Fixed Income

Real GDP

```
gdp.all <- data.table::fread(file.path(data.dir, "imf-dm-export.csv"))

gdp.col.names <- as.character(t(gdp.all[1, ]))

colnames(gdp.all) <- gdp.col.names
colnames(gdp.all)[1] <- "Country"

gdp.all <- gdp.all[-1]

gdp.all$Country
```

```
  [1] ""
  [2] "Afghanistan"
  [3] "Albania"
  [4] "Algeria"
  [5] "Angola"
  [6] "Antigua and Barbuda"
  [7] "Argentina"
  [8] "Armenia"
  [9] "Aruba"
 [10] "Australia"
 [11] "Austria"
 [12] "Azerbaijan"
 [13] "Bahamas, The"
 [14] "Bahrain"
 [15] "Bangladesh"
 [16] "Barbados"
 [17] "Belarus"
 [18] "Belgium"
 [19] "Belize"
 [20] "Benin"
 [21] "Bhutan"
 [22] "Bolivia"
 [23] "Bosnia and Herzegovina"
 [24] "Botswana"
 [25] "Brazil"
 [26] "Brunei Darussalam"
 [27] "Bulgaria"
 [28] "Burkina Faso"
 [29] "Burundi"
 [30] "Cabo Verde"
```

```
 [31] "Cambodia"
 [32] "Cameroon"
 [33] "Canada"
 [34] "Central African Republic"
 [35] "Chad"
 [36] "Chile"
 [37] "China, People's Republic of"
 [38] "Colombia"
 [39] "Comoros"
 [40] "Congo, Dem. Rep. of the"
 [41] "Congo, Republic of "
 [42] "Costa Rica"
 [43] "Croatia"
 [44] "Cyprus"
 [45] "Czech Republic"
 [46] "CÃ´te d'Ivoire"
 [47] "Denmark"
 [48] "Djibouti"
 [49] "Dominica"
 [50] "Dominican Republic"
 [51] "Ecuador"
 [52] "Egypt"
 [53] "El Salvador"
 [54] "Equatorial Guinea"
 [55] "Eritrea"
 [56] "Estonia"
 [57] "Eswatini"
 [58] "Ethiopia"
 [59] "Fiji"
 [60] "Finland"
 [61] "France"
 [62] "Gabon"
 [63] "Gambia, The"
 [64] "Georgia"
 [65] "Germany"
 [66] "Ghana"
 [67] "Greece"
 [68] "Grenada"
 [69] "Guatemala"
 [70] "Guinea"
 [71] "Guinea-Bissau"
 [72] "Guyana"
 [73] "Haiti"
 [74] "Honduras"
 [75] "Hong Kong SAR"
```

```
 [76] "Hungary"
 [77] "Iceland"
 [78] "India"
 [79] "Indonesia"
 [80] "Iran"
 [81] "Iraq"
 [82] "Ireland"
 [83] "Israel"
 [84] "Italy"
 [85] "Jamaica"
 [86] "Japan"
 [87] "Jordan"
 [88] "Kazakhstan"
 [89] "Kenya"
 [90] "Kiribati"
 [91] "Korea, Republic of"
 [92] "Kosovo"
 [93] "Kuwait"
 [94] "Kyrgyz Republic"
 [95] "Lao P.D.R."
 [96] "Latvia"
 [97] "Lebanon"
 [98] "Lesotho"
 [99] "Liberia"
[100] "Libya"
[101] "Lithuania"
[102] "Luxembourg"
[103] "Macao SAR"
[104] "Madagascar"
[105] "Malawi"
[106] "Malaysia"
[107] "Maldives"
[108] "Mali"
[109] "Malta"
[110] "Marshall Islands"
[111] "Mauritania"
[112] "Mauritius"
[113] "Mexico"
[114] "Micronesia, Fed. States of"
[115] "Moldova"
[116] "Mongolia"
[117] "Montenegro"
[118] "Morocco"
[119] "Mozambique"
[120] "Myanmar"
```

```
[121] "Namibia"
[122] "Nauru"
[123] "Nepal"
[124] "Netherlands"
[125] "New Zealand"
[126] "Nicaragua"
[127] "Niger"
[128] "Nigeria"
[129] "North Macedonia"
[130] "Norway"
[131] "Oman"
[132] "Pakistan"
[133] "Palau"
[134] "Panama"
[135] "Papua New Guinea"
[136] "Paraguay"
[137] "Peru"
[138] "Philippines"
[139] "Poland"
[140] "Portugal"
[141] "Puerto Rico"
[142] "Qatar"
[143] "Romania"
[144] "Russian Federation"
[145] "Rwanda"
[146] "Saint Kitts and Nevis"
[147] "Saint Lucia"
[148] "Saint Vincent and the Grenadines"
[149] "Samoa"
[150] "San Marino"
[151] "Saudi Arabia"
[152] "Senegal"
[153] "Serbia"
[154] "Seychelles"
[155] "Sierra Leone"
[156] "Singapore"
[157] "Slovak Republic"
[158] "Slovenia"
[159] "Solomon Islands"
[160] "Somalia"
[161] "South Africa"
[162] "South Sudan, Republic of"
[163] "Spain"
[164] "Sri Lanka"
[165] "Sudan"
```

```
[166] "Suriname"
[167] "Sweden"
[168] "Switzerland"
[169] "Syria"
[170] "SÃ£o TomÃ© and PrÃncipe"
[171] "Taiwan Province of China"
[172] "Tajikistan"
[173] "Tanzania"
[174] "Thailand"
[175] "Timor-Leste"
[176] "Togo"
[177] "Tonga"
[178] "Trinidad and Tobago"
[179] "Tunisia"
[180] "Turkey"
[181] "Turkmenistan"
[182] "Tuvalu"
[183] "Uganda"
[184] "Ukraine"
[185] "United Arab Emirates"
[186] "United Kingdom"
[187] "United States"
[188] "Uruguay"
[189] "Uzbekistan"
[190] "Vanuatu"
[191] "Venezuela"
[192] "Vietnam"
[193] "Yemen"
[194] "Zambia"
[195] "Zimbabwe"
[196] "Africa (Region)"
[197] "Asia and Pacific"
[198] "Australia and New Zealand"
[199] "Caribbean"
[200] "Central America"
[201] "Central Asia and the Caucasus"
[202] "East Asia"
[203] "Eastern Europe"
[204] "Europe"
[205] "Middle East (Region)"
[206] "North Africa"
[207] "North America"
[208] "Pacific Islands"
[209] "South America"
[210] "South Asia"
```

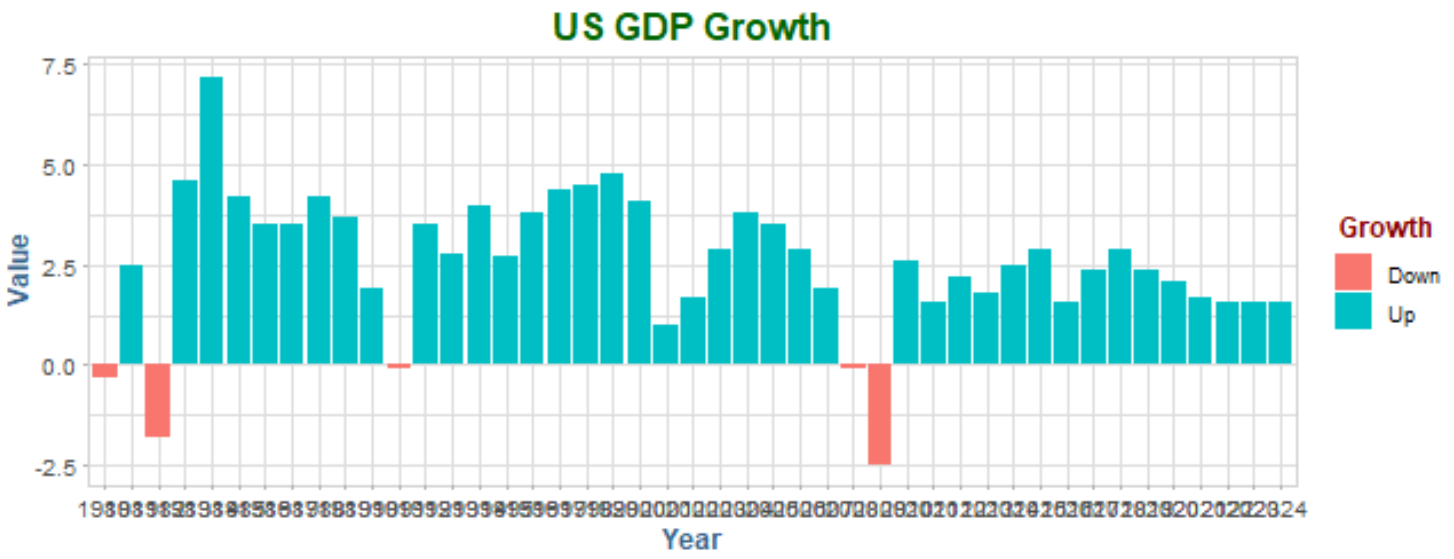
```
[211] "Southeast Asia"
[212] "Sub-Saharan Africa (Region)"
[213] "Western Europe"
[214] "Western Hemisphere (Region)"
[215] "ASEAN-5"
[216] "Advanced economies"
[217] "Emerging and Developing Asia"
[218] "Emerging and Developing Europe"
[219] "Emerging market and developing economies"
[220] "Euro area"
[221] "European Union"
[222] "Latin America and the Caribbean"
[223] "Major advanced economies (G7)"
[224] "Middle East and Central Asia"
[225] "Other advanced economies"
[226] "Sub-Saharan Africa"
[227] "World"
[228] ""
[229] "Â©IMF, 2019"
```

```
us.rgdp <- gdp.all[Country == "United States"]
us.rgdp <- t(us.rgdp)

us.gdp <- data.table(Year = rownames(us.rgdp)[-1], Value = us.rgdp[-1])
```

```
us.gdp$Value <- as.numeric(us.gdp$Value)
us.gdp$Historical <- ifelse(us.gdp$Year <= 2012, us.gdp$Value, 0)
us.gdp$Projected <- ifelse(us.gdp$Year > 2012, us.gdp$Value, 0)
us.gdp$Growth <- ifelse(us.gdp$Value >= 0, "Up", "Down")

ggplot(us.gdp, aes(Year, Value, fill = Growth)) +
   geom_bar(stat = "identity") +
   labs(title = "US GDP Growth")
```



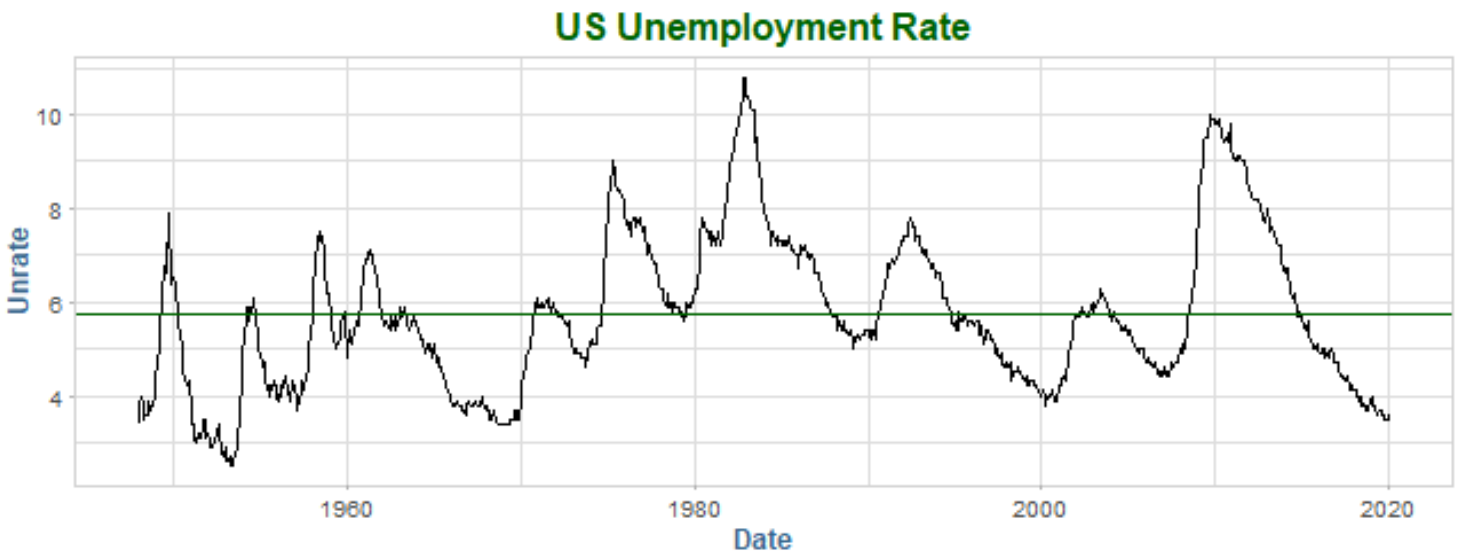
Unemployment Rate

```
US.unempl <- data.table::fread(file.path(data.dir, "UNRATE.csv"))

US.unempl$Date <- as.Date(US.unempl$DATE, "%Y-%m-%d")
US.unempl$DATE = NULL
US.unempl <- US.unempl[, .(Date, Unrate = UNRATE)]

US.unempy.avg <- mean(US.unempl$Unrate)

ggplot(US.unempl, aes(Date, Unrate)) +
   geom_line() +
   geom_hline(yintercept = US.unempy.avg, col = "darkgreen") +
   labs(title = "US Unemployment Rate")
```



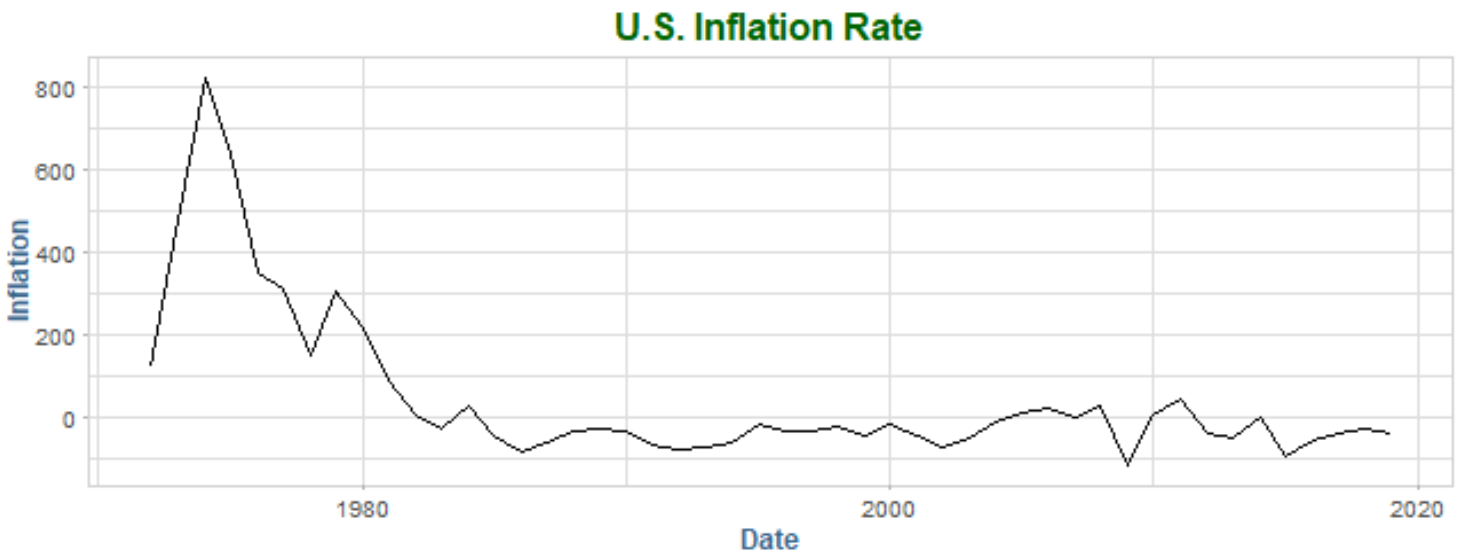
Inflation Rate

```
US.CPI <- data.table::fread(file.path(data.dir, "FPCPITOTLZGUSA.csv"))
us.Lag12 <- Lag(US.CPI$FPCPITOTLZGUSA, k = 12)

US.CPI$Date <- as.Date(US.CPI$DATE, "%Y-%m-%d")
US.CPI$DATE = NULL

US.CPI.Index <- data.table(Date = US.CPI$Date, CPI = US.CPI$FPCPITOTLZGUSA, us.Lag12)
US.CPI.Index[, Inflation := (CPI/Lag.12 - 1)*100]
US.CPI.Index <- US.CPI.Index[!is.na(US.CPI.Index$Inflation)]

ggplot(US.CPI.Index, aes(Date, Inflation)) +
   geom_line() +
   labs(title = "U.S. Inflation Rate")
```



US Treasuries

```
rate.files <- list.files(data.dir, pattern = "DGS*")
rate.file.paths <- sapply(rate.files, function(file){ file.path(data.dir, file)})

rates <- lapply(rate.file.paths, data.table::fread)
dt.rates <- as.data.table(rates)
```

```
Warning in as.data.table.list(rates): Item 1 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 2 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 3 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 4 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 5 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 6 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 8 has 1306 rows but longest item has
2666; recycled with remainder.

Warning in as.data.table.list(rates): Item 9 has 1306 rows but longest item has
2666; recycled with remainder.
```

```
Warning in as.data.table.list(rates): Item 10 has 1306 rows but longest item has
2666; recycled with remainder.
```

```
parse.rate.info <- function(data) {

   colnames(data) -> cols
   mat <- as.matrix(data)

   dt <- data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"),
                    Rate = as.numeric(mat[, 2]))
   colnames(dt) <- c("Date", cols[2])
   dt
}

rate.3m <- parse.rate.info(rates$DGS3MO.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.6m <- parse.rate.info(rates$DGS6MO.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.1y <- parse.rate.info(rates$DGS1.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.2y <- parse.rate.info(rates$DGS2.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.3y <- parse.rate.info(rates$DGS3.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.5y <- parse.rate.info(rates$DGS5.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.7y <- parse.rate.info(rates$DGS7.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.10y <- parse.rate.info(rates$DGS10.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.20y <- parse.rate.info(rates$DGS20.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

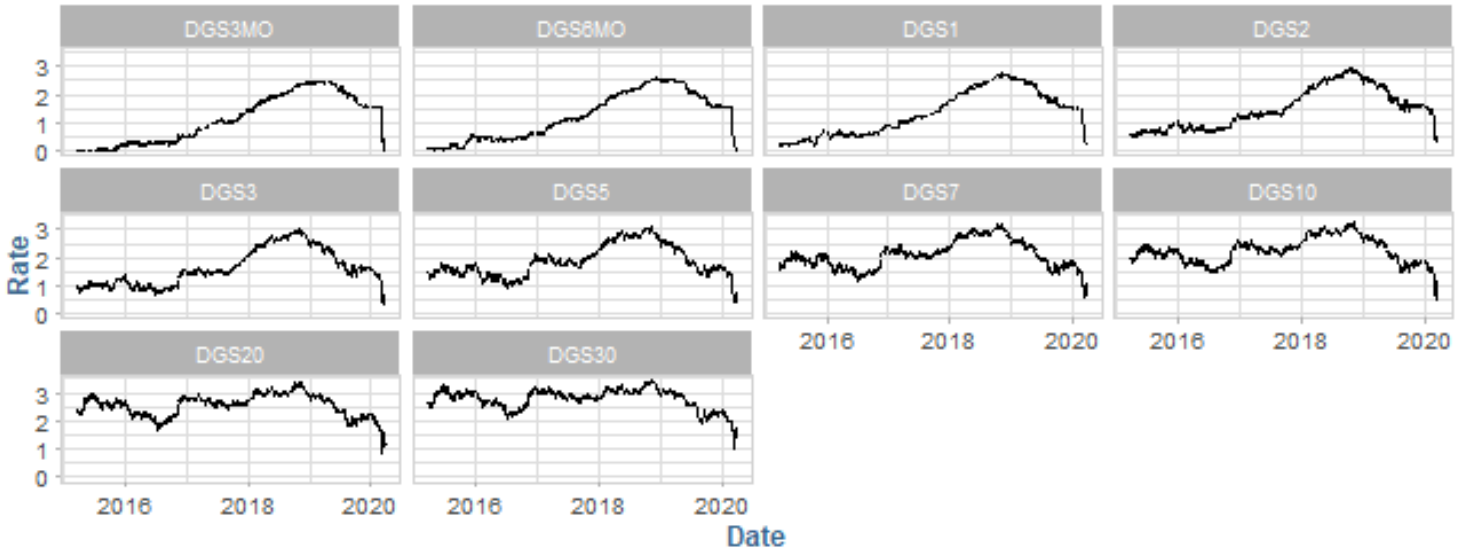
```
rate.30y <- parse.rate.info(rates$DGS30.csv)
```

```
Warning in data.table(Date = as.Date(mat[, 1], "%Y-%m-%d"), Rate =
as.numeric(mat[, : NAs introduced by coercion
```

```
rate.combined <- merge(rate.3m, rate.6m, by = "Date")
rate.combined <- merge(rate.combined, rate.1y, by = "Date")
rate.combined <- merge(rate.combined, rate.2y, by = "Date")
rate.combined <- merge(rate.combined, rate.3y, by = "Date")
rate.combined <- merge(rate.combined, rate.5y, by = "Date")
rate.combined <- merge(rate.combined, rate.7y, by = "Date")
rate.combined <- merge(rate.combined, rate.10y, by = "Date")
rate.combined <- merge(rate.combined, rate.20y, by = "Date")
rate.combined <- merge(rate.combined, rate.30y, by = "Date")

rate.long <- melt(rate.combined, id.vars = "Date", value.name = "Rate", variable.name = "Period

ggplot(rate.long, aes(Date, Rate, group = Period)) +
   geom_line() +
   facet_wrap(~Period)
```



```
current.rates <- rate.combined[Date >= "1990-1-1"]

current.rates <- current.rates[complete.cases(current.rates)]
current.rates[, sign.diff := DGS30 - DGS3MO]
current.rates[, inverted := sign.diff == min(sign.diff)]

inverted <- current.rates[inverted == T]
inverted
```

```
         Date DGS3MO DGS6MO DGS1 DGS2 DGS3 DGS5 DGS7 DGS10 DGS20 DGS30
1: 2019-08-28   1.99   1.89 1.74  1.5 1.42 1.37 1.42  1.47  1.76  1.94
   sign.diff inverted
1:     -0.05     TRUE
```

```
current.rates[, upward := sign.diff == max(sign.diff)]

upward <- current.rates[upward == T]
upward
```

```
         Date DGS3MO DGS6MO DGS1 DGS2 DGS3 DGS5 DGS7 DGS10 DGS20 DGS30
1: 2015-06-26   0.01   0.08 0.29 0.72 1.09 1.75  2.2  2.49  2.98  3.25
   sign.diff inverted upward
1:      3.24    FALSE   TRUE
```

```
current.rates[, abs.diff := abs(DGS30 - DGS3MO)]
current.rates[, flat := abs.diff == min(abs.diff)]

flat <- current.rates[flat == T]
flat
```

```
         Date DGS3MO DGS6MO DGS1 DGS2 DGS3 DGS5 DGS7 DGS10 DGS20 DGS30
1: 2019-09-04   1.97   1.87 1.69 1.43 1.36 1.32  1.4  1.47  1.77  1.97
   sign.diff inverted upward abs.diff flat
1:         0    FALSE  FALSE        0 TRUE
```

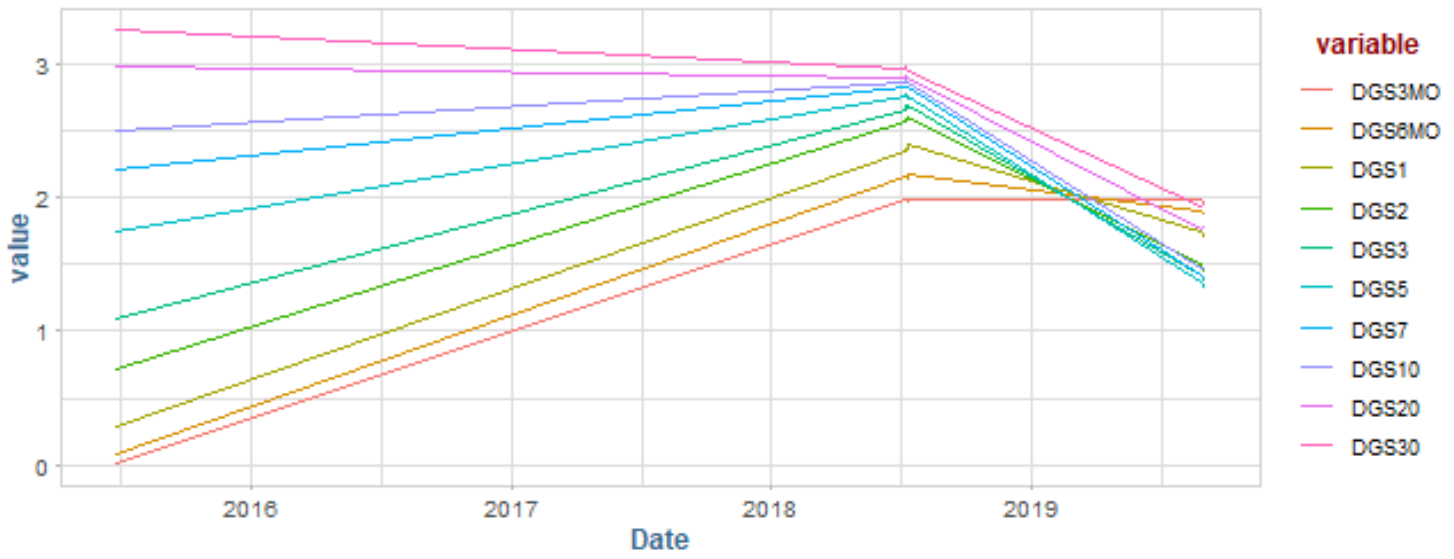
```
current.rates[, abs.diff2 := abs(DGS30 - DGS10)]
current.rates[, flat2 := abs.diff2 == min(abs.diff2)]

flat2 <- current.rates[flat2 == T]
```

```
rate.info <- rbind(inverted[, 1:11], upward[, 1:11], flat[, 1:11], flat2[, 1:11])

rate.info.flat <- melt(rate.info, id.vars = "Date")

ggplot(rate.info.flat, aes(Date, value, group = variable)) +
    geom_line(aes(col = variable))
```



Inverted Yield Curves

```
slope <- merge(rate.3m, rate.30y, by = "Date")

ggplot(slope) +
   geom_line(aes(Date, DGS3MO), col = "darkgreen") +
   geom_line(aes(Date, DGS30), col = "darkblue") +
   geom_rect(data = slope[1], mapping = aes(xmin = as.Date("2020-2-15"), xmax = as.Date("2020-3
   labs(title = "3M vs. 30 Year")
```