APT

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Arbritage Pricing Theory, & Modelling

The history of asset pricing and associated models have witnessed numerous landmark developments over the past century, each standing on the shoulders of the previous and striving to to reach above and beyond. **Arbritage Pricing Theory (APT)** proposed by economist Stephen Ross in 1976 and published with real world data in possible use case in the seminal work published in 1980 (http://doi.wiley.com/10.1111/j.1540-6261.1980.tb02197.x). This model builds forward on Markowitz Portfolio Theory (MPT), its application in selecting assets using Capital Asset Pricing Model (CAPM) and their limitations. While CAPM alongside with MPT considers previous individual asset returns, they don't allow to mathematically (& thus more objectively) to incorporate various macroeconomic and other factors in this model. Over long periods of time, even inflation eats into absolute returns observed over time. APT provides a mathematical framework to handle such issues, one of the first of its kind.

APT model uses the same mathematical strategy of linear regression as with CAPM except instead of being limited to just market risk measured in comparison to a market index, APT allows of any number of parameters. They can be market risk as in CAPM, additional parameters like *Small Minus Big (SmB) (market capitalization)* and *High Minus Low (HmL) (book to market ratio)* like in **Fama-French model** and they can be disparately other factors like inflation or political risk in the market place of the country or build up inventory items on the accounting sheets of a company. The model allows such flexibility for users, often improved by leveraing insights from experienced fund managers.

APT model can thus be generalized and depicted by the following mathematical equation:

$$r_j = \alpha_j + \lambda_{j1} f_1 + \lambda_{j2} f_2 + \ldots + \lambda_{jn} f_n + \epsilon_j$$

where the different linearly added terms can be different factors like political risk or inflation or SmB or HmL or others. As linear regression model is used for prediction, the underlying assumptions of linear regression are also implied for feature selection in APT model.

As part of this assignment, we model **NIFTY monthly returns** as a function of **monthly 10 yr G-Ssec bond yields** and **monthly inflation**.

Data collection and preprocessing

Loading necessary libraries first as follows:

```
rm(list=ls())
knitr::opts_chunk$set(echo = TRUE)

setwd("~/QRS/Finance Stuff/APT")

libraries_required = c('lubridate', 'xts')

for(i in seq(libraries_required))
{
  if(!(libraries_required[i] %in% rownames(installed.packages())))
  {
    try(expr = install.packages('libraries_required[i]'), silent = T)
  }
  try(expr = library(libraries_required[i], character.only = T), silent = T)
}
```

```
##
## Attaching package: 'lubridate'
```

```
## The following object is masked from 'package:base':
##
##     date
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
options(warn=-1)
```

Next, we obtain India's 10yr G-Sec bond yield from investing.com (https://in.investing.com/rates-bonds/india-10-year-bond-yield-historical-data). We save in file 'India 10-Year Bond Yield Historical Data Monthly.csv', load it and have a look.

```
India_10_yr_bond <- read.csv(file = "India 10-Year Bond Yield Historical Data Monthly.csv",
                             header = T, stringsAsFactors = F)

head(India_10_yr_bond,10)
```

```
##        Date Price  Open  High   Low Change..
## 1  01/08/19 6.390 6.369 6.432 6.324    0.33%
## 2  01/07/19 6.369 6.906 6.930 6.266   -7.41%
## 3  01/06/19 6.879 6.949 7.097 6.734   -2.18%
## 4  01/05/19 7.032 7.411 7.426 7.030   -5.15%
## 5  01/04/19 7.414 7.356 7.497 7.229    0.93%
## 6  01/03/19 7.346 7.588 7.590 7.301   -3.23%
## 7  01/02/19 7.591 7.470 7.699 7.425    1.44%
## 8  01/01/19 7.483 7.401 7.650 7.350    1.53%
## 9  01/12/18 7.370 7.646 7.703 7.218   -3.12%
## 10 01/11/18 7.607 7.831 7.840 7.576   -3.13%
```

Next, we utilise the date column to generate the time series. We also change the date to only year and month are our model is for monthly data (same frequency as inflation data, which we load later).

```
India_10_yr_bond$Date <- as.Date(India_10_yr_bond$Date, format="%d/%m/%y")

head(India_10_yr_bond)
```

```
##         Date Price  Open  High   Low Change..
## 1 2019-08-01 6.390 6.369 6.432 6.324    0.33%
## 2 2019-07-01 6.369 6.906 6.930 6.266   -7.41%
## 3 2019-06-01 6.879 6.949 7.097 6.734   -2.18%
## 4 2019-05-01 7.032 7.411 7.426 7.030   -5.15%
## 5 2019-04-01 7.414 7.356 7.497 7.229    0.93%
## 6 2019-03-01 7.346 7.588 7.590 7.301   -3.23%
```

```
India_10_yr_bond$Date <- format(India_10_yr_bond$Date, format="%y-%m")

head(India_10_yr_bond)
```

```
##    Date Price  Open  High   Low Change..
## 1 19-08 6.390 6.369 6.432 6.324    0.33%
## 2 19-07 6.369 6.906 6.930 6.266   -7.41%
## 3 19-06 6.879 6.949 7.097 6.734   -2.18%
## 4 19-05 7.032 7.411 7.426 7.030   -5.15%
## 5 19-04 7.414 7.356 7.497 7.229    0.93%
## 6 19-03 7.346 7.588 7.590 7.301   -3.23%
```

Next, we load our standard NIFTY time series data.

```
NIFTY_monthly <- read.csv(file = "NIFTY_monthly.csv", header = T, stringsAsFactors = F)

head(NIFTY_monthly)
```

```
##        Date    Open    High     Low   Close Shares.Traded
## 1 16 Jul 09 4223.50 4305.00 4205.50 4231.40     292288337
## 2 17 Jul 09 4231.45 4390.40 4230.15 4374.95     250233020
## 3 20 Jul 09 4377.90 4510.30 4377.90 4502.25     280309302
## 4 21 Jul 09 4501.50 4524.00 4436.60 4469.10     311984330
## 5 22 Jul 09 4469.30 4557.95 4380.45 4398.90     337796915
## 6 23 Jul 09 4409.70 4532.40 4405.95 4523.75     273052133
##   Turnover..Rs..Cr.
## 1          10209.96
## 2            9545.1
## 3          10151.33
## 4          10289.73
## 5          11688.74
## 6             10580
```

```
NIFTY_monthly$Date <- as.Date(NIFTY_monthly$Date, format="%d %b %y")

head(NIFTY_monthly)
```

```
##         Date    Open    High     Low   Close Shares.Traded
## 1 2009-07-16 4223.50 4305.00 4205.50 4231.40     292288337
## 2 2009-07-17 4231.45 4390.40 4230.15 4374.95     250233020
## 3 2009-07-20 4377.90 4510.30 4377.90 4502.25     280309302
## 4 2009-07-21 4501.50 4524.00 4436.60 4469.10     311984330
## 5 2009-07-22 4469.30 4557.95 4380.45 4398.90     337796915
## 6 2009-07-23 4409.70 4532.40 4405.95 4523.75     273052133
##   Turnover..Rs..Cr.
## 1          10209.96
## 2            9545.1
## 3          10151.33
## 4          10289.73
## 5          11688.74
## 6             10580
```

```
NIFTY_monthly$Date <- format(NIFTY_monthly$Date, format="%y-%m")

head(NIFTY_monthly)
```

```
##    Date    Open    High     Low   Close Shares.Traded Turnover..Rs..Cr.
## 1 09-07 4223.50 4305.00 4205.50 4231.40     292288337          10209.96
## 2 09-07 4231.45 4390.40 4230.15 4374.95     250233020            9545.1
## 3 09-07 4377.90 4510.30 4377.90 4502.25     280309302          10151.33
## 4 09-07 4501.50 4524.00 4436.60 4469.10     311984330          10289.73
## 5 09-07 4469.30 4557.95 4380.45 4398.90     337796915          11688.74
## 6 09-07 4409.70 4532.40 4405.95 4523.75     273052133             10580
```

```
NIFTY_monthly <- NIFTY_monthly[,1:5]

head(NIFTY_monthly)
```

```
##    Date    Open    High     Low   Close
## 1 09-07 4223.50 4305.00 4205.50 4231.40
## 2 09-07 4231.45 4390.40 4230.15 4374.95
## 3 09-07 4377.90 4510.30 4377.90 4502.25
## 4 09-07 4501.50 4524.00 4436.60 4469.10
## 5 09-07 4469.30 4557.95 4380.45 4398.90
## 6 09-07 4409.70 4532.40 4405.95 4523.75
```

```
temp_name <- colnames(NIFTY_monthly)

colnames(NIFTY_monthly) <- temp_name

head(NIFTY_monthly)
```

```
##    Date    Open    High     Low   Close
## 1 09-07 4223.50 4305.00 4205.50 4231.40
## 2 09-07 4231.45 4390.40 4230.15 4374.95
## 3 09-07 4377.90 4510.30 4377.90 4502.25
## 4 09-07 4501.50 4524.00 4436.60 4469.10
## 5 09-07 4469.30 4557.95 4380.45 4398.90
## 6 09-07 4409.70 4532.40 4405.95 4523.75
```

Next, we combine by ‘Date’ column, NIFTY returns and the bond yield data.

```
Combined <- merge(x = NIFTY_monthly[,c(1,5)], y = India_10_yr_bond[,1:2], by = "Date", all.y
 = TRUE)

colnames(Combined) <- c("Date","NIFTY_Close","India_10_yr_bond_RF")

# head(Combined,40)
tail(Combined,40)
```

```
##       Date NIFTY_Close India_10_yr_bond_RF
## 2403 18-10    10198.40               7.853
## 2404 18-10    10386.60               7.853
## 2405 18-11    10380.45               7.607
## 2406 18-11    10553.00               7.607
## 2407 18-11    10524.00               7.607
## 2408 18-11    10530.00               7.607
## 2409 18-11    10585.20               7.607
## 2410 18-11    10482.20               7.607
## 2411 18-11    10582.50               7.607
## 2412 18-12          NA               7.370
## 2413 19-01          NA               7.483
## 2414 19-02          NA               7.591
## 2415 19-03          NA               7.346
## 2416 19-04          NA               7.414
## 2417 19-05          NA               7.032
## 2418 19-06          NA               6.879
## 2419 19-07          NA               6.369
## 2420 19-08          NA               6.390
## 2421 98-03          NA              12.086
## 2422 98-04          NA              11.781
## 2423 98-05          NA              12.049
## 2424 98-06          NA              12.117
## 2425 98-07          NA              12.200
## 2426 98-08          NA              12.241
## 2427 98-09          NA              12.287
## 2428 98-10          NA              12.302
## 2429 98-11          NA              12.221
## 2430 98-12          NA              12.213
## 2431 99-01          NA              12.219
## 2432 99-02          NA              12.223
## 2433 99-03          NA              11.994
## 2434 99-04          NA              11.886
## 2435 99-05          NA              11.700
## 2436 99-06          NA              11.851
## 2437 99-07          NA              11.673
## 2438 99-08          NA              11.588
## 2439 99-09          NA              11.634
## 2440 99-10          NA              11.521
## 2441 99-11          NA              11.384
## 2442 99-12          NA              11.197
```

```
Combined <- na.omit(Combined)

head(Combined)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF
## 115 09-07     4231.40               6.998
## 116 09-07     4374.95               6.998
## 117 09-07     4502.25               6.998
## 118 09-07     4469.10               6.998
## 119 09-07     4398.90               6.998
## 120 09-07     4523.75               6.998
```

```
Combined$NIFTY_ret <- c(NA,100*diff(Combined$NIFTY_Close)/Combined$NIFTY_Close[-1])

head(Combined)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF  NIFTY_ret
## 115 09-07     4231.40               6.998         NA
## 116 09-07     4374.95               6.998  3.2811804
## 117 09-07     4502.25               6.998  2.8274752
## 118 09-07     4469.10               6.998 -0.7417601
## 119 09-07     4398.90               6.998 -1.5958535
## 120 09-07     4523.75               6.998  2.7598784
```

```
Combined <- na.omit(Combined)

head(Combined)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF  NIFTY_ret
## 116 09-07     4374.95               6.998  3.2811804
## 117 09-07     4502.25               6.998  2.8274752
## 118 09-07     4469.10               6.998 -0.7417601
## 119 09-07     4398.90               6.998 -1.5958535
## 120 09-07     4523.75               6.998  2.7598784
## 121 09-07     4568.55               6.998  0.9806175
```

Converting annual bond yield to monthly

```
Combined$India_10_yr_bond_RF_monthly <- (((((Combined$India_10_yr_bond_RF/100)+1)^10)^(1/(10*
12))) - 1)*100

head(Combined,10)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF   NIFTY_ret
## 116 09-07     4374.95               6.998  3.28118036
## 117 09-07     4502.25               6.998  2.82747515
## 118 09-07     4469.10               6.998 -0.74176009
## 119 09-07     4398.90               6.998 -1.59585351
## 120 09-07     4523.75               6.998  2.75987842
## 121 09-07     4568.55               6.998  0.98061748
## 122 09-07     4572.30               6.998  0.08201562
## 123 09-07     4564.10               6.998 -0.17966302
## 124 09-07     4513.50               6.998 -1.12108120
## 125 09-07     4571.45               6.998  1.26765031
##     India_10_yr_bond_RF_monthly
## 116                   0.5652579
## 117                   0.5652579
## 118                   0.5652579
## 119                   0.5652579
## 120                   0.5652579
## 121                   0.5652579
## 122                   0.5652579
## 123                   0.5652579
## 124                   0.5652579
## 125                   0.5652579
```

Calculating market risk premium (MRP)

```
for (i in seq(dim(Combined)[[1]]))
{
  Combined[i,"MRP"] <- mean(Combined[1:i,"NIFTY_ret"]) - Combined[i,"India_10_yr_bond_RF_mont
hly"]
}

head(Combined,20)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF   NIFTY_ret
## 116 09-07     4374.95               6.998  3.28118036
## 117 09-07     4502.25               6.998  2.82747515
## 118 09-07     4469.10               6.998 -0.74176009
## 119 09-07     4398.90               6.998 -1.59585351
## 120 09-07     4523.75               6.998  2.75987842
## 121 09-07     4568.55               6.998  0.98061748
## 122 09-07     4572.30               6.998  0.08201562
## 123 09-07     4564.10               6.998 -0.17966302
## 124 09-07     4513.50               6.998 -1.12108120
## 125 09-07     4571.45               6.998  1.26765031
## 126 09-07     4636.45               6.998  1.40193467
## 127 09-08     4711.40               7.434  1.59082226
## 128 09-08     4680.50               7.434 -0.66018588
## 129 09-08     4694.15               7.434  0.29078747
## 130 09-08     4585.50               7.434 -2.36942536
## 131 09-08     4481.40               7.434 -2.32293480
## 132 09-08     4437.65               7.434 -0.98588217
## 133 09-08     4471.35               7.434  0.75368737
## 134 09-08     4457.50               7.434 -0.31071228
## 135 09-08     4605.00               7.434  3.20304017
##     India_10_yr_bond_RF_monthly         MRP
## 116                   0.5652579  2.71592246
## 117                   0.5652579  2.48906986
## 118                   0.5652579  1.22370725
## 119                   0.5652579  0.37750258
## 120                   0.5652579  0.74092617
## 121                   0.5652579  0.68666508
## 122                   0.5652579  0.51953545
## 123                   0.5652579  0.36147841
## 124                   0.5652579  0.13394313
## 125                   0.5652579  0.19078806
## 126                   0.5652579  0.24950521
## 127                   0.5993432  0.28009146
## 128                   0.5993432  0.16165910
## 129                   0.5993432  0.12807233
## 130                   0.5993432 -0.07838374
## 131                   0.5993432 -0.25612713
## 132                   0.5993432 -0.33430938
## 133                   0.5993432 -0.30716196
## 134                   0.5993432 -0.33889321
## 135                   0.5993432 -0.19176370
```

```
tail(Combined,20)
```

```
##       Date NIFTY_Close India_10_yr_bond_RF   NIFTY_ret
## 2392 18-10    10472.50               7.853  2.27118644
## 2393 18-10    10512.50               7.853  0.38049941
## 2394 18-10    10584.75               7.853  0.68258580
## 2395 18-10    10453.05               7.853 -1.25991935
## 2396 18-10    10303.55               7.853 -1.45095622
## 2397 18-10    10245.25               7.853 -0.56904419
## 2398 18-10    10146.80               7.853 -0.97025663
## 2399 18-10    10224.75               7.853  0.76236583
## 2400 18-10    10124.90               7.853 -0.98618258
## 2401 18-10    10030.00               7.853 -0.94616152
## 2402 18-10    10250.85               7.853  2.15445548
## 2403 18-10    10198.40               7.853 -0.51429636
## 2404 18-10    10386.60               7.853  1.81195001
## 2405 18-11    10380.45               7.607 -0.05924599
## 2406 18-11    10553.00               7.607  1.63508007
## 2407 18-11    10524.00               7.607 -0.27556062
## 2408 18-11    10530.00               7.607  0.05698006
## 2409 18-11    10585.20               7.607  0.52148283
## 2410 18-11    10482.20               7.607 -0.98261815
## 2411 18-11    10582.50               7.607  0.94779116
##      India_10_yr_bond_RF_monthly        MRP
## 2392                   0.6319803 -0.5972491
## 2393                   0.6319803 -0.5970973
## 2394                   0.6319803 -0.5968131
## 2395                   0.6319803 -0.5973811
## 2396                   0.6319803 -0.5980324
## 2397                   0.6319803 -0.5982966
## 2398                   0.6319803 -0.5987364
## 2399                   0.6319803 -0.5984171
## 2400                   0.6319803 -0.5988634
## 2401                   0.6319803 -0.5992918
## 2402                   0.6319803 -0.5983640
## 2403                   0.6319803 -0.5986035
## 2404                   0.6319803 -0.5978265
## 2405                   0.6128328 -0.5787198
## 2406                   0.6128328 -0.5780210
## 2407                   0.6128328 -0.5781564
## 2408                   0.6128328 -0.5781467
## 2409                   0.6128328 -0.5779345
## 2410                   0.6128328 -0.5783778
## 2411                   0.6128328 -0.5779800
```

With Market Risk Premium and NIFTY index returns in place, we next proceed to add monthly inflation data to our time series for linear regression of the APT model. We obtain the monthly inflation data on India from the website: https://www.inflation.eu/inflation-rates/india/historic-inflation/cpi-inflation-india-2019.aspx (https://www.inflation.eu/inflation-rates/india/historic-inflation/cpi-inflation-india-2019.aspx)

We copy the monthly figures onto a csv and process it further to prepare for integration with the inflation time series data with NIFTY returns and 10-year G-Sec bond yields. **We also extract the current month from the first column and use it to build the time series.**

```
India_monthly_Inflation <- read.csv(file = "inflation_India_monthly_basis.csv", header = T,
                                    stringsAsFactors = F)

head(India_monthly_Inflation)
```

```
##                   Monthly_basis inflation
## 1  january 2009 - december 2008     0.68%
## 2  february 2009 - january 2009     0.00%
## 3    march 2009 - february 2009     0.00%
## 4       april 2009 - march 2009     1.35%
## 5         may 2009 - april 2009     0.67%
## 6          june 2009 - may 2009     1.32%
```

```
for(j in seq(dim(India_monthly_Inflation)[1]))
{
  temp_vector <- rev(strsplit(India_monthly_Inflation[j,1], split = ' ')[[1]])[1:2]

  temp_vector_2 <- strsplit(temp_vector[2],split='')[[1]]

  temp_vector_2[1] <- toupper(temp_vector_2[1])

  temp_vector[2] <- paste0(temp_vector_2, collapse = '')

  temp_vector[3] <- "01"

  India_monthly_Inflation[j,"Date"] <- paste0(temp_vector, collapse = ' ')
}

head(India_monthly_Inflation)
```

```
##                   Monthly_basis inflation            Date
## 1  january 2009 - december 2008     0.68% 2008 December 01
## 2  february 2009 - january 2009     0.00%  2009 January 01
## 3    march 2009 - february 2009     0.00% 2009 February 01
## 4       april 2009 - march 2009     1.35%    2009 March 01
## 5         may 2009 - april 2009     0.67%    2009 April 01
## 6          june 2009 - may 2009     1.32%      2009 May 01
```

```
tail(India_monthly_Inflation)
```

```
##                    Monthly_basis inflation            Date
## 121  january 2019 - december 2018     1.99% 2018 December 01
## 122  february 2019 - january 2019     0.00%  2019 January 01
## 123    march 2019 - february 2019     0.65% 2019 February 01
## 124       april 2019 - march 2019     0.97%    2019 March 01
## 125         may 2019 - april 2019     0.64%    2019 April 01
## 126          june 2019 - may 2019     0.64%      2019 May 01
```

```
India_monthly_Inflation <- India_monthly_Inflation[2:3]

head(India_monthly_Inflation)
```

```
##   inflation             Date
## 1     0.68% 2008 December 01
## 2     0.00%  2009 January 01
## 3     0.00% 2009 February 01
## 4     1.35%    2009 March 01
## 5     0.67%    2009 April 01
## 6     1.32%      2009 May 01
```

```
tail(India_monthly_Inflation)
```

```
##     inflation             Date
## 121     1.99% 2018 December 01
## 122     0.00%  2019 January 01
## 123     0.65% 2019 February 01
## 124     0.97%    2019 March 01
## 125     0.64%    2019 April 01
## 126     0.64%      2019 May 01
```

```
India_monthly_Inflation$inflation <- as.numeric(gsub("%", "",India_monthly_Inflation$inflatio
n))

head(India_monthly_Inflation)
```

```
##   inflation             Date
## 1      0.68 2008 December 01
## 2      0.00  2009 January 01
## 3      0.00 2009 February 01
## 4      1.35    2009 March 01
## 5      0.67    2009 April 01
## 6      1.32      2009 May 01
```

```
tail(India_monthly_Inflation)
```

```
##     inflation             Date
## 121      1.99 2018 December 01
## 122      0.00  2019 January 01
## 123      0.65 2019 February 01
## 124      0.97    2019 March 01
## 125      0.64    2019 April 01
## 126      0.64      2019 May 01
```

```
colnames(India_monthly_Inflation) <- c("Inflation_%","Date")

head(India_monthly_Inflation)
```

```
##   Inflation_%            Date
## 1        0.68 2008 December 01
## 2        0.00  2009 January 01
## 3        0.00 2009 February 01
## 4        1.35    2009 March 01
## 5        0.67    2009 April 01
## 6        1.32      2009 May 01
```

```
tail(India_monthly_Inflation)
```

```
##     Inflation_%            Date
## 121        1.99 2018 December 01
## 122        0.00  2019 January 01
## 123        0.65 2019 February 01
## 124        0.97    2019 March 01
## 125        0.64    2019 April 01
## 126        0.64      2019 May 01
```

```
India_monthly_Inflation$Date <- as.Date(India_monthly_Inflation$Date, format="%Y %B %d")

head(India_monthly_Inflation)
```

```
##   Inflation_%       Date
## 1        0.68 2008-12-01
## 2        0.00 2009-01-01
## 3        0.00 2009-02-01
## 4        1.35 2009-03-01
## 5        0.67 2009-04-01
## 6        1.32 2009-05-01
```

```
tail(India_monthly_Inflation)
```

```
##     Inflation_%       Date
## 121        1.99 2018-12-01
## 122        0.00 2019-01-01
## 123        0.65 2019-02-01
## 124        0.97 2019-03-01
## 125        0.64 2019-04-01
## 126        0.64 2019-05-01
```

```
India_monthly_Inflation$Date <- format(India_monthly_Inflation$Date, format="%y-%m")

head(India_monthly_Inflation)
```

```
##   Inflation_%  Date
## 1        0.68 08-12
## 2        0.00 09-01
## 3        0.00 09-02
## 4        1.35 09-03
## 5        0.67 09-04
## 6        1.32 09-05
```

```
tail(India_monthly_Inflation)
```

```
##     Inflation_%  Date
## 121        1.99 18-12
## 122        0.00 19-01
## 123        0.65 19-02
## 124        0.97 19-03
## 125        0.64 19-04
## 126        0.64 19-05
```

```
head(Combined)
```

```
##      Date NIFTY_Close India_10_yr_bond_RF  NIFTY_ret
## 116 09-07     4374.95               6.998  3.2811804
## 117 09-07     4502.25               6.998  2.8274752
## 118 09-07     4469.10               6.998 -0.7417601
## 119 09-07     4398.90               6.998 -1.5958535
## 120 09-07     4523.75               6.998  2.7598784
## 121 09-07     4568.55               6.998  0.9806175
##     India_10_yr_bond_RF_monthly       MRP
## 116                   0.5652579 2.7159225
## 117                   0.5652579 2.4890699
## 118                   0.5652579 1.2237072
## 119                   0.5652579 0.3775026
## 120                   0.5652579 0.7409262
## 121                   0.5652579 0.6866651
```

```
tail(Combined)
```

```
##       Date NIFTY_Close India_10_yr_bond_RF   NIFTY_ret
## 2406 18-11     10553.0               7.607  1.63508007
## 2407 18-11     10524.0               7.607 -0.27556062
## 2408 18-11     10530.0               7.607  0.05698006
## 2409 18-11     10585.2               7.607  0.52148283
## 2410 18-11     10482.2               7.607 -0.98261815
## 2411 18-11     10582.5               7.607  0.94779116
##      India_10_yr_bond_RF_monthly        MRP
## 2406                   0.6128328 -0.5780210
## 2407                   0.6128328 -0.5781564
## 2408                   0.6128328 -0.5781467
## 2409                   0.6128328 -0.5779345
## 2410                   0.6128328 -0.5783778
## 2411                   0.6128328 -0.5779800
```

Now, with this inflation time series dataframe, we combine using left join with the previous data frame consisting of the NIFTY returns and 10-year bond yields.

```
All_Factors <- merge(x = Combined, y = India_monthly_Inflation, by = "Date", all.y = TRUE)

head(All_Factors)
```

```
##    Date NIFTY_Close India_10_yr_bond_RF NIFTY_ret
## 1 08-12          NA                  NA        NA
## 2 09-01          NA                  NA        NA
## 3 09-02          NA                  NA        NA
## 4 09-03          NA                  NA        NA
## 5 09-04          NA                  NA        NA
## 6 09-05          NA                  NA        NA
##   India_10_yr_bond_RF_monthly MRP Inflation_%
## 1                          NA  NA        0.68
## 2                          NA  NA        0.00
## 3                          NA  NA        0.00
## 4                          NA  NA        1.35
## 5                          NA  NA        0.67
## 6                          NA  NA        1.32
```

```
tail(All_Factors)
```

```
##       Date NIFTY_Close India_10_yr_bond_RF NIFTY_ret
## 2304 18-12          NA                  NA        NA
## 2305 19-01          NA                  NA        NA
## 2306 19-02          NA                  NA        NA
## 2307 19-03          NA                  NA        NA
## 2308 19-04          NA                  NA        NA
## 2309 19-05          NA                  NA        NA
##      India_10_yr_bond_RF_monthly MRP Inflation_%
## 2304                          NA  NA        1.99
## 2305                          NA  NA        0.00
## 2306                          NA  NA        0.65
## 2307                          NA  NA        0.97
## 2308                          NA  NA        0.64
## 2309                          NA  NA        0.64
```

```
All_Factors <- na.omit(All_Factors)

head(All_Factors)
```

```
##     Date NIFTY_Close India_10_yr_bond_RF  NIFTY_ret
## 8  09-07     4374.95               6.998  3.2811804
## 9  09-07     4502.25               6.998  2.8274752
## 10 09-07     4469.10               6.998 -0.7417601
## 11 09-07     4398.90               6.998 -1.5958535
## 12 09-07     4523.75               6.998  2.7598784
## 13 09-07     4568.55               6.998  0.9806175
##    India_10_yr_bond_RF_monthly       MRP Inflation_%
## 8                    0.5652579 2.7159225        1.25
## 9                    0.5652579 2.4890699        1.25
## 10                   0.5652579 1.2237072        1.25
## 11                   0.5652579 0.3775026        1.25
## 12                   0.5652579 0.7409262        1.25
## 13                   0.5652579 0.6866651        1.25
```

```
tail(All_Factors)
```

```
##       Date NIFTY_Close India_10_yr_bond_RF   NIFTY_ret
## 2298 18-11     10553.0               7.607  1.63508007
## 2299 18-11     10524.0               7.607 -0.27556062
## 2300 18-11     10530.0               7.607  0.05698006
## 2301 18-11     10585.2               7.607  0.52148283
## 2302 18-11     10482.2               7.607 -0.98261815
## 2303 18-11     10582.5               7.607  0.94779116
##      India_10_yr_bond_RF_monthly        MRP Inflation_%
## 2298                   0.6128328 -0.5780210       -0.33
## 2299                   0.6128328 -0.5781564       -0.33
## 2300                   0.6128328 -0.5781467       -0.33
## 2301                   0.6128328 -0.5779345       -0.33
## 2302                   0.6128328 -0.5783778       -0.33
## 2303                   0.6128328 -0.5779800       -0.33
```

```
dim(All_Factors)
```

```
## [1] 2296    7
```

```
APT_data <- All_Factors[,c("NIFTY_ret", "MRP", "Inflation_%")]

head(APT_data)
```

```
##     NIFTY_ret       MRP Inflation_%
## 8   3.2811804 2.7159225        1.25
## 9   2.8274752 2.4890699        1.25
## 10 -0.7417601 1.2237072        1.25
## 11 -1.5958535 0.3775026        1.25
## 12  2.7598784 0.7409262        1.25
## 13  0.9806175 0.6866651        1.25
```

```
tail(APT_data)
```

```
##        NIFTY_ret        MRP Inflation_%
## 2298  1.63508007 -0.5780210       -0.33
## 2299 -0.27556062 -0.5781564       -0.33
## 2300  0.05698006 -0.5781467       -0.33
## 2301  0.52148283 -0.5779345       -0.33
## 2302 -0.98261815 -0.5783778       -0.33
## 2303  0.94779116 -0.5779800       -0.33
```

```
dim(APT_data)
```

```
## [1] 2296    3
```

With the data ready, we finally proceed onto the regression for APT as follows with NIFTY returns being the:

```
summary(lm(APT_data$NIFTY_ret~APT_data$MRP+APT_data$`Inflation_%`))
```

```
##
## Call:
## lm(formula = APT_data$NIFTY_ret ~ APT_data$MRP + APT_data$`Inflation_%`)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.3190 -0.5559  0.0140  0.5730  3.6619
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)              0.34575    0.08902   3.884 0.000106 ***
## APT_data$MRP             0.59516    0.14786   4.025 5.88e-05 ***
## APT_data$`Inflation_%`   0.05085    0.02607   1.951 0.051230 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.003 on 2293 degrees of freedom
## Multiple R-squared:  0.00899,    Adjusted R-squared:  0.008126
## F-statistic:  10.4 on 2 and 2293 DF,  p-value: 3.187e-05
```

Conclusion of our Arbritage Pricing Theory modelling

We see that with alpha = 0.1, both **Inflation** and **Market Risk Premium** are **significant**.

With alpha = 0.05 cutoff, **Inflation** is **insignificant** whereas **Market Risk Premium** is **significant**.

Lastly, we close by clearing the workspace

```
rm(list=ls())
```