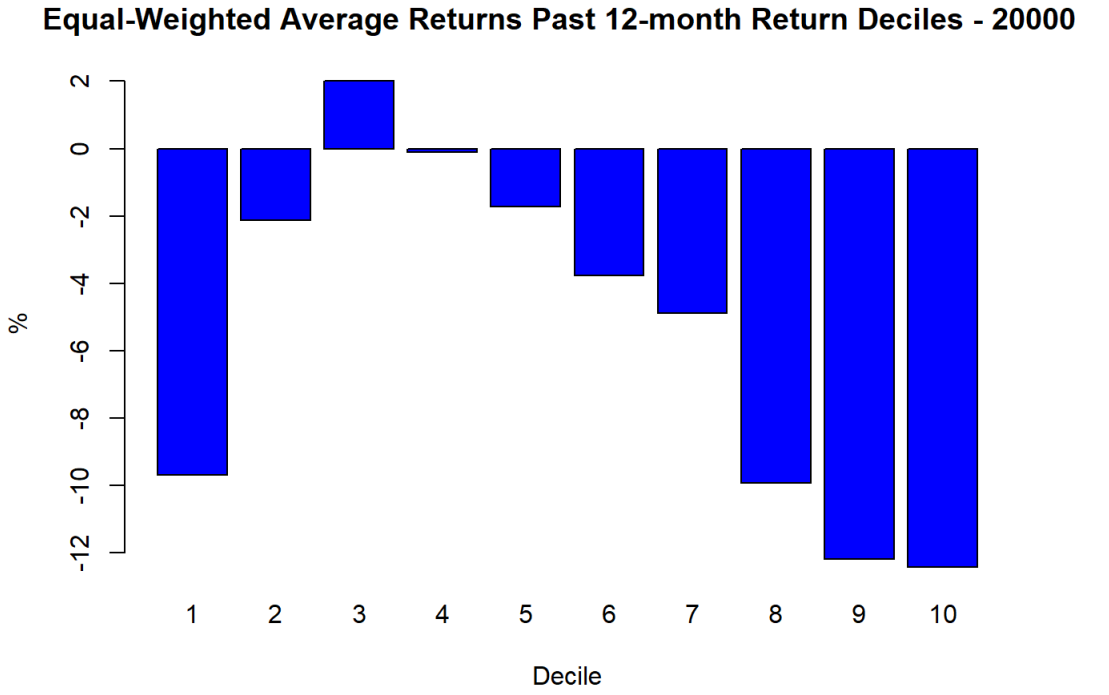
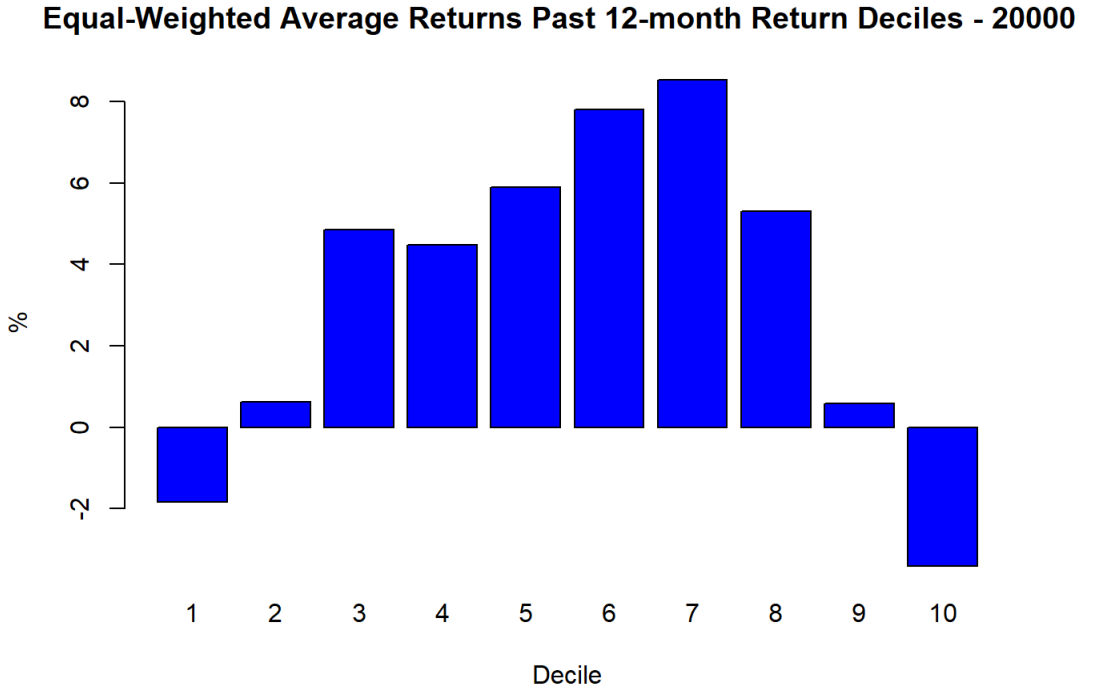
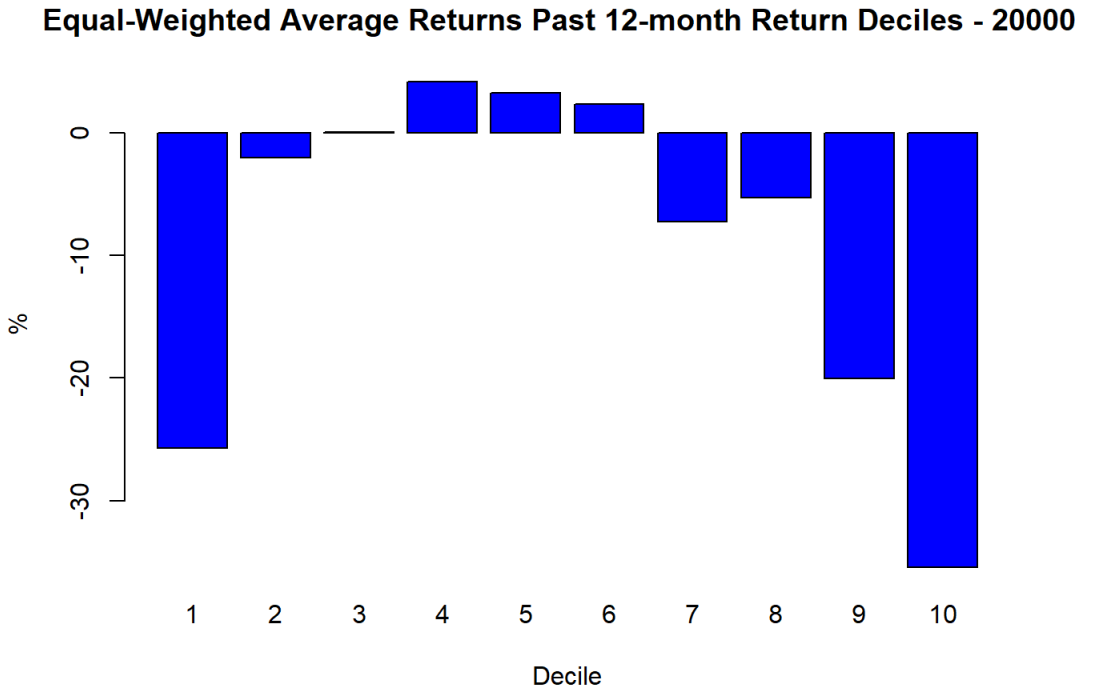
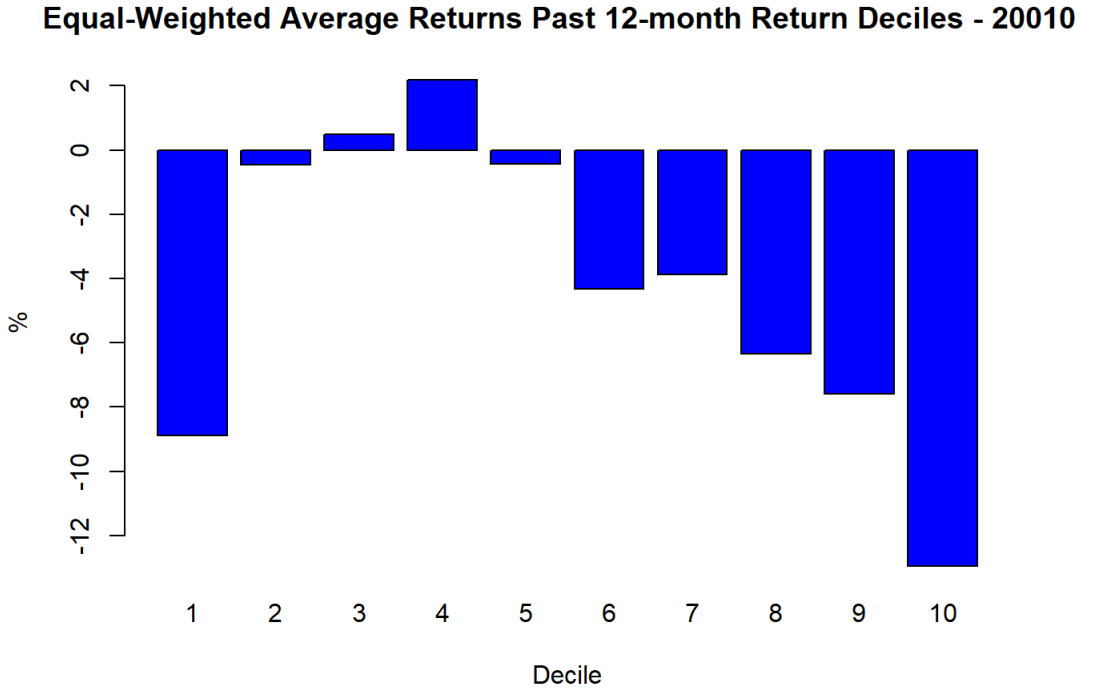
4
5
6
7
8
9
10
Decile

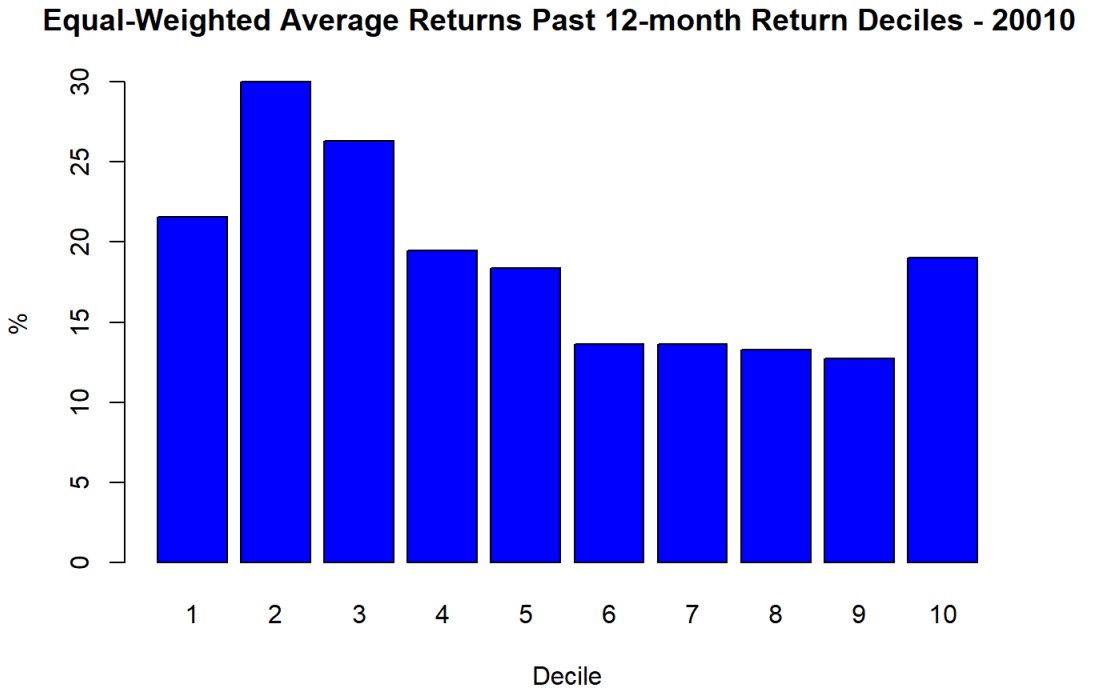

Equal-Weighted Average Returns Past 12-month Return Deciles - 20000
%
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
Decile

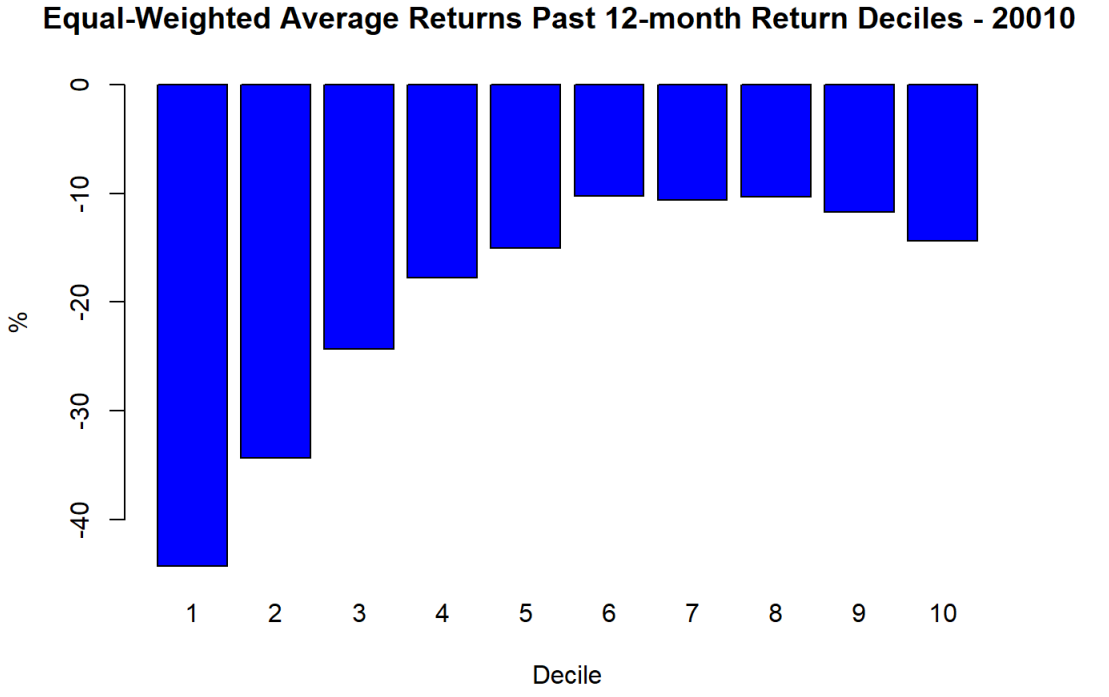

Equal-Weighted Average Returns Past 12-month Return Deciles - 20000
%
2
0
-2
-4
-6
-8
-10
-12
1
2
3
4
5
6
7
8
9
10
Decile

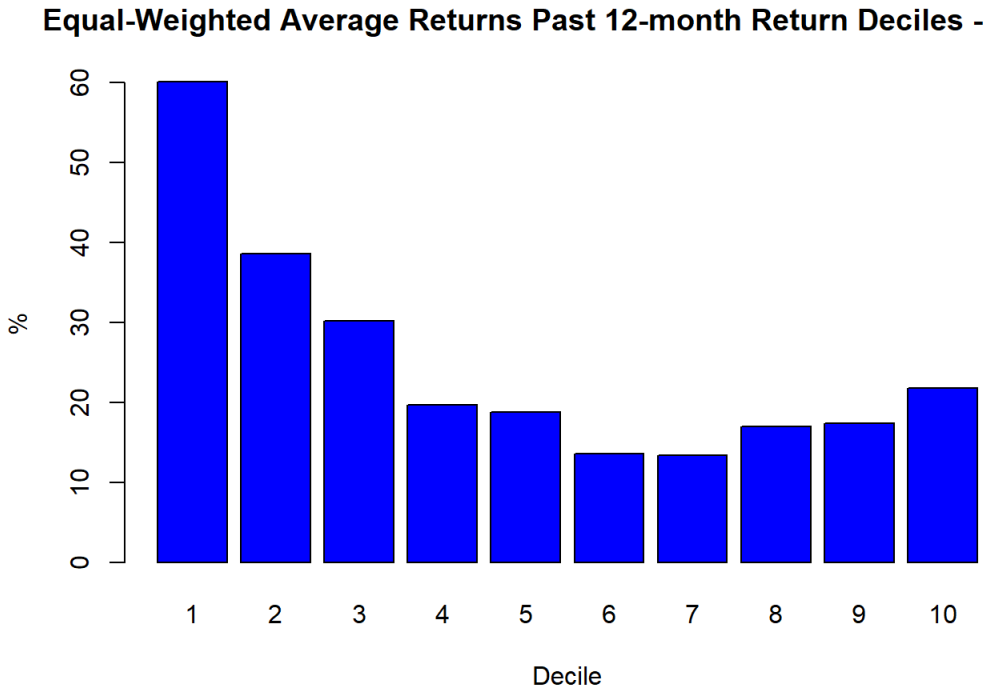

Equal-Weighted Average Returns Past 12-month Return Deciles - 20000
%
8
6
4
2
0
-2
1
2
3
4
5
6
7
8
9
10
Decile

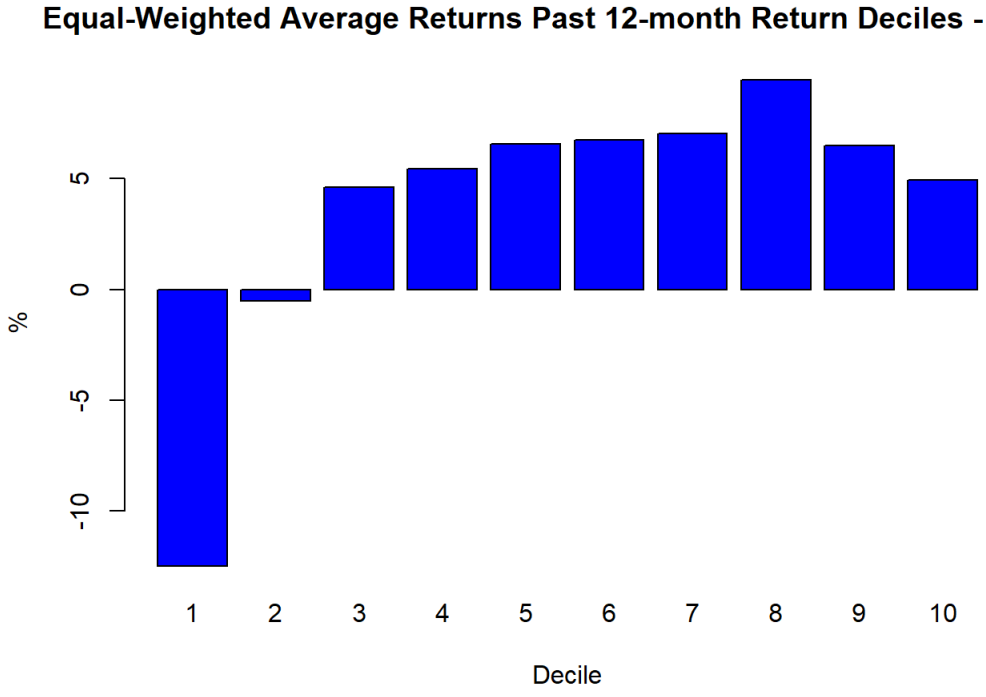

Equal-Weighted Average Returns Past 12-month Return Deciles - 20000
0
-10
-20
-30
%
1
2
3
4
5
6
7
8
9
10
Decile

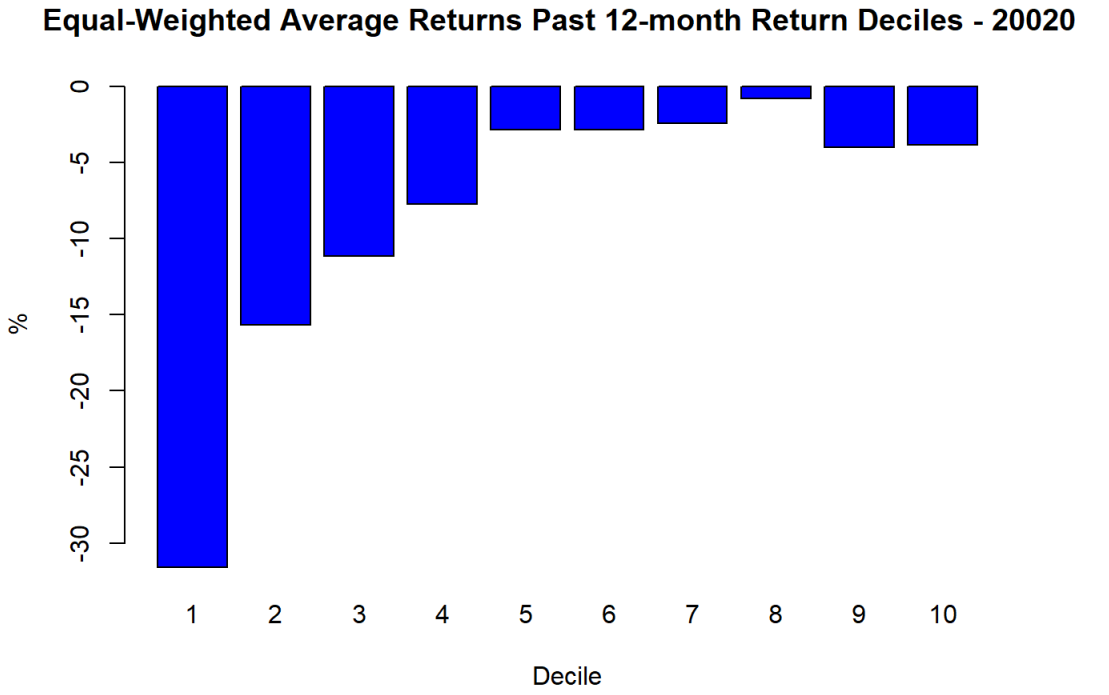

Equal-Weighted Average Returns Past 12-month Return Deciles - 20010
2
0
-2
-4
-6
-8
-10
-12
%
1
2
3
4
5
6
7
8
9
10
Decile

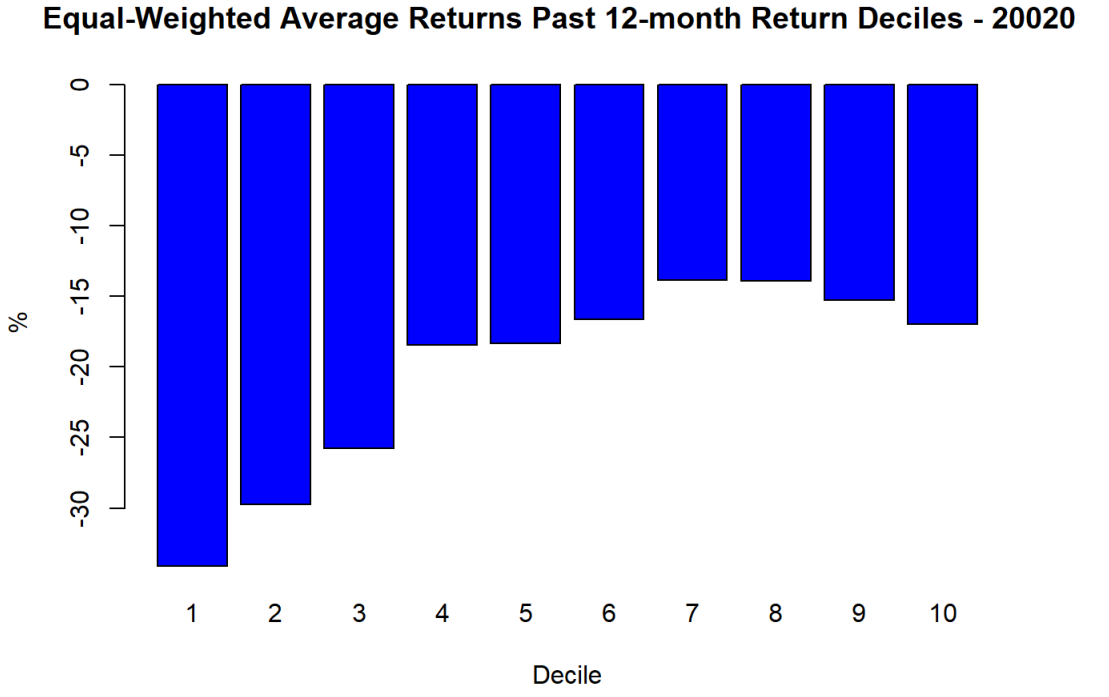

Equal-Weighted Average Returns Past 12-month Return Deciles - 20010
%
0
5
10
15
20
25
30
1
2
3
4
5
6
7
8
9
10
Decile

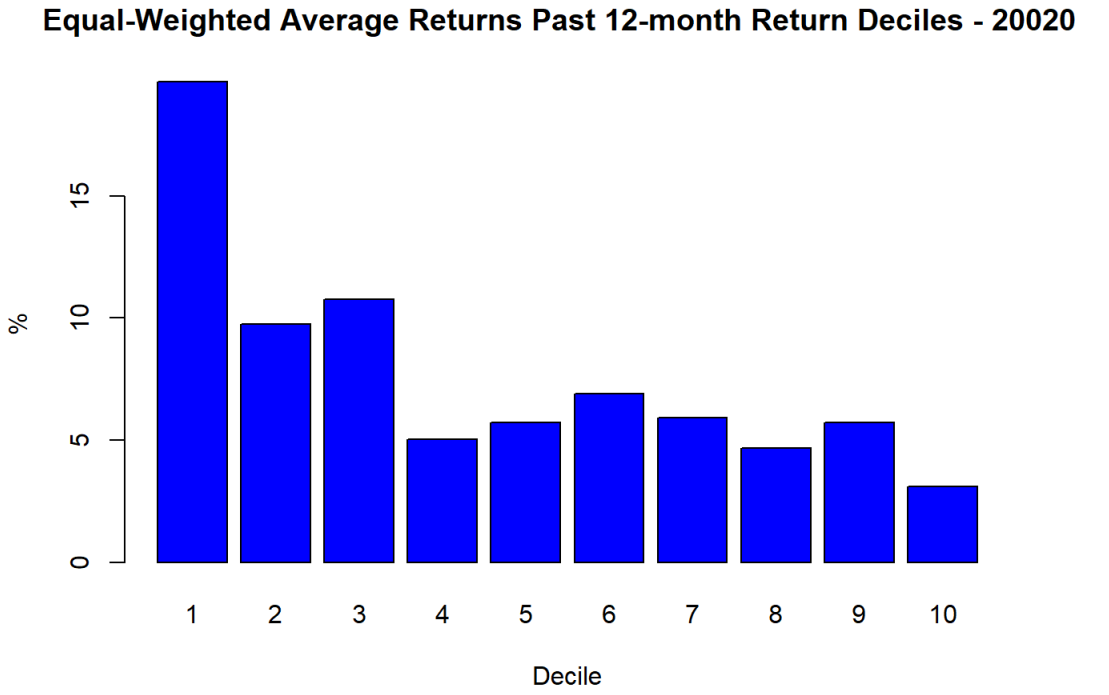

Equal-Weighted Average Returns Past 12-month Return Deciles - 20010
%
0
-10
-20
-30
-40
1
2
3
4
5
6
7
8
9
10
Decile

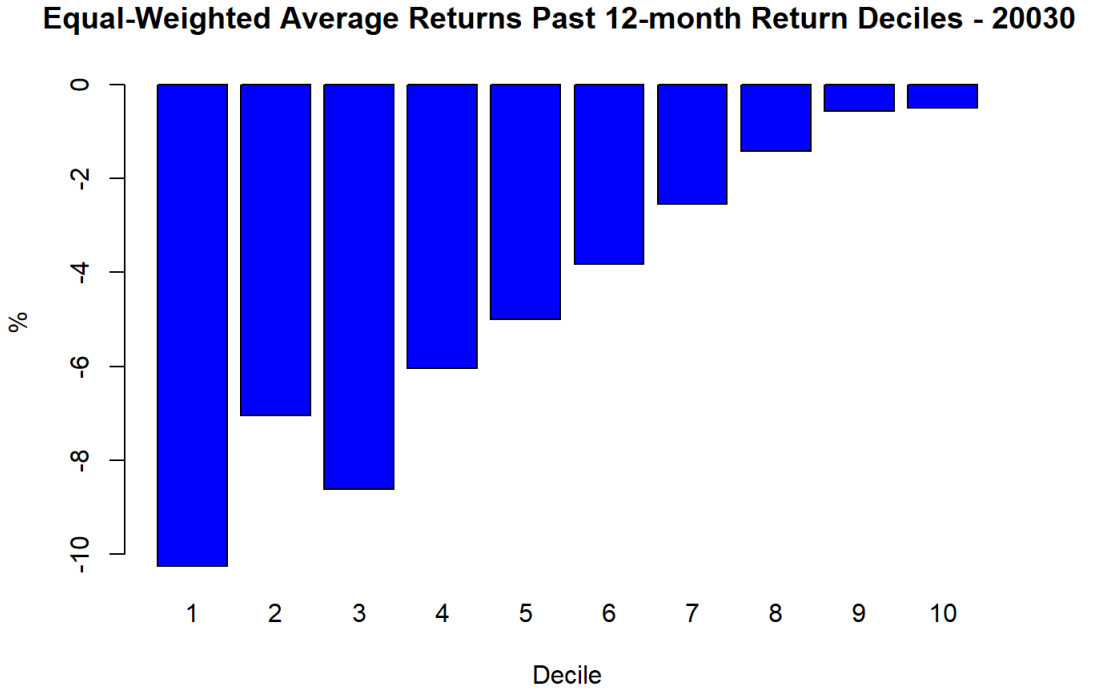

Equal-Weighted Average Returns Past 12-month Return Deciles - 20010
%
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10
Decile

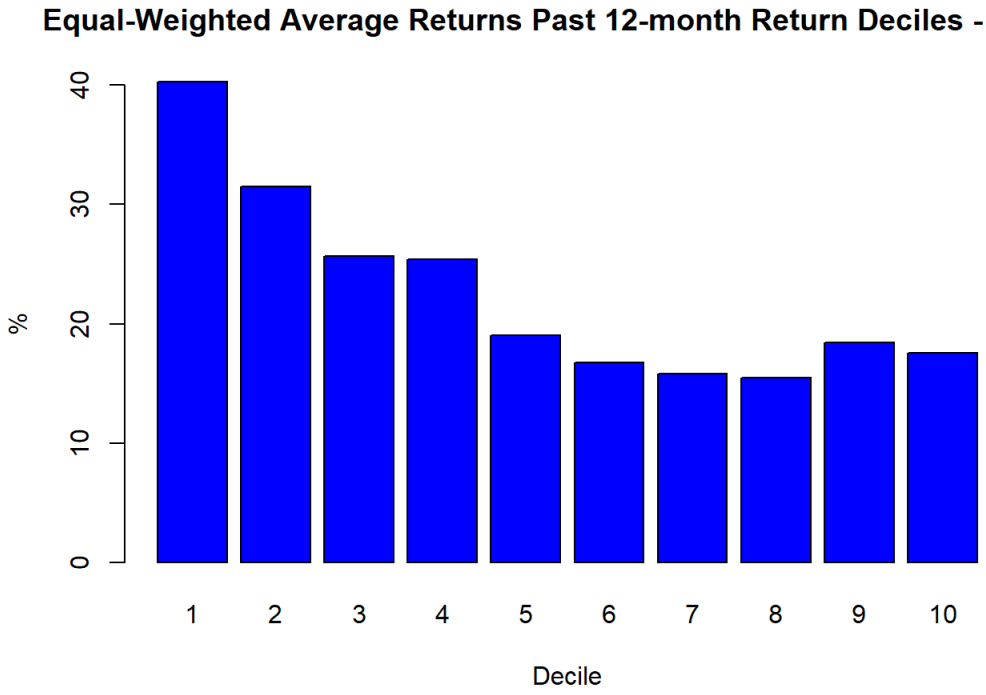

Equal-Weighted Average Returns Past 12-month Return Deciles - 20020
%
-10
-5
0
5
1
2
3
4
5
6
7
8
9
10
Decile

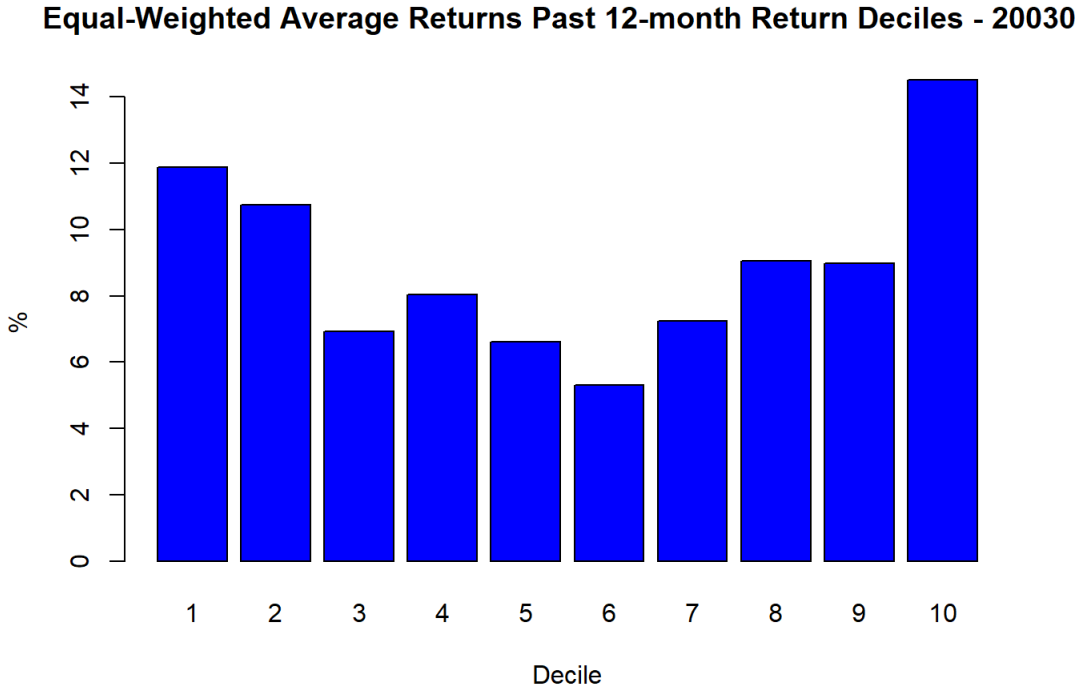

Equal-Weighted Average Returns Past 12-month Return Deciles - 20020
%
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
6
7
8
9
10
Decile

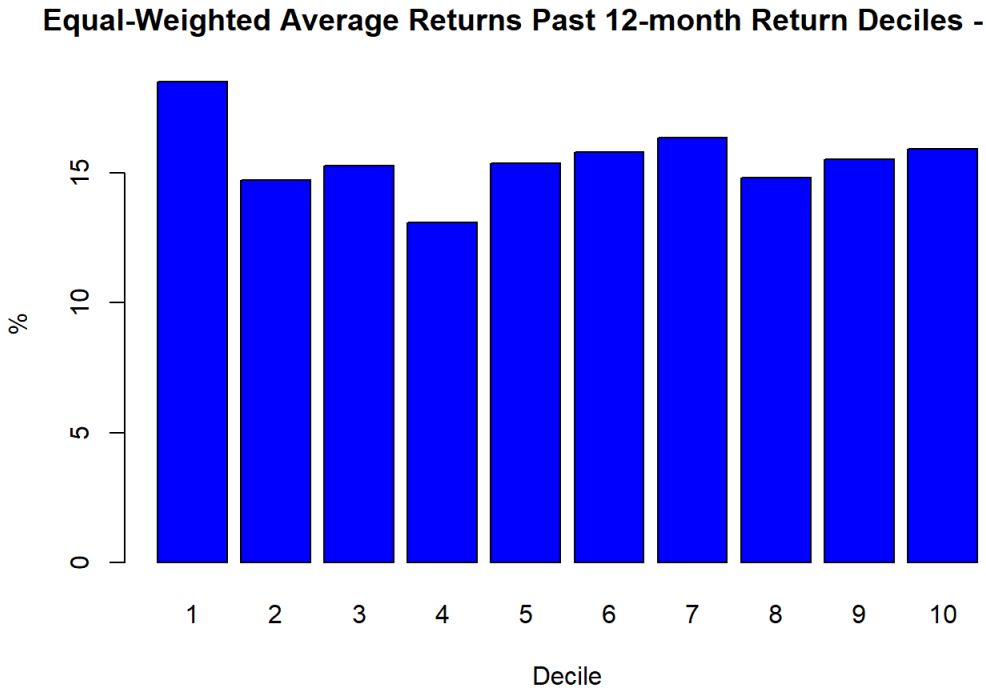

Equal-Weighted Average Returns Past 12-month Return Deciles - 20020
%
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
6
7
8
9
10
Decile

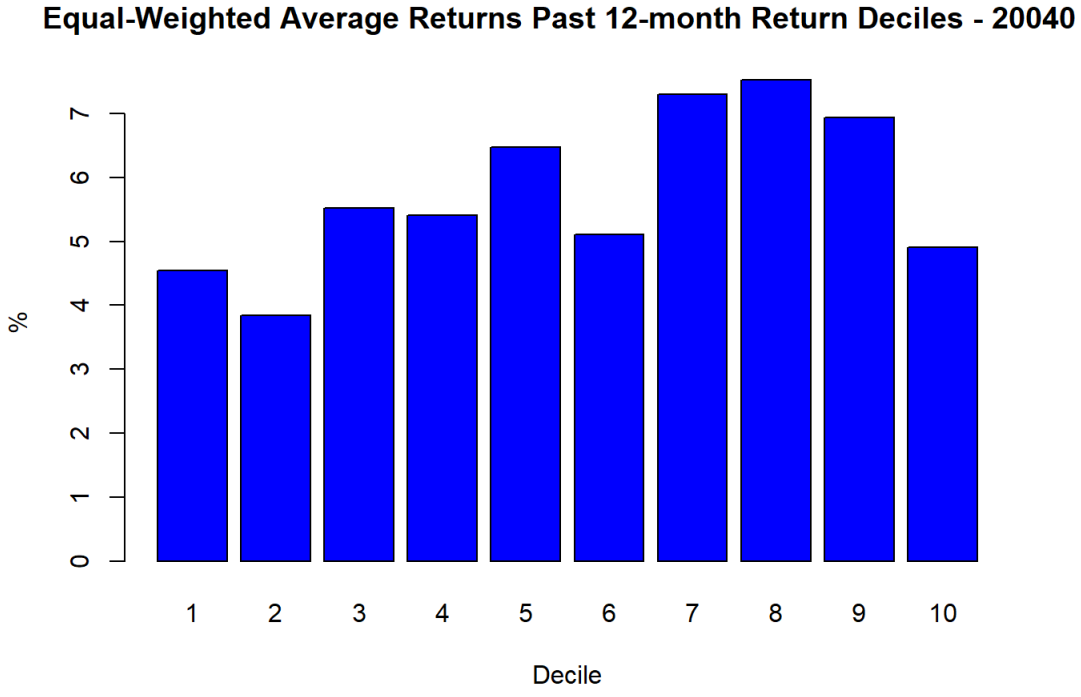

Equal-Weighted Average Returns Past 12-month Return Deciles - 20020
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

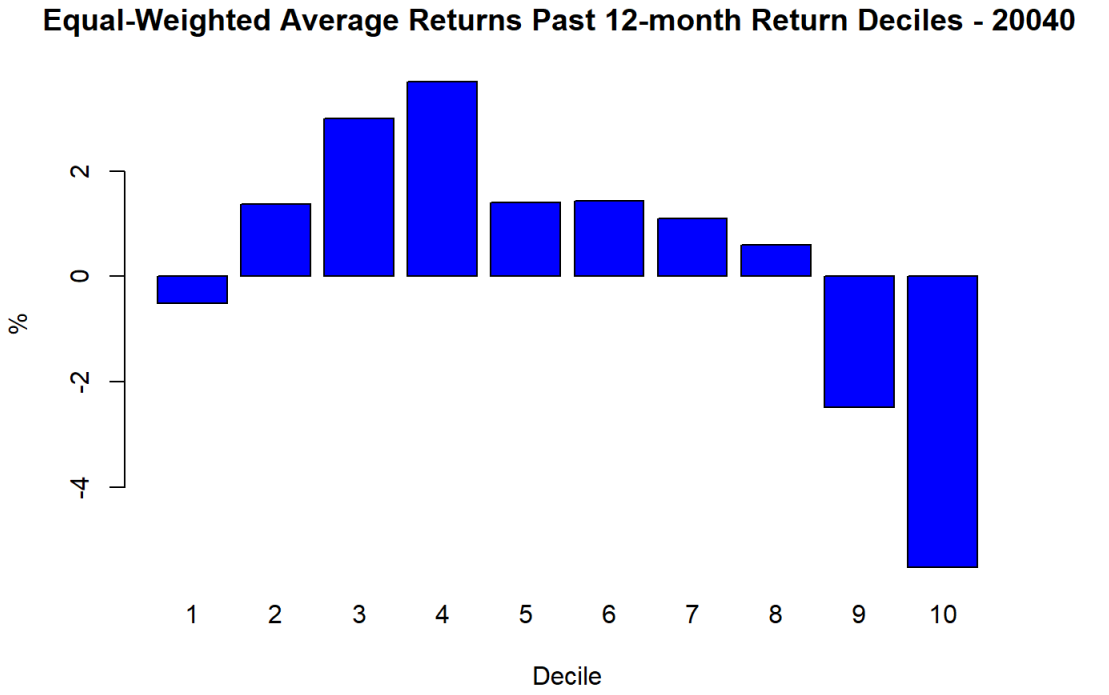

Equal-Weighted Average Returns Past 12-month Return Deciles - 20030
%
-10
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

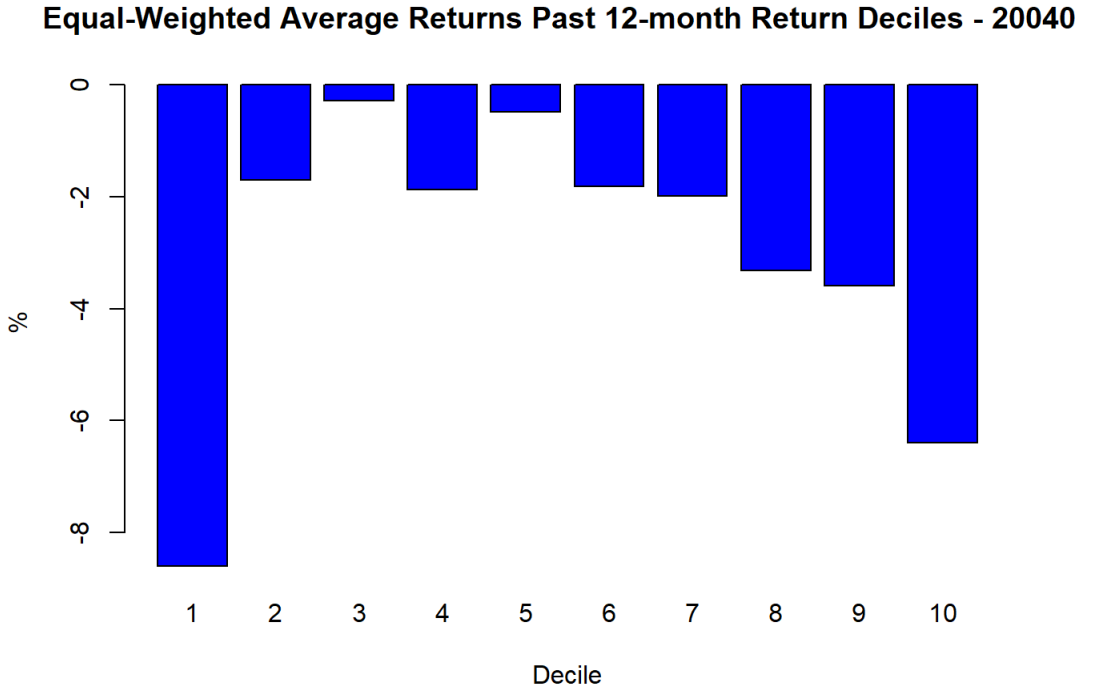

Equal-Weighted Average Returns Past 12-month Return Deciles - 20030
%
0
10
20
30
40
1
2
3
4
5
6
7
8
9
10
Decile

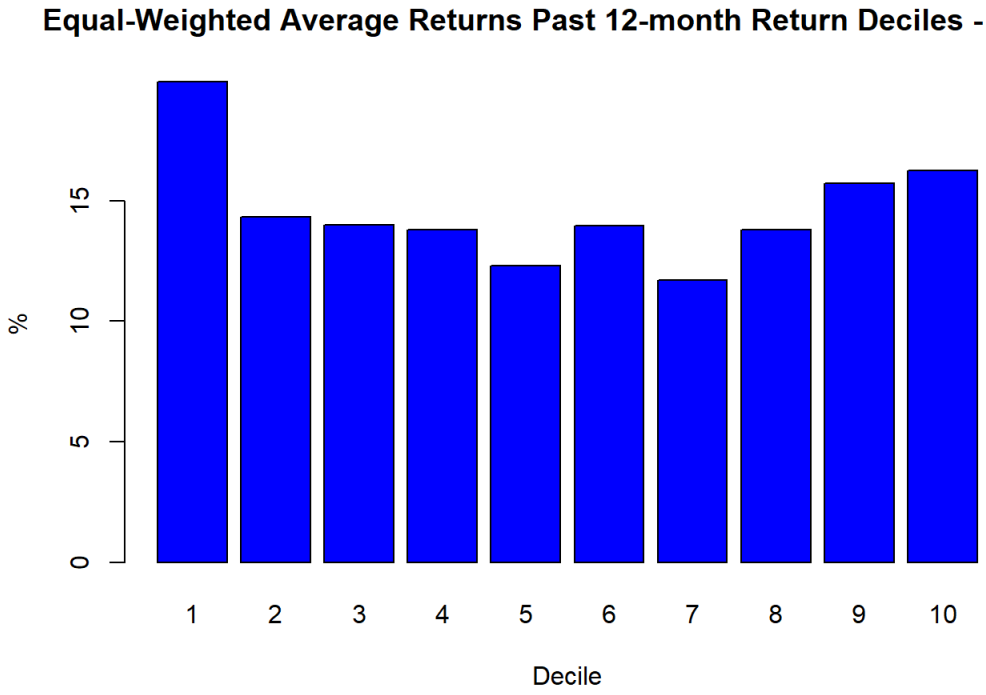

Equal-Weighted Average Returns Past 12-month Return Deciles - 20030
%
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
Decile

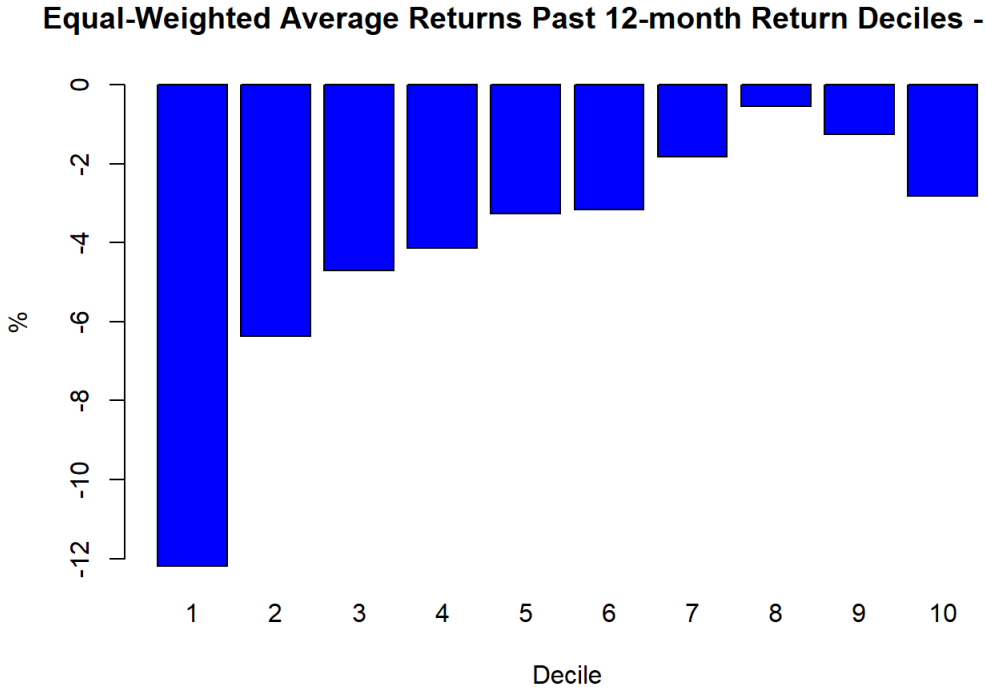

Equal-Weighted Average Returns Past 12-month Return Deciles - 20030
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

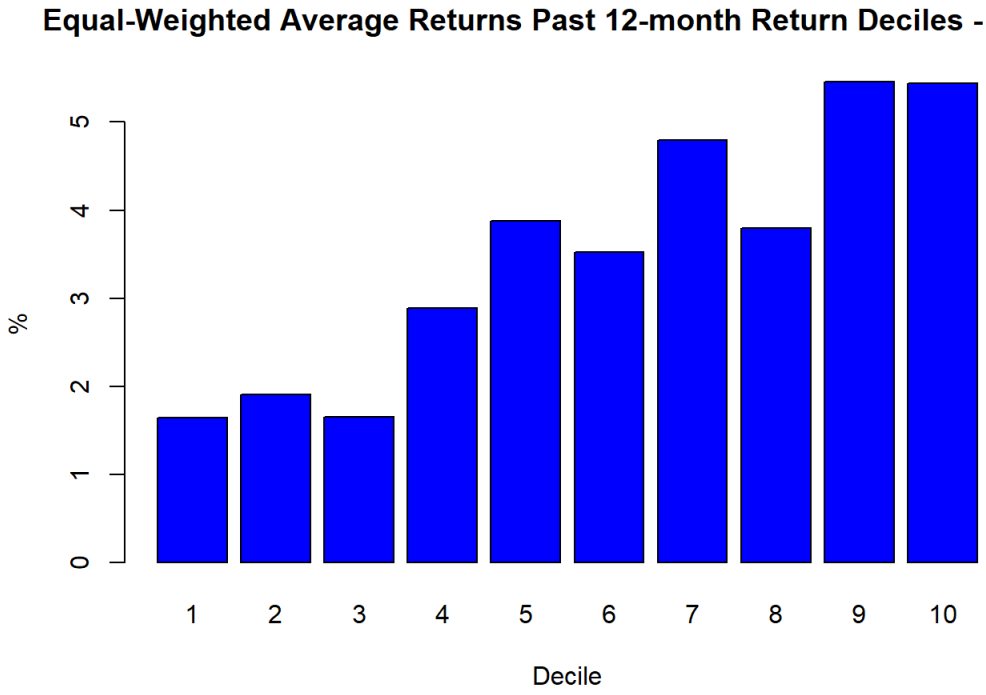

Equal-Weighted Average Returns Past 12-month Return Deciles - 20040
%
0
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9
10
Decile

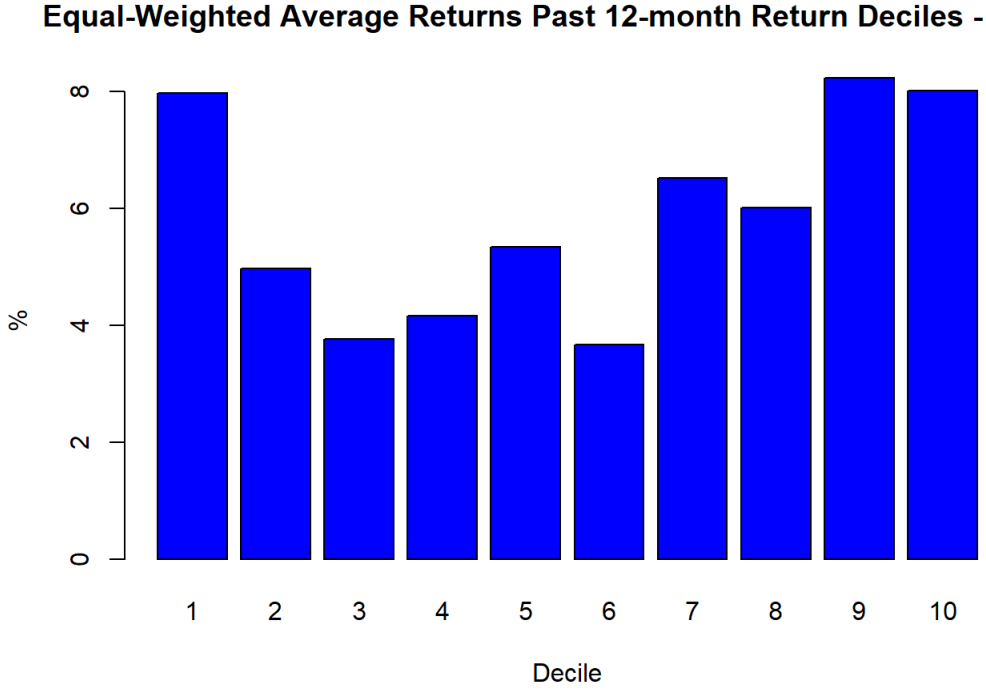

Equal-Weighted Average Returns Past 12-month Return Deciles - 20040
%
2
0
-2
-4
1
2
3
4
5
6
7
8
9
10
Decile

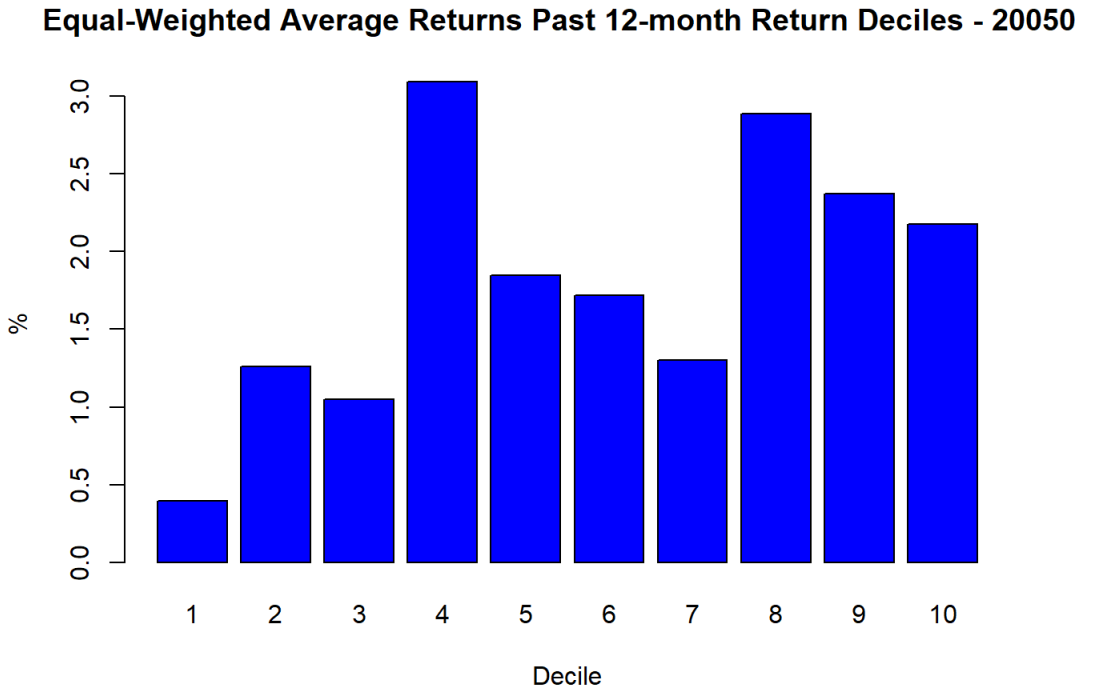

Equal-Weighted Average Returns Past 12-month Return Deciles - 20040
%
0
-2
-4
-6
-8
1
2
3
4
5
6
7
8
9
10
Decile

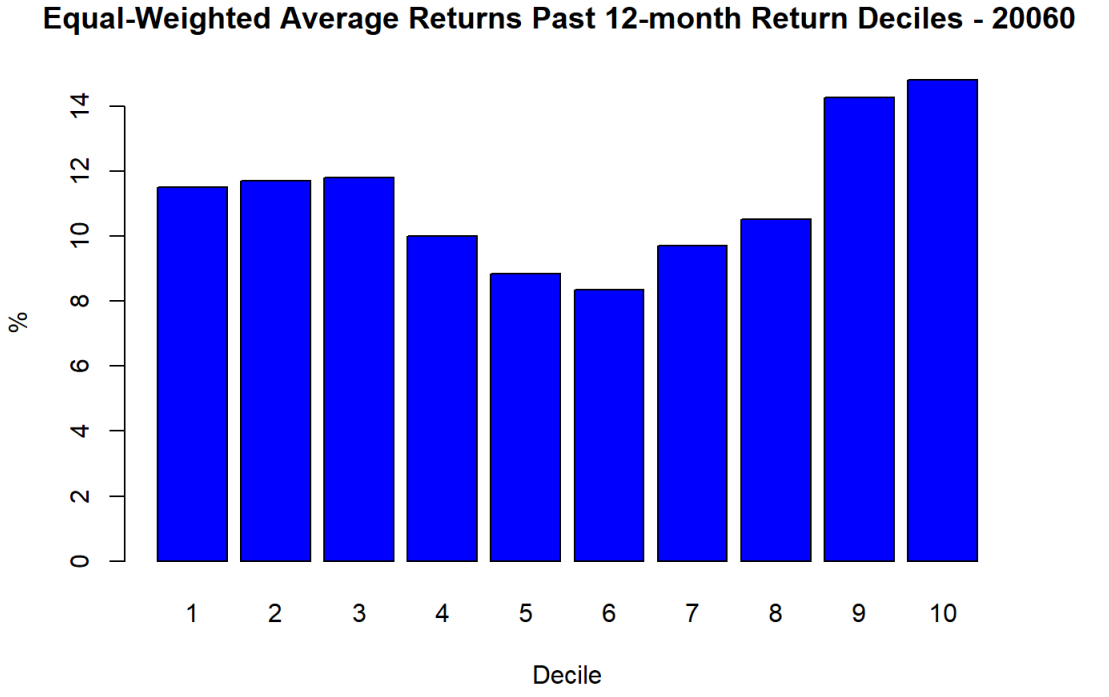

Equal-Weighted Average Returns Past 12-month Return Deciles - 20040
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

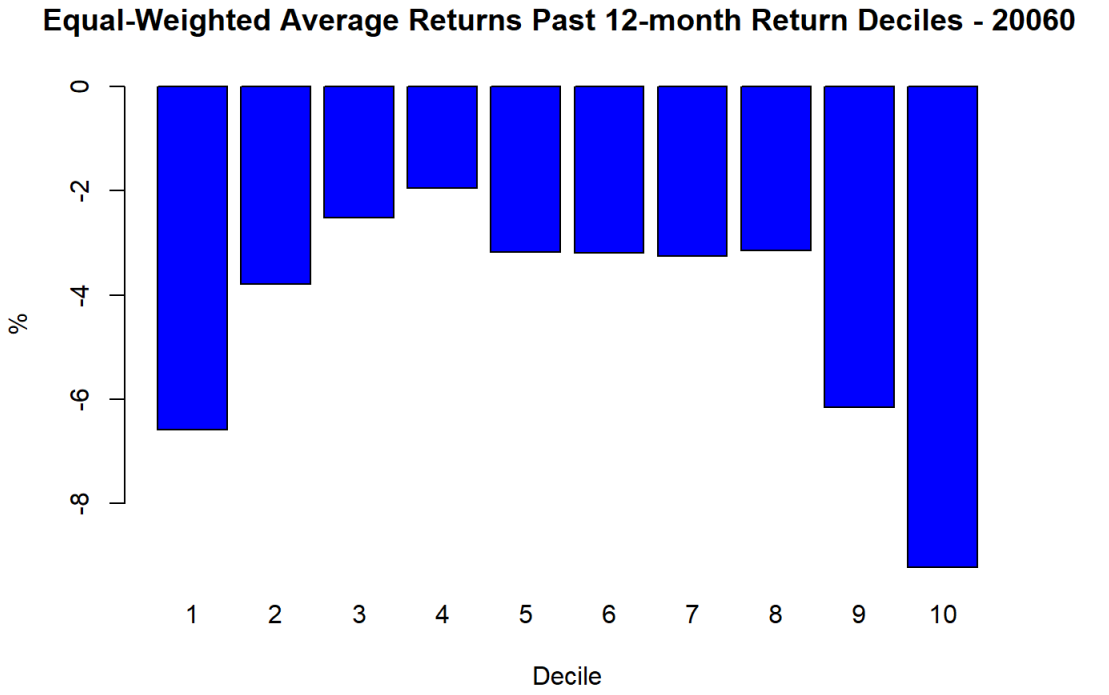

Equal-Weighted Average Returns Past 12-month Return Deciles - 20050
%
-12
-10
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

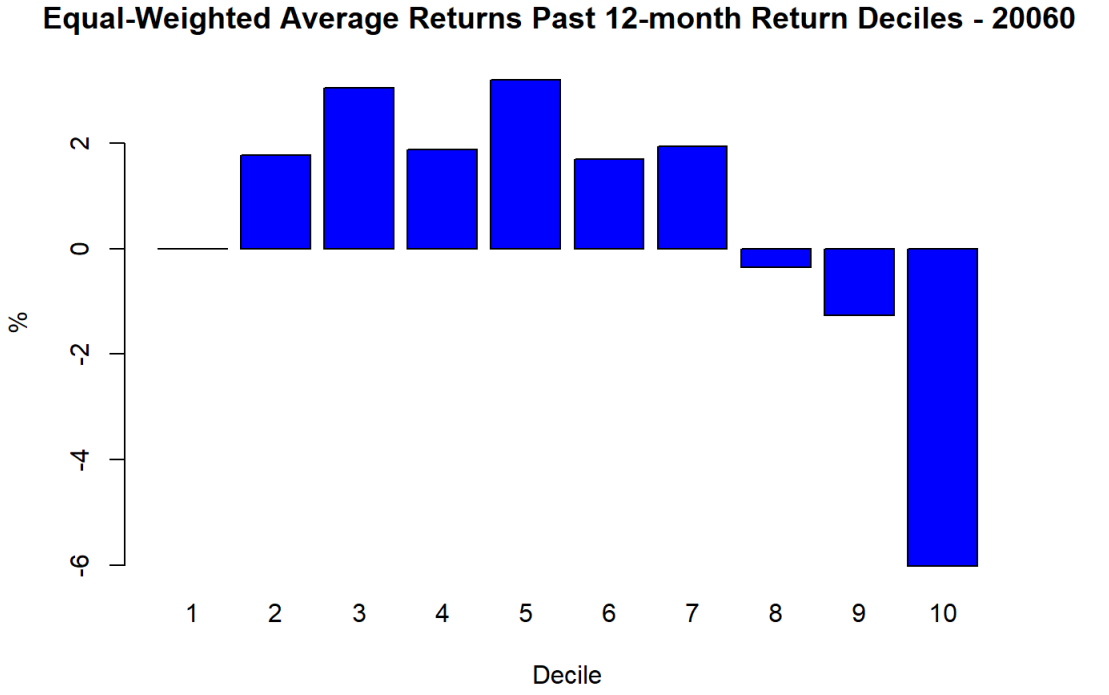

Equal-Weighted Average Returns Past 12-month Return Deciles - 20050
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

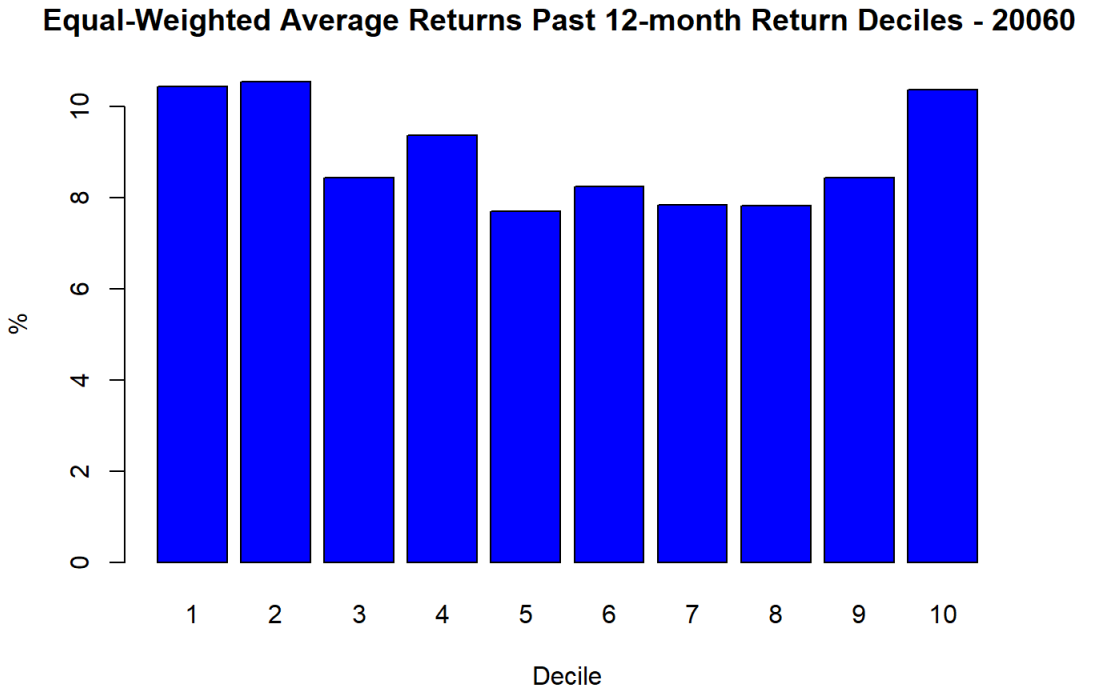

Equal-Weighted Average Returns Past 12-month Return Deciles - 20050
%
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

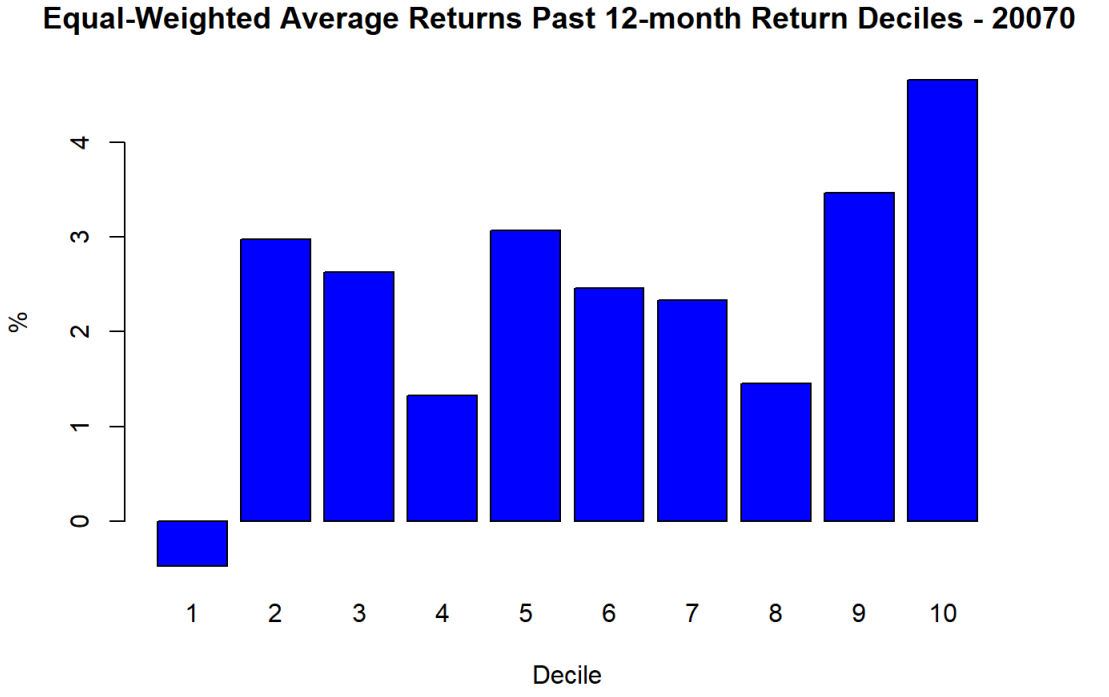

Equal-Weighted Average Returns Past 12-month Return Deciles - 20050
%
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1
2
3
4
5
6
7
8
9
10
Decile

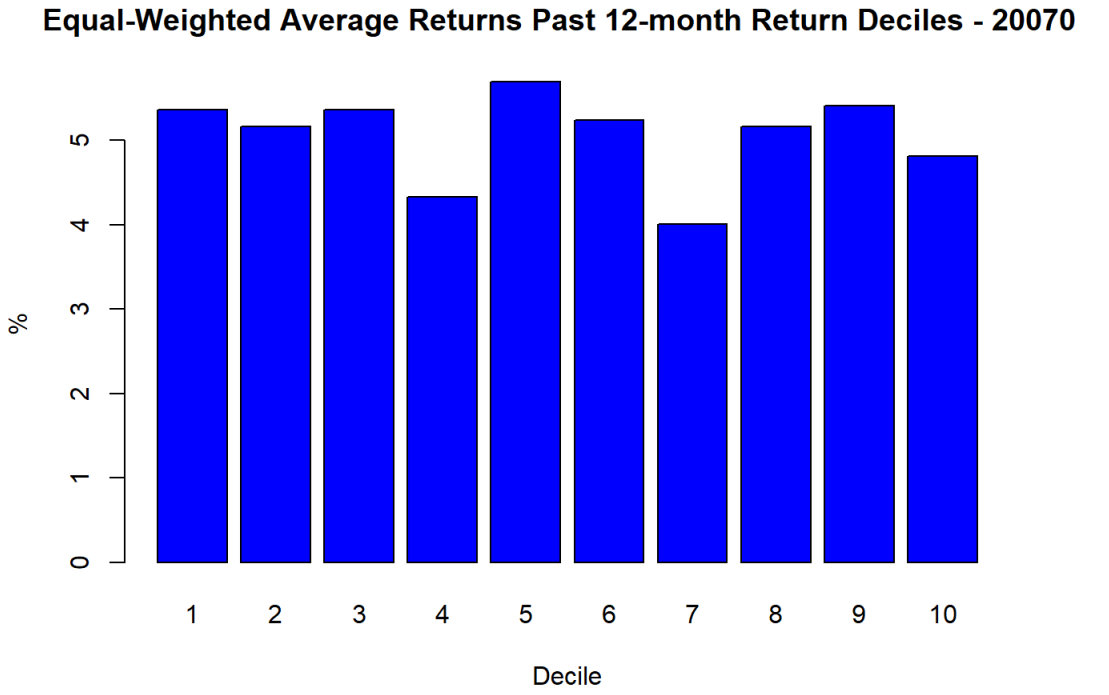

Equal-Weighted Average Returns Past 12-month Return Deciles - 20060
%
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
Decile

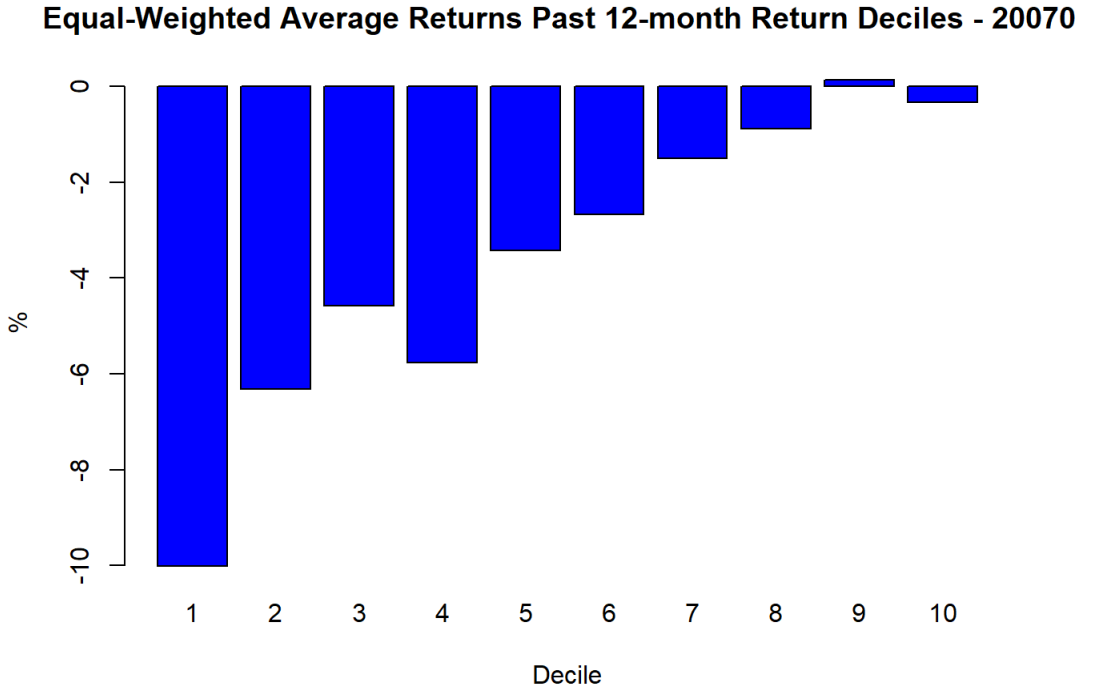

Equal-Weighted Average Returns Past 12-month Return Deciles - 20060
%
0
-2
-4
-6
-8
1
2
3
4
5
6
7
8
9
10
Decile

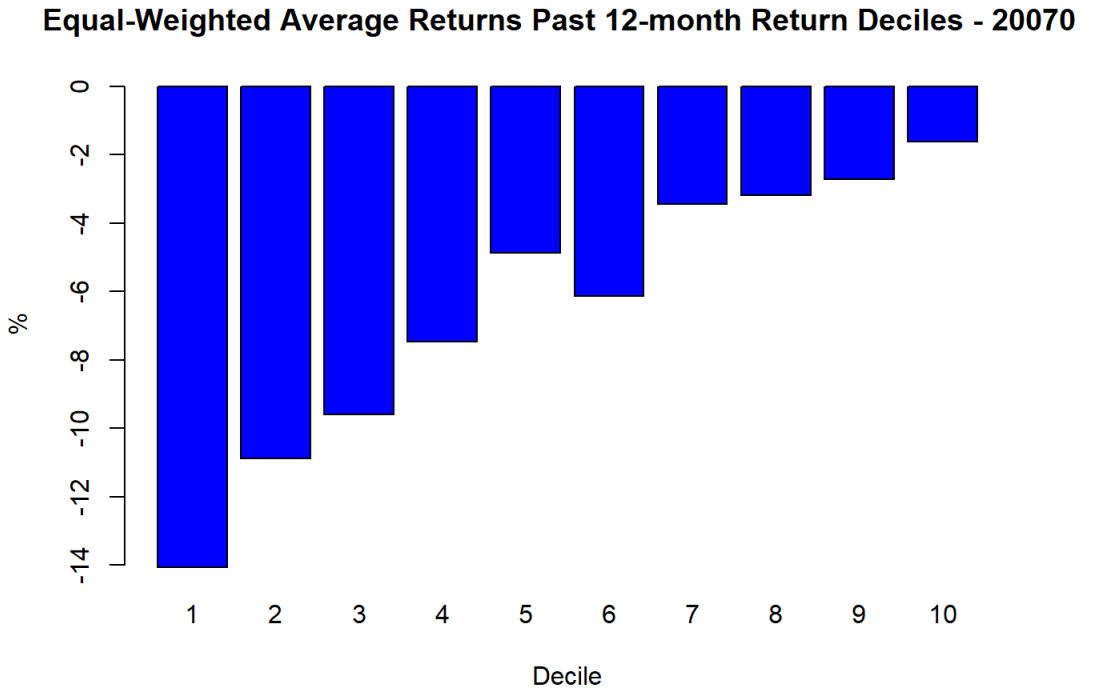

Equal-Weighted Average Returns Past 12-month Return Deciles - 20060
%
2
0
-2
-4
-6
1
2
3
4
5
6
7
8
9
10
Decile

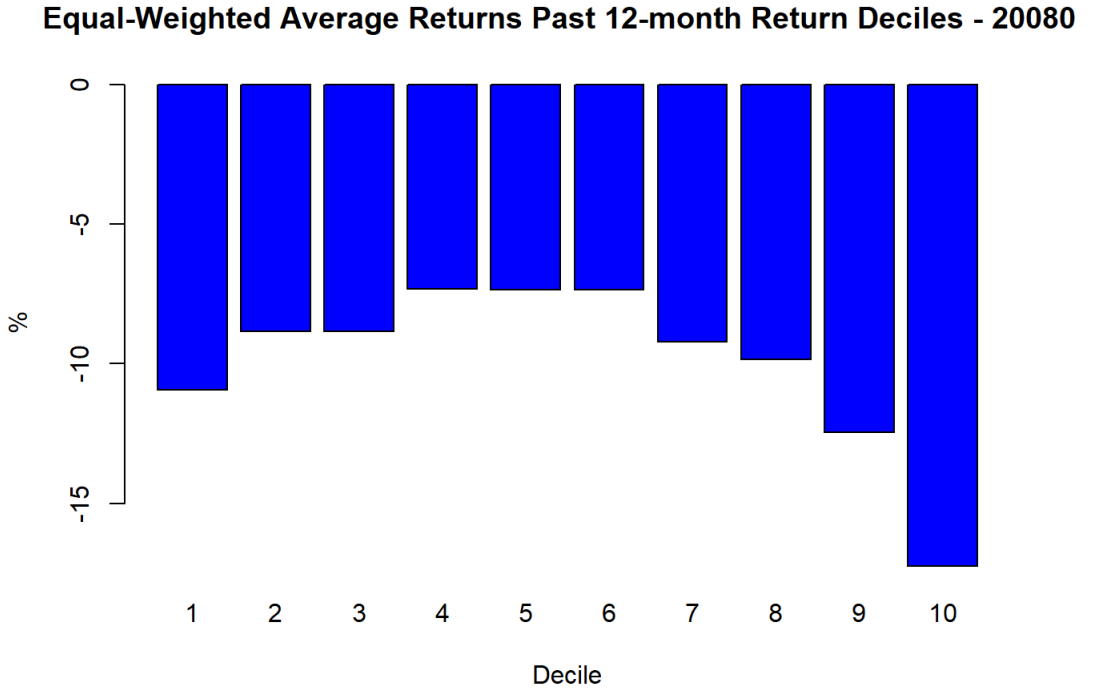

Equal-Weighted Average Returns Past 12-month Return Deciles - 20060
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

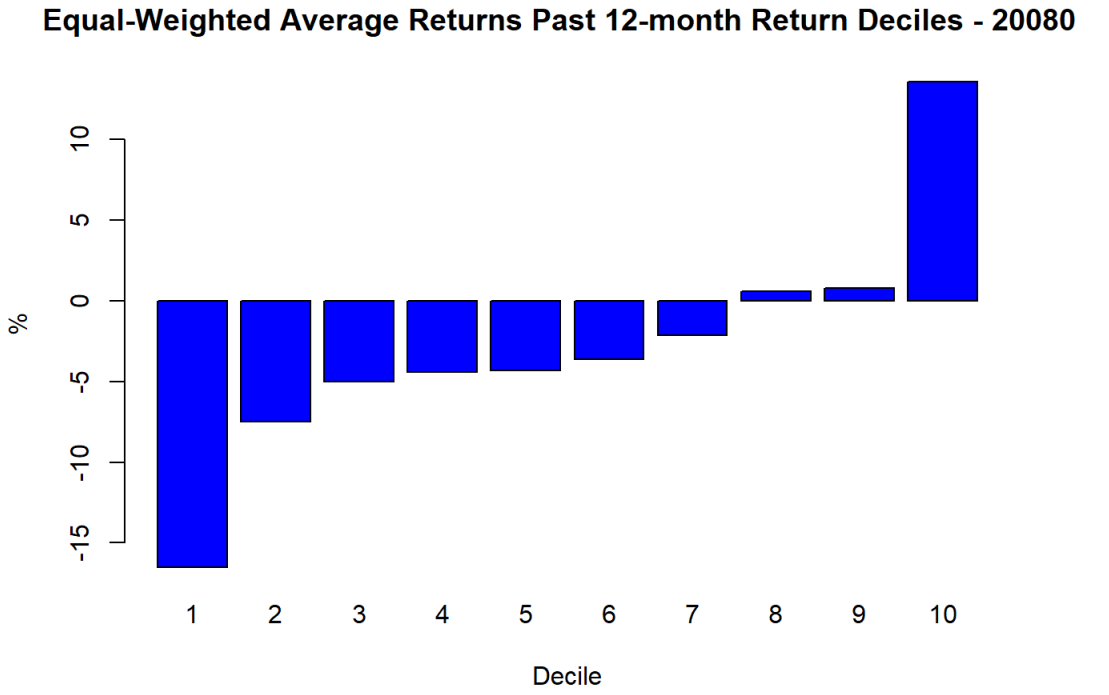

Equal-Weighted Average Returns Past 12-month Return Deciles - 20070
%
0
1
2
3
4
1
2
3
4
5
6
7
8
9
10
Decile

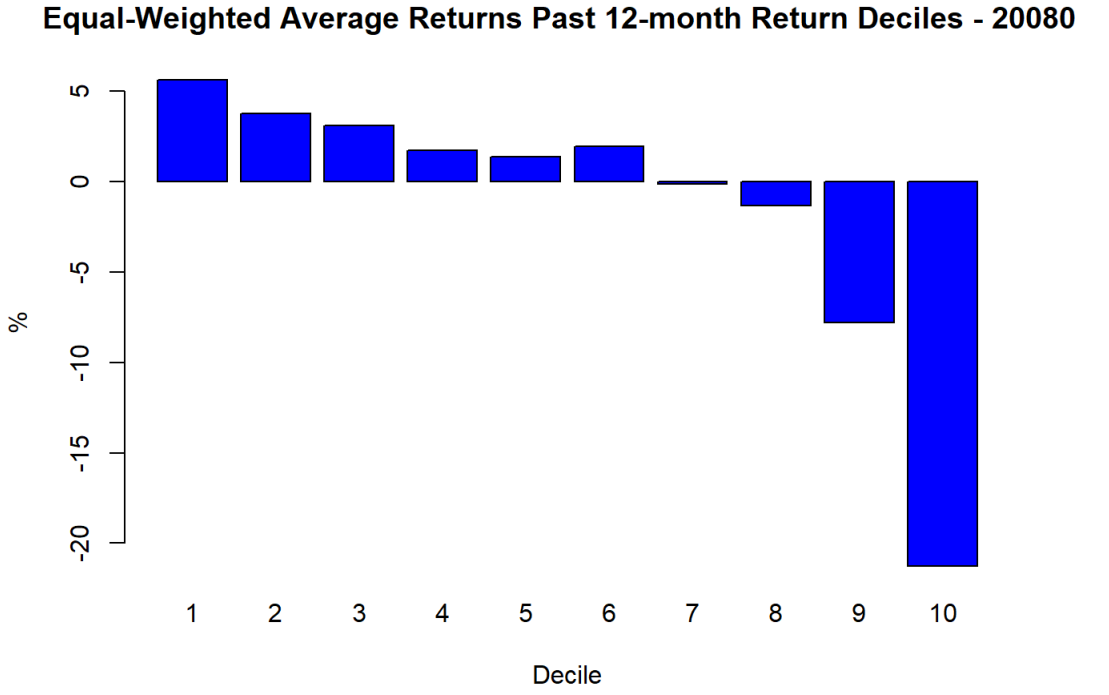

Equal-Weighted Average Returns Past 12-month Return Deciles - 20070
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

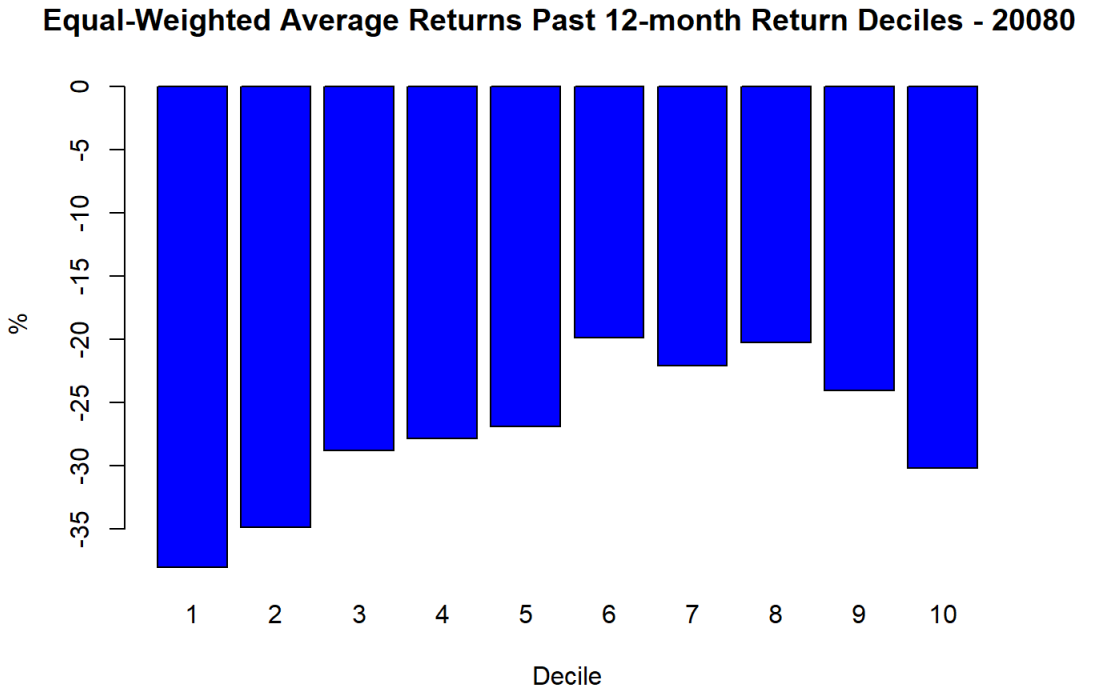

Equal-Weighted Average Returns Past 12-month Return Deciles - 20070
%
-10
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

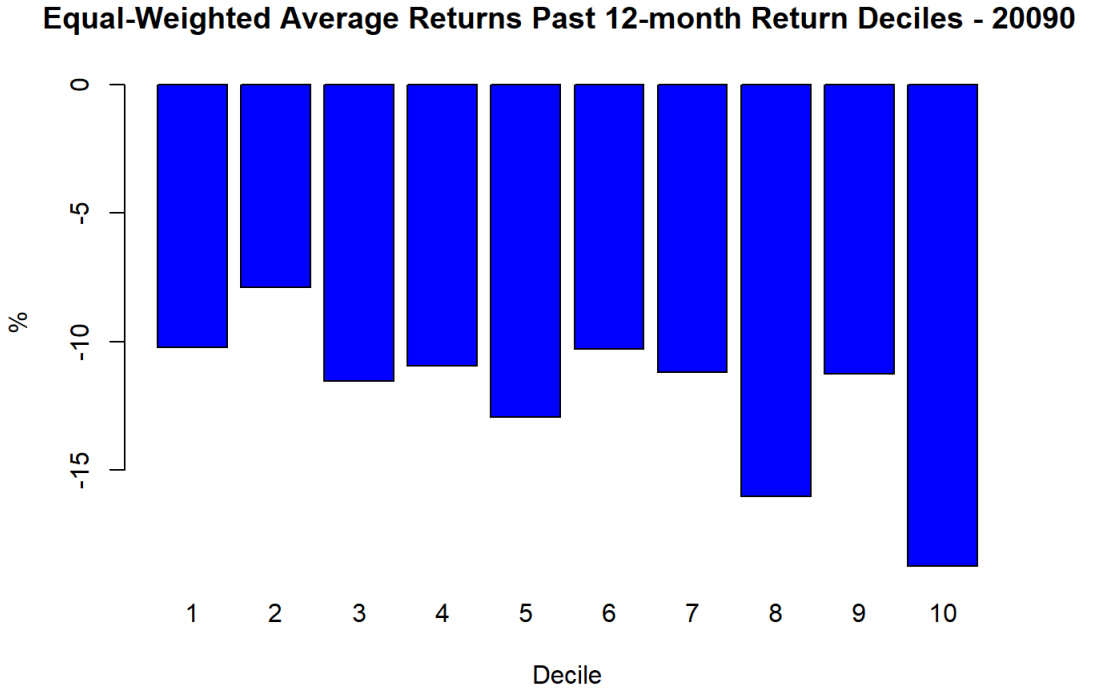

Equal-Weighted Average Returns Past 12-month Return Deciles - 20070
0
-2
-4
-6
-8
-10
-12
-14
%
1
2
3
4
5
6
7
8
9
10
Decile

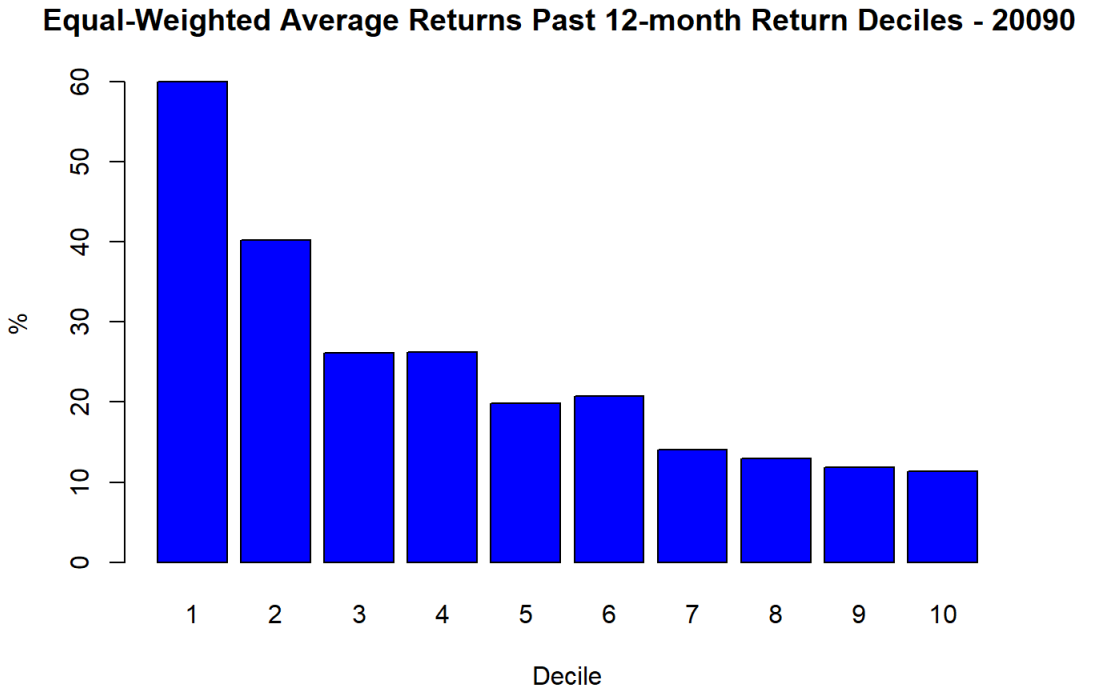

Equal-Weighted Average Returns Past 12-month Return Deciles - 20080
0
-5
-10
-15
%
1
2
3
4
5
6
7
8
9
10
Decile

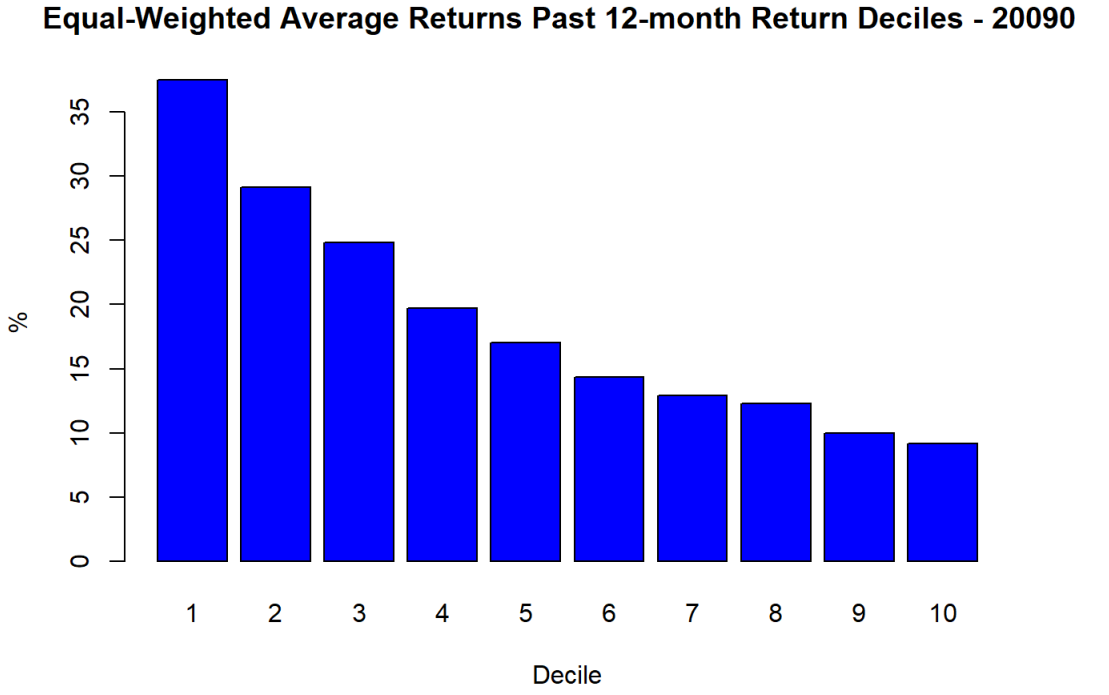

Equal-Weighted Average Returns Past 12-month Return Deciles - 20080
%
10
5
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
Decile

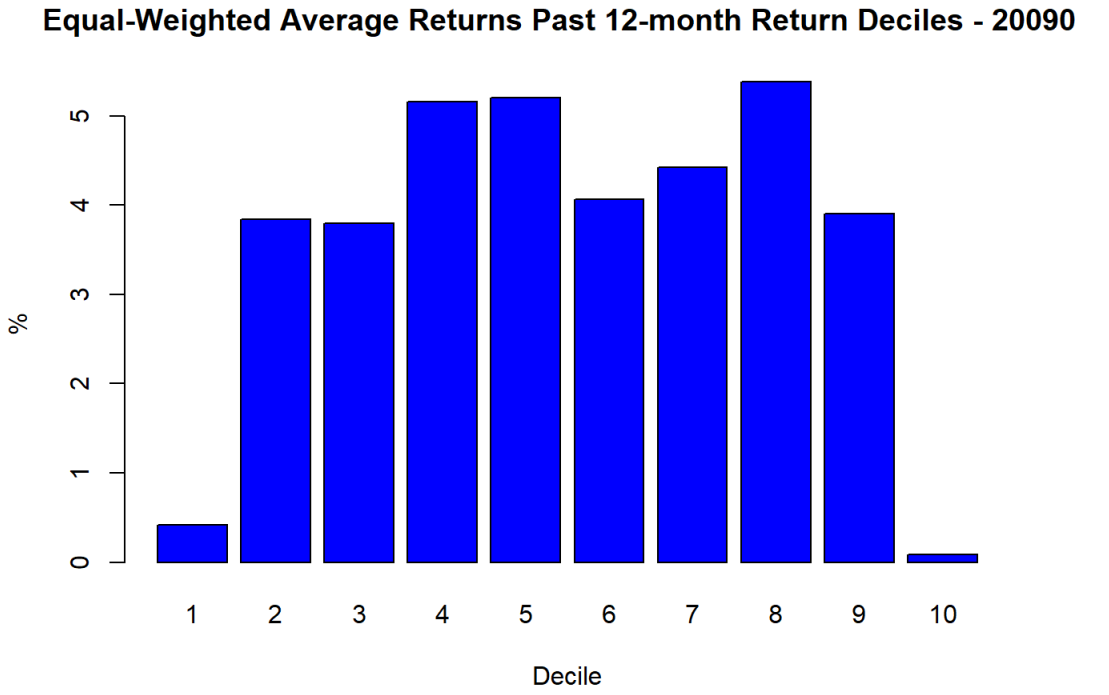

Equal-Weighted Average Returns Past 12-month Return Deciles - 20080
%
5
0
-5
-10
-15
-20
1
2
3
4
5
6
7
8
9
10
Decile

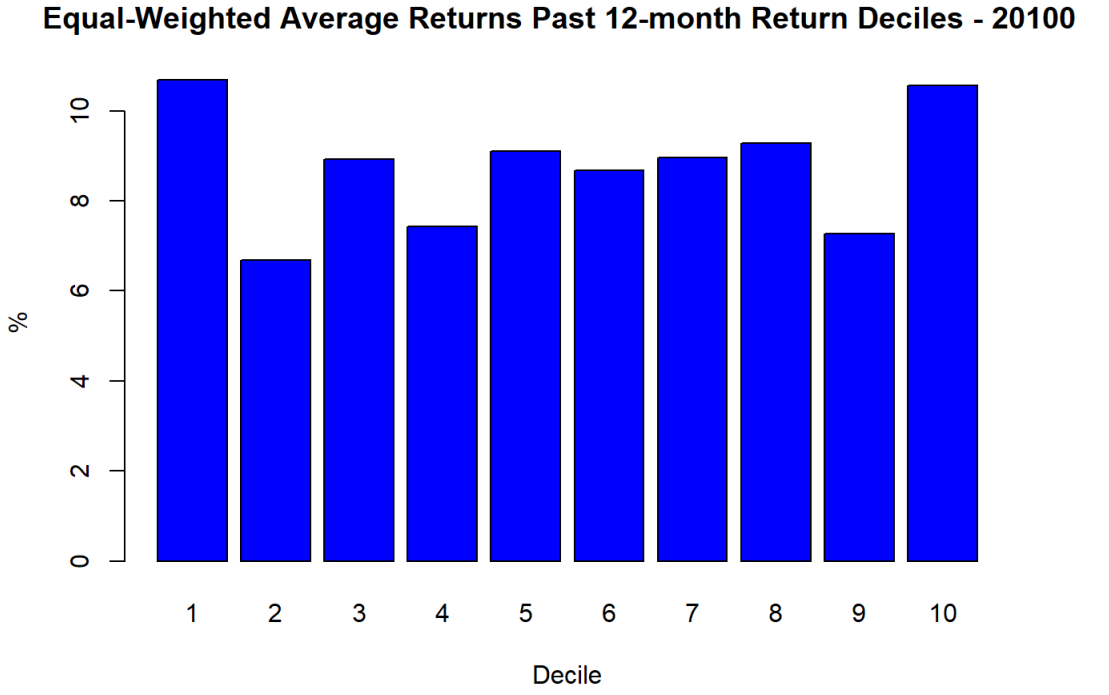

Equal-Weighted Average Returns Past 12-month Return Deciles - 20080
0
-5
-10
-15
-20
-25
-30
-35
%
1
2
3
4
5
6
7
8
9
10
Decile

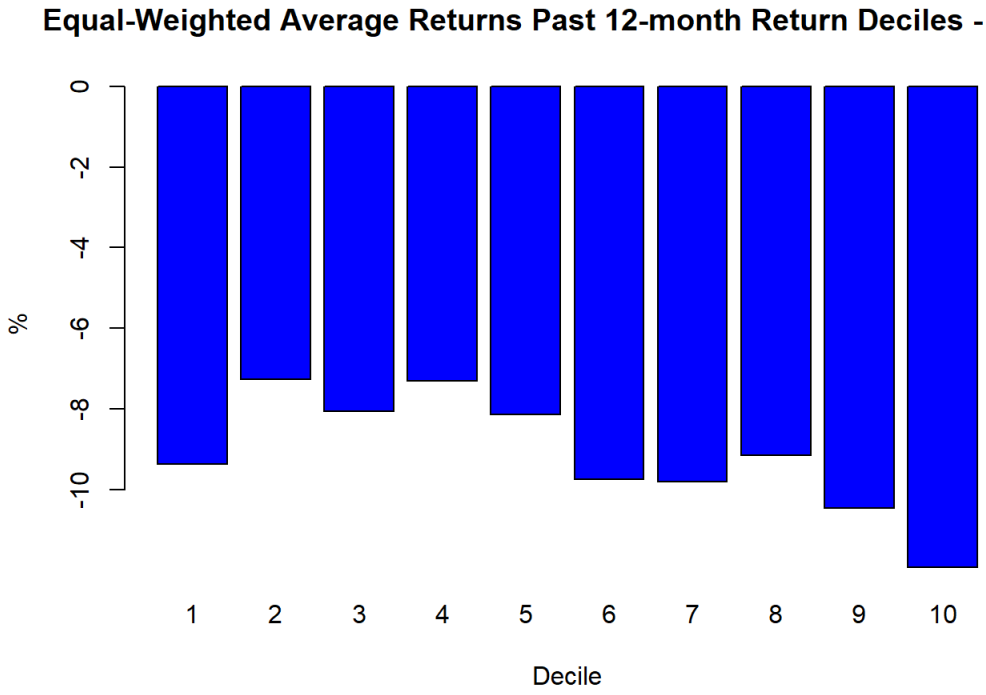

Equal-Weighted Average Returns Past 12-month Return Deciles - 20090
0
-5
-10
-15
%
1
2
3
4
5
6
7
8
9
10
Decile

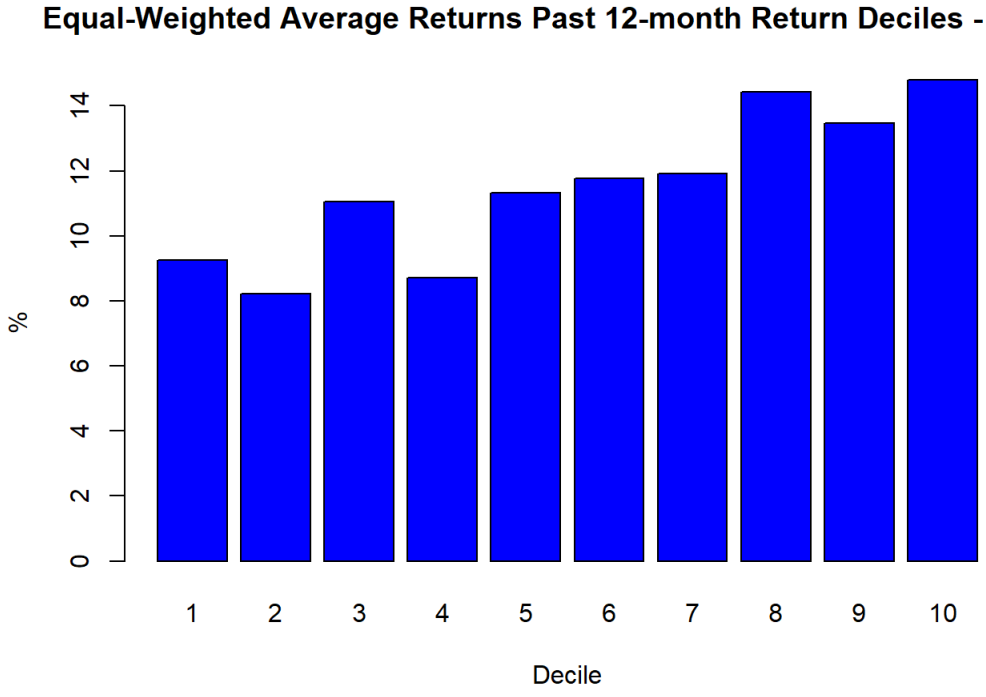

Equal-Weighted Average Returns Past 12-month Return Deciles - 20090
%
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10
Decile

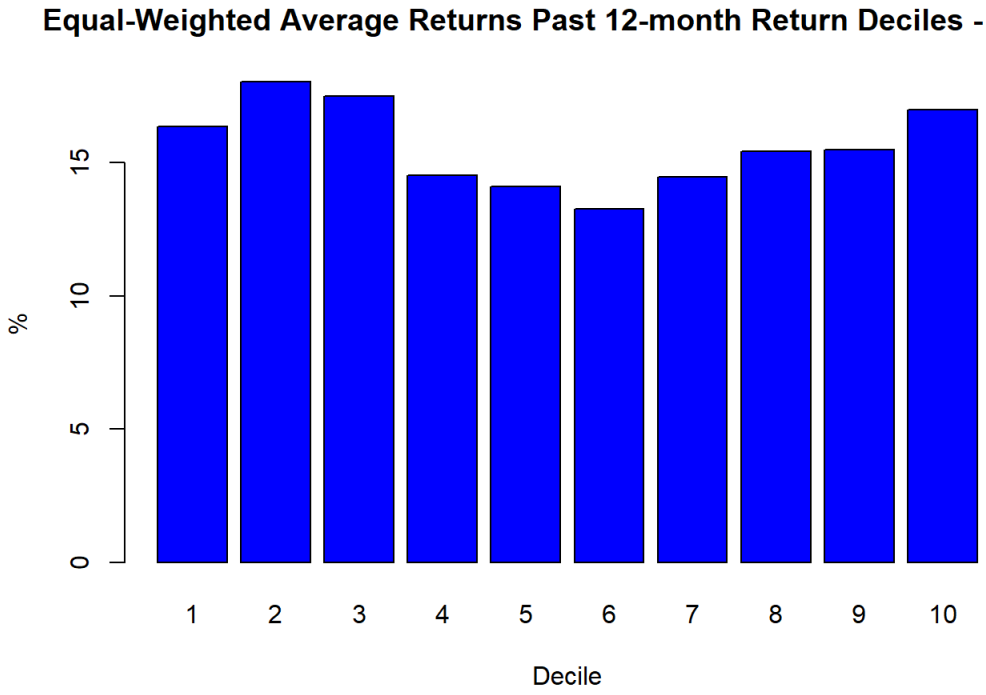

Equal-Weighted Average Returns Past 12-month Return Deciles - 20090
%
0
5
10
15
20
25
30
35
1
2
3
4
5
6
7
8
9
10
Decile

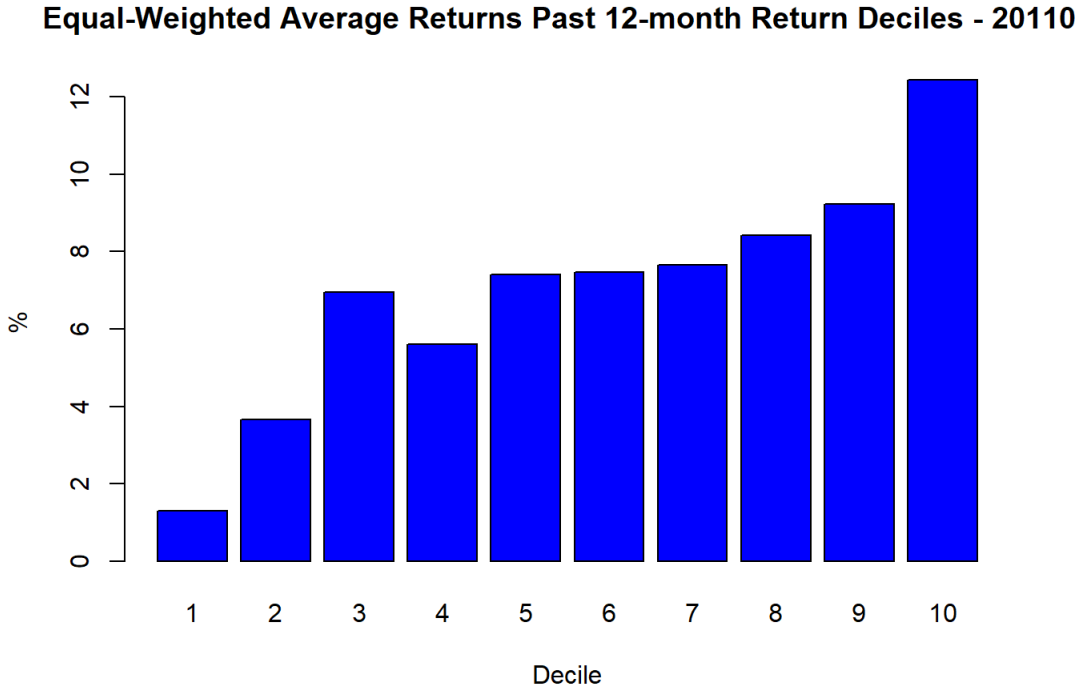

Equal-Weighted Average Returns Past 12-month Return Deciles - 20090
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

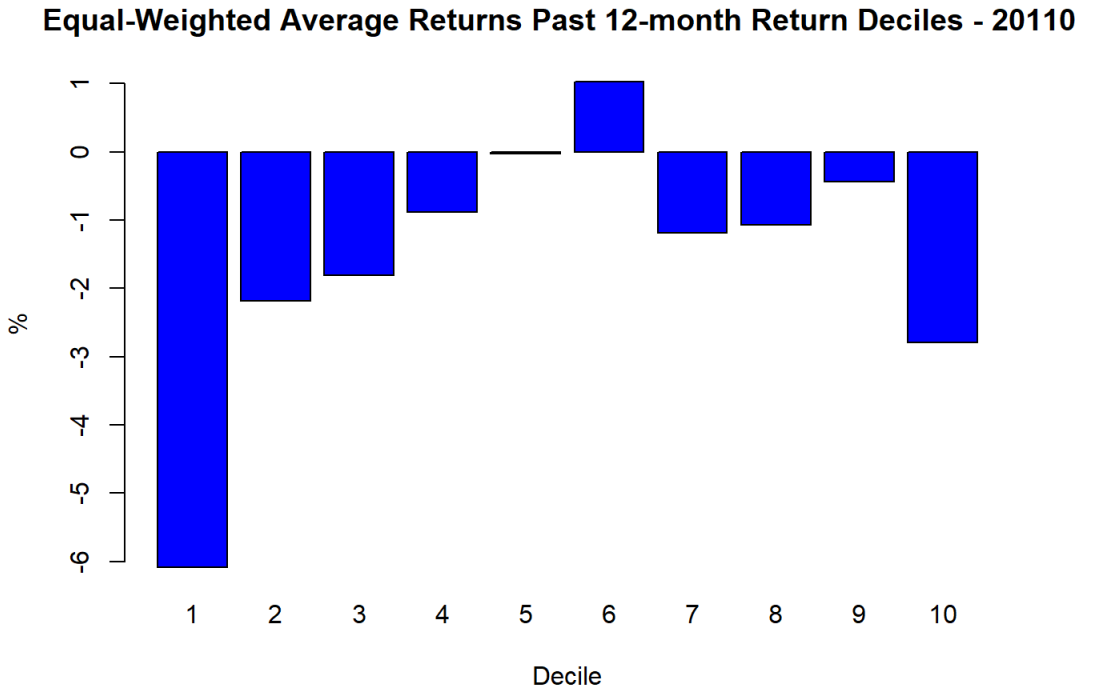

Equal-Weighted Average Returns Past 12-month Return Deciles - 20100
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

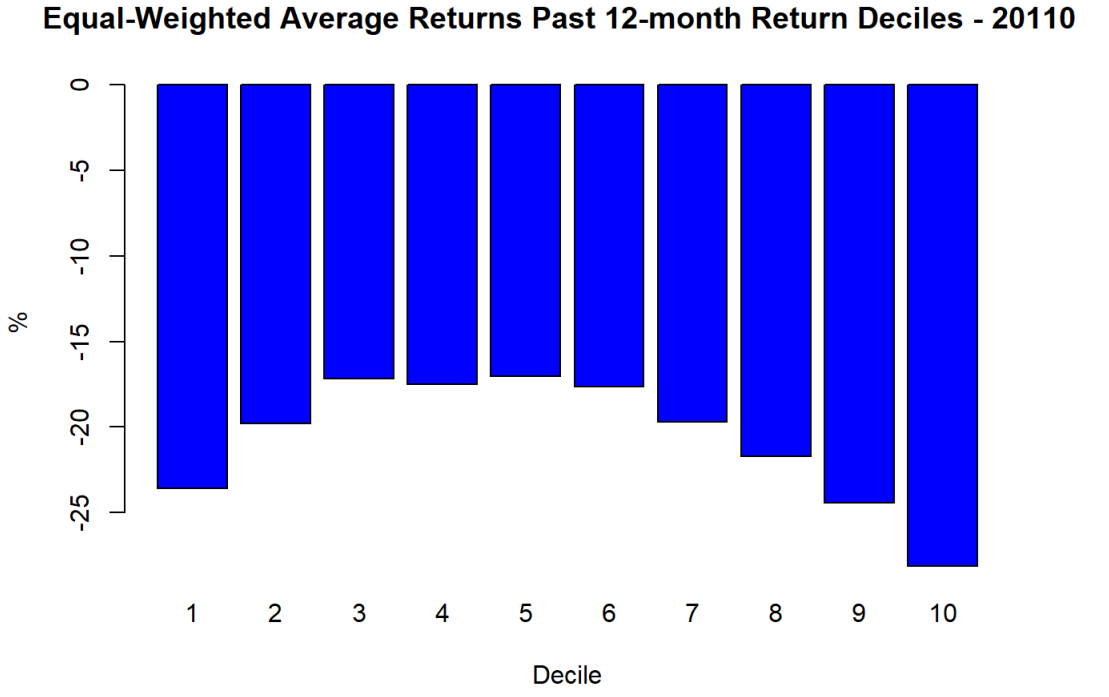

Equal-Weighted Average Returns Past 12-month Return Deciles - 20100
%
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
Decile

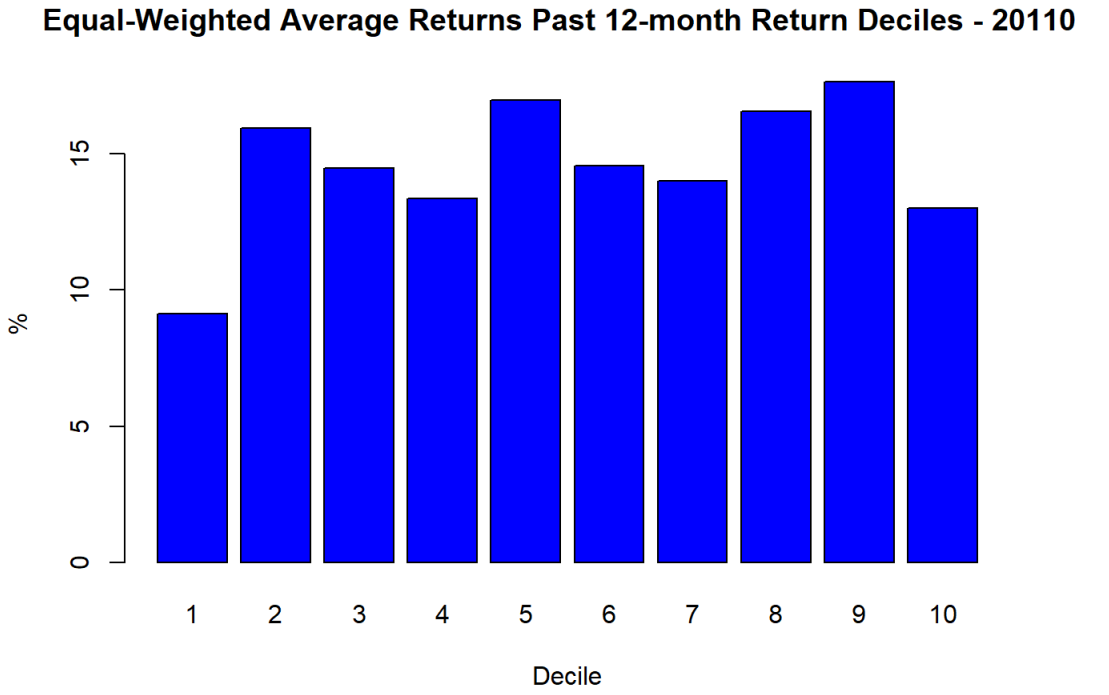

Equal-Weighted Average Returns Past 12-month Return Deciles - 20100
%
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
Decile

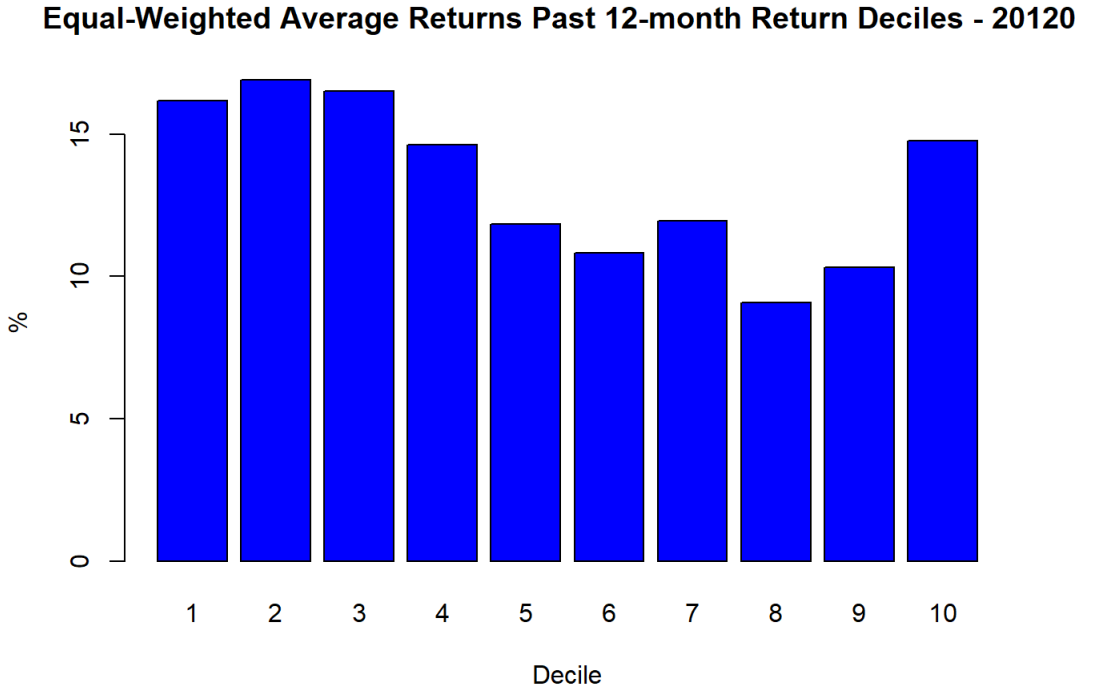

Equal-Weighted Average Returns Past 12-month Return Deciles - 20100
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

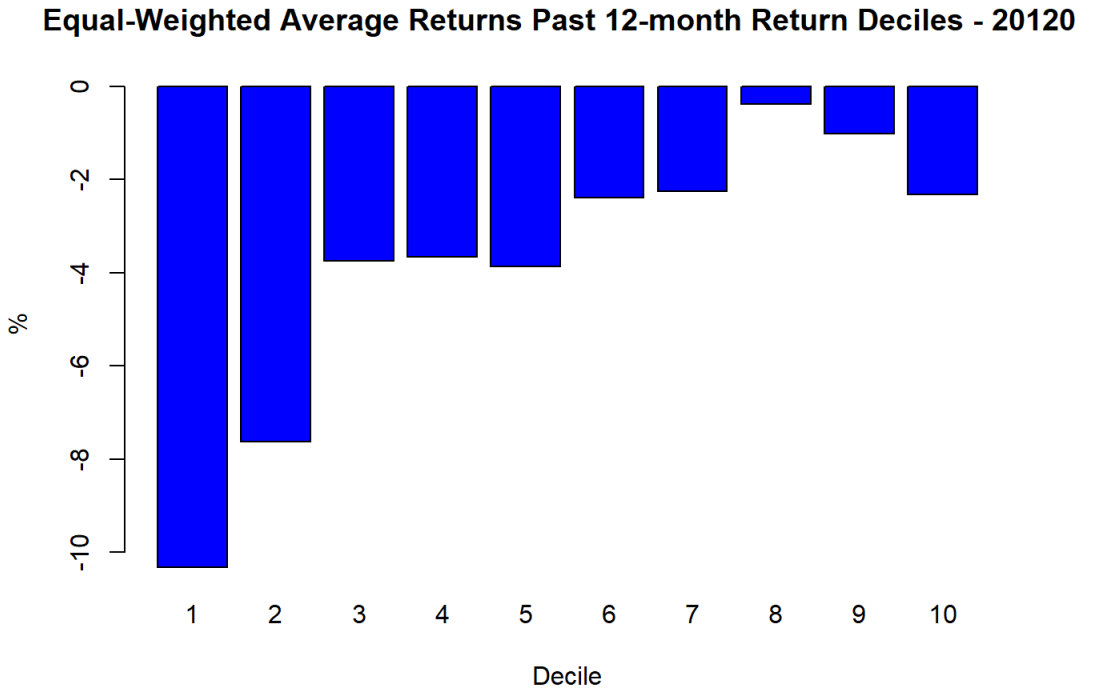

Equal-Weighted Average Returns Past 12-month Return Deciles - 20110
%
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
Decile

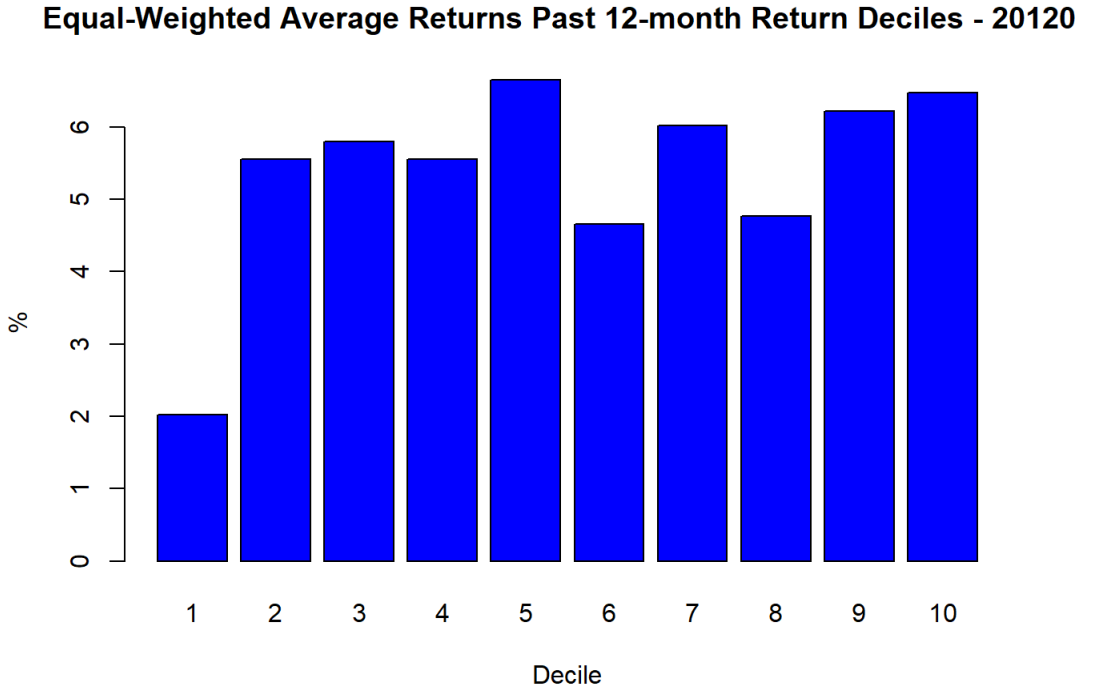

Equal-Weighted Average Returns Past 12-month Return Deciles - 20110
%
1
0
-1
-2
-3
-4
-5
-6
1
2
3
4
5
6
7
8
9
10
Decile

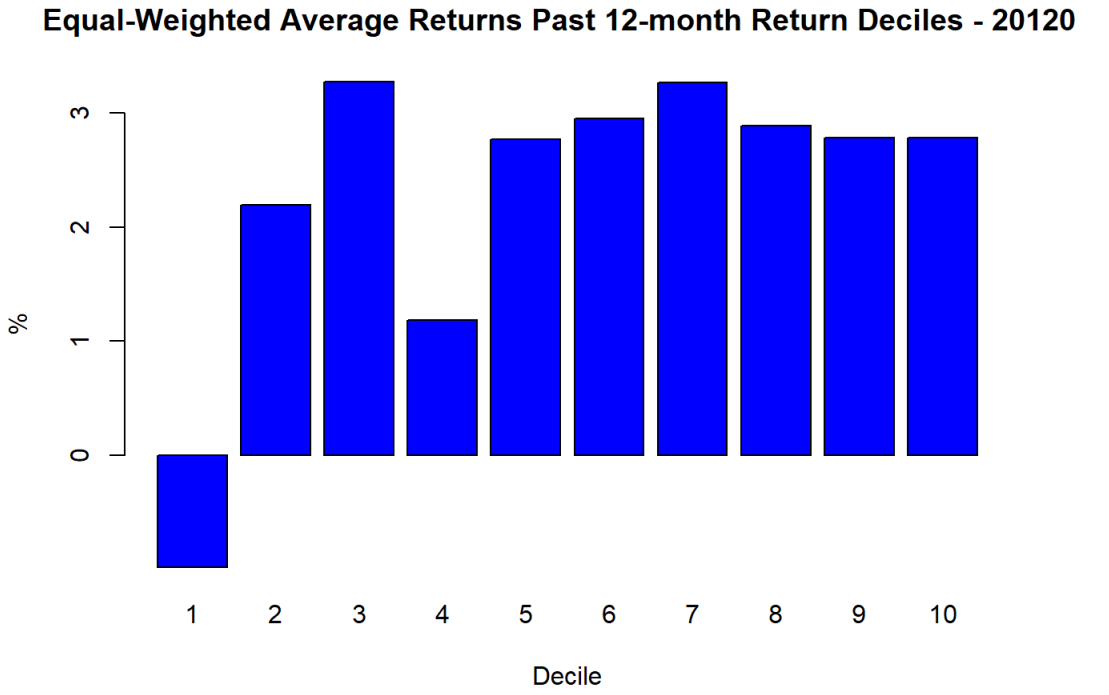

Equal-Weighted Average Returns Past 12-month Return Deciles - 20110
%
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
Decile

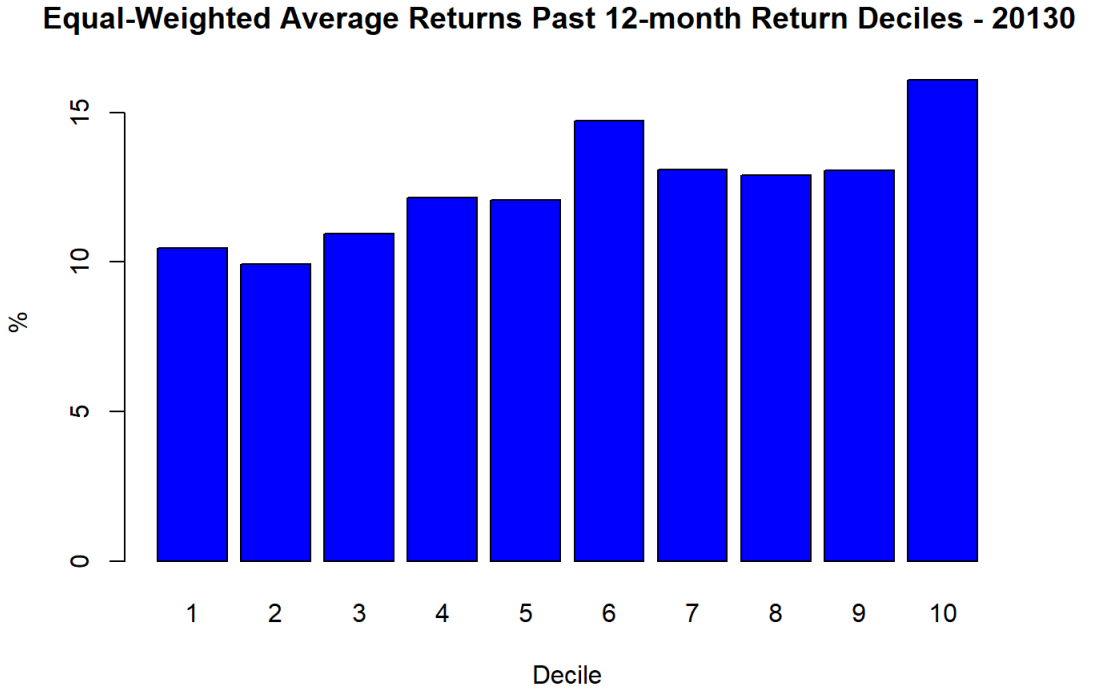

Equal-Weighted Average Returns Past 12-month Return Deciles - 20110
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

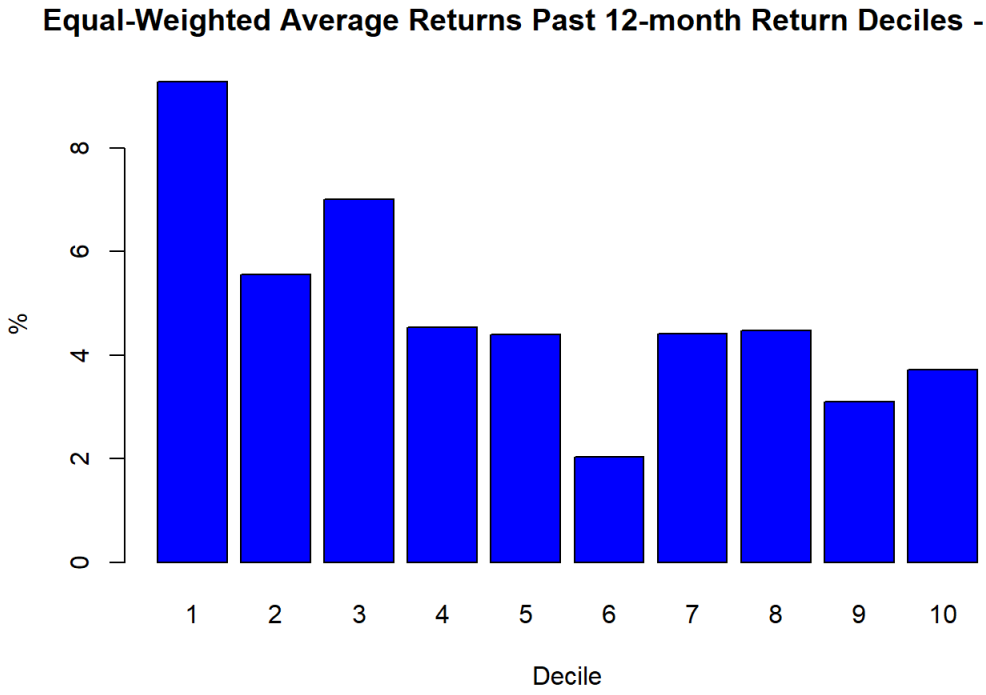

Equal-Weighted Average Returns Past 12-month Return Deciles - 20120
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

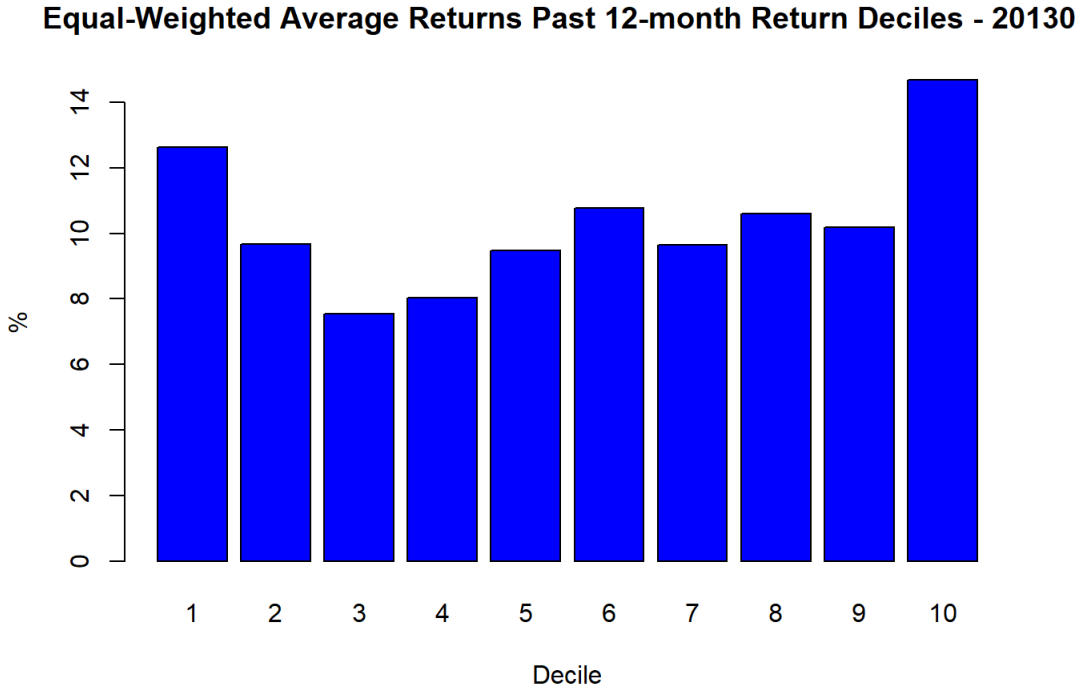

Equal-Weighted Average Returns Past 12-month Return Deciles - 20120
%
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
Decile

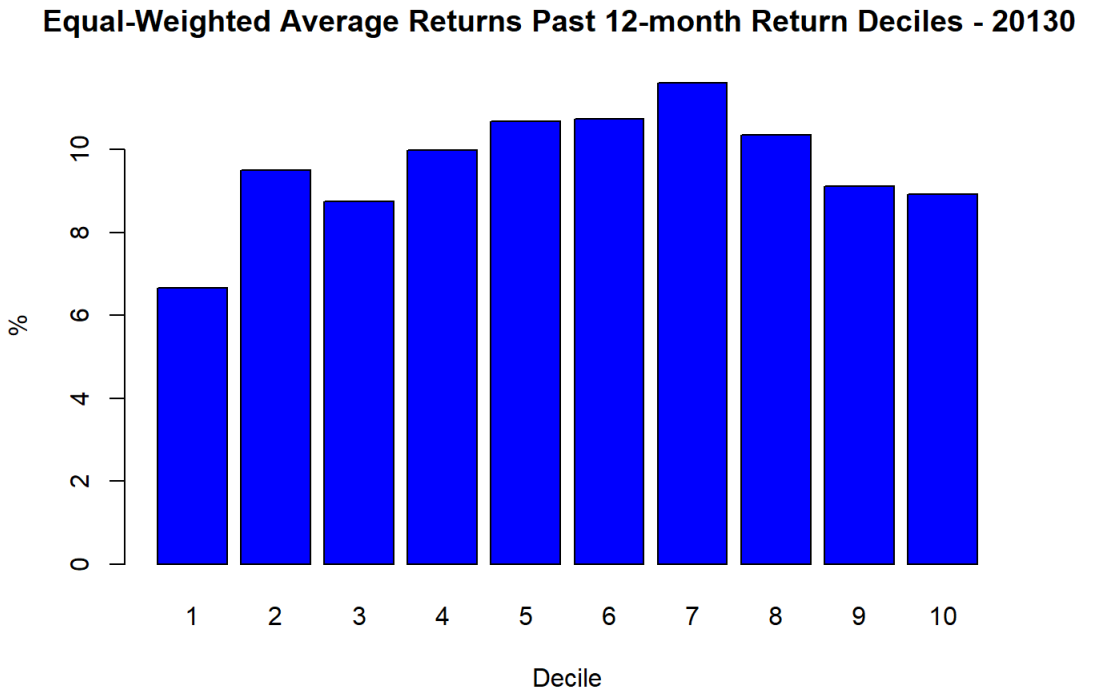

Equal-Weighted Average Returns Past 12-month Return Deciles - 20120
%
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
Decile

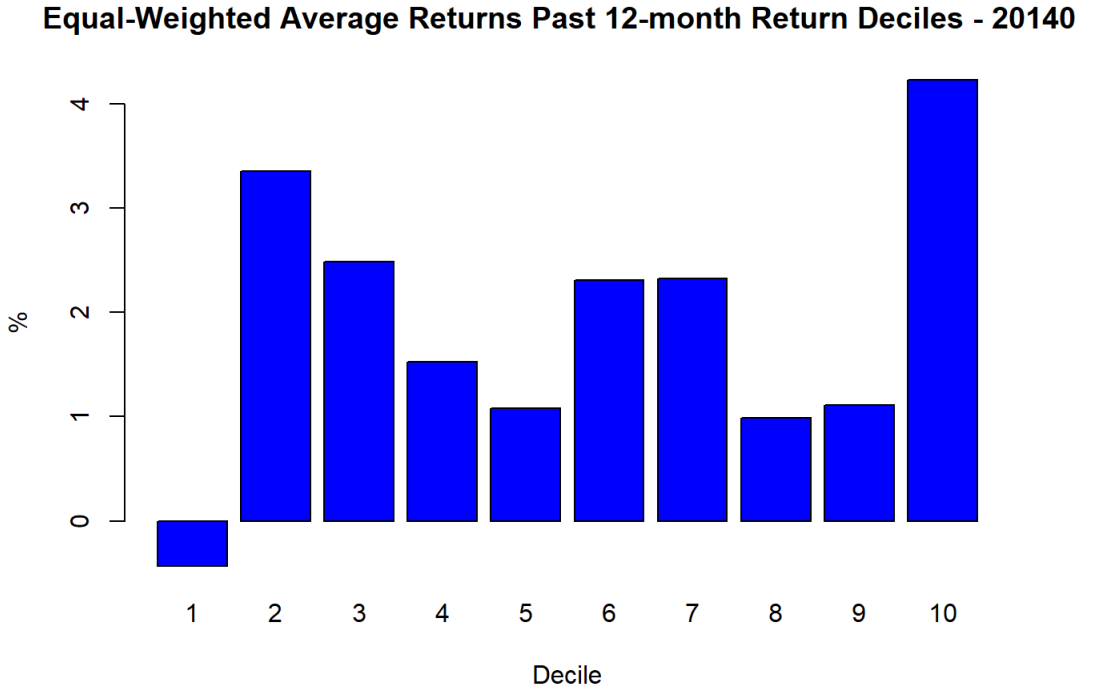

Equal-Weighted Average Returns Past 12-month Return Deciles - 20120
%
0
1
2
3
1
2
3
4
5
6
7
8
9
10
Decile

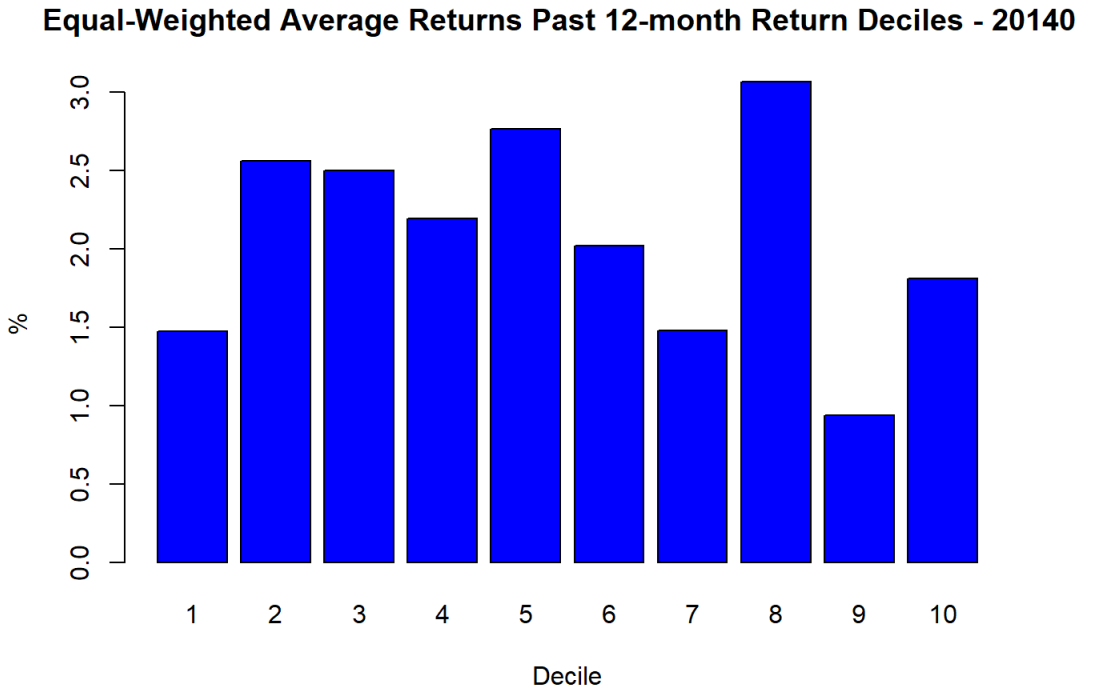

Equal-Weighted Average Returns Past 12-month Return Deciles - 20130
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

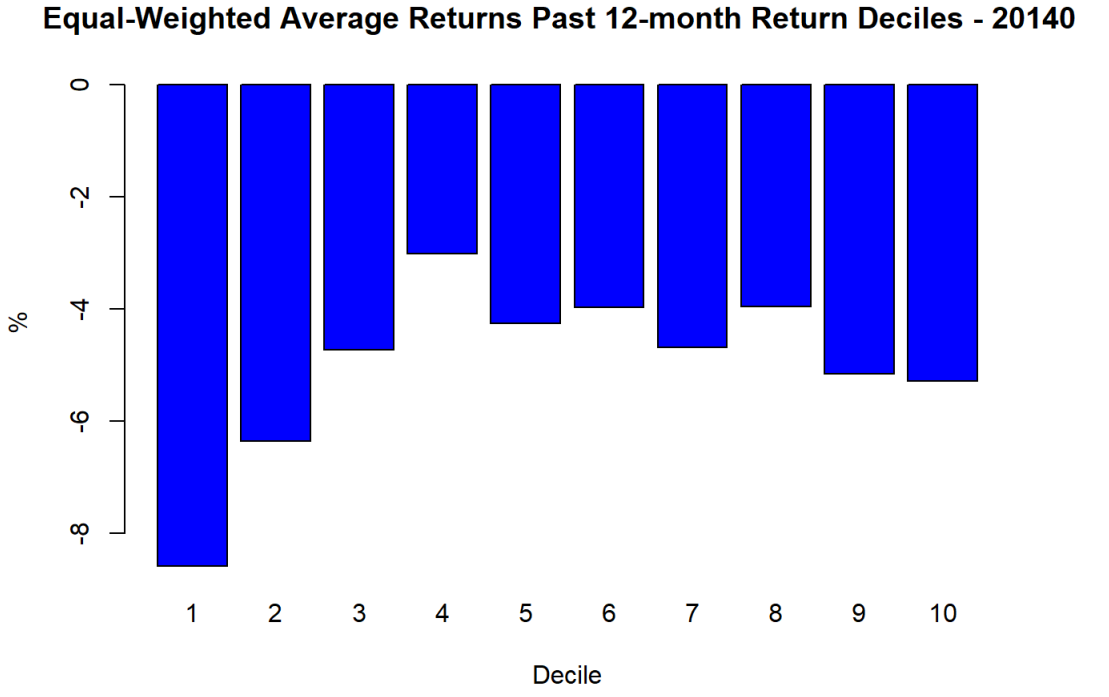

Equal-Weighted Average Returns Past 12-month Return Deciles - 20130
%
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

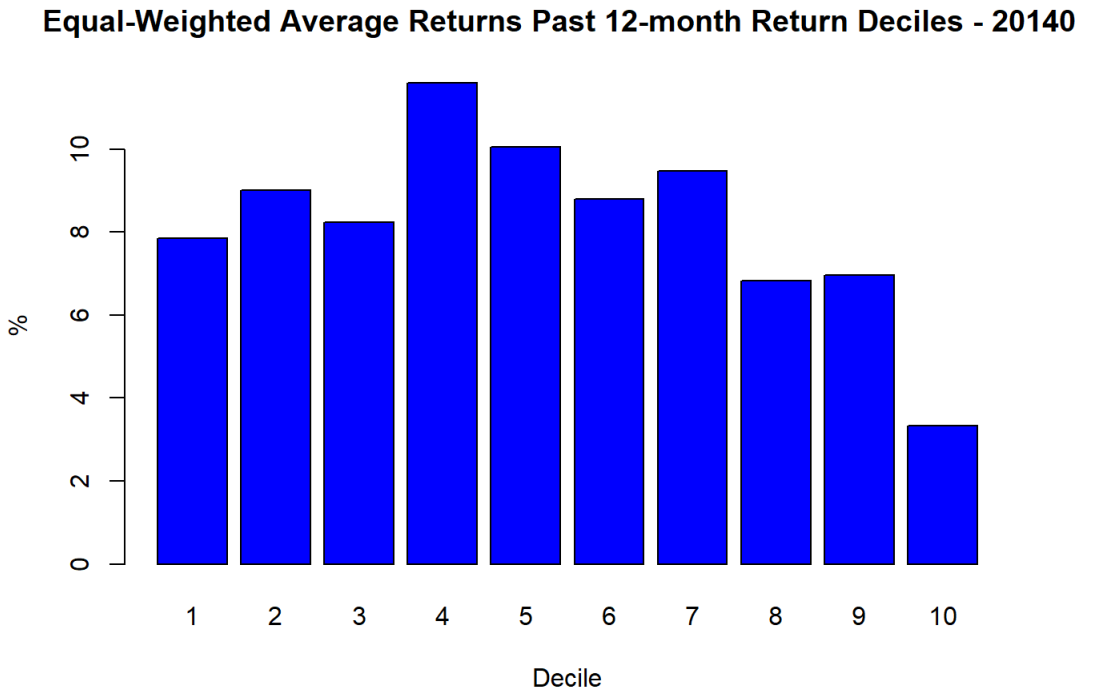

Equal-Weighted Average Returns Past 12-month Return Deciles - 20130
%
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
Decile

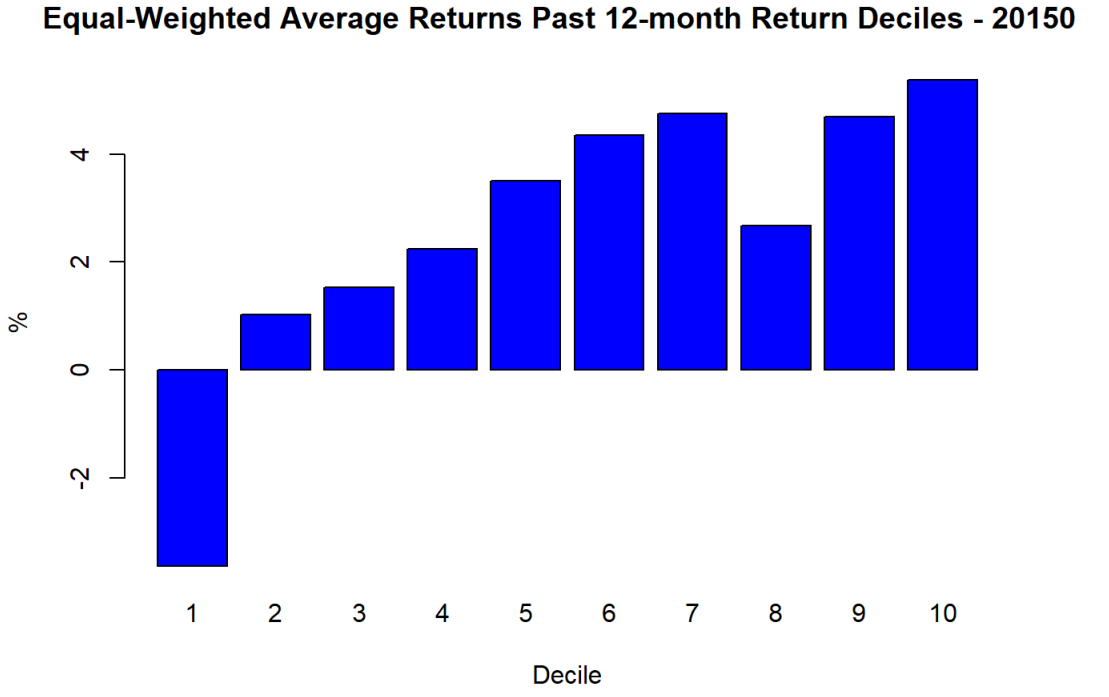

Equal-Weighted Average Returns Past 12-month Return Deciles - 20130
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

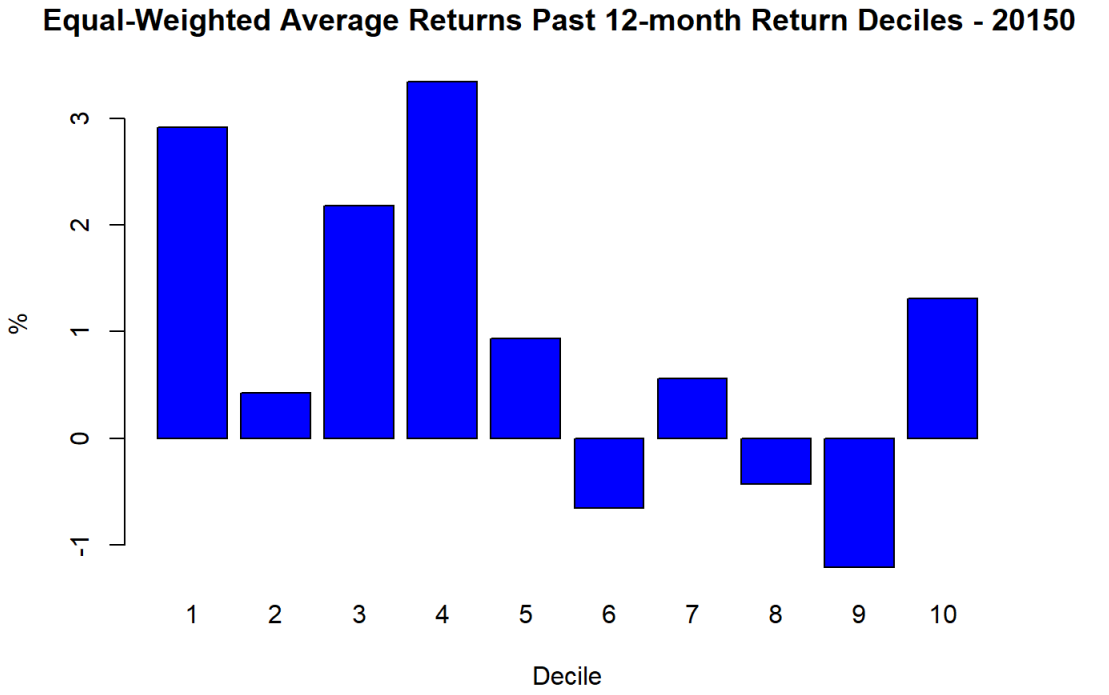

Equal-Weighted Average Returns Past 12-month Return Deciles - 20140
%
0
1
2
3
4
1
2
3
4
5
6
7
8
9
10
Decile

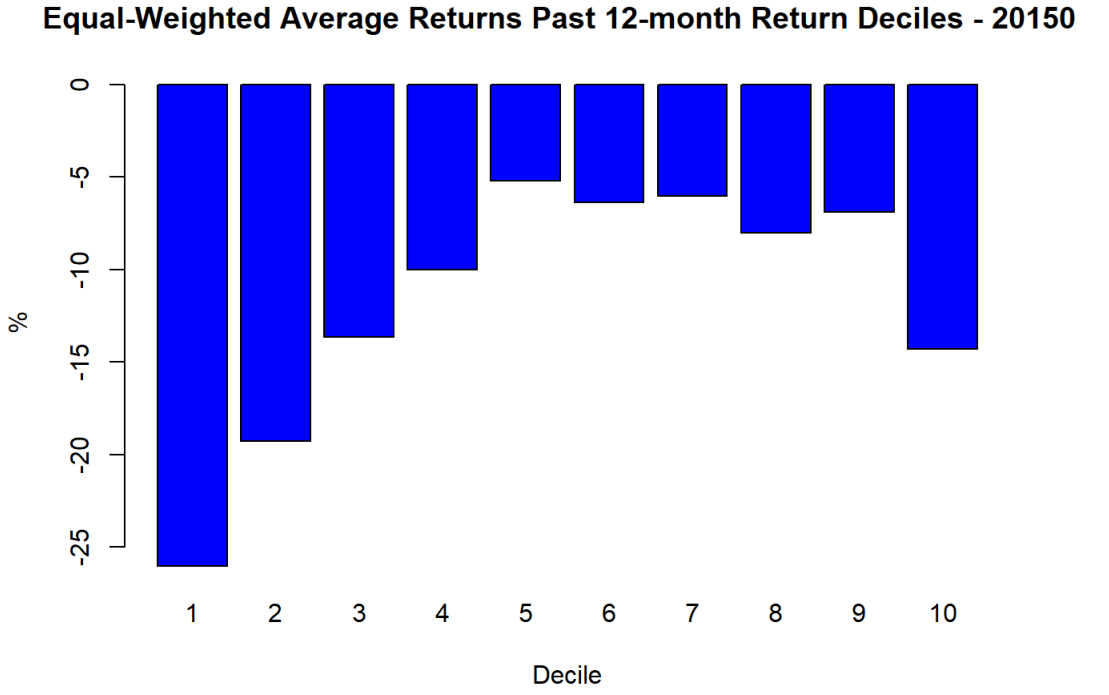

Equal-Weighted Average Returns Past 12-month Return Deciles - 20140
%
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1
2
3
4
5
6
7
8
9
10
Decile

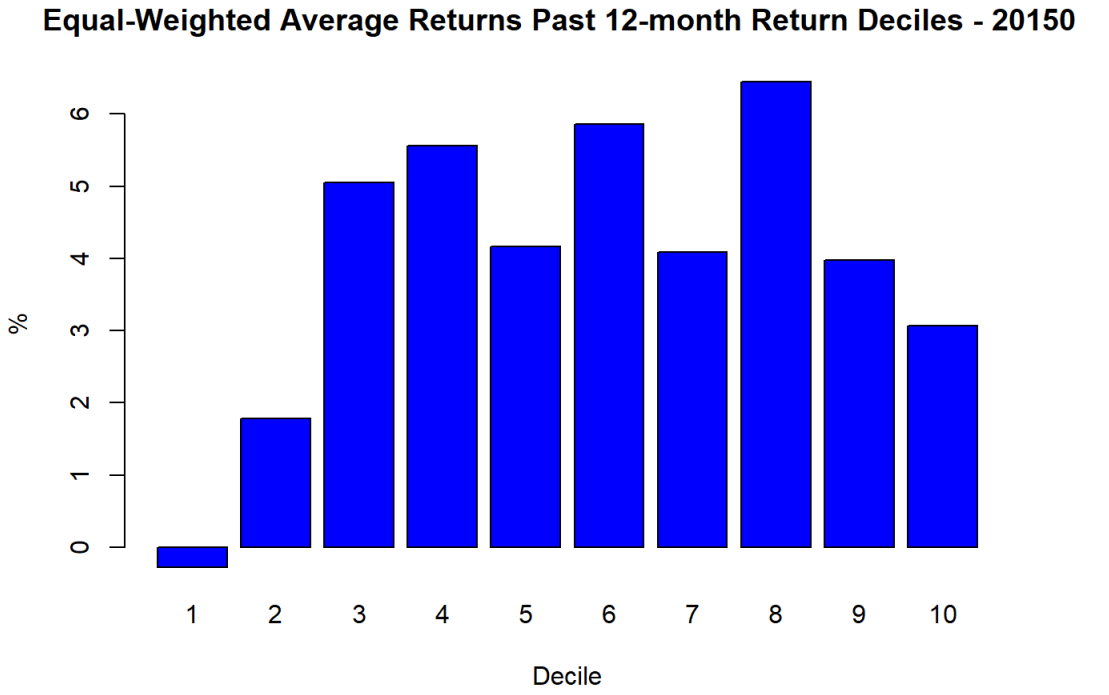

Equal-Weighted Average Returns Past 12-month Return Deciles - 20140
%
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

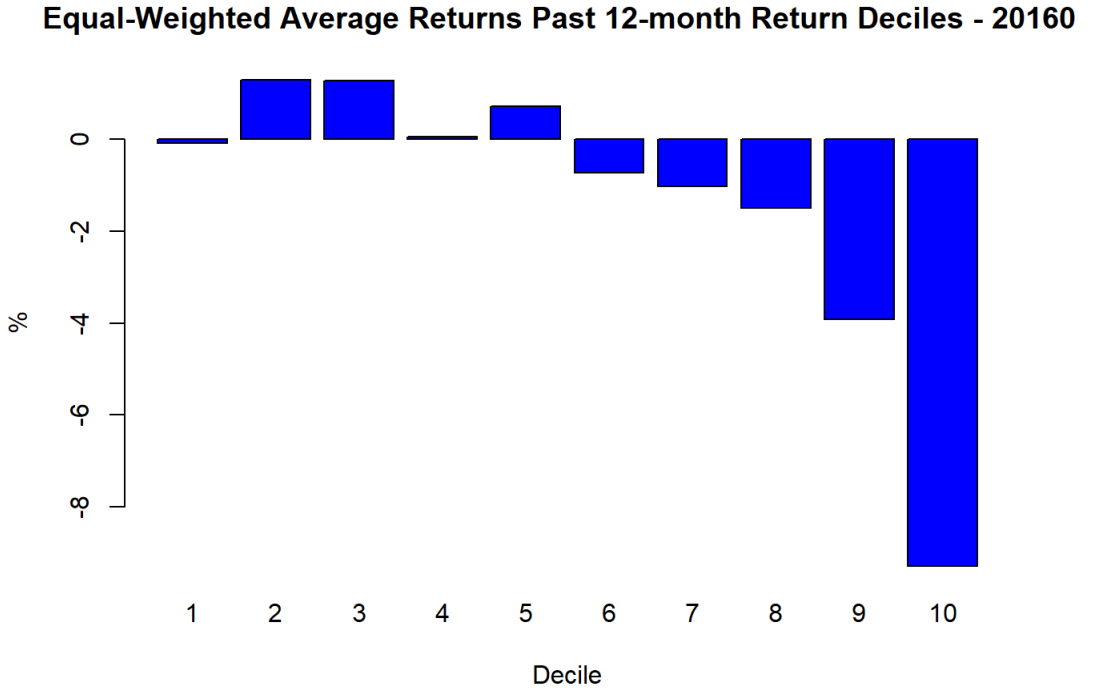

Equal-Weighted Average Returns Past 12-month Return Deciles - 20140
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

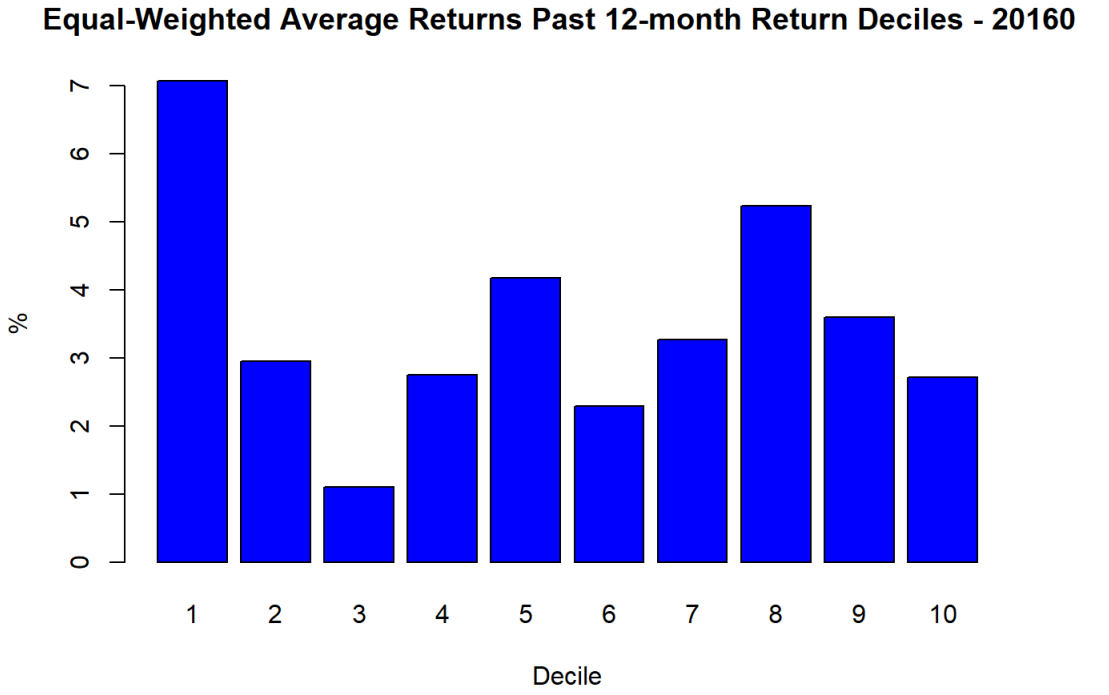

Equal-Weighted Average Returns Past 12-month Return Deciles - 20150
%
-2
0
2
4
1
2
3
4
5
6
7
8
9
10
Decile

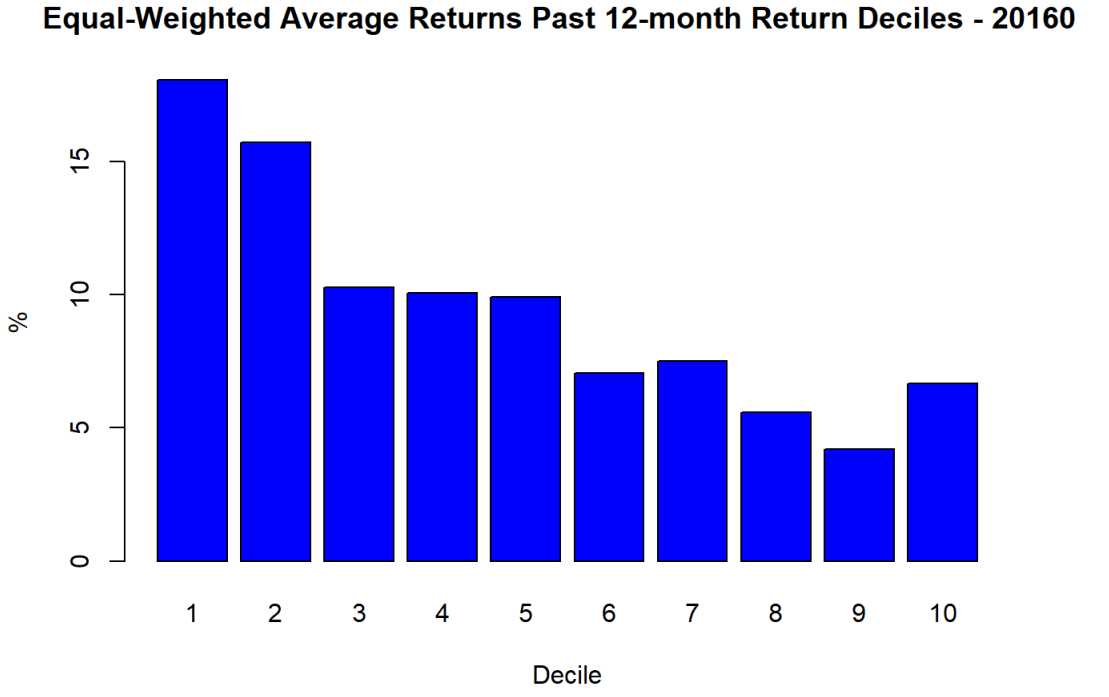

Equal-Weighted Average Returns Past 12-month Return Deciles - 20150
%
3
2
1
0
-1
1
2
3
4
5
6
7
8
9
10
Decile

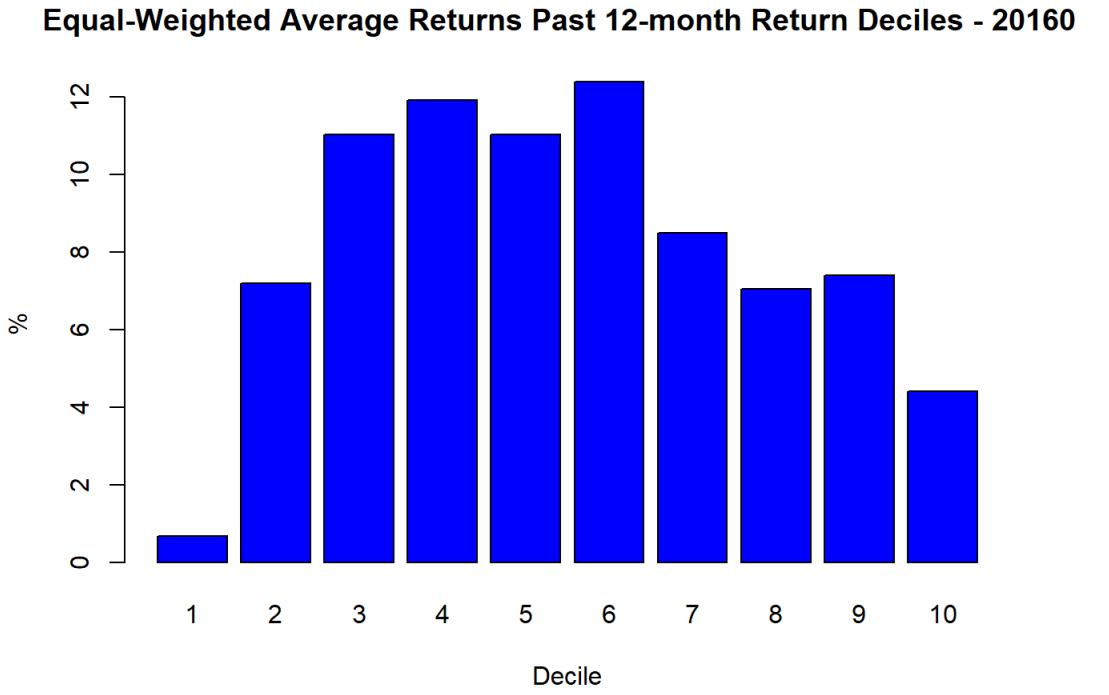

Equal-Weighted Average Returns Past 12-month Return Deciles - 20150
%
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
Decile

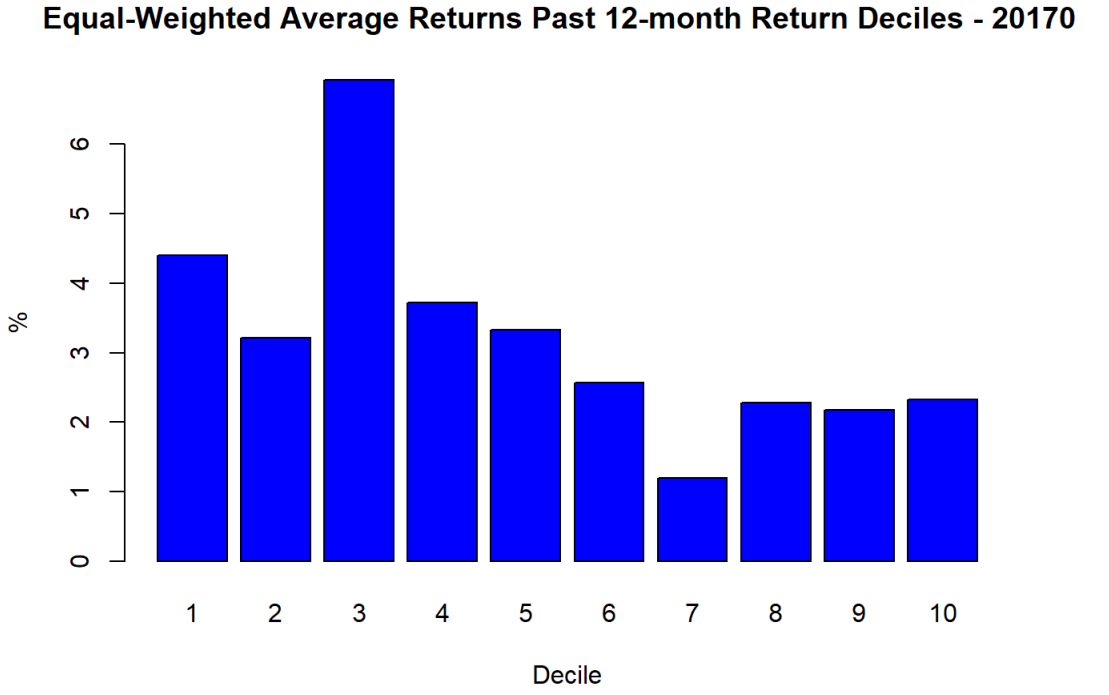

Equal-Weighted Average Returns Past 12-month Return Deciles - 20150
%
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
Decile

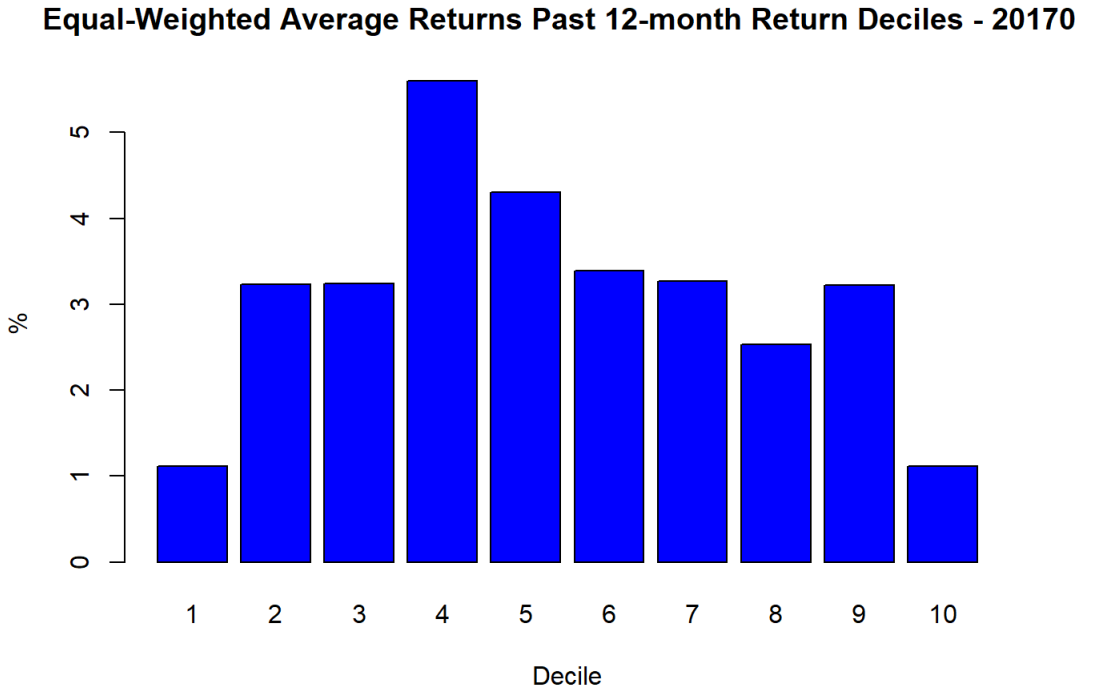

Equal-Weighted Average Returns Past 12-month Return Deciles - 20160
%
-8
-6
-4
-2
0
1
2
3
4
5
6
7
8
9
10
Decile

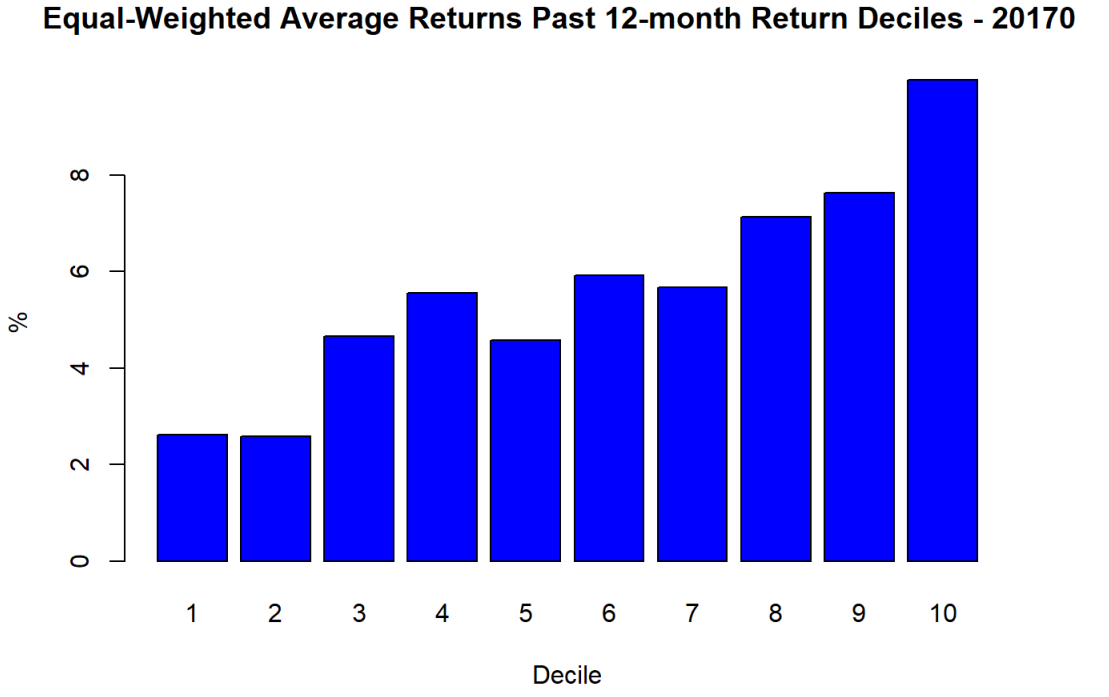

Equal-Weighted Average Returns Past 12-month Return Deciles - 20160
%
0
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9
10
Decile

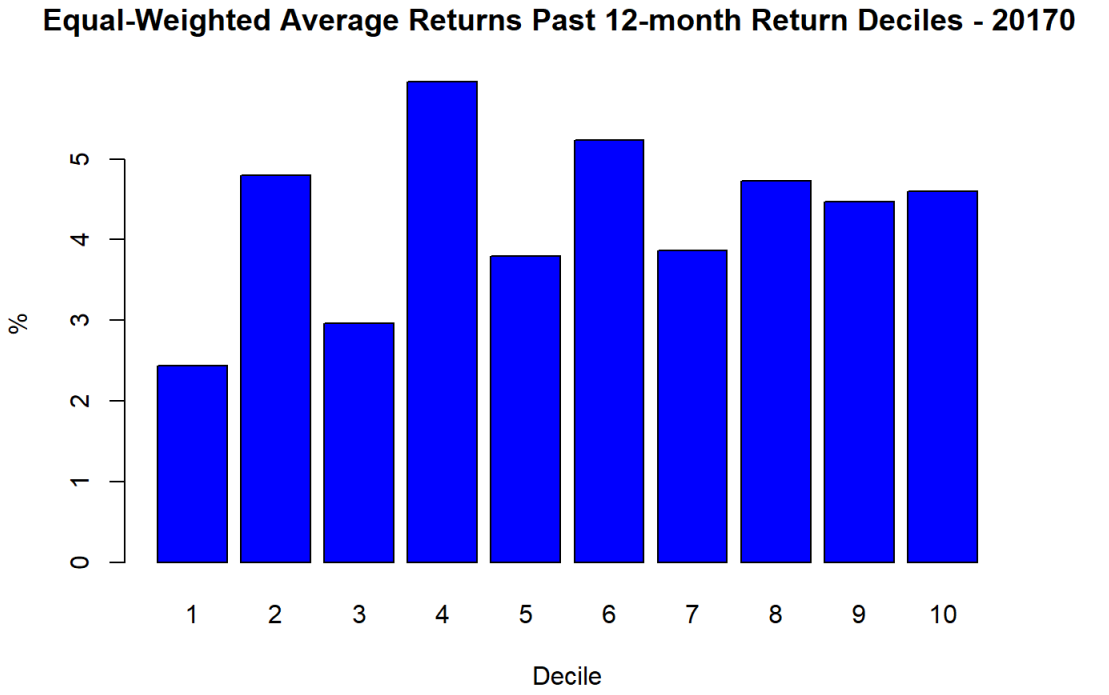

Equal-Weighted Average Returns Past 12-month Return Deciles - 20160
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

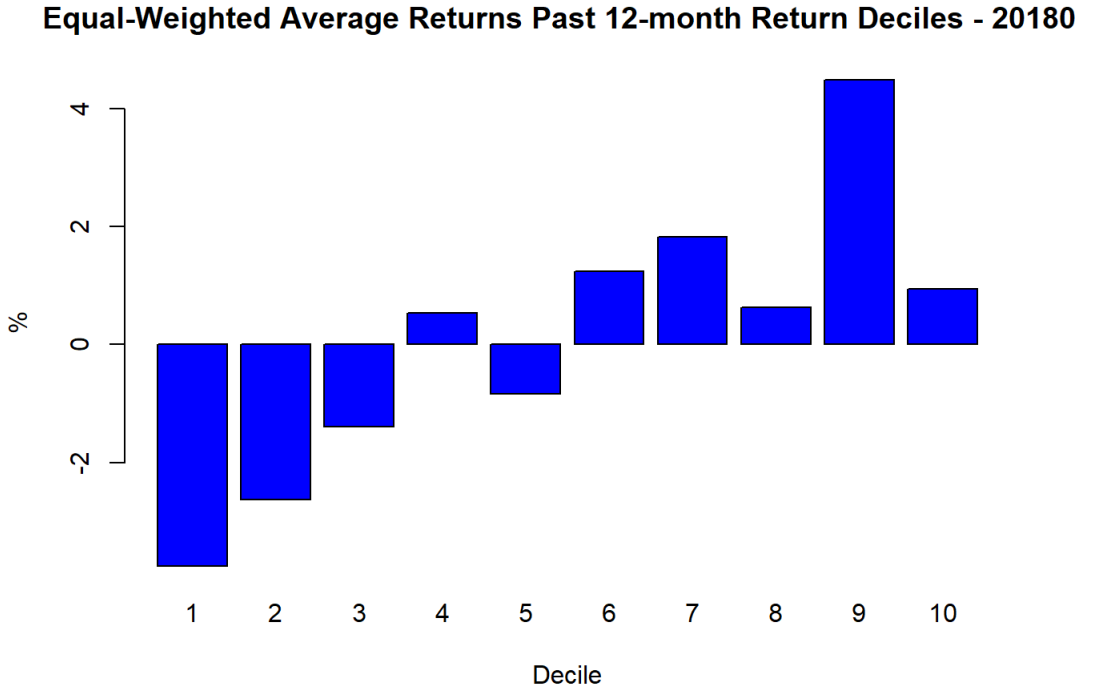

Equal-Weighted Average Returns Past 12-month Return Deciles - 20160
%
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
Decile

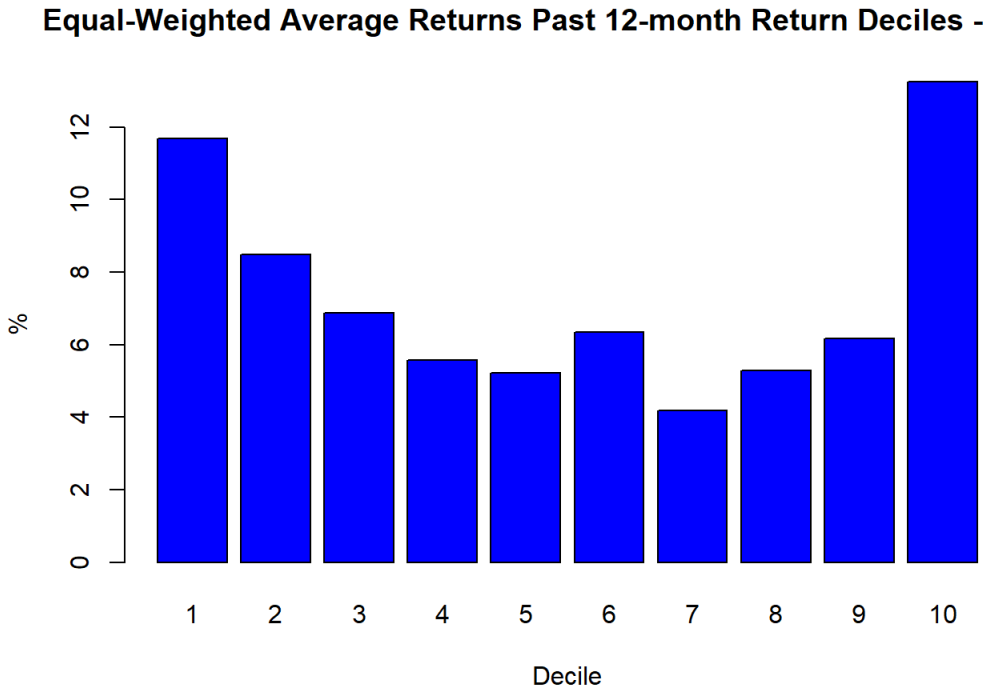

Equal-Weighted Average Returns Past 12-month Return Deciles - 20170
%
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
Decile

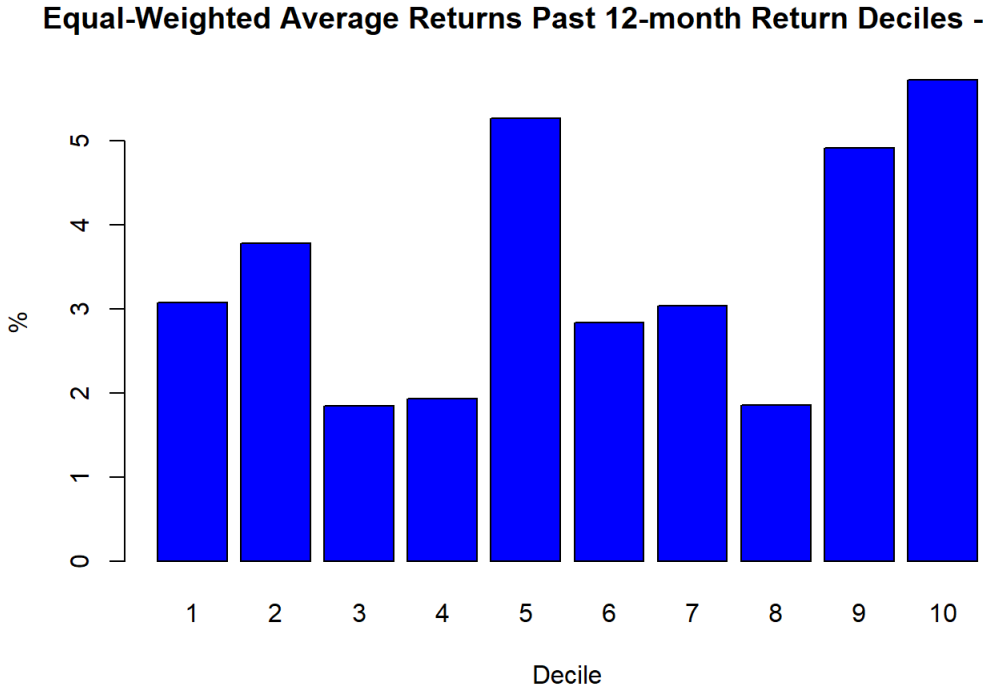

Equal-Weighted Average Returns Past 12-month Return Deciles - 20170
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

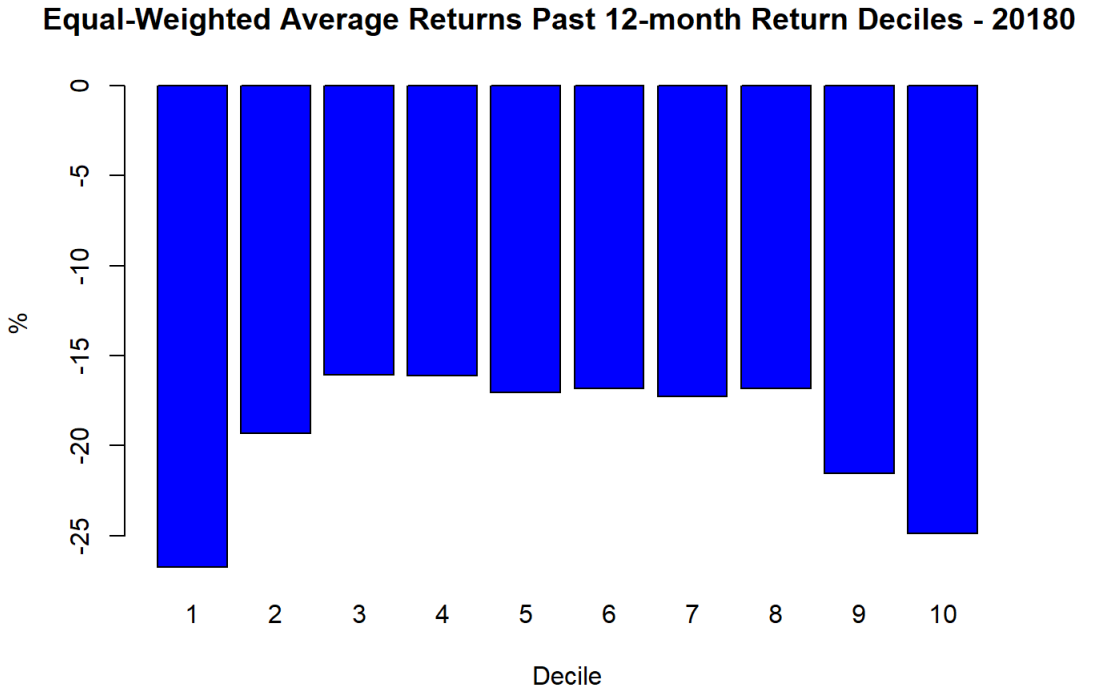

Equal-Weighted Average Returns Past 12-month Return Deciles - 20170
%
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

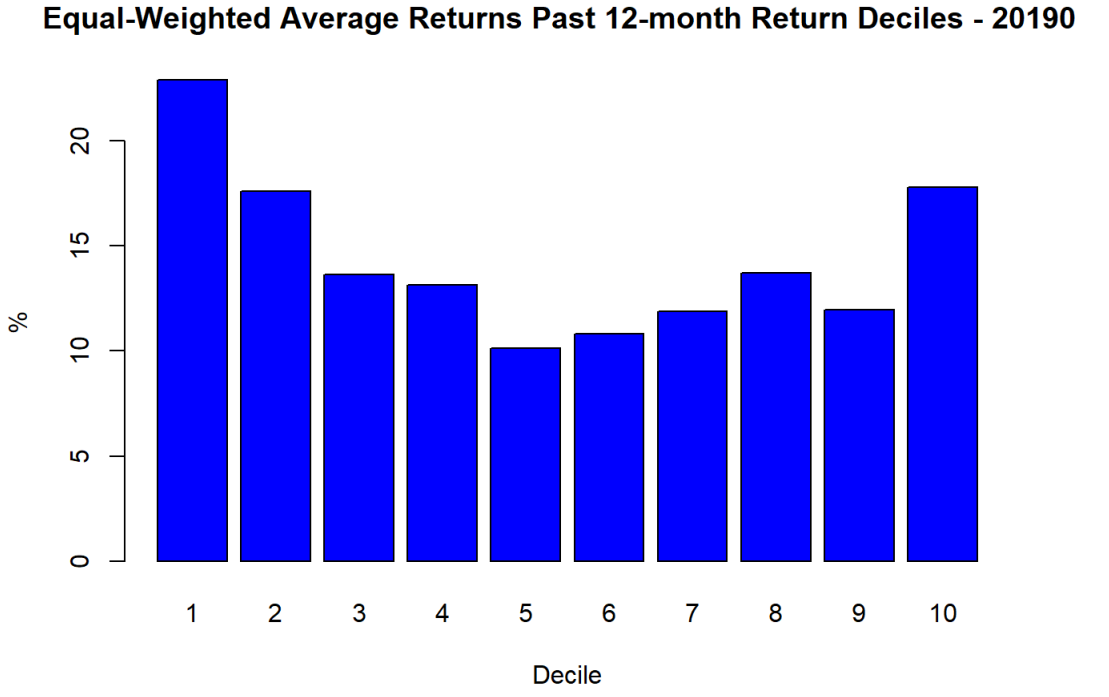

Equal-Weighted Average Returns Past 12-month Return Deciles - 20170
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

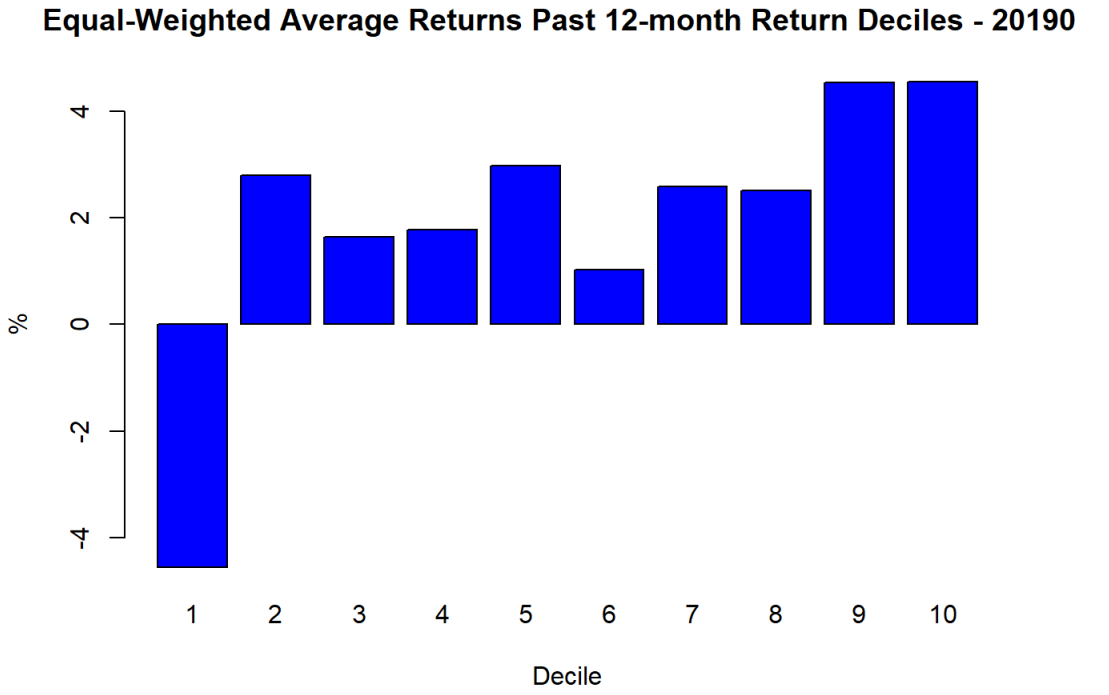

Equal-Weighted Average Returns Past 12-month Return Deciles - 20180
%
-2
0
2
4
1
2
3
4
5
6
7
8
9
10
Decile

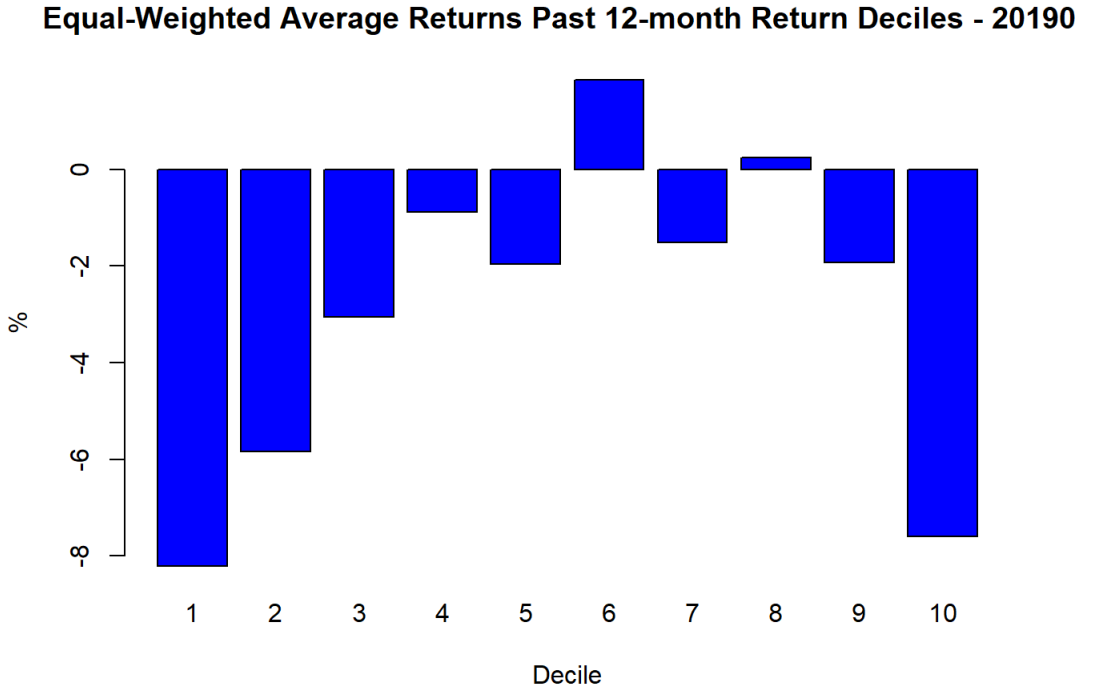

Equal-Weighted Average Returns Past 12-month Return Deciles - 20180
%
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
Decile

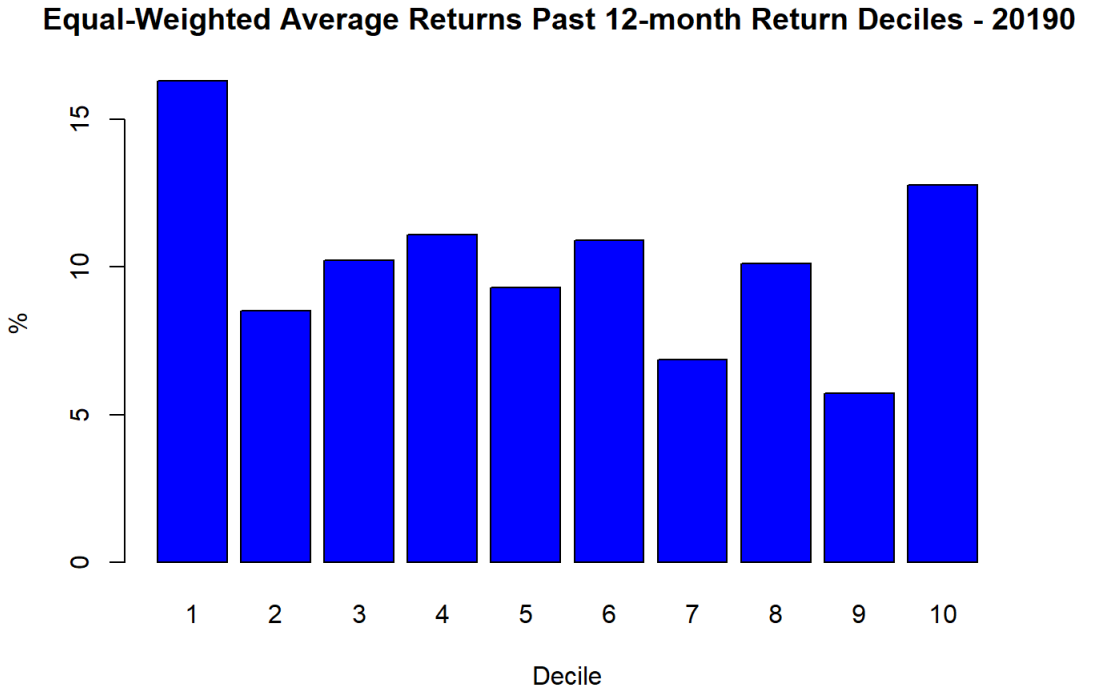

Equal-Weighted Average Returns Past 12-month Return Deciles - 20180
%
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
Decile

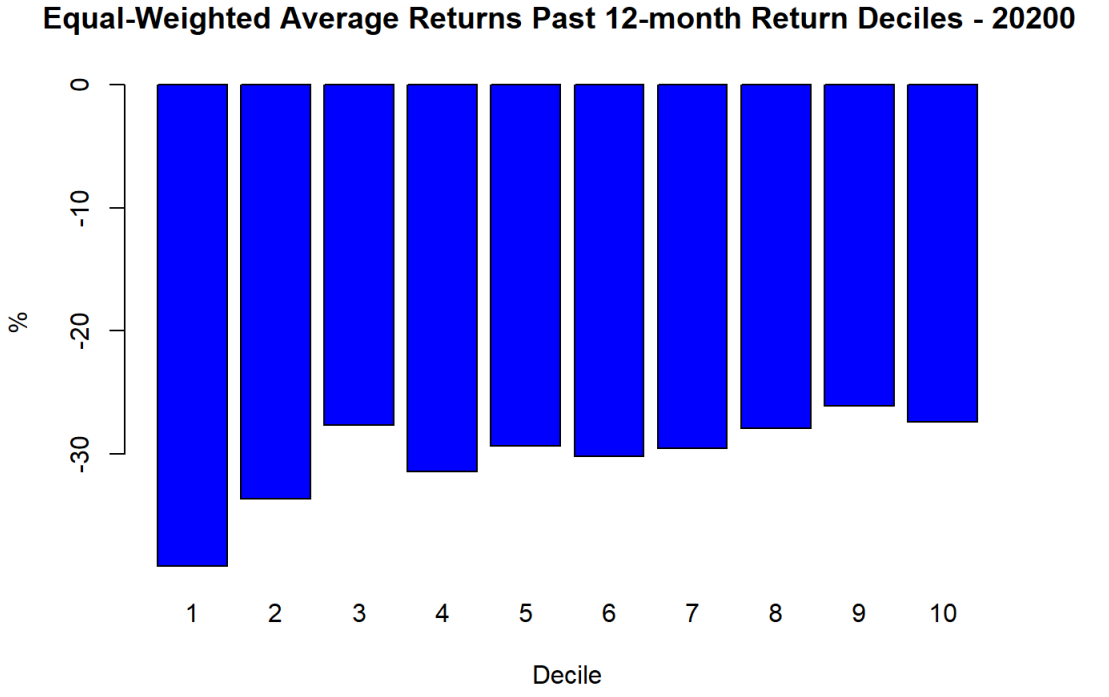

Equal-Weighted Average Returns Past 12-month Return Deciles - 20180
%
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
Decile

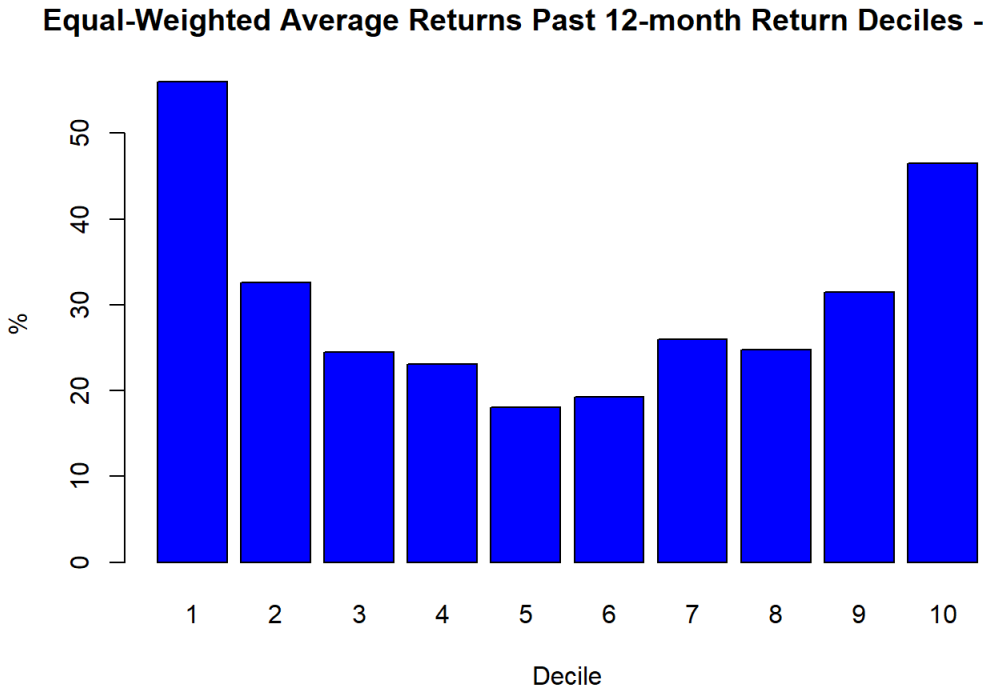

Equal-Weighted Average Returns Past 12-month Return Deciles - 20190
%
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
Decile

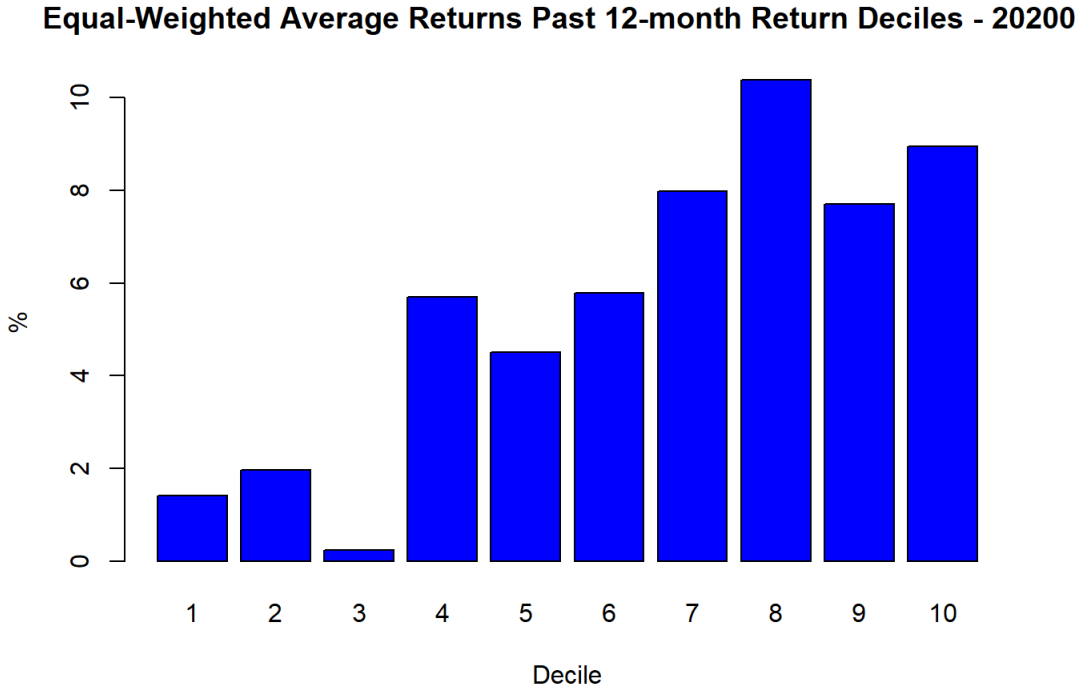

Equal-Weighted Average Returns Past 12-month Return Deciles - 20190
%
4
2
0
-2
-4
1
2
3
4
5
6
7
8
9
10
Decile

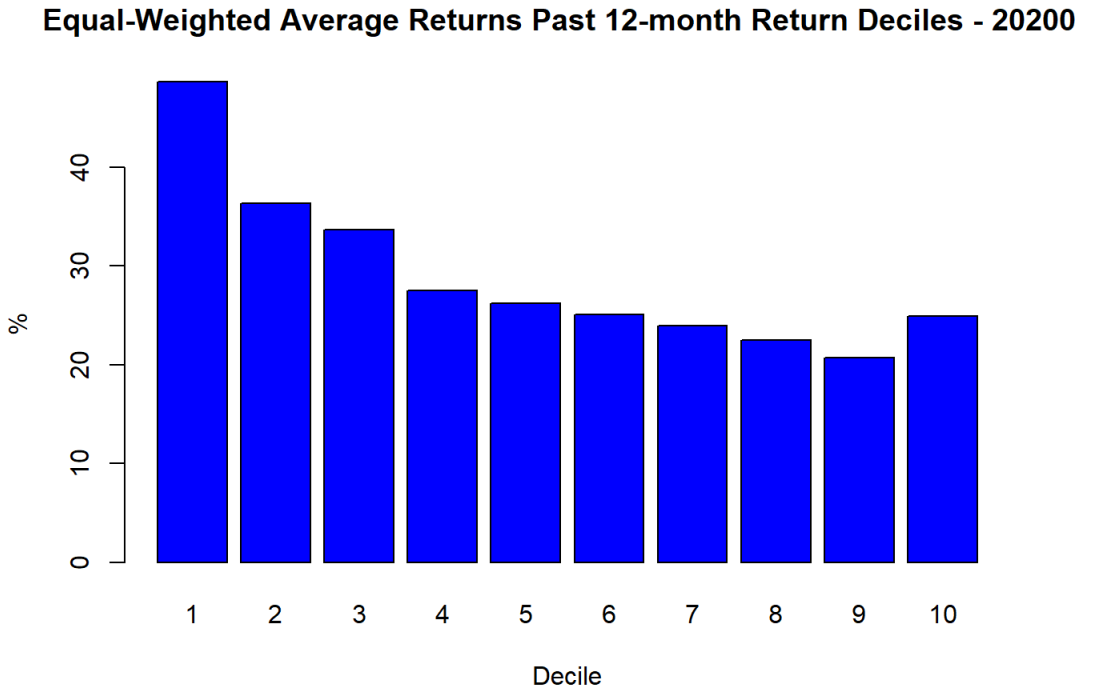

Equal-Weighted Average Returns Past 12-month Return Deciles - 20190
%
0
-2
-4
-6
-8
1
2
3
4
5
6
7
8
9
10
Decile

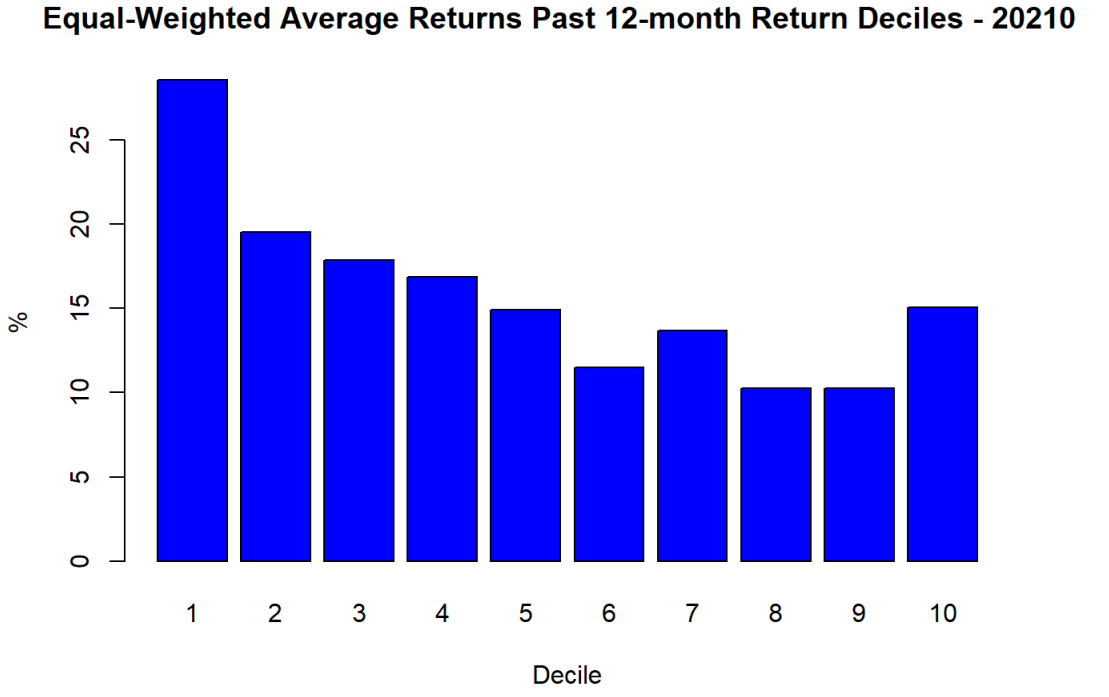

Equal-Weighted Average Returns Past 12-month Return Deciles - 20190
%
0
5
10
15
1
2
3
4
5
6
7
8
9
10
Decile

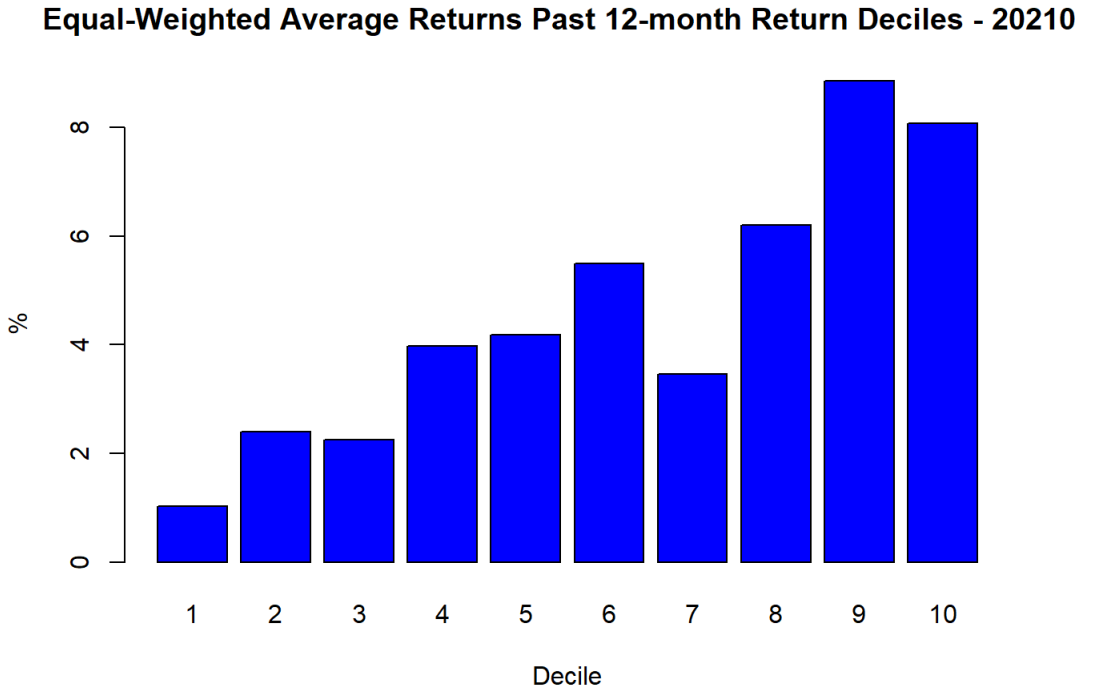

Equal-Weighted Average Returns Past 12-month Return Deciles - 20200
%
-30
-20
-10
0
1
2
3
4
5
6
7
8
9
10
Decile

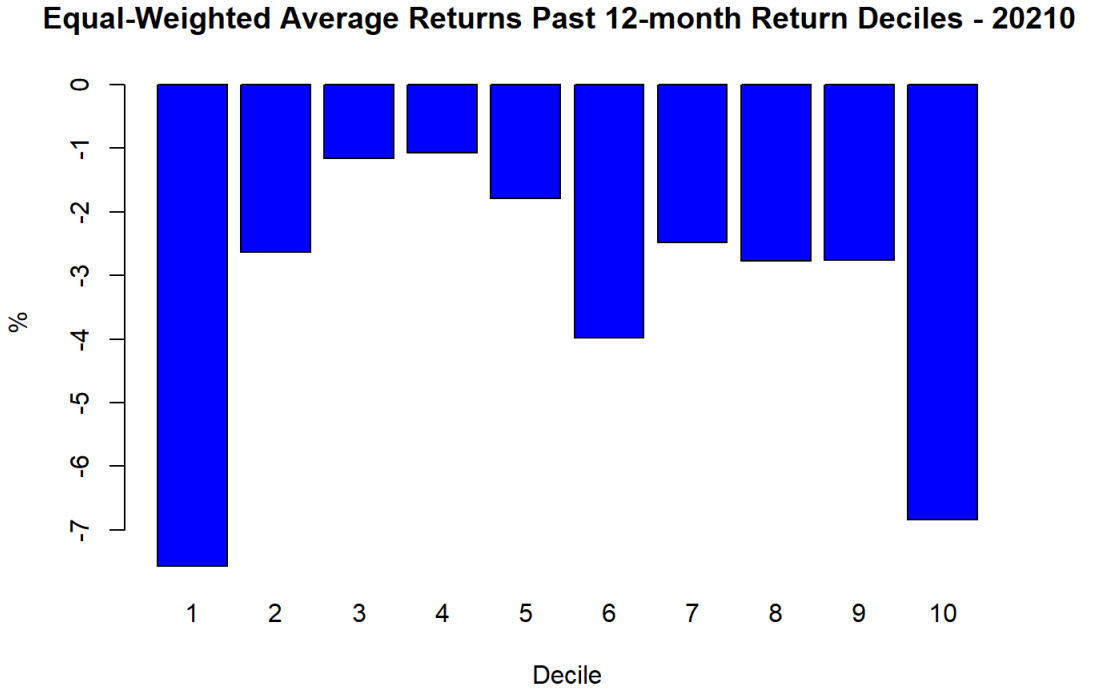

Equal-Weighted Average Returns Past 12-month Return Deciles - 20200
%
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
Decile

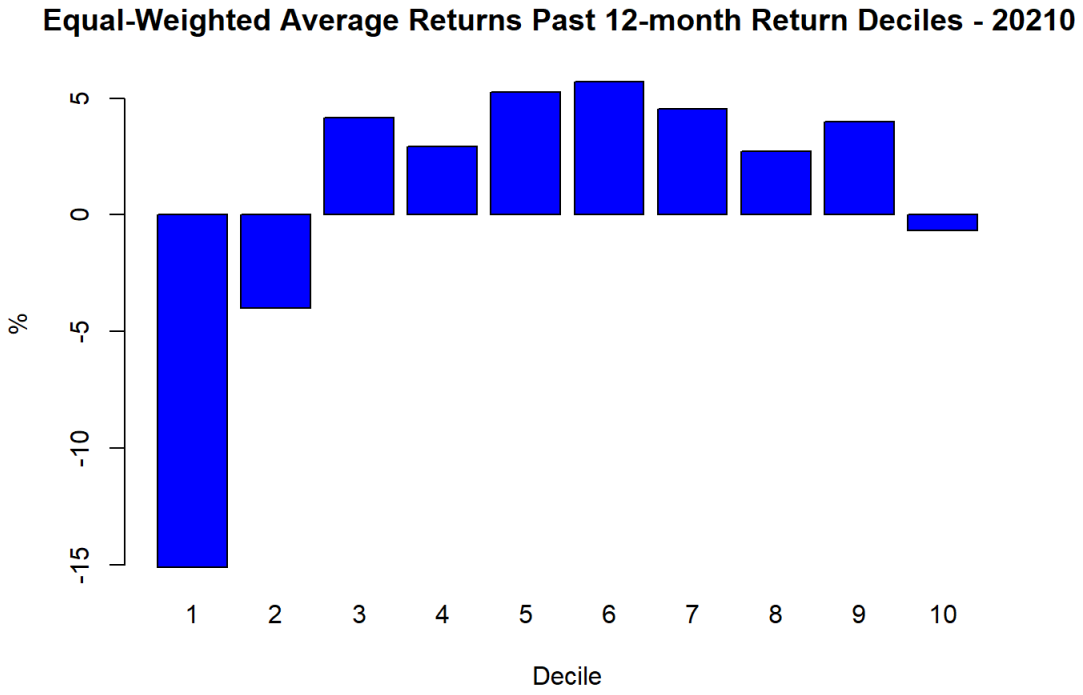

Equal-Weighted Average Returns Past 12-month Return Deciles - 20200
%
0
2
4
6
8
10
1
2
3
4
5
6
7
8
9
10
Decile

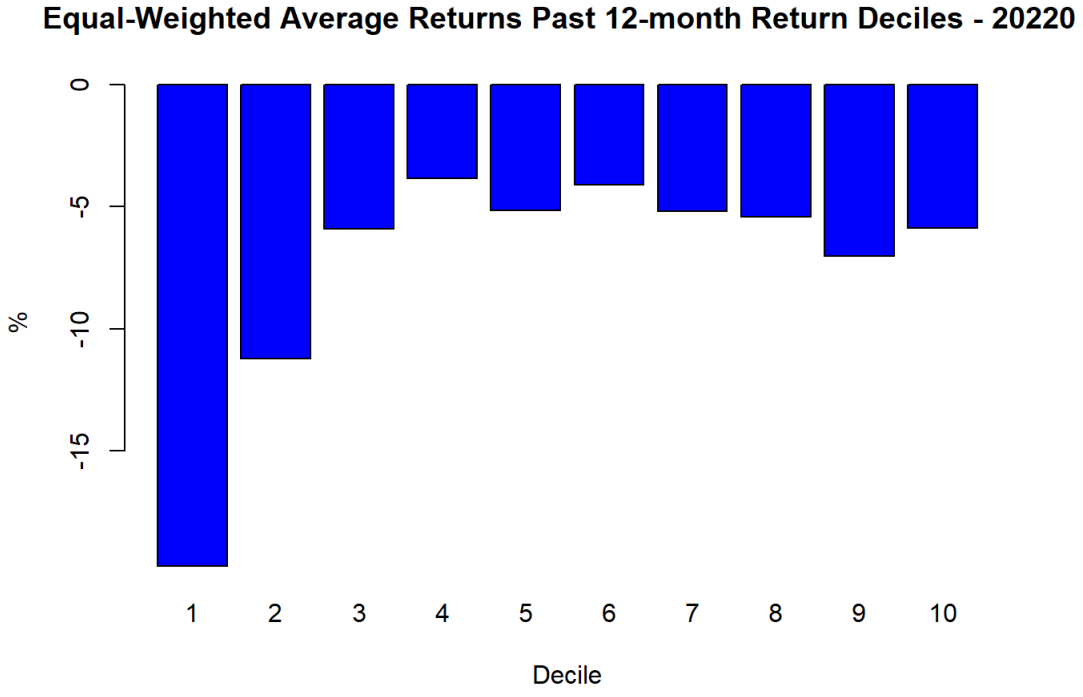

Equal-Weighted Average Returns Past 12-month Return Deciles - 20200
%
0
10
20
30
40
1
2
3
4
5
6
7
8
9
10
Decile

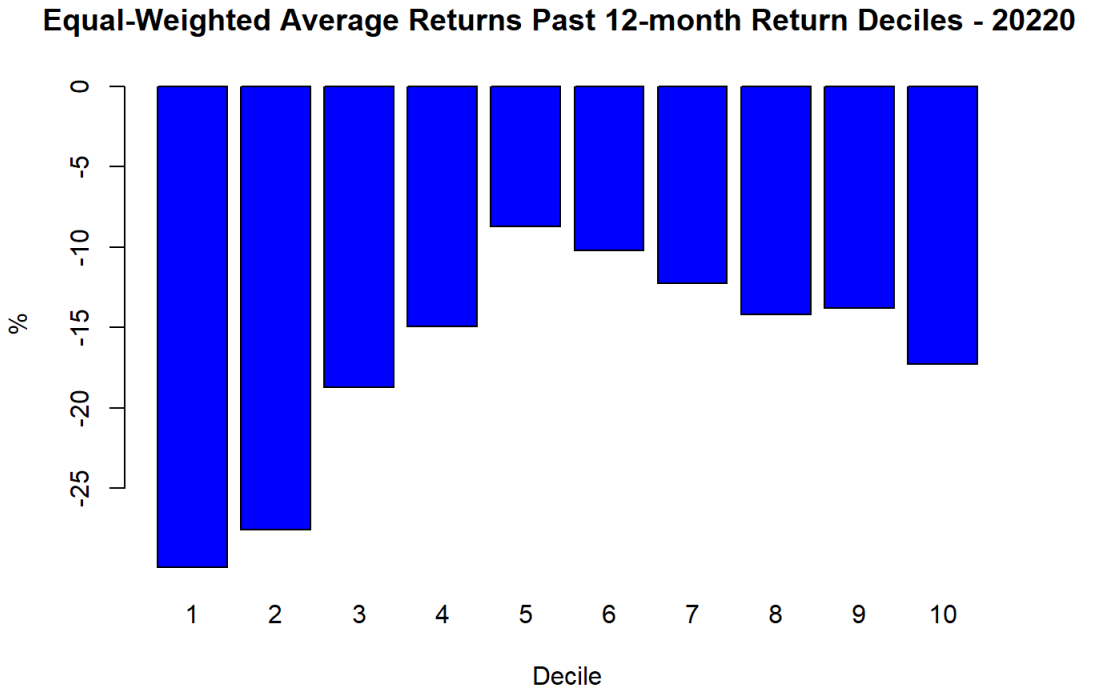

Equal-Weighted Average Returns Past 12-month Return Deciles - 20210
%
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
Decile

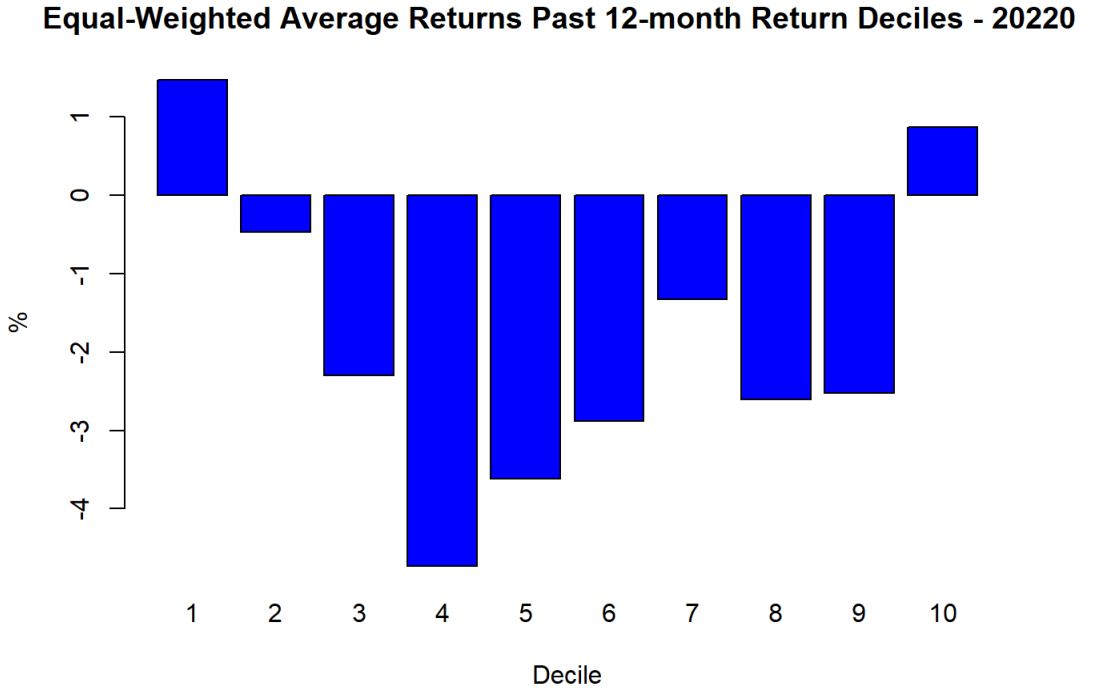

Equal-Weighted Average Returns Past 12-month Return Deciles - 20210
%
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
Decile

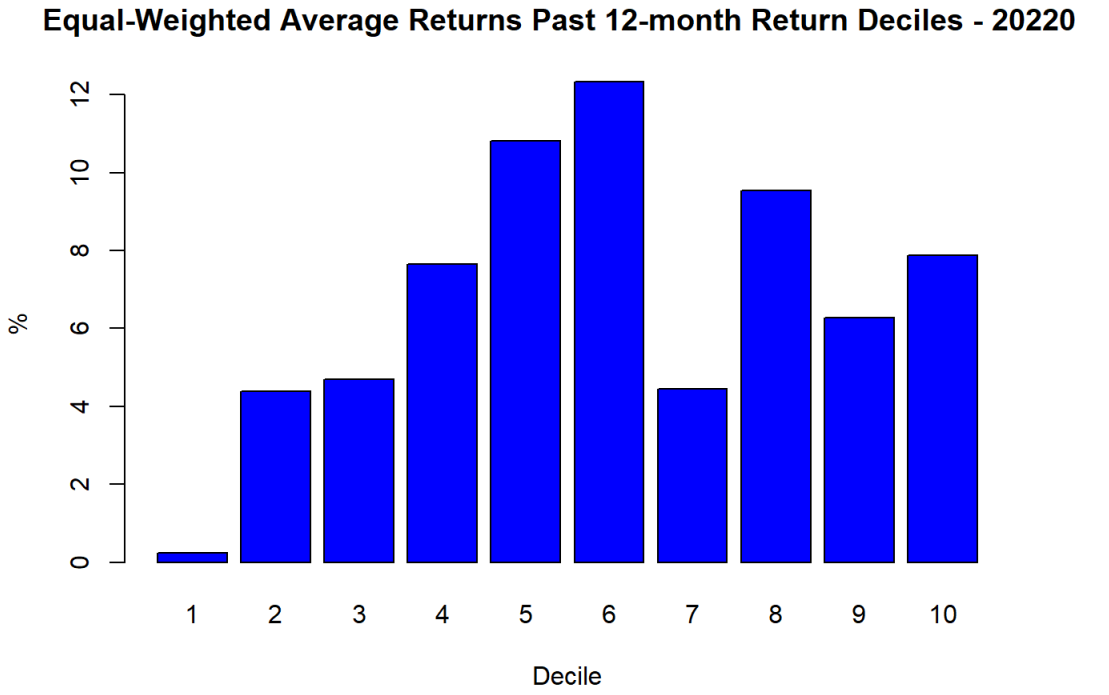

Equal-Weighted Average Returns Past 12-month Return Deciles - 20210
%
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 20210
%
5
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 20220
%
0
-5
-10
-15
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 20220
%
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
Decile


Equal-Weighted Average Returns Past 12-month Return Deciles - 20220
%
1
0
-1
-2
-3
-4
1
2
3
4
5
6
7
8
9
10
Decile




```
# Function to convert year and quarter to quarter end date
convert_to_quarter_end <- function(year, quarter) {
  if (quarter == 1) {
    return(paste(year, "03", "31", sep = "-"))
  } else if (quarter == 2) {
    return(paste(year, "06", "30", sep = "-"))
  } else if (quarter == 3) {
    return(paste(year, "09", "30", sep = "-"))
  } else if (quarter == 4) {
    return(paste(year, "12", "31", sep = "-"))
  }
}

# Apply the function to each combination
decile_df$QuarterEnd <- mapply(convert_to_quarter_end, decile_df$year, decile_df$quarter)

# Convert the matrix to an xts object
decile_xts <- xts(decile_df[, paste0("Decile ", 1:10)], order.by = as.yearqtr(as.Date(decile_df$QuarterEnd)))

# Display the resulting dataframe
decile_xts
```

```
           Decile.1     Decile.2     Decile.3    Decile.4      Decile.5
1980 Q1 -0.132138434 -0.109760589 -0.119120955 -0.11649526 -0.1188694744
1980 Q2  0.210635638  0.202452939  0.157249174  0.19473517  0.1659983179
1980 Q3  0.090398774  0.112165259  0.094554805  0.08957218  0.1056985819
1980 Q4 -0.002976620  0.026494224  0.017309750  0.02330171  0.0434515829
1981 Q1  0.105378473  0.119775922  0.109964192  0.11861298  0.1137743452
1981 Q2  0.004107959  0.042885840  0.025349202  0.02518792  0.0252543021
1981 Q3 -0.131836920 -0.098857601 -0.114091653 -0.13219215 -0.1196436436
1981 Q4  0.057020508  0.076031267  0.078175306  0.08912271  0.1066397785
1982 Q1 -0.168398631 -0.164819008 -0.124432776 -0.10208605 -0.0816153772
1982 Q2 -0.097585967 -0.034411264 -0.033334411 -0.01133397 -0.0003520636
    ...
2020 Q3  0.014050625  0.019605441  0.002371124  0.05702685  0.0450647343
2020 Q4  0.486811179  0.363867791  0.336594280  0.27525027  0.2623650425
```

```
2021 Q1  0.285813847  0.195537982  0.178874767  0.16866591  0.1494181428
2021 Q2  0.010243419  0.023932486  0.022524234  0.03976503  0.0417467509
2021 Q3 -0.075654530 -0.026272776 -0.011595393 -0.01068878 -0.0178529193
2021 Q4 -0.150867790 -0.039857555  0.041779872  0.02911582  0.0525121434
2022 Q1 -0.197087578 -0.112069722 -0.059094833 -0.03853760 -0.0515424980
2022 Q2 -0.299092453 -0.275786581 -0.187179057 -0.14932333 -0.0870585822
2022 Q3  0.014718860 -0.004689793 -0.023027641 -0.04728629 -0.0361690928
2022 Q4  0.002339480  0.043794194  0.047040691  0.07645304  0.1081485673
           Decile.6     Decile.7    Decile.8     Decile.9    Decile.10
1980 Q1 -0.116361367 -0.104484624 -0.09124703 -0.074898607 -0.104379401
1980 Q2  0.200631019  0.188148223  0.19352315  0.196086959  0.278493505
1980 Q3  0.169384187  0.163343600  0.20288349  0.225085063  0.330081926
1980 Q4  0.068673549  0.098726945  0.12019241  0.141362049  0.199474985
1981 Q1  0.098968792  0.040487335  0.03820466  0.006678853 -0.012938933
1981 Q2  0.031071707  0.031385548  0.02640292  0.029727704 -0.016638234
1981 Q3 -0.118571283 -0.138136904 -0.14516339 -0.162856670 -0.199567202
1981 Q4  0.079944089  0.079182572  0.09749176  0.124966602  0.093375193
1982 Q1 -0.050114580 -0.029642518 -0.02367725 -0.041474272 -0.069122837
1982 Q2  0.006087262  0.004454051  0.01906239  0.033051854  0.006677199
    ...
2020 Q3  0.057872668  0.079841377  0.10389712  0.077002899  0.089451193
2020 Q4  0.251044531  0.239846842  0.22511104  0.207459314  0.249350891
2021 Q1  0.114850867  0.136728292  0.10250162  0.102459340  0.150501631
2021 Q2  0.054983574  0.034523170  0.06192577  0.088535232  0.080641996
2021 Q3 -0.039858830 -0.024866525 -0.02774166 -0.027554020 -0.068412139
2021 Q4  0.057058059  0.045512559  0.02716548  0.039989994 -0.006724343
2022 Q1 -0.041126642 -0.051697920 -0.05422151 -0.070364156 -0.058750047
2022 Q2 -0.101986416 -0.122438076 -0.14210286 -0.137977574 -0.173022552
2022 Q3 -0.028818008 -0.013285235 -0.02604626 -0.025296700  0.008664076
2022 Q4  0.123320709  0.044531726  0.09531309  0.062795269  0.078690926
```

Momentum Investing Comments

Sorting Function for Decile Portfolios

The `decile_sorts` function sorts stocks into deciles based on the specified signal and calculates the equal-weighted average returns for each decile.

The function `decile_sorts` handles the data sorting into deciles based on the past 12-month return signal. It also calculates the average return for each decile and optionally plots these returns.

Loop Over Each Year and Quarter

This loop processes each year and quarter, loading the respective data, and calculating the decile returns. It stores these returns in `decile_df`

Convert Year and Quarter to Quarter End Date

The function `convert_to_quarter_end` converts the year and quarter into the corresponding quarter-end date, essential for accurate time-series analysis.

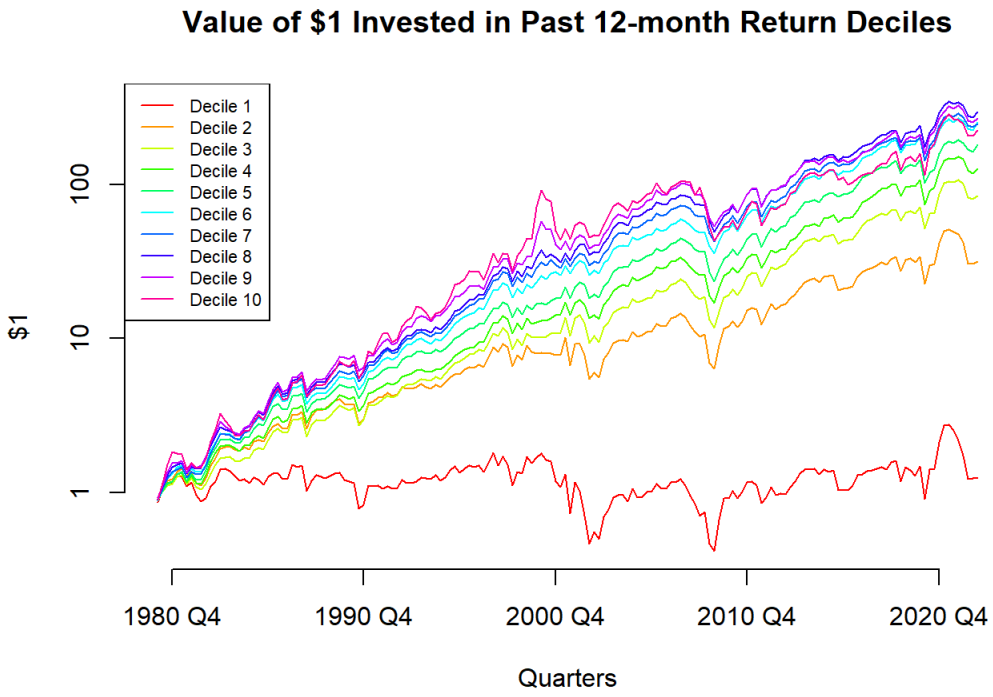
Convert to XTS and Display Data

Convert the data frame `decile_df` to an XTS object for time series analysis and visualization.

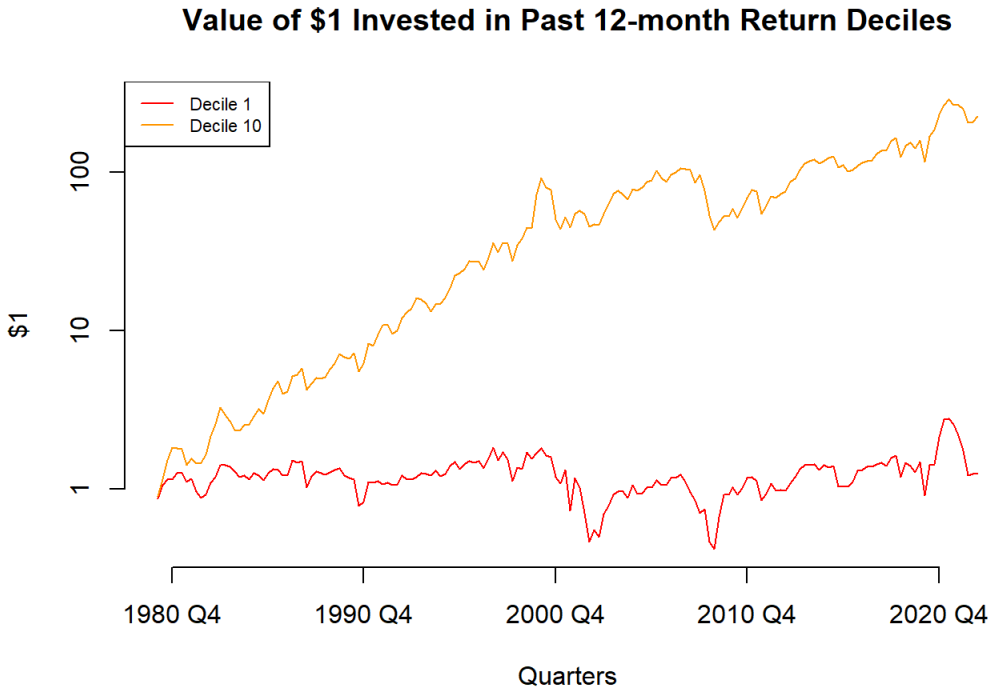
The XTS object `decile_xts` now contains the decile returns for each time period, allowing for advanced time-series analysis and visualization. There is extensive data processing as we loop over each year and quarter, but allows for detailed tracking of the historical performance of decile portfolios

3. Performance Evaluation

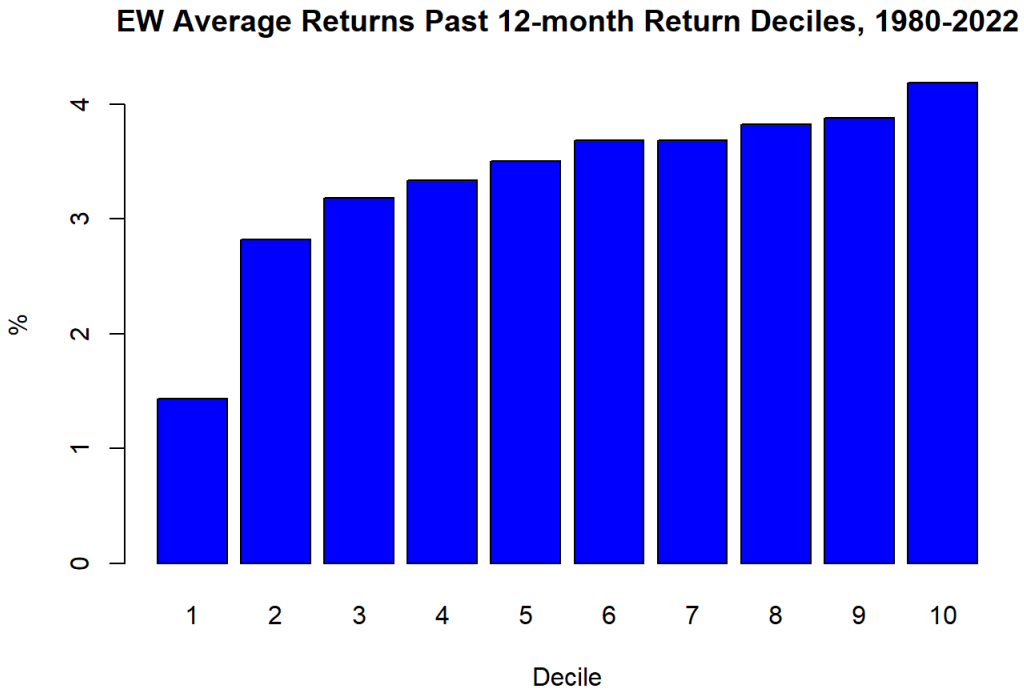
```
# Calculate cumulative returns for each decile
cumulative_returns <- apply(decile_xts + 1, 2, cumprod)

# Plot cumulative returns for each decile
matplot(index(decile_xts), cumulative_returns, type = "l", lty = 1, col = rainbow(10),
        xlab = "Quarters", ylab = "$1", main = paste("Value of $1 Invested in", description, "Deciles"), log = "y"

# Customizing the y-axis to display as 1, 10, 100, 1000, etc.
y_ticks <- c(1, 10, 100, 1000)
axis(2, at = y_ticks, labels = y_ticks)

x_ticks <- c('1980 Q4', '1990 Q4', '2000 Q4', '2010 Q4', '2020 Q4')
axis(1, at = as.yearqtr(x_ticks), labels = x_ticks)

# Add legend
legend("topleft", legend = colnames(decile_xts), col = rainbow(10), lty = 1, cex = 0.7)
```




```
# Plot cumulative returns for each decile
matplot(index(decile_xts), cumulative_returns[,c(1,10)], type = "l", lty = 1, col = rainbow(10),
        xlab = "Quarters", ylab = "$1", main = paste("Value of $1 Invested in", description, "Deciles"), log = "y"

# Customizing the y-axis to display as 1, 10, 100, 1000, etc.
y_ticks <- c(1, 10, 100, 1000)
axis(2, at = y_ticks, labels = y_ticks)

x_ticks <- c('1980 Q4', '1990 Q4', '2000 Q4', '2010 Q4', '2020 Q4')
axis(1, at = as.yearqtr(x_ticks), labels = x_ticks)

# Add legend
legend("topleft", legend = colnames(decile_xts)[c(1,10)], col = rainbow(10), lty = 1, cex = 0.7)
```

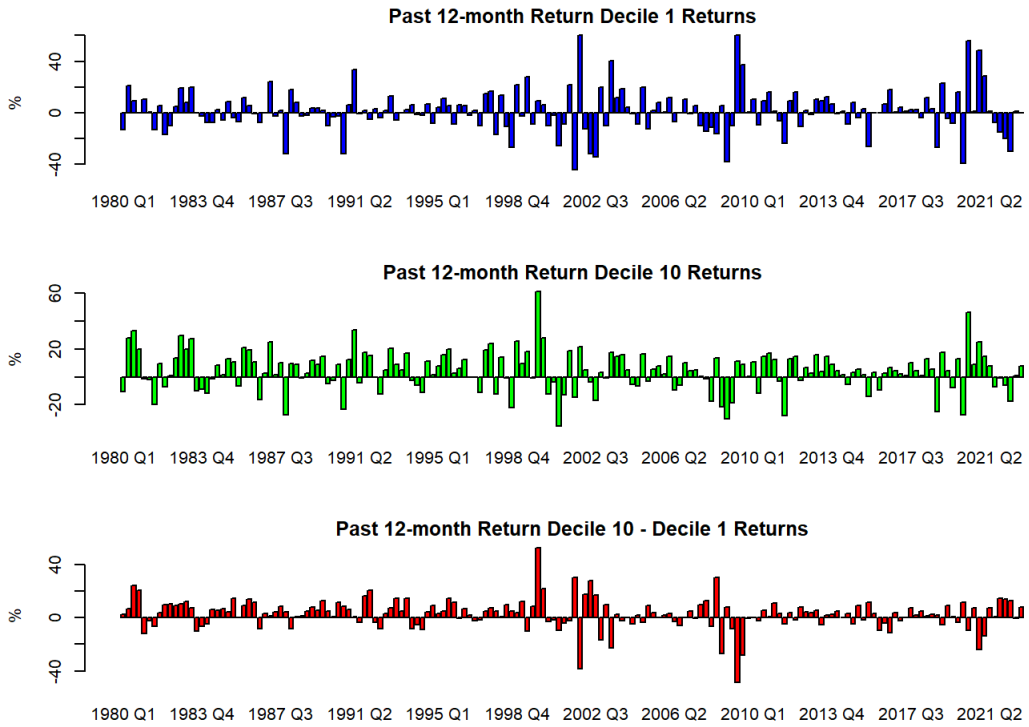



```
barplot(colMeans(decile_xts) * 100, names.arg = 1:10,
        main = paste("EW Average Returns", description, "Deciles, 1980-2022"),
        xlab = "Decile", ylab = "%", col = "blue")
```




```
# Set up the plotting area
par(mfrow = c(3, 1), mar = c(4, 4, 2, 1))

# Plot decile 1 returns
barplot(decile_xts[,1] * 100,
```

```
        main = paste(description, "Decile 1 Returns"), ylab = "%", col = "blue")

# Plot decile 10 returns
barplot(decile_xts[,10] * 100,
        main = paste(description, "Decile 10 Returns"), ylab = "%", col = "green")

# Plot decile 10 minus decile 1 returns
barplot((decile_xts[,10]-decile_xts[,1]) * 100,
        main = paste(description, "Decile 10 - Decile 1 Returns"), ylab = "%", col = "red")
```




```
# Reset plotting parameters
par(mfrow = c(1, 1))
```

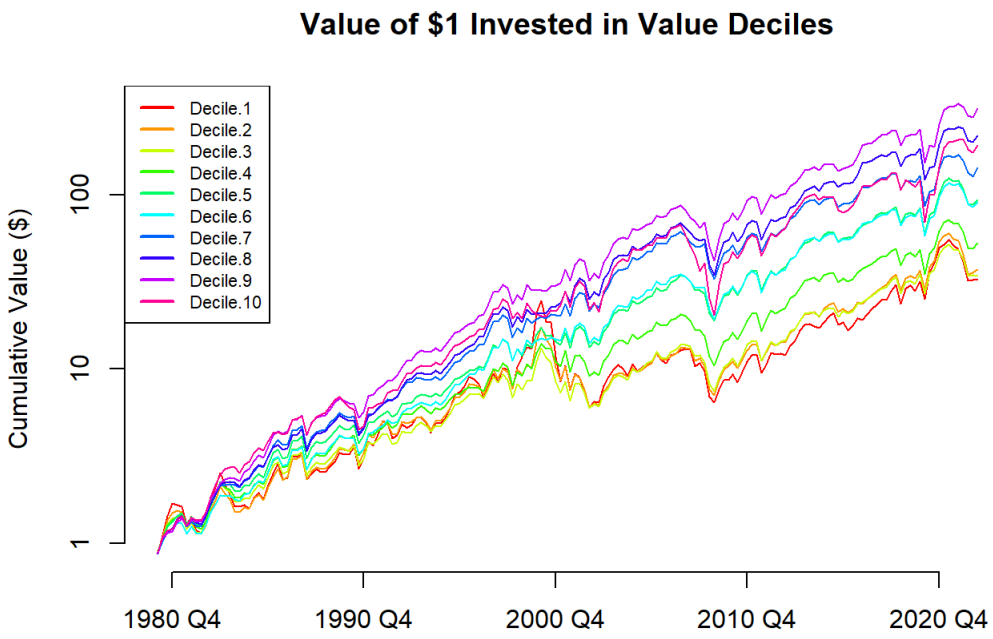
```
univariate_sorts <- function(signal, description, trade_direction = "High-Low",  start_year = 1980, end_year = 202

  # Define the range of years and quarters
  years <- start_year:end_year
  quarters <- 1:4

  # Generate all combinations of years and quarters
  decile_df <- expand.grid(year = years, quarter = quarters)
  decile_df[, paste0("Decile ", 1:10)] <- NaN

  # Loop over each year and calculate decile sorted portfolio returns
  for (year in years) {
    for (quarter in quarters){
      yearq <- year*100 + quarter
      # Load the dataset for the current year
      data <- read.csv(paste(datalink, as.character(yearq), ".csv", sep = ""))

      # Calculate decile returns for the current year
      decile_returns <- decile_sorts(data = data, signal = signal, description = description, plot = yearly_barplot

      # Store the results in the matrix
      decile_df[decile_df$year == year & decile_df$quarter == quarter, paste0("Decile ", 1:10)] <- as.numeric(decil
```

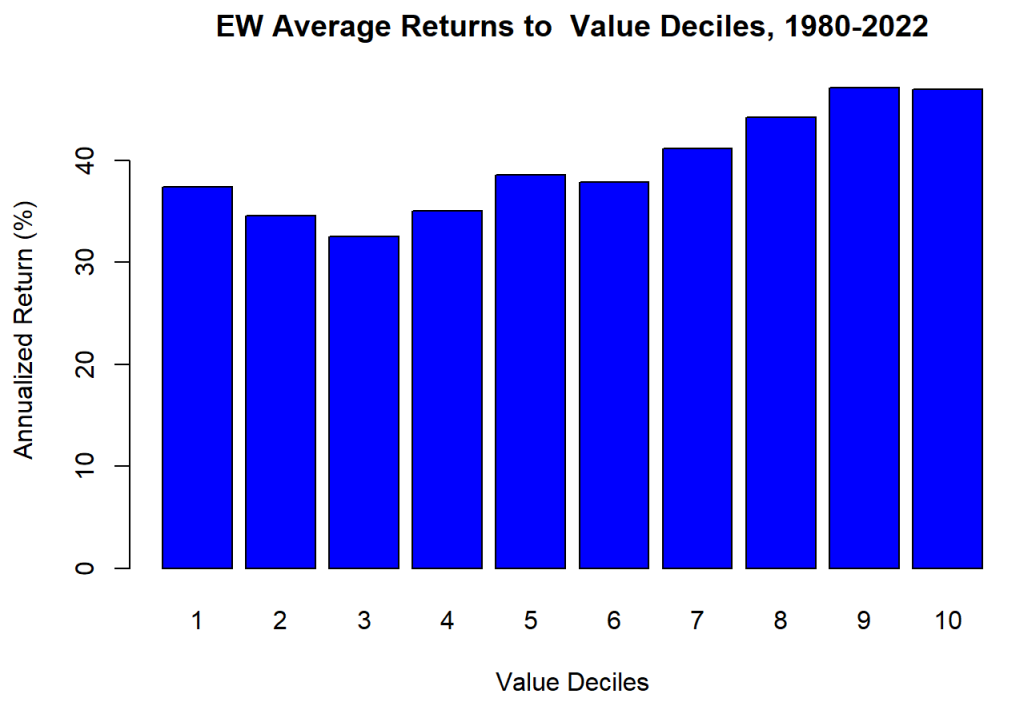
```
  }
}

# Function to convert year and quarter to quarter end date
convert_to_quarter_end <- function(year, quarter) {
  if (quarter == 1) {
    return(paste(year, "03", "31", sep = "-"))
  } else if (quarter == 2) {
    return(paste(year, "06", "30", sep = "-"))
  } else if (quarter == 3) {
    return(paste(year, "09", "30", sep = "-"))
  } else if (quarter == 4) {
    return(paste(year, "12", "31", sep = "-"))
  }
}

# Apply the function to each combination
decile_df$QuarterEnd <- mapply(convert_to_quarter_end, decile_df$year, decile_df$quarter)

# Convert the matrix to an xts object
decile_xts <- xts(decile_df[, paste0("Decile ", 1:10)], order.by = as.yearqtr(as.Date(decile_df$QuarterEnd)))

if (trade_direction == "High-Low"){
  decile_xts$LongShort <- decile_xts[,10] - decile_xts[,1]
} else{
  decile_xts$LongShort <- decile_xts[,1] - decile_xts[,10]
}


# Calculate cumulative returns for each decile
cumulative_returns <- apply(decile_xts + 1, 2, cumprod)

# Plot cumulative returns for each decile
matplot(index(decile_xts), cumulative_returns[,1:10], type = "l", lty = 1, col = rainbow(10),
        xlab = "", ylab = "Cumulative Value ($)", main = paste("Value of $1 Invested in", description, "Deciles"))

# Customizing the y-axis to display as 1, 10, 100, 1000, etc.
y_ticks <- c(1, 10, 100, 1000)
axis(2, at = y_ticks, labels = y_ticks)

x_ticks <- c('1980 Q4', '1990 Q4', '2000 Q4', '2010 Q4', '2020 Q4')
axis(1, at = as.yearqtr(x_ticks), labels = x_ticks)

# Add legend
legend("topleft", legend = colnames(decile_xts[,1:10]), col = rainbow(10), lty = 1, lwd = 2, cex = 0.7)

barplot(colMeans(decile_xts[,1:10]) * 12 * 100, names.arg = 1:10,
        main = paste("EW Average Returns to ", description, "Deciles, 1980-2022"),
        xlab = paste(description, "Deciles"), ylab = "Annualized Return (%)", col = "blue")
# Set up the plotting area
par(mfrow = c(3, 1), mar = c(4, 4, 2, 1))


# Set y-axis limits
y_limits <- c(min(decile_xts[,1:10]), max(decile_xts[,1:10])) * 100

# Plot decile 1 returns
barplot(decile_xts[,1] * 100, ylim = y_limits,
        main = paste("Quarterly Returns to", description, "Decile 1"), ylab = "Return (%)", col = "blue")

# Plot decile 10 returns
barplot(decile_xts[,10] * 100, ylim = y_limits,
        main = paste("Quarterly Returns to", description, "Decile 10"), ylab = "Return (%)", col = "green")
```

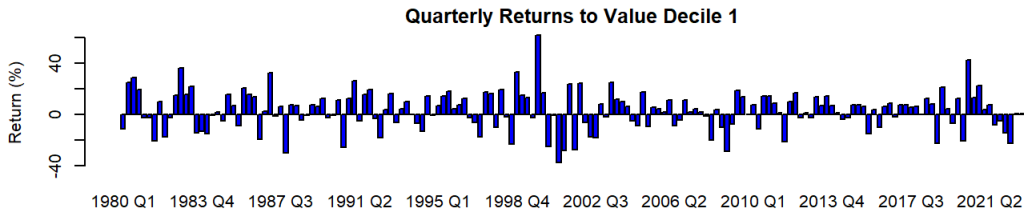
```
  # Plot decile 10 minus decile 1 returns
  barplot(decile_xts$LongShort * 100, ylim = y_limits,
          main = paste("Quarterly Returns to", description, "Decile 10 - Decile 1"), ylab = "Return (%)", col = "re

  # Reset plotting parameters
  par(mfrow = c(1, 1))

  # Plot cumulative returns for each decile
  matplot(index(decile_xts), cumulative_returns[,11], type = "l", lty = 1, lwd = 2, col = rainbow(10),
          xlab = "", ylab = "Cumulative Value ($)", main = paste("Value of $1 Invested in the", trade_direction, de

  return(decile_xts)
}
```

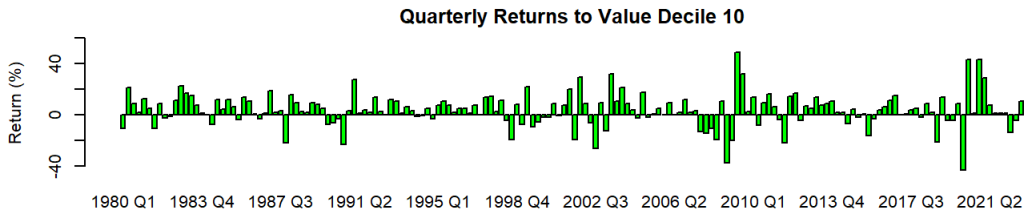
Value Investing

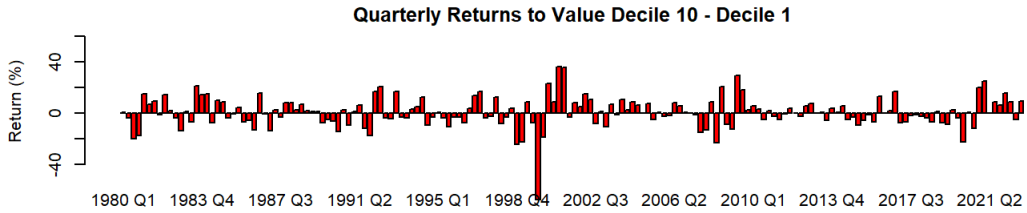
```
value_deciles <- univariate_sorts(signal = "be_me", description = "Value")
```

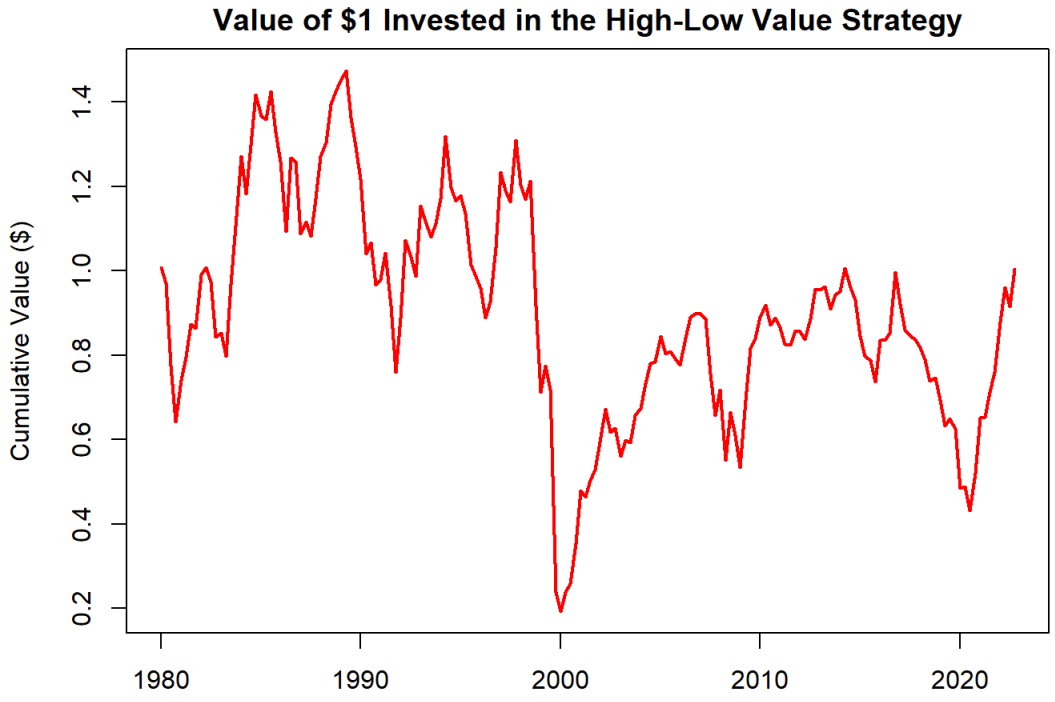



EW Average Returns to Value Deciles, 1980-2022
Annualized Return (%)
0
10
20
30
40
1
2
3
4
5
6
7
8
9
10
Value Deciles


Quarterly Returns to Value Decile 1
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2


Quarterly Returns to Value Decile 10
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2


Quarterly Returns to Value Decile 10 - Decile 1
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2



Graph 1: Value of $1 Invested in Value Deciles

Graph Interpretation: This graph shows the growth of $1 invested in each value decile from 1980 to 2022. Deciles are formed based on the Book-to-Market (B/M) ratio, with Decile 1 representing stocks with the lowest B/M ratios (often growth stocks) and Decile 10 representing stocks with the highest B/M ratios (often value stocks).

Strategy: Buy stocks in higher deciles (7-10) as these stocks have high Book-to-Market ratios, indicating value stocks that are potentially undervalued. Sell stocks in lower deciles (1-3) as these stocks have lower Book-to-Market ratios, indicating growth stocks that might be overvalued.

Graph 2: EW Average Returns to Value Deciles

Graph Interpretation: The bar graph shows the average annualized returns for each decile. Higher deciles show higher returns.

Strategy: Favor investing in stocks with higher B/M ratios (Deciles 9-10) to capture the value premium.

Graph 3: Quarterly Returns to Value based on Decile

Graph Interpretation: The bar plots display the quarterly returns and spread, highlighting the performance of certain value and growth stocks of varying deciles. A positive spread indicates that value stocks outperform growth stocks.

Strategy: Monitor the spread for market trends and adjust positions accordingly.

Graph 4: Value of $1 Invested in the High-Low Value Strategy

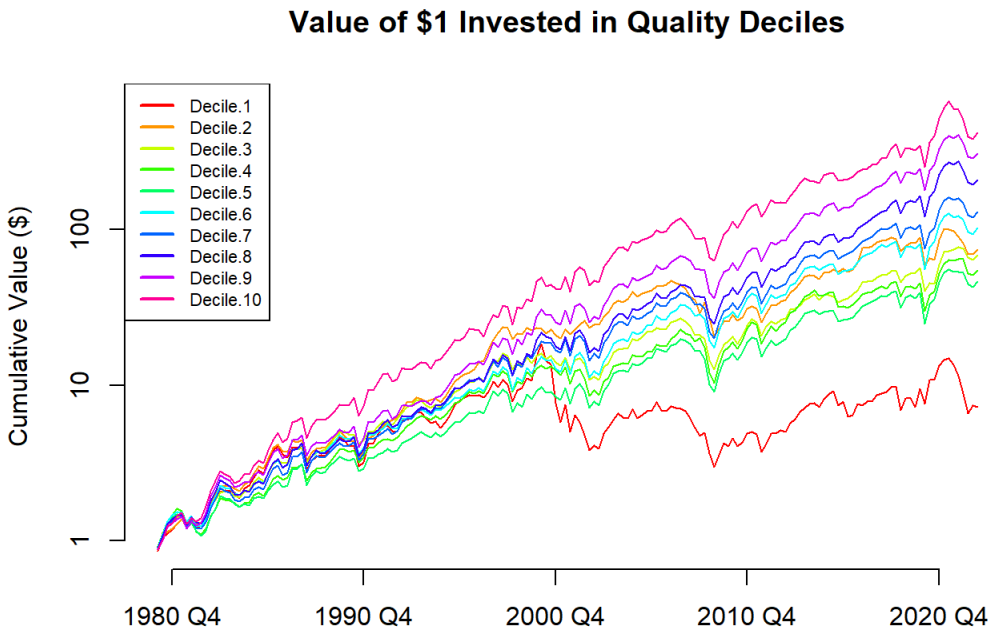
Graph Interpretation: This line graph shows how the cumulative return changes overtime from 1980-2020. The cumulative return stays volatile as time goes one with many peaks and lows. There are periods of underperformance in the late 1990s and early 200s, as wells as 2010 and 2020, most likely due to the housing-market crash and COVID-19 pandemic.

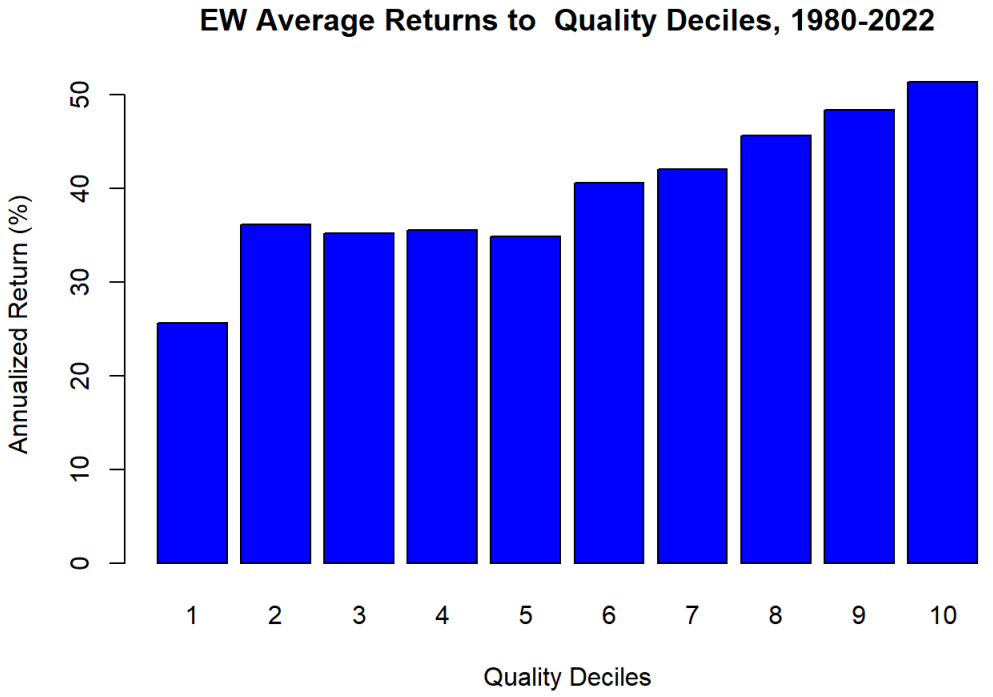
Strategy: Invest in stocks with high B/M ratios, typically considered value stocks. These stocks are often perceived as undervalued by the market, providing potential for higher returns when the market corrects its valuation. Short stocks with low B/M ratios as shoritng them

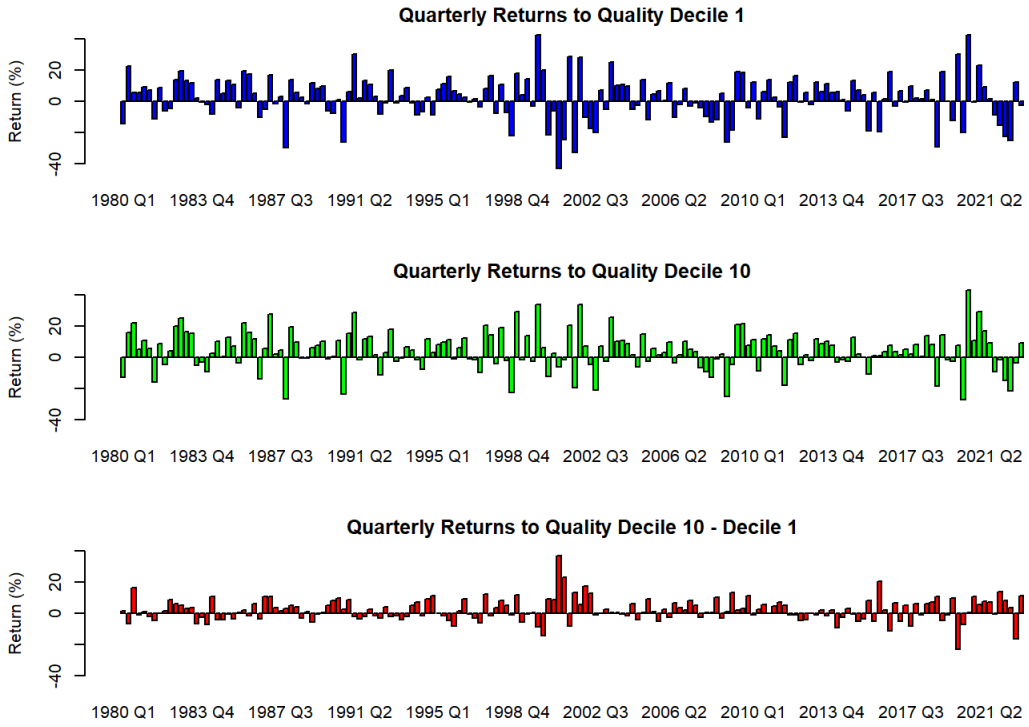
can potentially profit from price corrects. Overall, be vary as the performance varies significantly over time as shown by the graph with multiple periods of under performance.

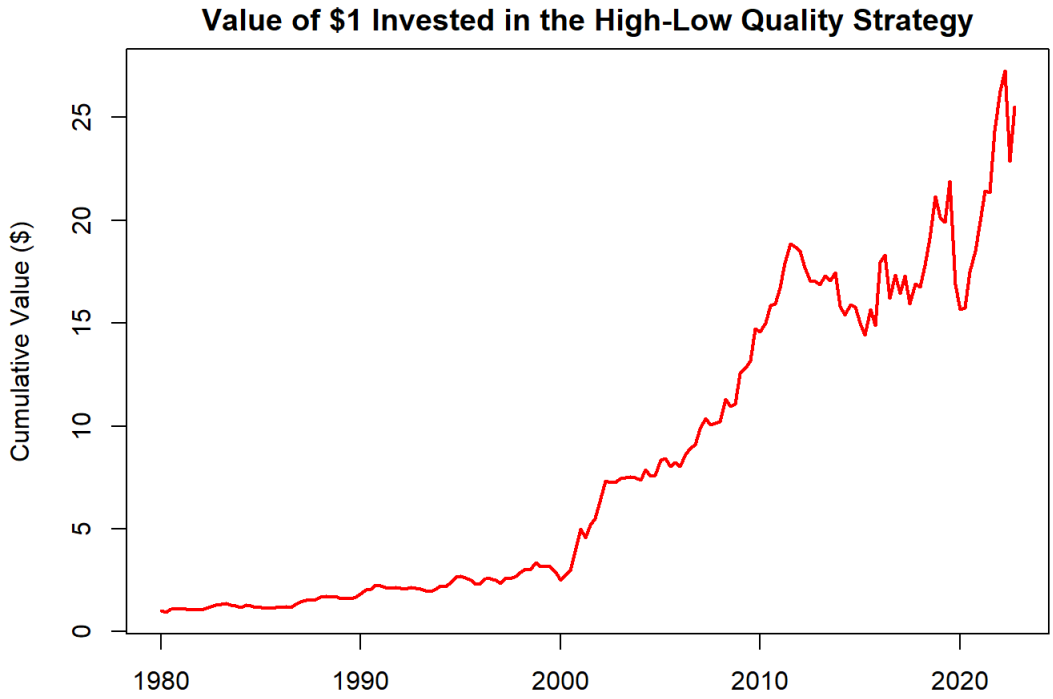
Quality Investing

```
# Quality Strategies
quality_deciles <- univariate_sorts(signal = "gp_at", description = "Quality")
```









Graph 1: Value of $1 Invested in Quality Deciles

Graph Interpretation: This graph tracks the growth of $1 invested in each quality decile, based on the gross profitability to assets ratio.

Strategy: Buy stocks in higher deciles (7-10) with higher quality metrics, indicating efficient and profitable companies. Sell stocks in lower deciles (1-3) as these stocks have lower gross profit to assets ratios, indicating less efficient companies.

Graph 2: EW Average Returns to Quality Deciles

Graph Interpretation: This graph shows the average annualized returns for each quality decile. Graph indicates higher deciles show higher returns.

Strategy: Prioritize stocks in higher quality deciles (Deciles 9-10) to benefit from the quality premium.

Graph 3: Quarterly Returns to Quality based on Decile

Graph Interpretation: Quarterly return bar plots for Decile 1, Decile 10, and the spread between them, indicating performance differences based on quality metrics.

Strategy: Use the spread between high and low-quality stocks to gauge market conditions and adjust portfolios to capitalize on quality-driven performance.

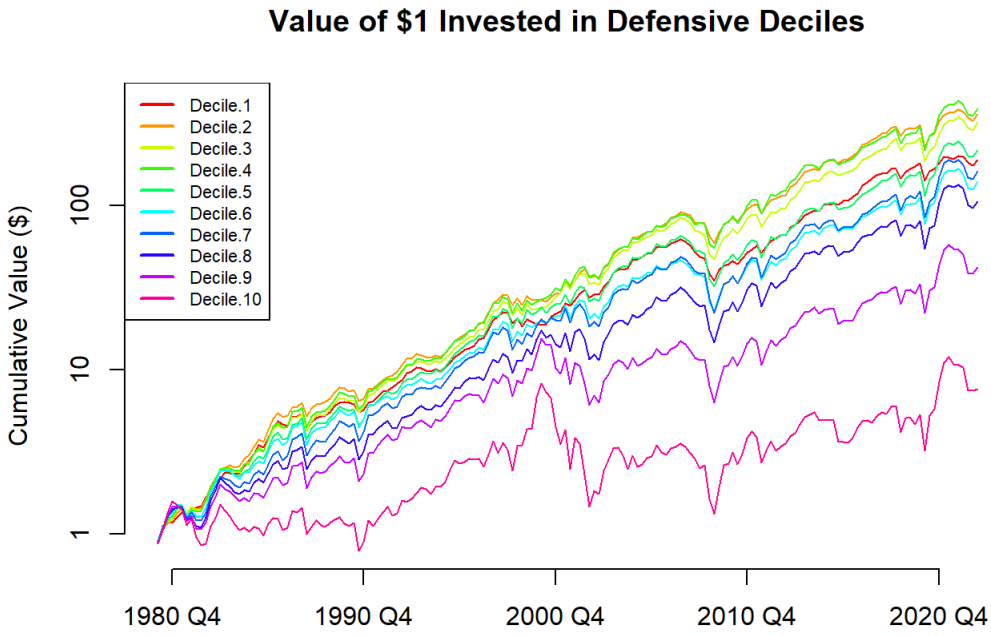
Graph 4: Value of $1 Invested in the High-Low Quality Strategy

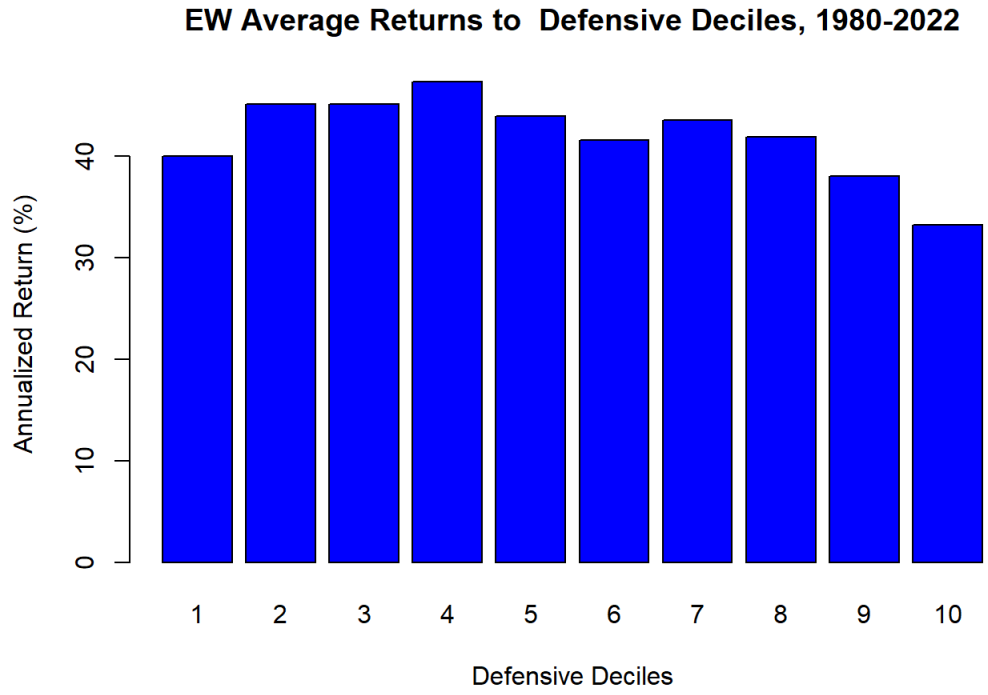
Graph Interpretation: This line graph shows how the cumulative return changes overtime from 1980-2020 from a strategy that buys high-quality stocks (Decile 10) and shorts low-quality stocks (Decile 1). The cumulative return larger as time goes on. There is a slight drop in 2020, most likely due to the 2020 COVID-19 pandemic

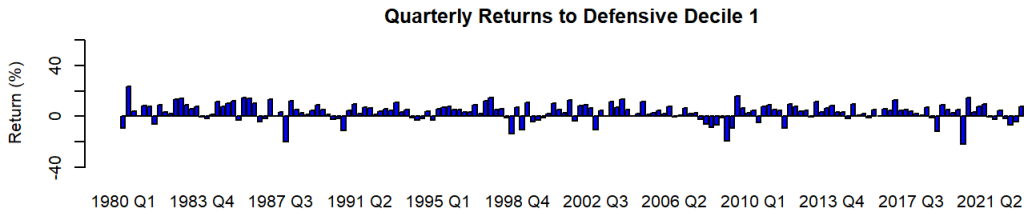
Strategy: Implement a long-short strategy favoring high-quality stocks while shorting low-quality stocks to exploit the quality premium.

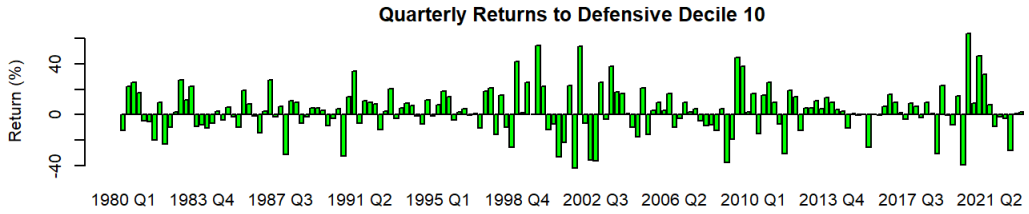
Defensive (Low Risk) Investing

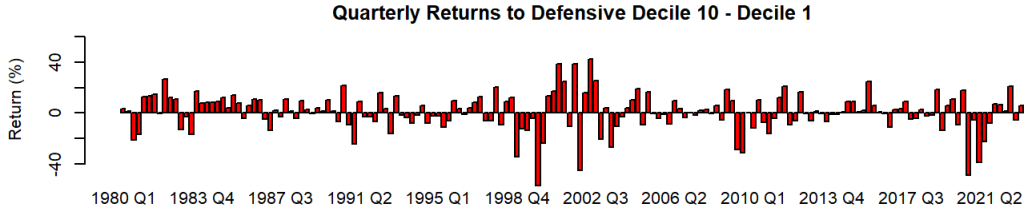
```
# Defensive Strategies
quality_deciles <- univariate_sorts(signal = "betabab_1260d", description = "Defensive", trade_direction = "Low-Hig
```

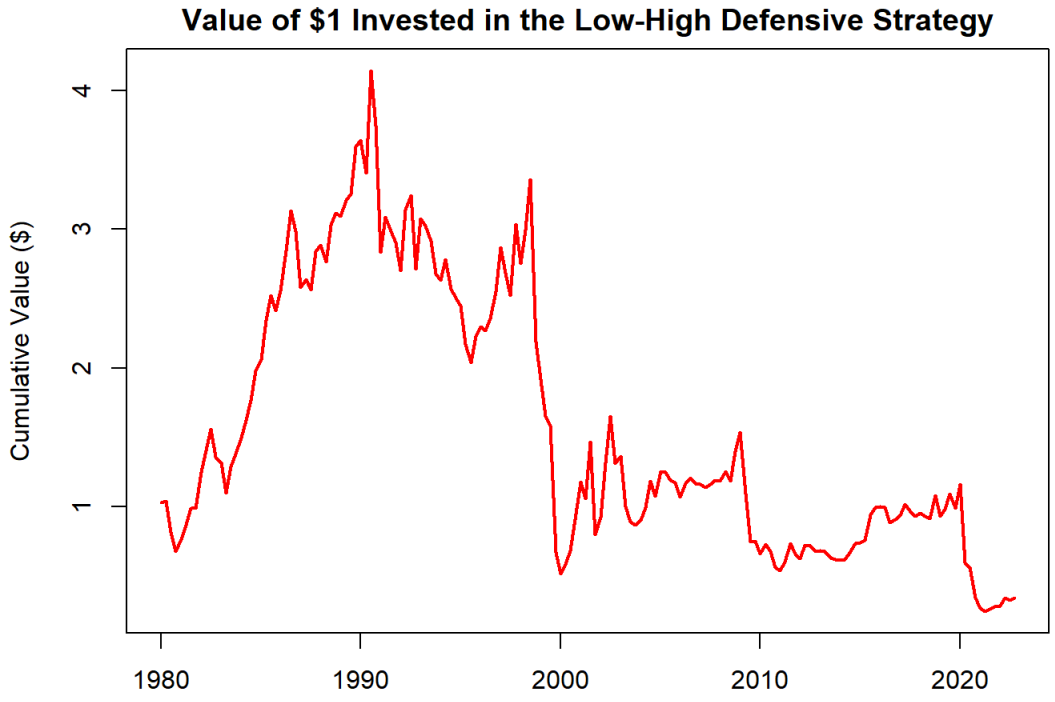



EW Average Returns to Defensive Deciles, 1980-2022
Annualized Return (%)
0
10
20
30
40
1
2
3
4
5
6
7
8
9
10
Defensive Deciles


Quarterly Returns to Defensive Decile 1
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2


Quarterly Returns to Defensive Decile 10
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2


Quarterly Returns to Defensive Decile 10 - Decile 1
Return (%)
-40
0
40
1980 Q1
1983 Q4
1987 Q3
1991 Q2
1995 Q1
1998 Q4
2002 Q3
2006 Q2
2010 Q1
2013 Q4
2017 Q3
2021 Q2



Graph 1: Value of $1 Invested in Defensive Deciles

Graph Interpretation: This graph tracks the growth of $1 invested in each quality defensive decile, based on beta, which is a measure of volatility.

Strategy: Buy stocks in lower deciles (1-3), which represent low-risk, low-volatility stocks that are less sensitive to market movements. Sell stocks in higher deciles (8-10), which are higher-risk, higher-volatility stocks.

Graph 2: EW Average Returns to Defensive Deciles

Graph Interpretation: This graph highlights the average annualized returns for each defensive decile, with lower deciles generally showing more stable returns.

Strategy: Focus on lower deciles for more stable, defensive investments, especially in volatile or bear markets.

Graph 3: Quarterly Returns to Defensive based on Decile

Graph Interpretation: These plots show the quarterly returns for Decile 1 (low risk), Decile 10 (high risk), and the spread between them, which can be indicative of risk premiums.

Strategy: Analyze the spread to assess risk aversion in the market and adjust investments to align with more defensive strategies but also discover the more aggressive strategies.

Graph 4: Value of $1 Invested in the High-Low Defensive Strategy

Graph Interpretation: The line graph tracks how much $1 invested in this strategy would grow over the years. The graph shows fluctuations and a general decline in value, especially noticeable from the late 1990s onwards. The most severe drops are seen during and after the Dot-Com bubble burst in the early 2000s and the 2008 Financial Crisis.

Strategy: With defensive investing, we think low-risk stocks will outperform high-risk stocks over time. This is based on the observation and our graphs that, on average, low-beta stocks have provided better risk-adjusted returns compared to high-beta stocks. So we want

to go long on low-risk (low beta) stocks as there stocks are characterized by lower valotility and seen as safer investments. We want to sell high-risk (high beta) stocks as there are more volatile and affected more by market fluctuations.