

Kalman filter StatArb Gold and Silver

Gold

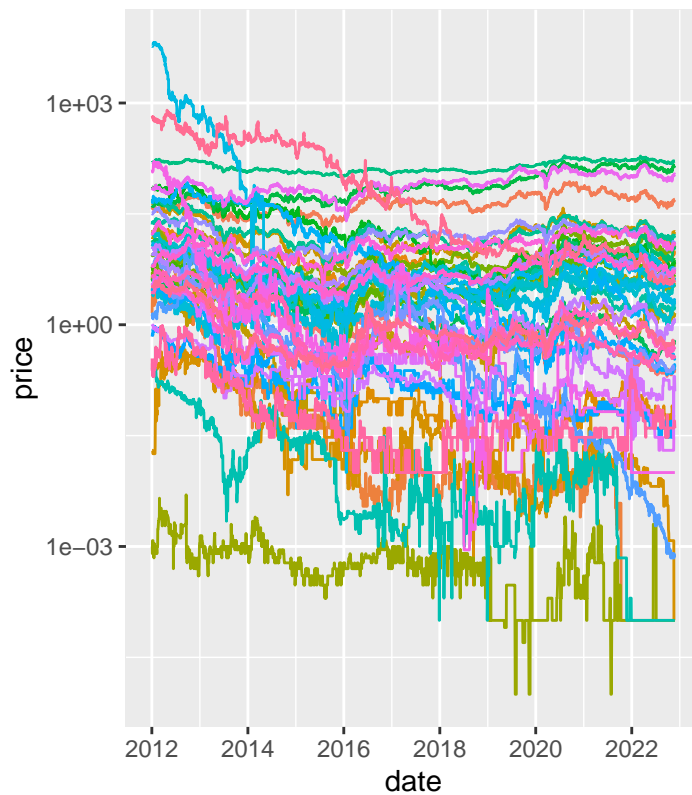
```
tickers <- c(read.csv("zacks_custom_screen_2022-04-18.csv")$Ticker, "GLD" )
```

```
prices <- tq_get(tickers, get = "stock.prices", to = "2022-11-28") %>% select(date, symbol, close) %>% spread
```

```
## Warning: x = 'DTRC', get = 'stock.prices': Error in getSymbols.yahoo(Symbols = "DTRC", env = <enviro  
## DTRC download failed after two attempts. Error message:  
## HTTP error 404.  
## Removing DTRC.
```

```
date <- prices$date  
prices <- prices %>% select(-date)  
xy <- xts(as.matrix(prices), order.by = date)  
xy <- xy[,which(colSums(is.na(xy))==0) %>% names()]  
tickers <- xy %>% colnames()  
list <- tickers[tickers != "GLD"]  
colnames(xy) <- tickers  
xy %>% as.data.frame() %>% mutate(date = as.Date(rownames(.))) %>% gather("stock", "price", -date) %>%  
  ggplot(aes(date, price, color=stock))+geom_line()+scale_y_log10()+ggtitle("Gold mining stocks")
```

Gold mining stocks



stock

AAU	FNV	NAK
AEM	GAU	NCMGY
AGCZ	GFI	NG
AGI	GLD	NGD
AHNR	GOLD	OROXF
AIVN	GORO	PGXPF
AU	GYPHQ	RGLD
AUGG	HMY	RYSMF
AUY	IAG	SA
BTG	IDR	SAND
CBLRF	JAGGF	THM
CGAU	KGC	TRX
CMCL	LODE	URHG
DPMLF	LONCF	USAU
DRD	MGHCF	VGZ
EGO	MXSG	

```
func <-function(t){
  i<-t
  x <- xy[, i]
  y <- xy[, "GLD"]
  x$int <- rep(1, nrow(x))
  delta <- 0.00001
  Vw <- delta/(1-delta)*diag(2)
  Ve <- 0.001
  R <- matrix(rep(0, 4), nrow=2)
  P <- matrix(rep(0, 4), nrow=2)
  beta <- matrix(rep(0, nrow(y)*2), ncol=2)
  y_est <- rep(0, nrow(y))
  e <- rep(0, nrow(y))
  Q <- rep(0, nrow(y))
  for(i in 1:nrow(y)) {
    if(i > 1) {
      beta[i, ] <- beta[i-1, ]
      R <- P + Vw
    }
    y_est[i] <- x[i, ] %*% beta[i, ]
    Q[i] <- x[i, ] %*% R %*% t(x[i, ]) + Ve

    e[i] <- y[i] - y_est[i]
    K <- R %*% t(x[i, ]) / Q[i]
```

```

    beta[i, ] <- beta[i, ] + K * e[i]
    P = R - K %*% x[i, ] %*% R
  }

  e <- xts(e, order.by=index(xy))
  sqrtQ <- xts(sqrt(Q), order.by=index(xy))
  signals <- merge(e, 15*sqrtQ, 15*-sqrtQ)
  colnames(signals) <- c("e", "sqrtQ", "negsqrtQ")

  sig <- ifelse((signals[1:length(index(signals))])$e > signals[1:length(index(signals))])$sqrtQ) & (lag.xts(
    ifelse((signals[1:length(index(signals))])$e < signals[1:length(index(signals))])$negsqrtQ) &
  colnames(sig) <- "sig"

  sig[sig == 0] <- NA
  sig <- na.locf(sig)
  sig <- diff(sig)/2
  plot(sig)

  sim <- merge(lag.xts(sig,1), beta[, 1], x[, 1], y)
  colnames(sim) <- c("sig", "hedge", tickers[1], tickers[2])

  i <- t

  sim$posX <- sim$sig * -1

  difference <-c(diff(sim[,3])/sim[,3][-1] )

  pnl <- sim$posX * difference

  print(pnl)

}
a <- sapply(list,func)

```

```

date <-rownames(as.data.frame(xy))
df

```

```

## function (x, df1, df2, ncp, log = FALSE)
## {
##   if (missing(ncp))
##     .Call(C_df, x, df1, df2, log)
##   else .Call(C_dnf, x, df1, df2, ncp, log)
## }
## <bytecode: 0x0000000030cfbc00>
## <environment: namespace:stats>

```

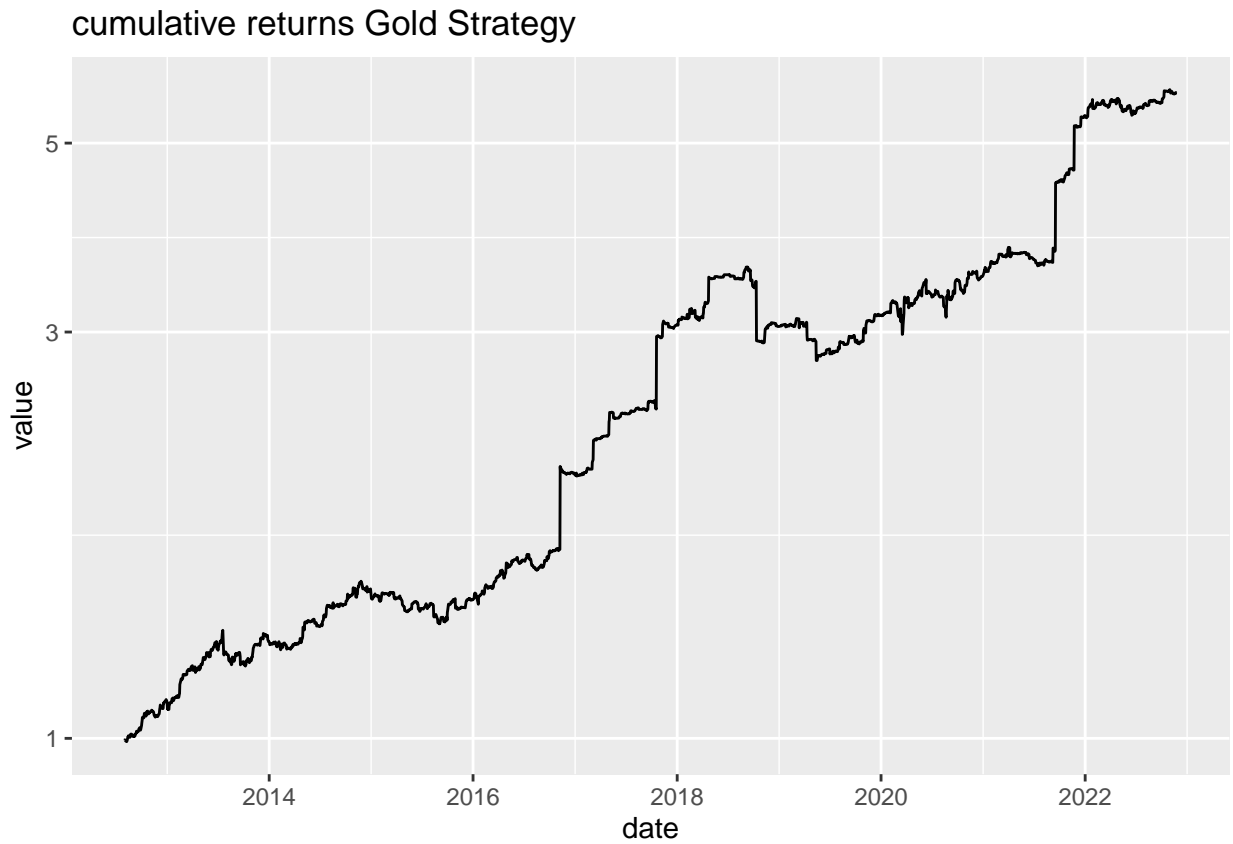
```

a<-a %>% as.data.frame()
a <-a %>% na.omit() %>% rowMeans() %>% as.vector()
gold_strategy <- data.frame(value=a)

```

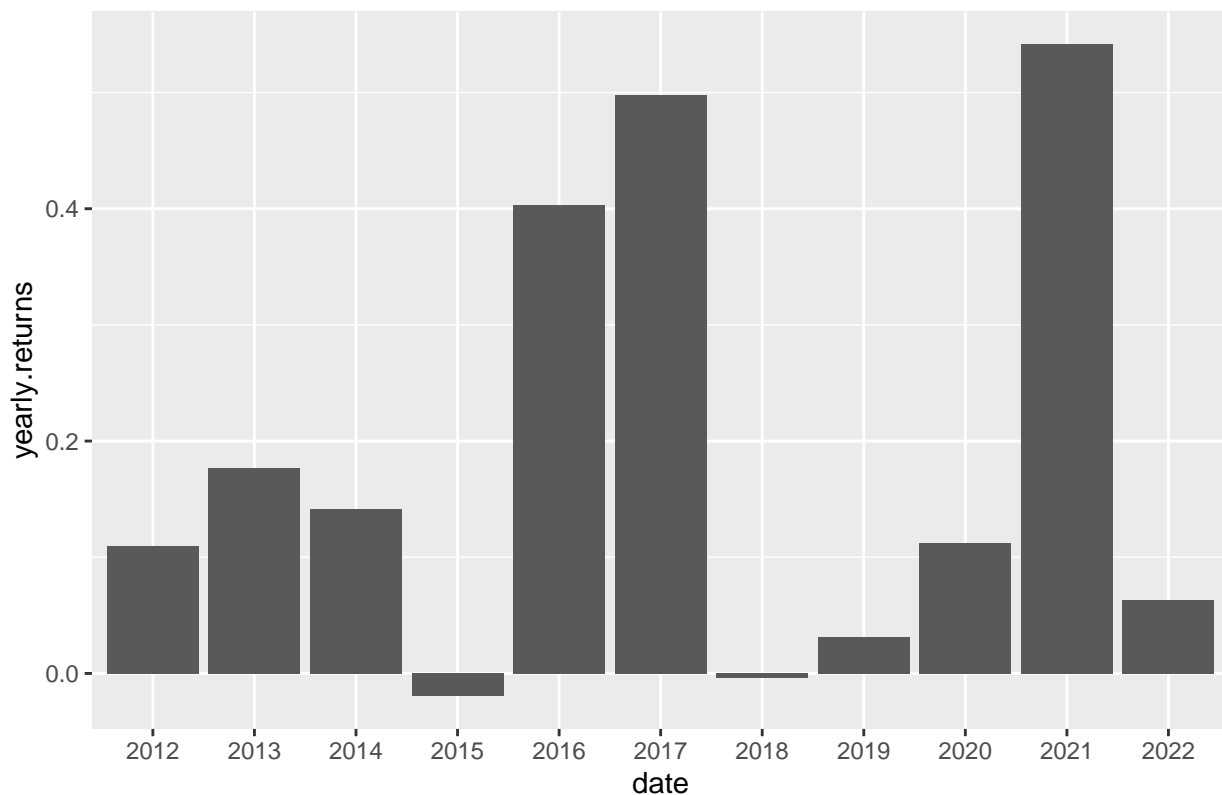
```
rownames(gold_strategy) <- date[(length(date)-(nrow(gold_strategy)-1)):length(date)]
gold_strategy <-gold_strategy %>% as.xts()

gold_strategy %>% as.data.frame() %>% mutate(date=as.Date(rownames(.)),value=cumprod(value+1)) %>%
  ggplot(aes(date,value))+geom_line()+scale_y_log10()+ ggtitle("cumulative returns Gold Strategy")
```



```
annualReturn(cumprod(gold_strategy+1)) %>% as.data.frame() %>% mutate(date=as.factor(round(year(as.Date
  ggplot(aes(date,yearly.returns))+geom_bar(stat = 'identity')+ ggtitle("Annual returns Gold Strategy")
```

Annual returns Gold Strategy



Silver

```
tickers <- c(read.csv("silver_mining.csv")$Ticker,"SLV" )
```

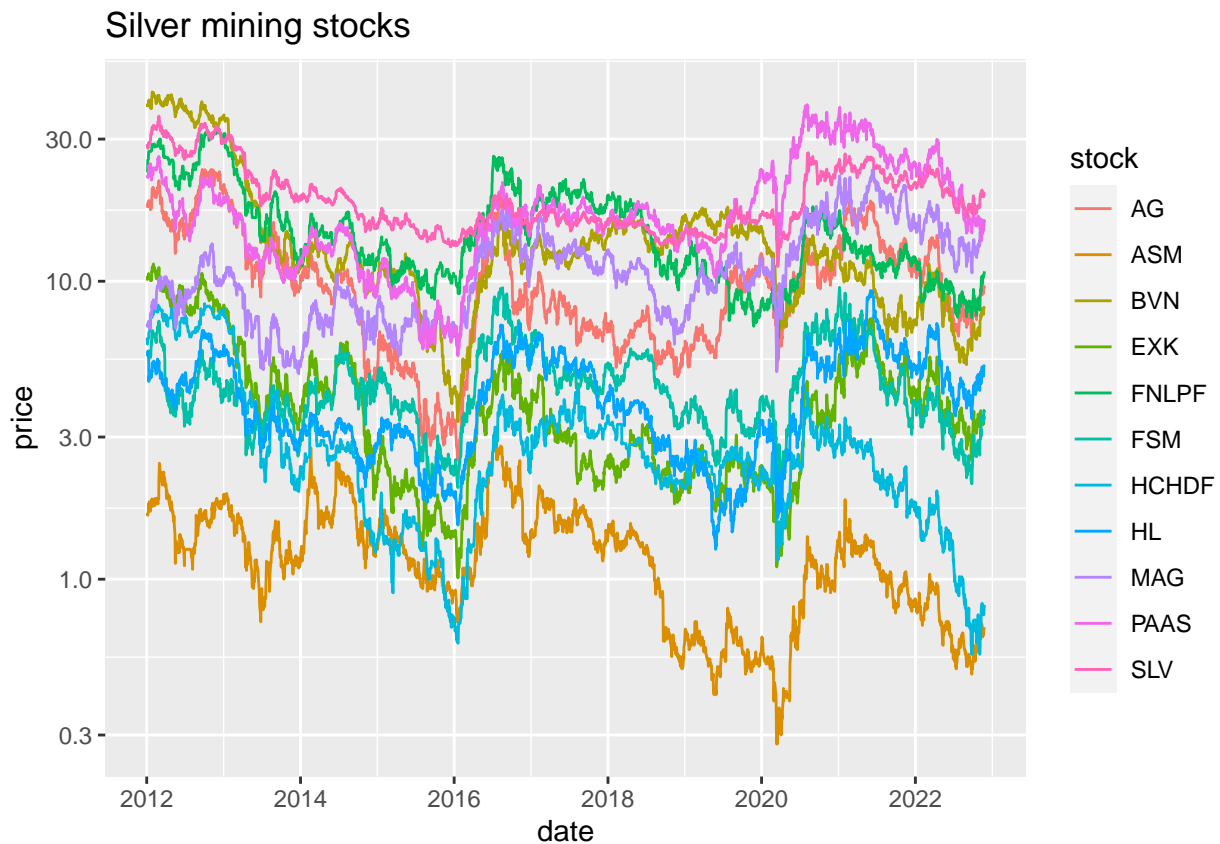
```
prices <- tq_get(tickers,get = "stock.prices",to = "2022-11-28") %>% select(date,symbol,close) %>% spr
```

```
## Warning: x = 'AXU', get = 'stock.prices': Error in getSymbols.yahoo(Symbols = "AXU", env = <environm
## AXU download failed after two attempts. Error message:
## HTTP error 404.
## Removing AXU.
```

```
## Warning: x = 'GPL', get = 'stock.prices': Error in getSymbols.yahoo(Symbols = "GPL", env = <environm
## GPL download failed after two attempts. Error message:
## HTTP error 404.
## Removing GPL.
```

```
date <- prices$date
prices <- prices %>% select(-date)
xy <- xts(as.matrix(prices),order.by = date)
xy <- xy[,which(colSums(is.na(xy))==0) %>% names()]
tickers <- xy %>% colnames()
list <- tickers[tickers != "SLV"]
```

```
colnames(xy) <- tickers
xy %>% as.data.frame() %>% mutate(date = as.Date(rownames(.))) %>% gather("stock", "price", -date) %>%
  ggplot(aes(date, price, color=stock)) + geom_line() + scale_y_log10() + ggtitle("Silver mining stocks")
```



```
func <-function(t){
  i<-t
  x <- xy[, i]
  y <- xy[, "SLV"]
  x$int <- rep(1, nrow(x))
  delta <- 0.0001
  Vw <- delta/(1-delta)*diag(2)
  Ve <- 0.001
  R <- matrix(rep(0, 4), nrow=2)
  P <- matrix(rep(0, 4), nrow=2)
  beta <- matrix(rep(0, nrow(y)*2), ncol=2)
  y_est <- rep(0, nrow(y))
  e <- rep(0, nrow(y))
  Q <- rep(0, nrow(y))
  for(i in 1:nrow(y)) {
    if(i > 1) {
      beta[i, ] <- beta[i-1, ]
      R <- P + Vw
    }
    y_est[i] <- x[i, ] %*% beta[i, ]
    Q[i] <- x[i, ] %*% R %*% t(x[i, ]) + Ve
  }
}
```

```

e[i] <- y[i] - y_est[i]
K <- R %*% t(x[i, ]) / Q[i]

beta[i, ] <- beta[i, ] + K * e[i]
P = R - K %*% x[i, ] %*% R
}

e <- xts(e, order.by=index(xy))
sqrtQ <- xts(sqrt(Q), order.by=index(xy))
signals <- merge(e, 3*sqrtQ, 3*-sqrtQ)
colnames(signals) <- c("e", "sqrtQ", "negsqrtQ")

sig <- ifelse((signals[1:length(index(signals))])$e > signals[1:length(index(signals))])$sqrtQ) & (lag.xt.
            ifelse((signals[1:length(index(signals))])$e < signals[1:length(index(signals))])$negsqrtQ) &
colnames(sig) <- "sig"

sig[sig == 0] <- NA
sig <- na.locf(sig)
sig <- diff(sig)/2

plot(sig)

sim <- merge(lag.xts(sig,1), beta[, 1], x[, 1], y)
colnames(sim) <- c("sig", "hedge", tickers[1], tickers[2])

i <- t

sim$posX <- sim$sig * -1

difference <-c(diff(sim[,3])/sim[,3][-1] )

pos<- sim$posX * difference

print(pos)

}
a <- sapply(list,func)

date <-rownames(as.data.frame(xy))

a<-a %>% as.data.frame()
a <-a %>% na.omit() %>% rowMeans() %>% as.vector()
silver_strategy <- data.frame(value=a)
rownames(silver_strategy) <- date[(length(date)-(nrow(silver_strategy)-1)):length(date)]
silver_strategy <-silver_strategy %>% as.xts()
silver_strategy %>% as.data.frame() %>% mutate(date=as.Date(rownames(.)),value=cumprod(value+1)) %>%
  ggplot(aes(date,value))+geom_line()+scale_y_log10()+ ggtitle("cumulative returns Silver Strategy")

```



```
annualReturn(cumprod(silver_strategy+1)) %>% as.data.frame() %>% mutate(date=as.factor(round(year(as.Date(date))))
ggplot(aes(date,yearly.returns))+geom_bar(stat = 'identity')+ ggtitle("Annual returns Silver Strategy")
```