RiskParity

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R Markdown

The data wrangling process is divided into two parts data1 and data2

```
setwd('D:/summer_codes')

CRSP_Bonds <- readRDS("CRSP_Bonds.rds")

# Function to Clean Bond Data - Data downloaded from crsp for the past 90 years
Data1 <- function(CRSP_Bonds){

  # Replacing -99 in Returns with NA's
  length(which(CRSP_Bonds$TMRETNUA == -99))# checking for negative numbers in returns
  CRSP_Bonds[TMRETNUA == -99, TMRETNUA:= NA]
  CRSP_Bonds[,Bond_lag_MV:= shift(TMTOTOUT,1), by = KYCRSPID]

  CRSP_Bonds$Year <- substr(CRSP_Bonds$MCALDT,1,4)
  CRSP_Bonds$Month <- as.integer(substr(CRSP_Bonds$MCALDT,6,7))

  # Calculating Equal weighted returns
  CRSP_Bonds[,Bond_Ew_Ret:=mean(TMRETNUA, na.rm = TRUE), by = MCALDT]

  # Calculating Value weighted returns
  CRSP_Bonds[,Bond_Vw_Ret:=as.numeric(Bond_lag_MV)/(sum(as.numeric(Bond_lag_MV),na.rm =T))
             *TMRETNUA,by = MCALDT]
  CRSP_Bonds[,Bond_Vw_Ret:=sum(Bond_Vw_Ret, na.rm=T), by=MCALDT]

  #Checking order WRT to CRSP id and MCALDT
  setorder(CRSP_Bonds,MCALDT)

  CRSP_Bonds[,Bond_lag_MV:= sum(Bond_lag_MV,na.rm = TRUE),by =MCALDT]

  #Output
  CRSP_Bonds$Year <- as.integer(CRSP_Bonds$Year)

  Answer = unique(CRSP_Bonds[(!is.na(Bond_Ew_Ret) & !is.na(Bond_Vw_Ret)),
                             list(Year,Month,Bond_lag_MV,Bond_Ew_Ret,Bond_Vw_Ret)])
  return(Answer)
}
# Monthly_CRSP_Bonds <- PS2_Q1(CRSP_Bonds)
##############################################################################################
# Now merging the Bond data and the stock universe for further calculation
##############################################################################################
Monthly_CRSP_Bonds <- Data1(CRSP_Bonds)
Monthly_CRSP_Stocks <- readRDS(file = "Monthly_CRSP_Stocks.rda")
Monthly_CRSP_Riskless <- read.csv("Monthly_CRSP_Riskless.csv")
Monthly_CRSP_Riskless$caldt <- as.character(Monthly_CRSP_Riskless$caldt)
```

```r
Monthly_CRSP_Riskless$caldt <- as.Date(Monthly_CRSP_Riskless$caldt, '%Y%m%d')

Data2 <- function(Monthly_CRSP_Stocks,Monthly_CRSP_Bonds,Monthly_CRSP_Riskless){

  Monthly_CRSP_Riskless$Year <- substr(Monthly_CRSP_Riskless$caldt,1,4)
  Monthly_CRSP_Riskless$Month <- as.integer(substr(Monthly_CRSP_Riskless$caldt,6,7))
  Monthly_CRSP_Riskless$Year <- as.integer(Monthly_CRSP_Riskless$Year)
  #Monthly_CRSP_Bonds$Year <- as.character(Monthly_CRSP_Bonds$Year)
  Merged = merge(x = Monthly_CRSP_Bonds, y = Monthly_CRSP_Stocks,by = c('Year','Month'))
  Merged = merge(x = Merged, y = Monthly_CRSP_Riskless, by =c('Year','Month'))

  Merged[,Stock_Excess_Vw_Ret:= Stock_Vw_Ret - t30ret, by = c('Year','Month') ]
  Merged[,Bond_Excess_Vw_Ret:= Bond_Vw_Ret - t30ret, by = c('Year','Month') ]

  #Output
  Merged$Year <- as.integer(Merged$Year)
  Answer2 = Merged[(!is.na(Stock_Excess_Vw_Ret) & !is.na(Bond_Excess_Vw_Ret)),
                   list(Year,Month,Stock_lag_MV = Stock_lag_MV,Stock_Excess_Vw_Ret,
                        Bond_lag_MV,Bond_Excess_Vw_Ret)]
  return(Answer2)
}
Monthly_CRSP_Universe <- Data2(Monthly_CRSP_Stocks,Monthly_CRSP_Bonds,
                               Monthly_CRSP_Riskless)
##############################################################################################
#Q3
##############################################################################################


Portfolios <- function(Monthly_CRSP_Universe){

  #Calculating the inverse the SD for stocks using t-1 months on a three year window
  Monthly_CRSP_Universe[,Stock_sigma_hat:= rollapply(data = shift(Stock_Excess_Vw_Ret,1),
                                                     width  = 36, FUN = sd,fill = NA ,align = 'right')]
  Monthly_CRSP_Universe[,Stock_inverse_sigma_hat:= 1/Stock_sigma_hat]

  Monthly_CRSP_Universe[,Bond_sigma_hat:= rollapply(data = shift(Bond_Excess_Vw_Ret,1),
                                                    width  = 36, FUN = sd,fill = NA ,align = 'right')]
  Monthly_CRSP_Universe[,Bond_inverse_sigma_hat:= 1/Bond_sigma_hat]

  #Calculating the Excess Value weighted returns
  Monthly_CRSP_Universe[,Excess_Vw_Ret:= Stock_lag_MV/(Stock_lag_MV + Bond_lag_MV) *
                          Stock_Excess_Vw_Ret
                        +Bond_lag_MV/(Stock_lag_MV + Bond_lag_MV) * Bond_Excess_Vw_Ret]

  #Calculating the 60/40  Value weighted returns
  Monthly_CRSP_Universe[,Excess_60_40_Ret:= (0.6 * Stock_Excess_Vw_Ret)
                        +(0.4 * Bond_Excess_Vw_Ret)]

  #Calculating the Unleverd K
  Monthly_CRSP_Universe[,Unlevered_k:=1/(Stock_inverse_sigma_hat + Bond_inverse_sigma_hat)]

  #Calculating the Excess Unleverd portfolio retuns
  Monthly_CRSP_Universe[,Excess_Unlevered_RP_Ret:= (Unlevered_k * Stock_inverse_sigma_hat *
```

```
                                                    Stock_Excess_Vw_Ret) +
                          (Unlevered_k * Bond_inverse_sigma_hat * Bond_Excess_Vw_Ret)]

  #Calculating the leverd K is kept constant over time
  Monthly_CRSP_Universe[,Levered_k:=sd(Excess_Vw_Ret,na.rm = T)/
                          sd(Stock_Excess_Vw_Ret*Stock_inverse_sigma_hat +
                          Bond_Excess_Vw_Ret * Bond_inverse_sigma_hat,na.rm = T)]

  #Calculating the Excess leverd portfolio retuns
  Monthly_CRSP_Universe[,Excess_Levered_RP_Ret:= (Levered_k * Stock_inverse_sigma_hat *
                                                  Stock_Excess_Vw_Ret) +
                          (Levered_k * Bond_inverse_sigma_hat * Bond_Excess_Vw_Ret)]

  Answer3 = Monthly_CRSP_Universe[,list(Year,Month,Stock_Excess_Vw_Ret,
                        Bond_Excess_Vw_Ret,Excess_Vw_Ret,Excess_60_40_Ret,
                        Stock_inverse_sigma_hat,Bond_inverse_sigma_hat,Unlevered_k,
                        Excess_Unlevered_RP_Ret,Levered_k,Excess_Levered_RP_Ret)]
  #list(Year, Month, Stock_lag_MV, Stock_Ew_Ret, Stock_Vw_Ret)
  #Output
  Port_Rets <- Answer3
}

Port_Rets <- Portfolios(Monthly_CRSP_Universe)
################################################################################################
#Q4
################################################################################################


Table <- function(Port_Rets){

  A <-  Port_Rets
  A[,Format:=formatC(Month,width = 2,flag = 0)]
  A[,Format1:=paste(Year,Format,sep = "")]
  A <- A[Format1 >= 192901 & Format1 <= 201006,]
  A <- A[,list(Stock_Excess_Vw_Ret,Bond_Excess_Vw_Ret,Excess_Vw_Ret,Excess_60_40_Ret
               ,Excess_Unlevered_RP_Ret,Excess_Levered_RP_Ret)]


  Output <- matrix(0, ncol=6, nrow=6)
  rownames(Output) <- c('CRSP stocks', 'CRSP bonds', 'Value-weighted portfolio',
                        '60/40 portfolio',
                        'unlevered RP', 'levered RP')

  colnames(Output) <- c('Annualized Mean', 't-stat of Annualized Mean',
                        'Annualized Standard Deviation',
                        'Annualized Sharpe Ratio', 'Skewness',
                        'Excess Kurtosis')

  Output[,1] <- apply(A,2,function(x) mean(x)*12)
  Output[,2] <- apply(A,2,function(i) t.test(i)$statistic)
  Output[,3] <- apply(A,2,function(i) sd(i)*sqrt(12))
  Output[,4] <- (Output[,1]/Output[,3])
  Output[,5] <- apply(A,2,function(i) skewness(i))
```

```
  Output[,6] <- apply(A,2,function(i) kurtosis(i))- 3

  return(Output)
}
```

CONCLUSION: Risk Parity holds up consistently in out-ofsample tests across time periods. Check the plot and output below

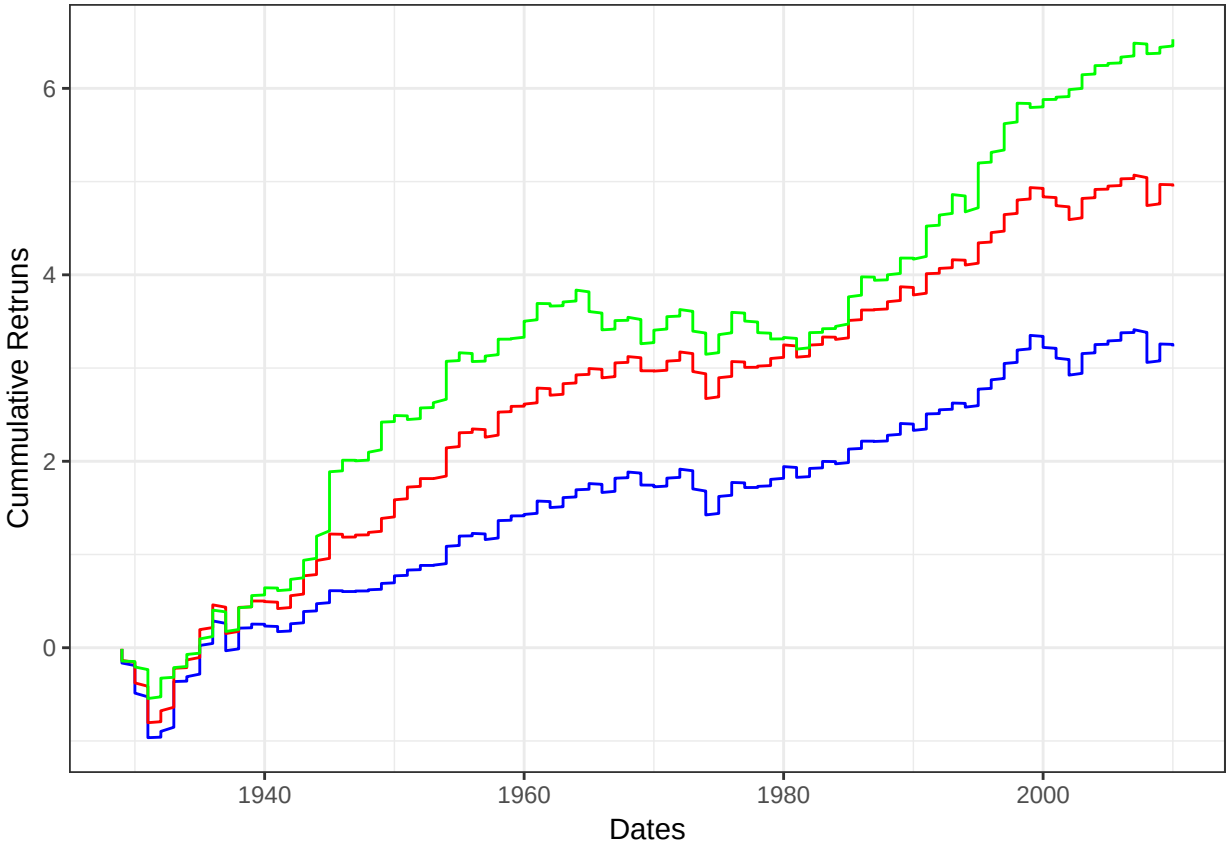
```
Output <- Table(Port_Rets)
Cum_ret <- Port_Rets
Cum_ret <-Cum_ret[,Format:=formatC(Month,width = 2,flag = 0)]
Cum_ret <-Cum_ret[,Format1:=paste(Year,Format,sep = "")]
Cum_ret <-Cum_ret <- Cum_ret[Format1 >= 192901 & Format1 <= 201006,]
Cum_ret <-Cum_ret <- Cum_ret[,list(Year,Stock_Excess_Vw_Ret,
                         Bond_Excess_Vw_Ret,Excess_Vw_Ret,Excess_60_40_Ret
                         ,Excess_Unlevered_RP_Ret,Excess_Levered_RP_Ret)]
Cum_ret <-Cum_ret[,Excess_Vw_Ret := mean(Excess_Vw_Ret), by = Year]
Cum_ret <-Cum_ret[,Excess_60_40_Ret := mean(Excess_60_40_Ret), by = Year]
Cum_ret <-Cum_ret[,Excess_Unlevered_RP_Ret := mean(Excess_Unlevered_RP_Ret), by = Year]
Cum_ret <-Cum_ret[,Excess_Levered_RP_Ret := mean(Excess_Levered_RP_Ret), by = Year]

# STandardizing All portfolio wrt Market porfolio Standard deviation
Cum_ret <-Cum_ret[,Excess_Vw_Ret := cumsum(Excess_Vw_Ret)]
Cum_ret <-Cum_ret[,Excess_60_40_Ret := cumsum(Excess_60_40_Ret*
                                            (Output[3,3]/Output[4,3]))]
Cum_ret <-Cum_ret[,Excess_Unlevered_RP_Ret := cumsum(Excess_Unlevered_RP_Ret*
                                                (Output[3,3]/Output[5,3]))]
Cum_ret <-Cum_ret[,Excess_Levered_RP_Ret := cumsum(Excess_Levered_RP_Ret*
                                                 (Output[3,3]/Output[6,3]))]

print(Output)
```

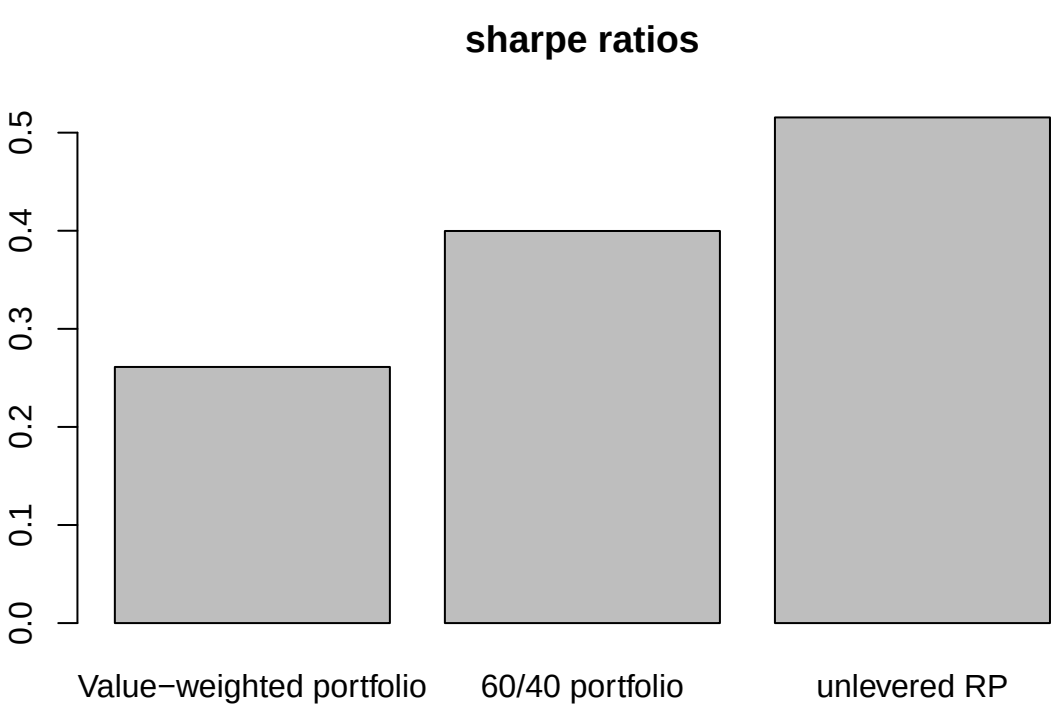
```
##                          Annualized Mean t-stat of Annualized Mean
## CRSP stocks                   0.06777345                  3.207578
## CRSP bonds                    0.01519707                  4.203610
## Value-weighted portfolio      0.03965940                  2.357433
## 60/40 portfolio               0.04674290                  3.608734
## unlevered RP                  0.02186947                  4.653993
## levered RP                    0.07973124                  4.760000
##                          Annualized Standard Deviation
## CRSP stocks                                 0.19074853
## CRSP bonds                                  0.03263744
## Value-weighted portfolio                    0.15187473
## 60/40 portfolio                             0.11693365
## unlevered RP                                0.04242203
## levered RP                                  0.15121693
##                          Annualized Sharpe Ratio    Skewness
## CRSP stocks                            0.3553026  0.21199242
## CRSP bonds                             0.4656329 -0.02106477
## Value-weighted portfolio               0.2611323  0.46135433
## 60/40 portfolio                        0.3997386  0.22869646
## unlevered RP                           0.5155216  0.04856159
## levered RP                             0.5272640 -0.36046847
##                          Excess Kurtosis
```

```
## CRSP stocks                    7.853317
## CRSP bonds                     4.568924
## Value-weighted portfolio      13.844103
## 60/40 portfolio                7.780905
## unlevered RP                   4.661398
## levered RP                     1.964569
```

Including Plots

```
## Loading required package: ggplot2
```




sharpe ratios
0.0
0.1
0.2
0.3
0.4
0.5
Value−weighted portfolio
60/40 portfolio
unlevered RP