

R Code for Lecture 10

```
# Load R packages
library(WindR)
library(TSA)
library(MTS)
library(vars)
library(dplyr)

# Download data from Wind and clean it
w.start()
index <- w.wsd("SP400.SPI,SP500.SPI","close",
               "2011-01-01","2014-12-31","TradingCalendar=NYSE")$Data %>%
  rename(SP400 = `SP400.SPI`, SP500 = `SP500.SPI`, date = `DATETIME`) %>%
  mutate(R.SP400 = (SP400-lag(SP400, n = 1L))/lag(SP400, n = 1L),
         R.SP500 = (SP500-lag(SP500, n = 1L))/lag(SP500, n = 1L))

# LSE of VAR(2) model of S&P 500/400 index
data <- filter(select(index, R.SP400, R.SP500), !is.na(R.SP500*R.SP400))
var.lse <- VAR(data, ic = "SC")
summary(var.lse)

##
## VAR Estimation Results:
## =====
## Endogenous variables: R.SP400, R.SP500
## Deterministic variables: const
## Sample size: 1004
## Log Likelihood: 7447.476
## Roots of the characteristic polynomial:
## 0.1039 0.01331
## Call:
## VAR(y = data, ic = "SC")
##
##
## Estimation results for equation R.SP400:
## =====
## R.SP400 = R.SP400.l1 + R.SP500.l1 + const
##
##           Estimate Std. Error t value Pr(>|t|)
## R.SP400.l1 0.1561876 0.1013750  1.541  0.1237
## R.SP500.l1 -0.2403031 0.1220906 -1.968  0.0493 *
## const      0.0005807 0.0003700  1.569  0.1169
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.0117 on 1001 degrees of freedom
## Multiple R-Squared: 0.00497, Adjusted R-squared: 0.002982
## F-statistic: 2.5 on 2 and 1001 DF, p-value: 0.08262
##
##
## Estimation results for equation R.SP500:
```

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## =====
## R.SP500 = R.SP400.l1 + R.SP500.l1 + const
##
##           Estimate Std. Error t value Pr(>|t|)
## R.SP400.l1  0.1546488  0.0840912   1.839   0.0662 .
## R.SP500.l1 -0.2467869  0.1012749  -2.437   0.0150 *
## const       0.0005788  0.0003069   1.886   0.0597 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009709 on 1001 degrees of freedom
## Multiple R-Squared:  0.008213,    Adjusted R-squared:  0.006232
## F-statistic: 4.145 on 2 and 1001 DF,  p-value: 0.01612
##
##
## Covariance matrix of residuals:
##      R.SP400  R.SP500
## R.SP400 0.000137 1.080e-04
## R.SP500 0.000108 9.426e-05
##
## Correlation matrix of residuals:
##      R.SP400 R.SP500
## R.SP400  1.0000  0.9506
## R.SP500  0.9506  1.0000
##
## # Test if S&P 400 index Granger causes S&P 500 index
causality(var.lse, cause = "R.SP400")
## $Granger
##
## Granger causality H0: R.SP400 do not Granger-cause R.SP500
##
## data:  VAR object var.lse
## F-Test = 3.3821, df1 = 1, df2 = 2002, p-value = 0.06605
##
## $Instant
##
## H0: No instantaneous causality between: R.SP400 and R.SP500
##
## data:  VAR object var.lse
## Chi-squared = 476.61, df = 1, p-value < 2.2e-16
##
## # Test if S&P 500 index Granger causes S&P 400 index
causality(var.lse, cause = "R.SP500")
## $Granger
##
## Granger causality H0: R.SP500 do not Granger-cause R.SP400
##
## data:  VAR object var.lse
## F-Test = 3.8739, df1 = 1, df2 = 2002, p-value = 0.04918

```

```
##
##
## $Instant
##
## H0: No instantaneous causality between: R.SP500 and R.SP400
##
## data: VAR object var.lse
## Chi-squared = 476.61, df = 1, p-value < 2.2e-16
var.lse <- VAR(data, p = 2)
summary(var.lse)

##
## VAR Estimation Results:
## =====
## Endogenous variables: R.SP400, R.SP500
## Deterministic variables: const
## Sample size: 1003
## Log Likelihood: 7447.585
## Roots of the characteristic polynomial:
## 0.1842 0.1842 0.1783 0.1783
## Call:
## VAR(y = data, p = 2)
##
##
## Estimation results for equation R.SP400:
## =====
## R.SP400 = R.SP400.l1 + R.SP500.l1 + R.SP400.l2 + R.SP500.l2 + const
##
##           Estimate Std. Error t value Pr(>|t|)
## R.SP400.l1 0.1582081 0.1018127 1.554 0.1205
## R.SP500.l1 -0.2427034 0.1227641 -1.977 0.0483 *
## R.SP400.l2 0.1532826 0.1015276 1.510 0.1314
## R.SP500.l2 -0.1309786 0.1224904 -1.069 0.2852
## const      0.0005628 0.0003708 1.518 0.1294
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.0117 on 998 degrees of freedom
## Multiple R-Squared: 0.008725, Adjusted R-squared: 0.004752
## F-statistic: 2.196 on 4 and 998 DF, p-value: 0.06754
##
##
## Estimation results for equation R.SP500:
## =====
## R.SP500 = R.SP400.l1 + R.SP500.l1 + R.SP400.l2 + R.SP500.l2 + const
##
##           Estimate Std. Error t value Pr(>|t|)
## R.SP400.l1 0.1546722 0.0842453 1.836 0.0667 .
## R.SP500.l1 -0.2464655 0.1015816 -2.426 0.0154 *
## R.SP400.l2 0.1848443 0.0840094 2.200 0.0280 *
## R.SP500.l2 -0.1509142 0.1013552 -1.489 0.1368
## const      0.0005550 0.0003069 1.809 0.0708 .
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.00968 on 998 degrees of freedom
## Multiple R-Squared:  0.01682, Adjusted R-squared:  0.01288
## F-statistic: 4.269 on 4 and 998 DF,  p-value: 0.001977
##
##
##
## Covariance matrix of residuals:
##           R.SP400  R.SP500
## R.SP400  0.0001369 0.0001077
## R.SP500  0.0001077 0.0000937
##
## Correlation matrix of residuals:
##           R.SP400 R.SP500
## R.SP400   1.0000  0.9508
## R.SP500   0.9508  1.0000
```

```
Psi(var.lse)
```

```
## , , 1
##
##           [,1]      [,2]
## [1,] 0.011698520 0.000000000
## [2,] 0.009204109 0.002997741
##
## , , 2
##
##           [,1]      [,2]
## [1,] -0.0003830687 -0.0007275622
## [2,] -0.0004590598 -0.0007388400
##
## , , 3
##
##           [,1]      [,2]
## [1,] 0.0006384487 -0.0003284272
## [2,] 0.0008272666 -0.0003828367
##
## , , 4
##
##           [,1]      [,2]
## [1,] -9.836346e-05 2.620558e-05
## [2,] -1.066719e-04 2.057320e-05
##
## , , 5
##
##           [,1]      [,2]
## [1,] -1.634283e-07 -1.045996e-06
## [2,] 4.244198e-06 -3.949716e-06
##
## , , 6
##
##           [,1]      [,2]
## [1,] -2.161608e-06 2.115335e-06
```

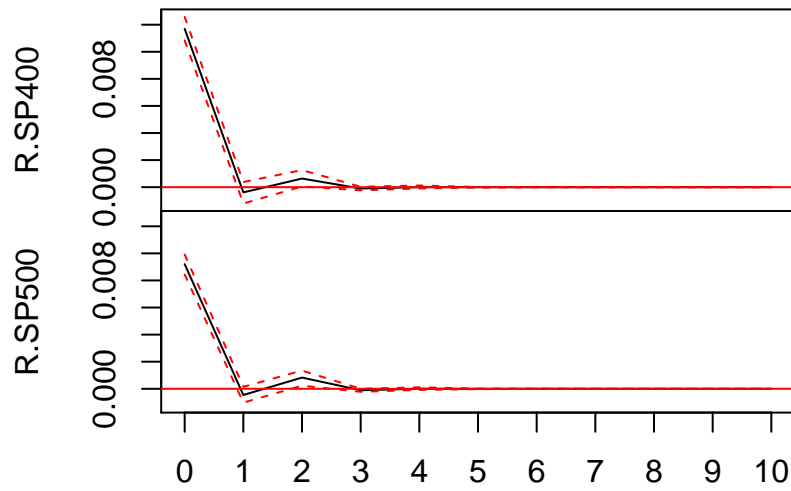
```

## [2,] -3.154953e-06 2.550848e-06
##
## , , 7
##
##          [,1]          [,2]
## [1,] -1.572155e-07 7.255890e-08
## [2,] -2.274717e-07 1.012092e-07
##
## , , 8
##
##          [,1]          [,2]
## [1,] 1.122300e-07 -2.294693e-08
## [2,] 1.083134e-07 -7.673210e-09
##
## , , 9
##
##          [,1]          [,2]
## [1,] -2.836809e-09 -3.902304e-09
## [2,] -4.068341e-09 -3.519879e-09
##
## , , 10
##
##          [,1]          [,2]
## [1,] 3.554763e-09 -2.275427e-09
## [2,] 4.962984e-09 -2.819662e-09
##
## , , 11
##
##          [,1]          [,2]
## [1,] -5.441089e-10 1.872243e-10
## [2,] -5.837792e-10 1.528850e-10

irf.var.lse <- irf(var.lse)
plot(irf.var.lse)

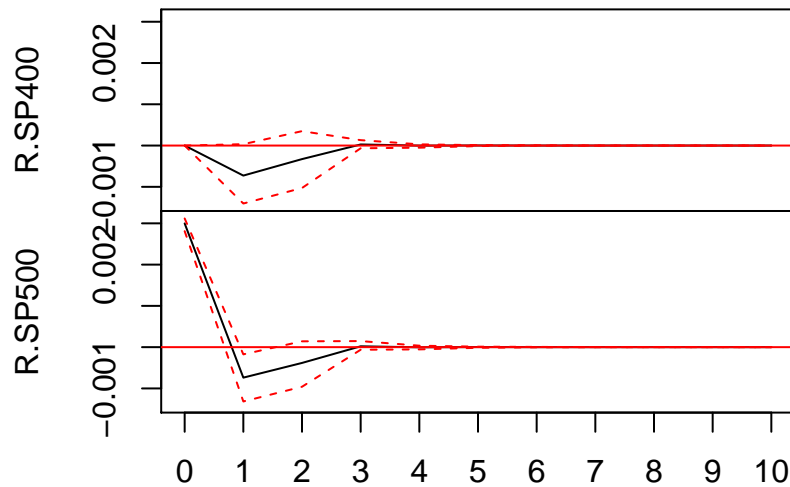
```

Orthogonal Impulse Response from R.SP400



95 % Bootstrap CI, 100 runs

Orthogonal Impulse Response from R.SP500



95 % Bootstrap CI, 100 runs

```
##
# Monte Carlo simulation of ECM model
n <- 200; e <- rnorm(n)
X = cumsum(e)
Y = X + rnorm(n, 0, 1/2)

t <- lm(Y ~ X)
hatZ <- residuals(t)[-c(1, n)]
summary(t)

##
## Call:
## lm(formula = Y ~ X)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.24300 -0.32628 -0.01923  0.32633  1.58047
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.043593   0.036801  -1.185    0.238
## X             1.003497   0.007592 132.185 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.485 on 198 degrees of freedom
```

```
## Multiple R-squared:  0.9888, Adjusted R-squared:  0.9887
## F-statistic: 1.747e+04 on 1 and 198 DF,  p-value: < 2.2e-16

dX <- diff(X); dY <- diff(Y)
data <- data.frame(embed(cbind(dY, dX), 2), hatZ)
colnames(data) <- c("dY0", "dX0", "dY1", "dX1", "hatZ")
attach(data)

ecm <- lm(dY0 ~ hatZ + dX1)
summary(ecm)

##
## Call:
## lm(formula = dY0 ~ hatZ + dX1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.73442 -0.78794  0.06556  0.75992  3.13936
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.01073    0.08103  -0.132   0.895
## hatZ        -1.23152    0.16913  -7.281 7.94e-12 ***
## dX1         -0.05064    0.08505  -0.595   0.552
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.14 on 195 degrees of freedom
## Multiple R-squared:  0.2226, Adjusted R-squared:  0.2146
## F-statistic: 27.92 on 2 and 195 DF,  p-value: 2.171e-11
```