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## CCAMP - Consumer Capital Asset Pricing Model

The goal is to create 10 regression models to identify beta values (risk)

Part of analysis is to create autocoreglama, investigate autocorrelation and apply reasonable Lag to solve autocorrelation problem. Autocorrelation means data correlated with itself over specific time

```
library(Hmisc)
```

```
## Loading required package: lattice
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

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

```
##
```

```
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      format.pval, units
```

```
CCAPM <- read.delim("Data/CCAPM.txt")
```

```
attach(CCAPM)
```

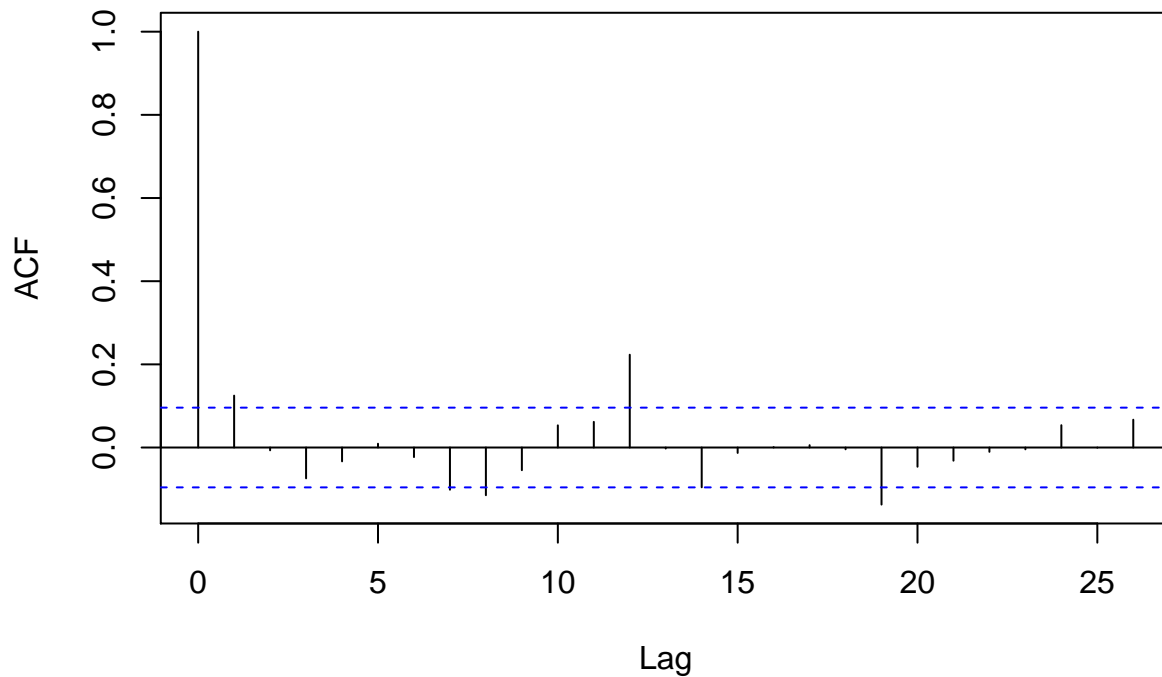
```
CCAPM[1:5,]
```

```
##      ENTRY      r1      r2      r3      r4      r5      r6      r7
## 1 1959:02  0.032750 0.017290  0.031550 0.025390 0.038210  0.03498 0.024620
## 2 1959:03  0.016350 0.021230  0.023310 0.020960 0.007620  0.01008 0.012740
## 3 1959:04  0.026960 0.014530  0.010370 0.034430 0.028730  0.03458 0.036310
## 4 1959:05  0.001786 0.020740 -0.005343 0.004528 0.014250 -0.00068 0.017130
## 5 1959:06 -0.010470 0.004005  0.005863 0.008635 0.007676  0.01416 0.009478
##      r8      r9      r10    rfree    cons
## 1 0.035580 0.017120  0.004037 0.002223 1.00203
## 2 0.003211 0.007321  0.002989 0.002304 1.01293
## 3 0.042530 0.018230  0.044660 0.002426 0.99169
## 4 0.009693 -0.003238  0.027940 0.002336 1.00867
## 5 0.004531 0.014150 -0.003220 0.002636 0.99797
```

It shows financial instrument dependency of consumers, where r1 is a smaller company and their return of investment. Continuously, r2 is a bigger company with a lower possible return and risk and etc.

```
acf(r1)
```

## Series r1

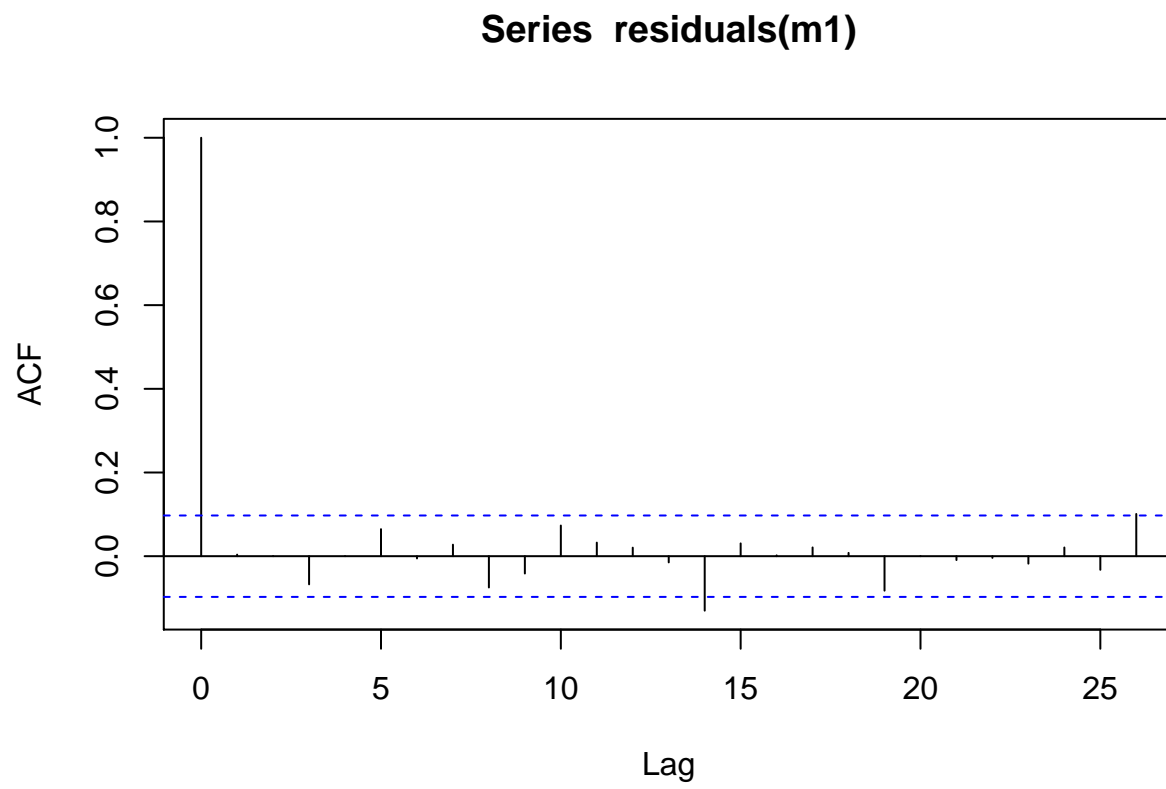


There is an autocorellation with 1, 7, 8, 12 months. Lag 8 (8 month) is not included since p value is to high and it does not required to solve autocorrelation problem

```
m1 <- lm(r1 ~ cons + Lag(r1, 1) + Lag(r1, 7) + Lag(r1, 12))
summary(m1)
```

```
##
## Call:
## lm(formula = r1 ~ cons + Lag(r1, 1) + Lag(r1, 7) + Lag(r1, 12))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.32377 -0.03707 -0.00291  0.02984  0.53827
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.11423    0.60696  -3.483 0.000550 ***
## cons         2.13044    0.60844   3.502 0.000515 ***
## Lag(r1, 1)   0.10387    0.04753   2.185 0.029454 *
## Lag(r1, 7)  -0.10444    0.04744  -2.202 0.028267 *
## Lag(r1, 12)  0.21409    0.04758   4.500 8.92e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.06773 on 401 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.1002, Adjusted R-squared:  0.0912
## F-statistic: 11.16 on 4 and 401 DF, p-value: 1.358e-08
```

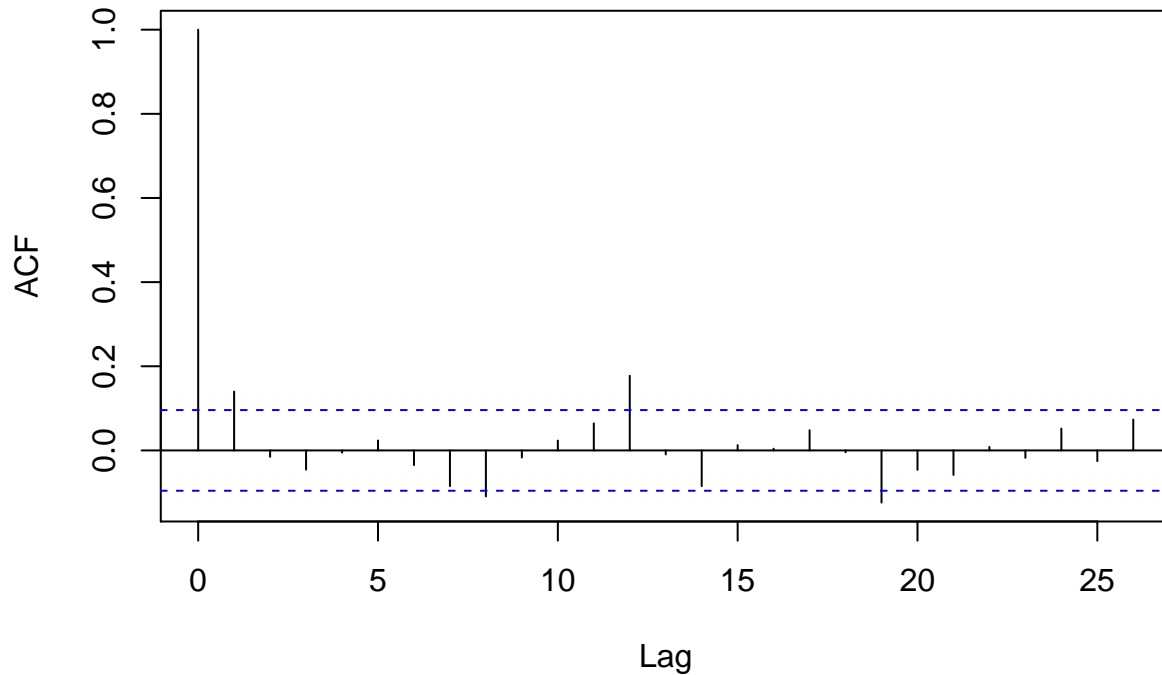
```
acf(residuals(m1))
```



By residuals autocoreglama, Lag problem is solved

```
acf(r2)
```

## Series r2



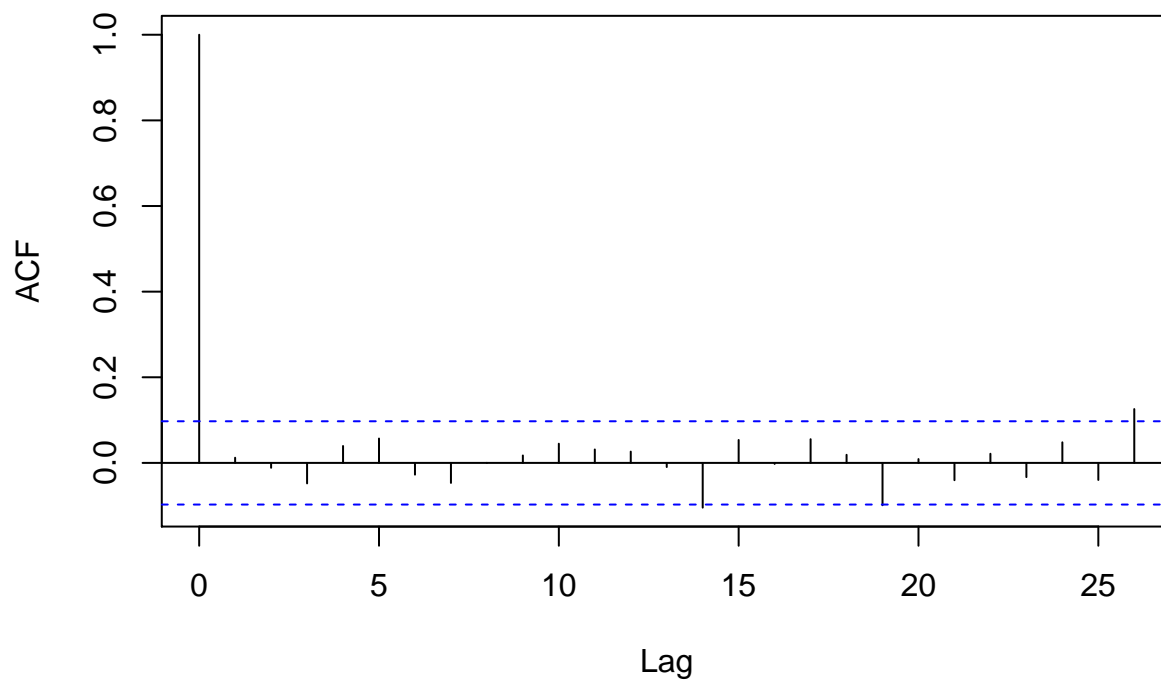
Autocorrelation with 1, 8, 12 months

```
m2 <- lm(r2 ~ cons + Lag(r2, 1) + Lag(r2, 8) + Lag(r2, 12))
summary(m2)
```

```
##
## Call:
## lm(formula = r2 ~ cons + Lag(r2, 1) + Lag(r2, 8) + Lag(r2, 12))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.31801 -0.03491 -0.00250  0.03204  0.40674
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -1.87289    0.53632  -3.492 0.000532 ***
## cons           1.88777    0.53758   3.512 0.000496 ***
## Lag(r2, 1)     0.11536    0.04804   2.401 0.016802 *
## Lag(r2, 8)    -0.09190    0.04790  -1.919 0.055740 .
## Lag(r2, 12)    0.16763    0.04781   3.506 0.000505 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05982 on 401 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.08607,    Adjusted R-squared:  0.07695
## F-statistic: 9.441 on 4 and 401 DF,  p-value: 2.657e-07
```

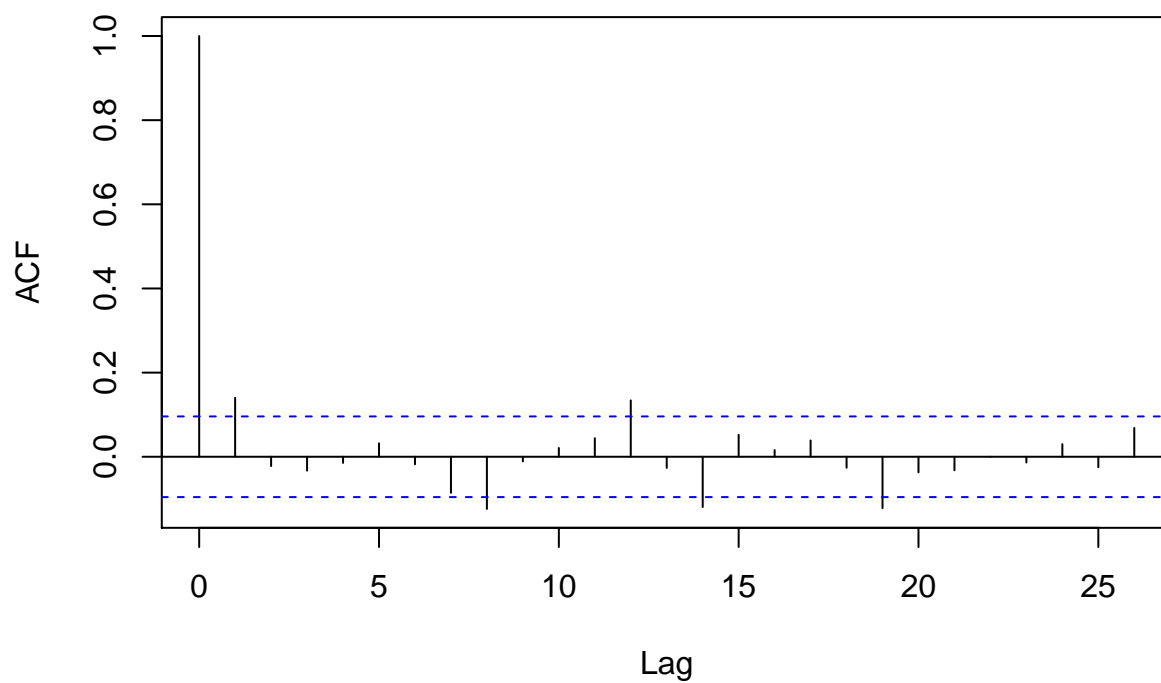
```
acf(residuals(m2))
```

**Series residuals(m2)**



```
acf(r3)
```

**Series r3**



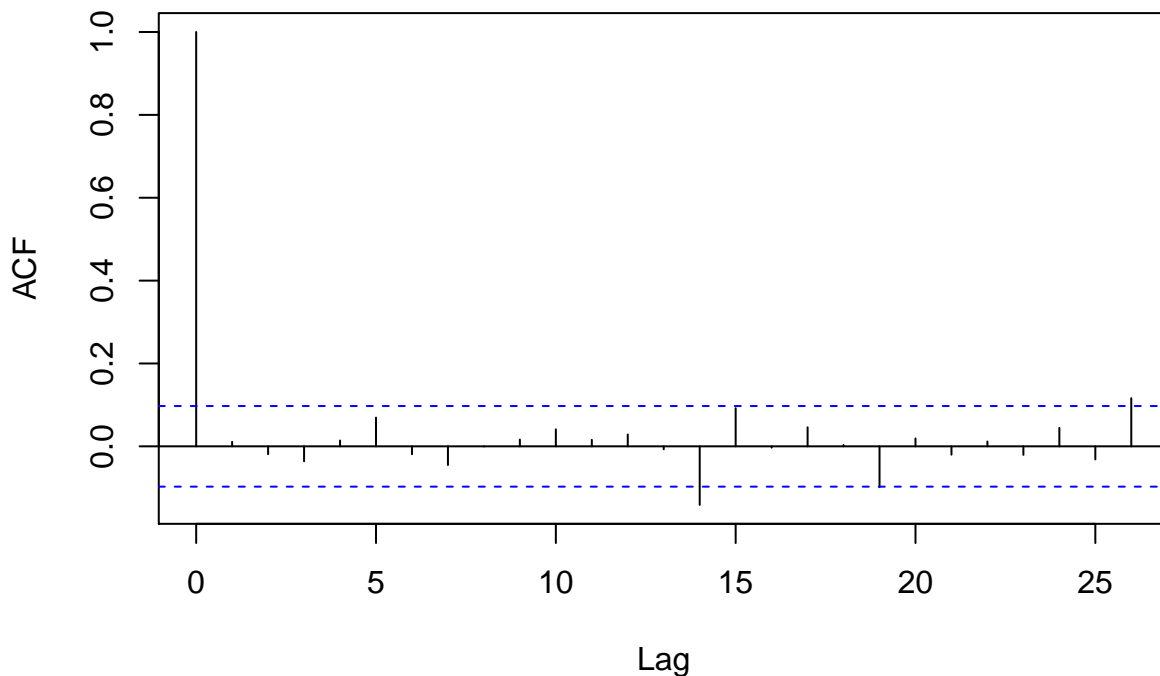
Autocorrelation with 1, 8, 12 months

```
m3 <- lm(r3 ~ cons + Lag(r3, 1) + Lag(r3, 8) + Lag(r3, 12))
summary(m3)

##
## Call:
## lm(formula = r3 ~ cons + Lag(r3, 1) + Lag(r3, 8) + Lag(r3, 12))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.31232 -0.03240 -0.00288  0.03160  0.35920
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.86258    0.51020  -3.651 0.000296 ***
## cons         1.87761    0.51142   3.671 0.000274 ***
## Lag(r3, 1)   0.11646    0.04820   2.416 0.016137 *
## Lag(r3, 8)  -0.10866    0.04803  -2.262 0.024220 *
## Lag(r3, 12)  0.12399    0.04792   2.587 0.010028 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05687 on 401 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.08011,    Adjusted R-squared:  0.07093
## F-statistic:  8.73 on 4 and 401 DF,  p-value: 9.145e-07

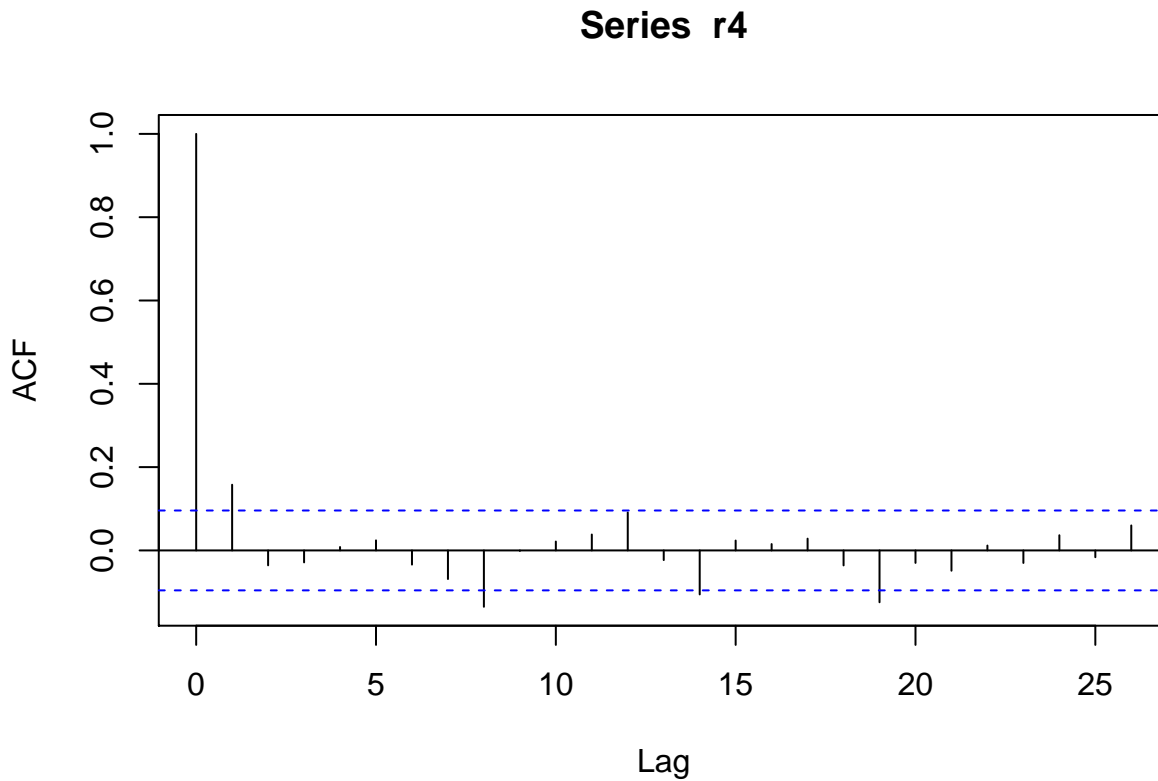
acf(residuals(m3))
```

### Series residuals(m3)



Lags of more than 12 months are not very significant for given regression model

```
acf(r4)
```



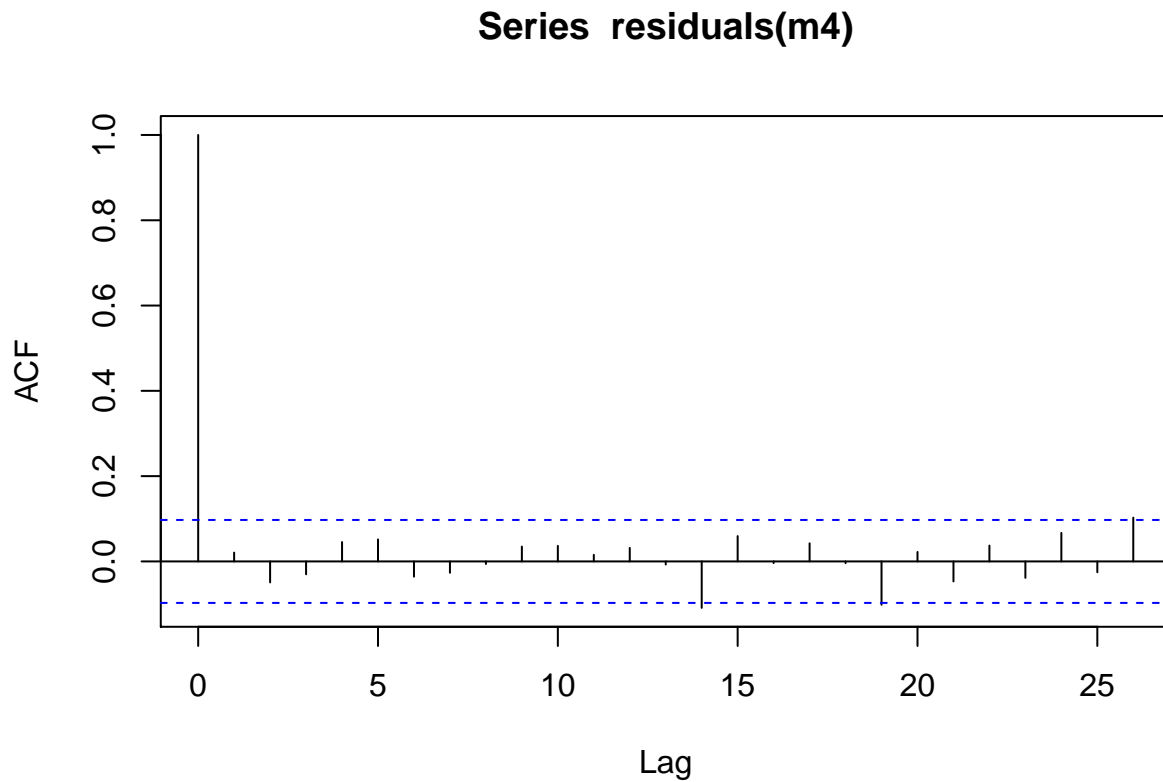
Autocorrelation with 1, 8, 12 months

```
m4 <- lm(r4 ~ cons + Lag(r4, 1) + Lag(r4, 8) + Lag(r4, 12))
summary(m4)
```

```
##
## Call:
## lm(formula = r4 ~ cons + Lag(r4, 1) + Lag(r4, 8) + Lag(r4, 12))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.294474 -0.034634 -0.001268  0.031823  0.296735
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.77604    0.48651  -3.651 0.000296 ***
## cons         1.79128    0.48767   3.673 0.000272 ***
## Lag(r4, 1)   0.13593    0.04813   2.824 0.004978 **
## Lag(r4, 8)  -0.12026    0.04798  -2.506 0.012595 *
## Lag(r4, 12)  0.08469    0.04789   1.768 0.077754 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0542 on 401 degrees of freedom
```

```
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.0795, Adjusted R-squared:  0.07031
## F-statistic: 8.658 on 4 and 401 DF,  p-value: 1.038e-06
```

```
acf(residuals(m4))
```

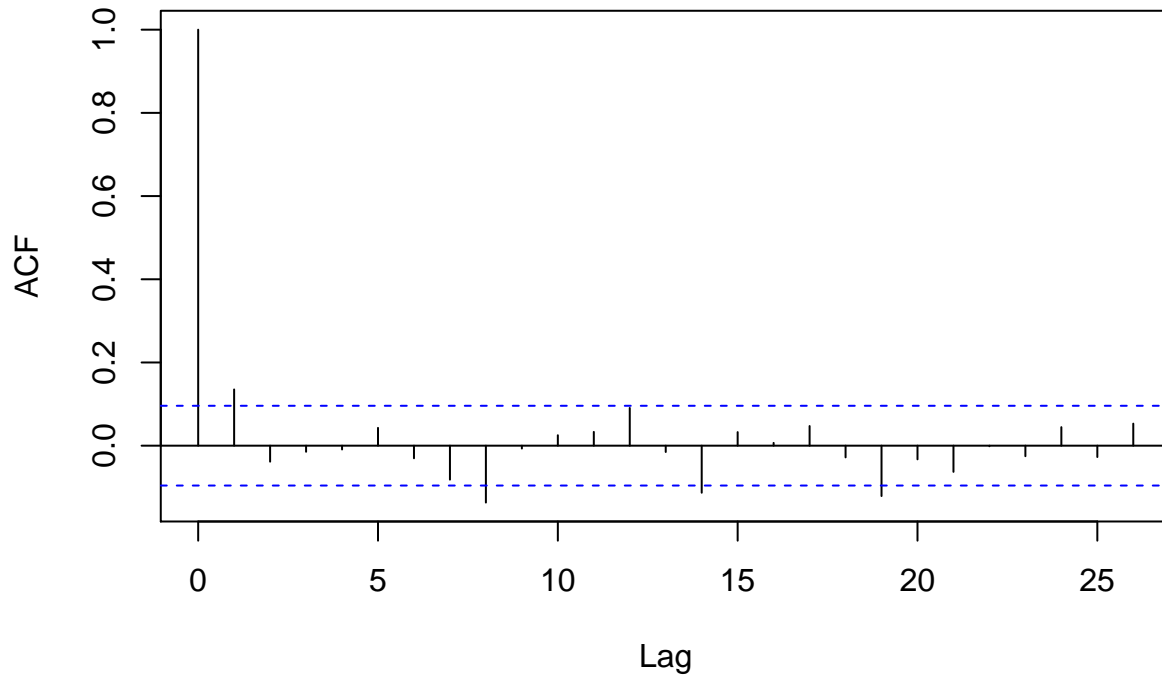


P value for Lag 12 is higher than 0.05, but lower than 0.10, so we will keep it since it is really important to solve autocorrelation case

```
acf(r5)
```



## Series r5



Autocorrelation with 1, 8, 12 months

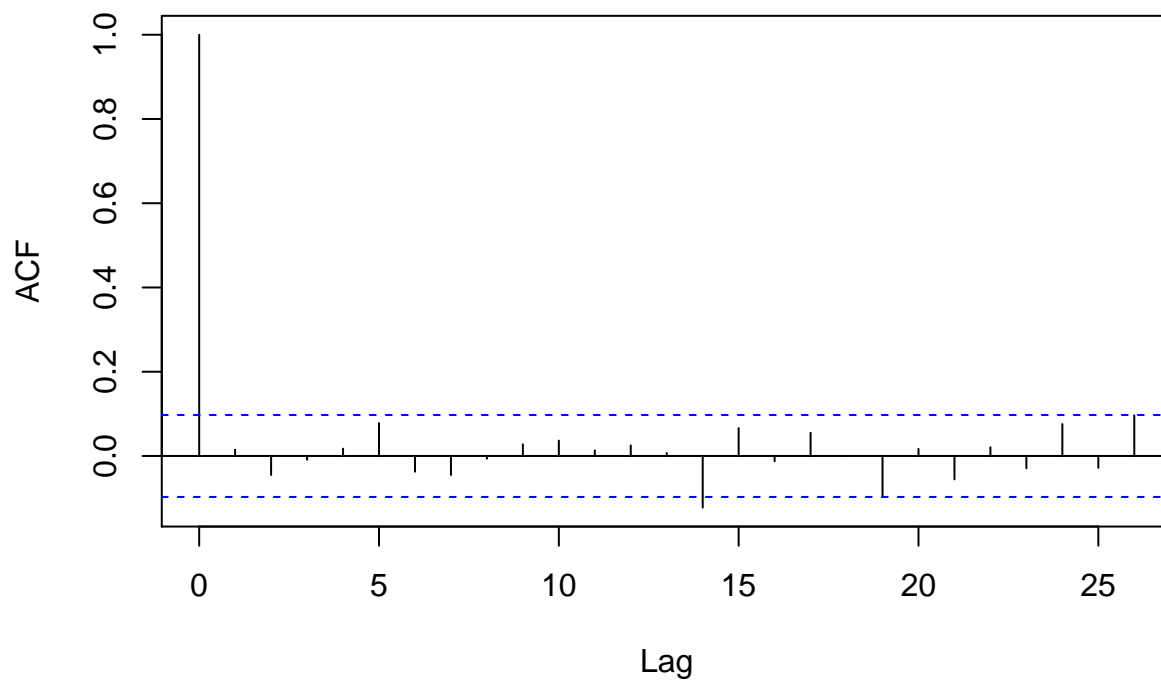
Important to mention that autocorrelation with 12 month influence is decreasing with every bigger company, lag with 12 month is decreasing

```
m5 <- lm(r5 ~ cons + Lag(r5, 1) + Lag(r5, 8) + Lag(r5, 12))
summary(m5)
```

```
##
## Call:
## lm(formula = r5 ~ cons + Lag(r5, 1) + Lag(r5, 8) + Lag(r5, 12))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.292242 -0.029150 -0.003697  0.030420  0.247445
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.68412    0.46811  -3.598 0.000361 ***
## cons         1.69862    0.46923   3.620 0.000332 ***
## Lag(r5, 1)    0.11196    0.04837   2.315 0.021139 *
## Lag(r5, 8)   -0.12066    0.04823  -2.502 0.012748 *
## Lag(r5, 12)  0.08259    0.04807   1.718 0.086584 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05213 on 401 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.07247,    Adjusted R-squared:  0.06322
## F-statistic: 7.833 on 4 and 401 DF,  p-value: 4.37e-06
```

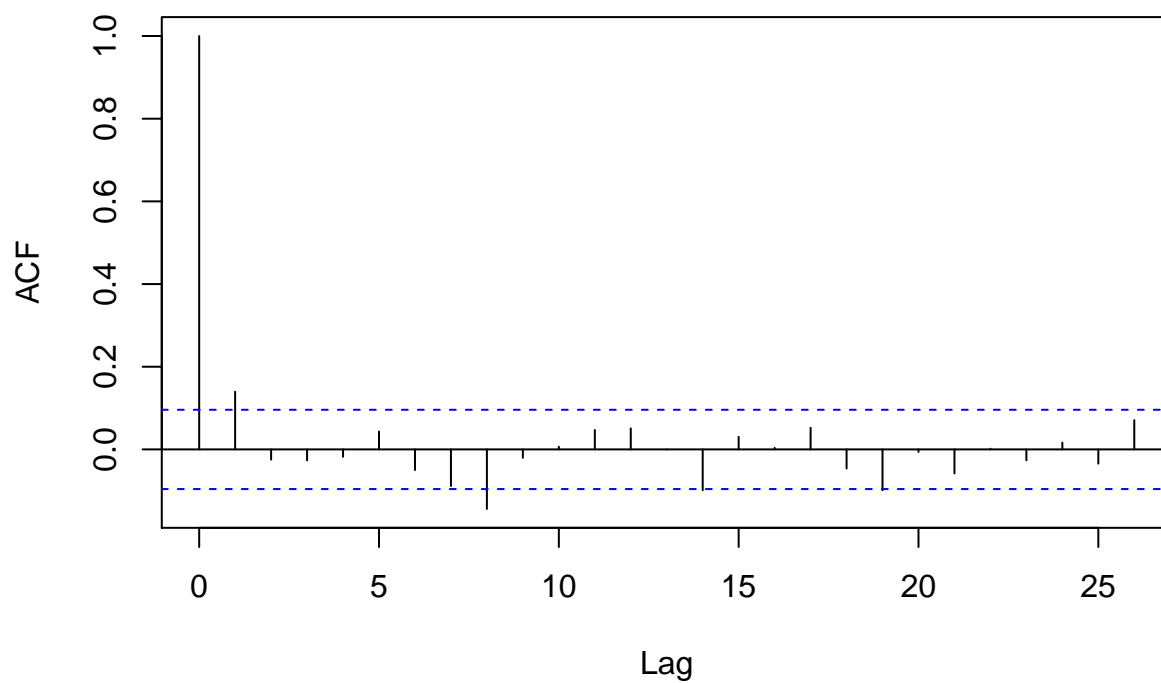
```
acf(residuals(m5))
```

**Series residuals(m5)**



```
acf(r6)
```

**Series r6**

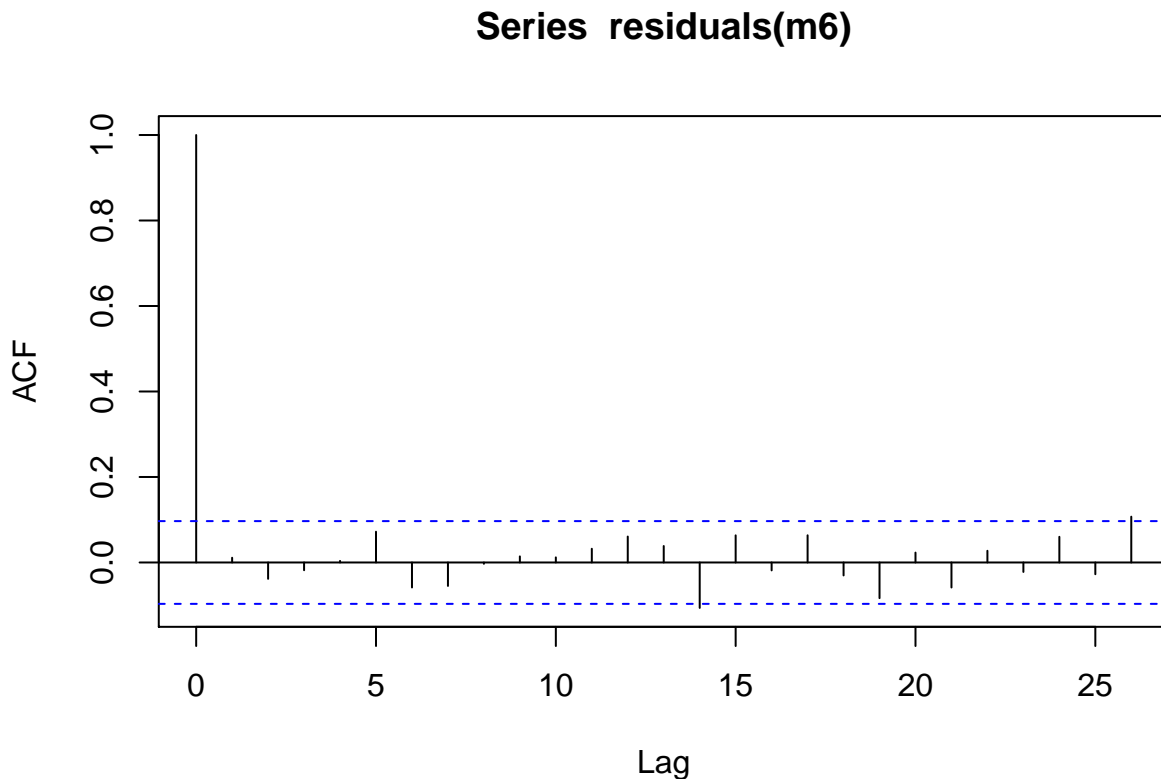


Autocorrelation with 1, 8 months, 12 is not significant anymore

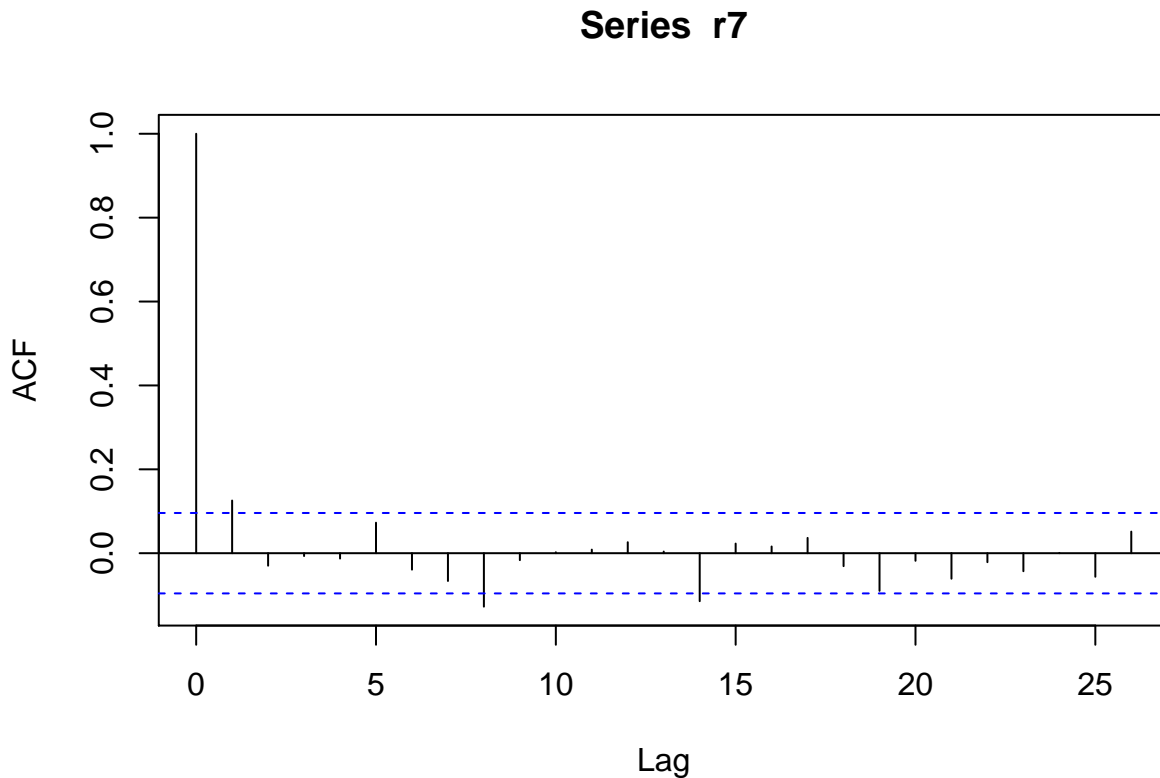
```
m6 <- lm(r6 ~ cons + Lag(r6, 1) + Lag(r6, 8))
summary(m6)
```

```
##
## Call:
## lm(formula = r6 ~ cons + Lag(r6, 1) + Lag(r6, 8))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.287929 -0.028799 -0.000591  0.029137  0.255026
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.63109    0.45363  -3.596 0.000363 ***
## cons         1.64666    0.45471   3.621 0.000330 ***
## Lag(r6, 1)   0.11511    0.04821   2.388 0.017412 *
## Lag(r6, 8)  -0.12752    0.04811  -2.651 0.008344 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05057 on 406 degrees of freedom
## (8 observations deleted due to missingness)
## Multiple R-squared:  0.06725,    Adjusted R-squared:  0.06036
## F-statistic: 9.757 on 3 and 406 DF,  p-value: 3.142e-06
```

```
acf(residuals(m6))
```



```
acf(r7)
```



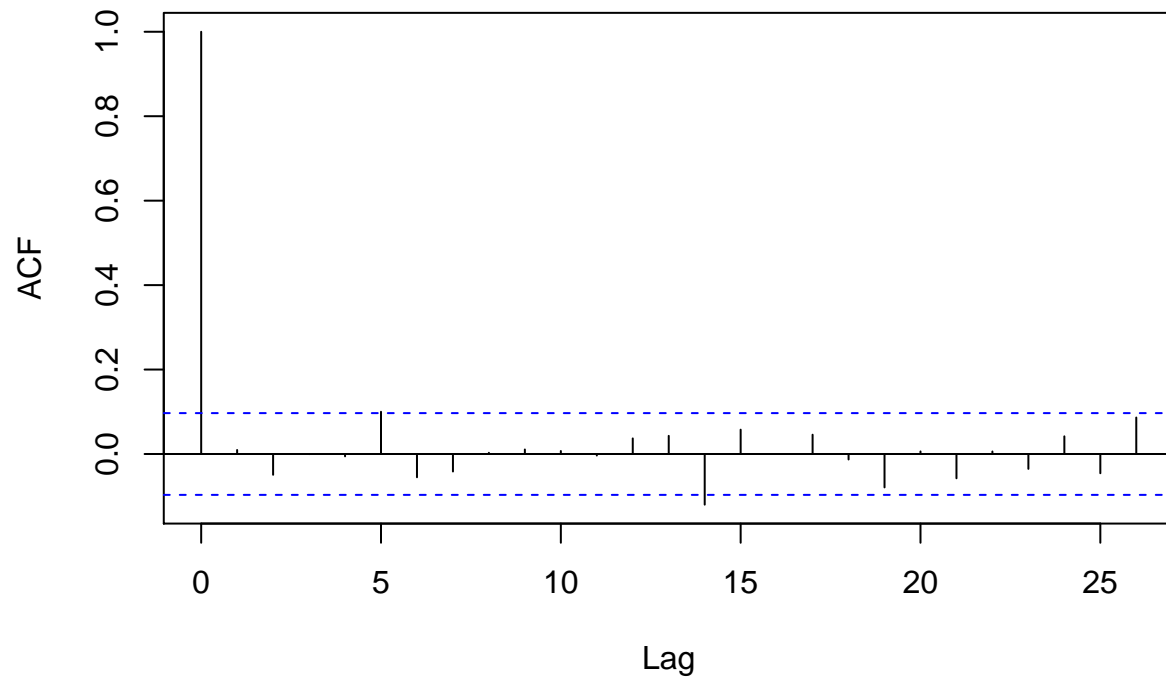
Autocorrelation with 1, 8 months

```
m7 <- lm(r7 ~ cons + Lag(r7, 1) + Lag(r7, 8))
summary(m7)
```

```
##
## Call:
## lm(formula = r7 ~ cons + Lag(r7, 1) + Lag(r7, 8))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.268149 -0.030375 -0.001133  0.030868  0.226422
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.60569    0.44105  -3.641 0.000307 ***
## cons         1.62056    0.44211   3.666 0.000280 ***
## Lag(r7, 1)   0.10224    0.04831   2.116 0.034916 *
## Lag(r7, 8)  -0.11633    0.04818  -2.415 0.016190 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.04915 on 406 degrees of freedom
## (8 observations deleted due to missingness)
## Multiple R-squared:  0.06101,    Adjusted R-squared:  0.05407
## F-statistic: 8.794 on 3 and 406 DF,  p-value: 1.162e-05
```

```
acf(residuals(m7))
```

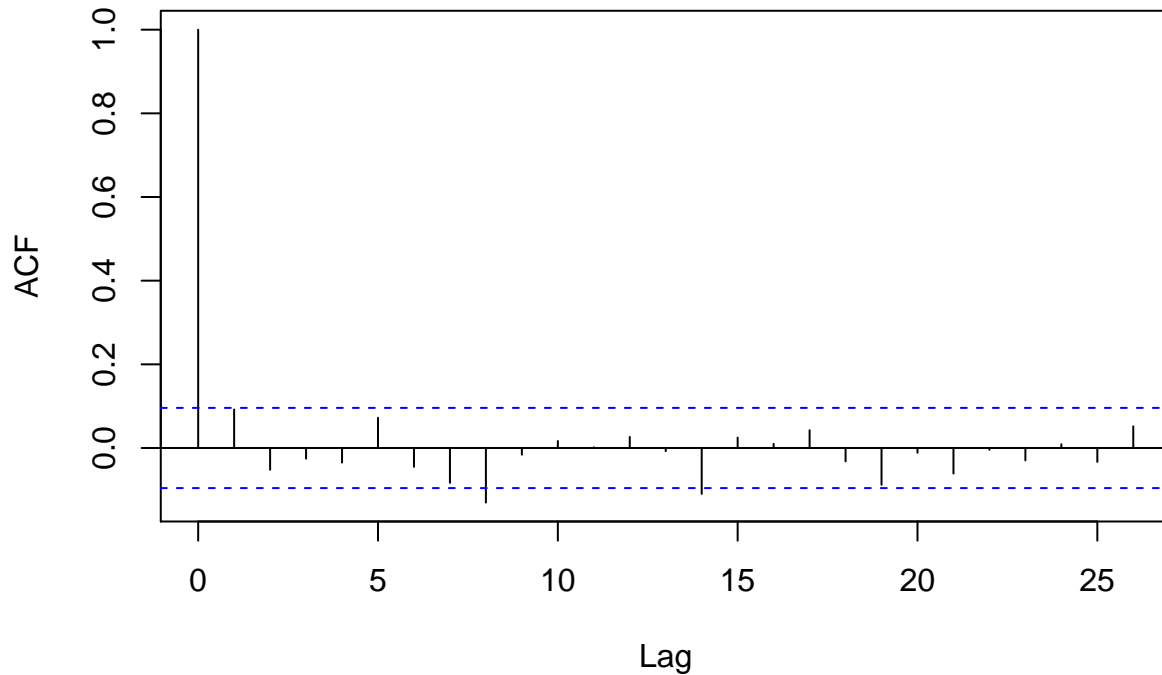
### Series residuals(m7)



Can be spotted that 5 month is very closed to be autocorrelated

```
acf(r8)
```

## Series r8



Autocorrelation with only 8 month

```
m8 <- lm(r8 ~ cons + Lag(r8, 8))
summary(m8)
```

```
##
## Call:
## lm(formula = r8 ~ cons + Lag(r8, 8))
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-0.274053	-0.025924	-0.000507	0.030080	0.209199

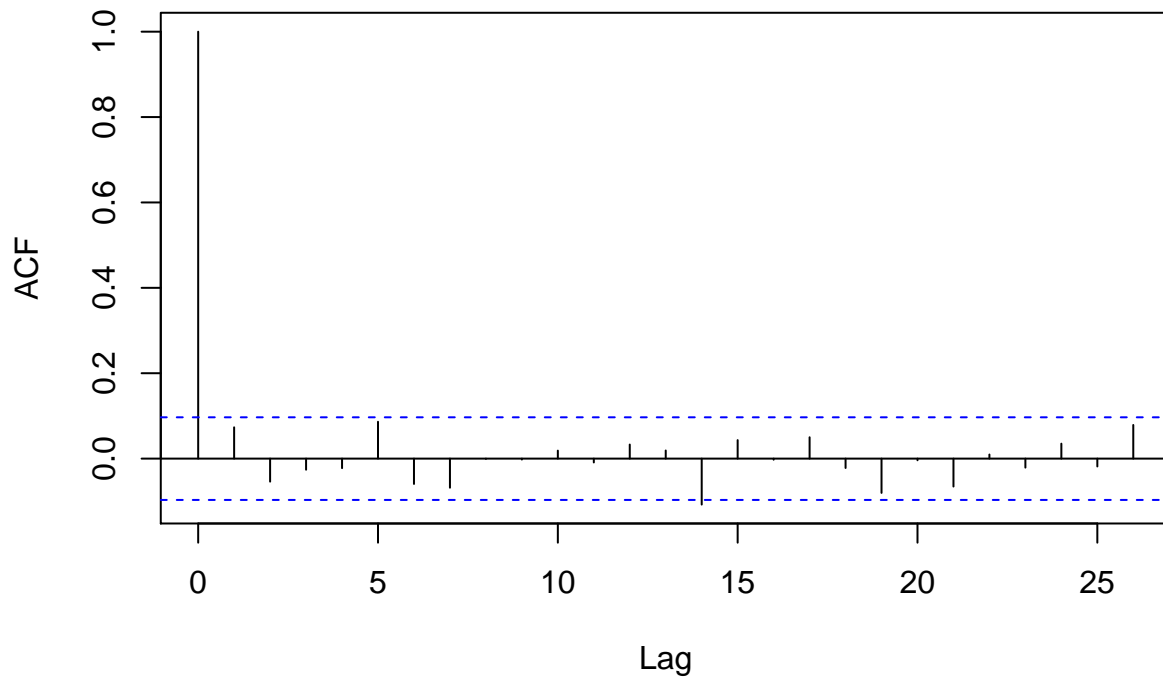
```
##
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t )	
(Intercept)	-1.5073	0.4310	-3.497	0.000522	***
cons	1.5234	0.4320	3.526	0.000469	***
Lag(r8, 8)	-0.1241	0.0484	-2.564	0.010708	*

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.04816 on 407 degrees of freedom
## (8 observations deleted due to missingness)
## Multiple R-squared:  0.04636,    Adjusted R-squared:  0.04167
## F-statistic: 9.892 on 2 and 407 DF,  p-value: 6.381e-05
```

```
acf(residuals(m8))
```

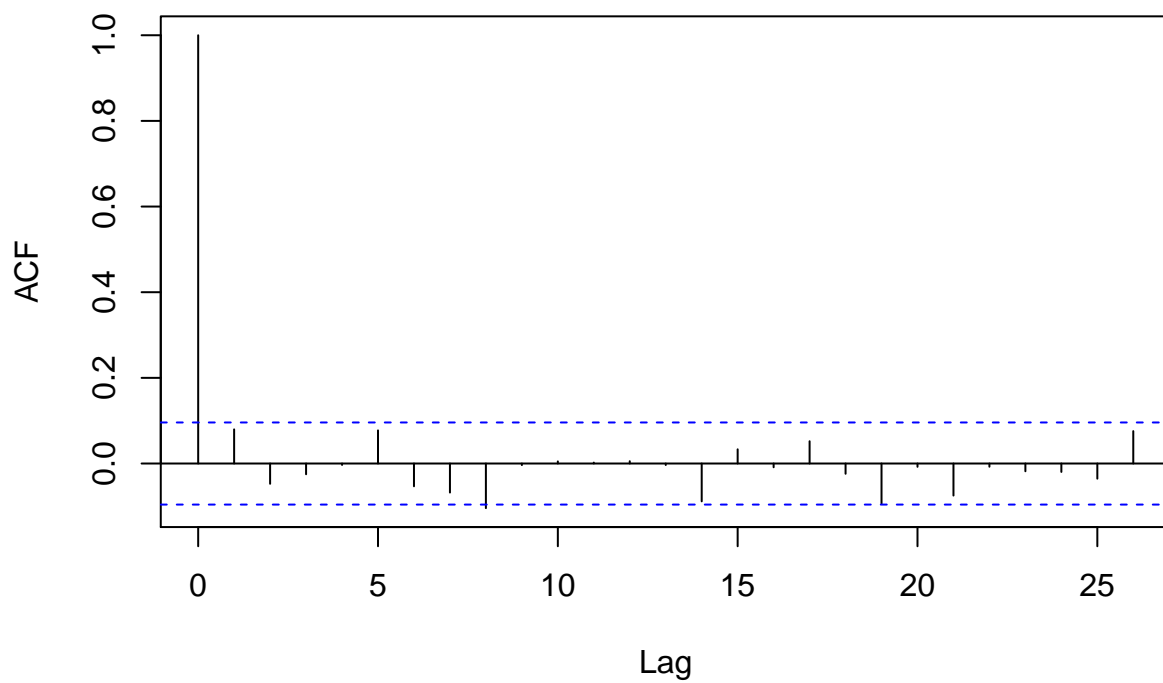
### Series residuals(m8)



Lag 8 has 10.7% p-value, assuming it is still significant, since it is around 10%

```
acf(r9)
```

### Series r9



Autocorrelation with 8 month

```
m9 <- lm(r9 ~ cons + Lag(r9, 8))
summary(m9)
```

```
##
## Call:
## lm(formula = r9 ~ cons + Lag(r9, 8))
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-0.238969	-0.027324	0.000292	0.025139	0.168048

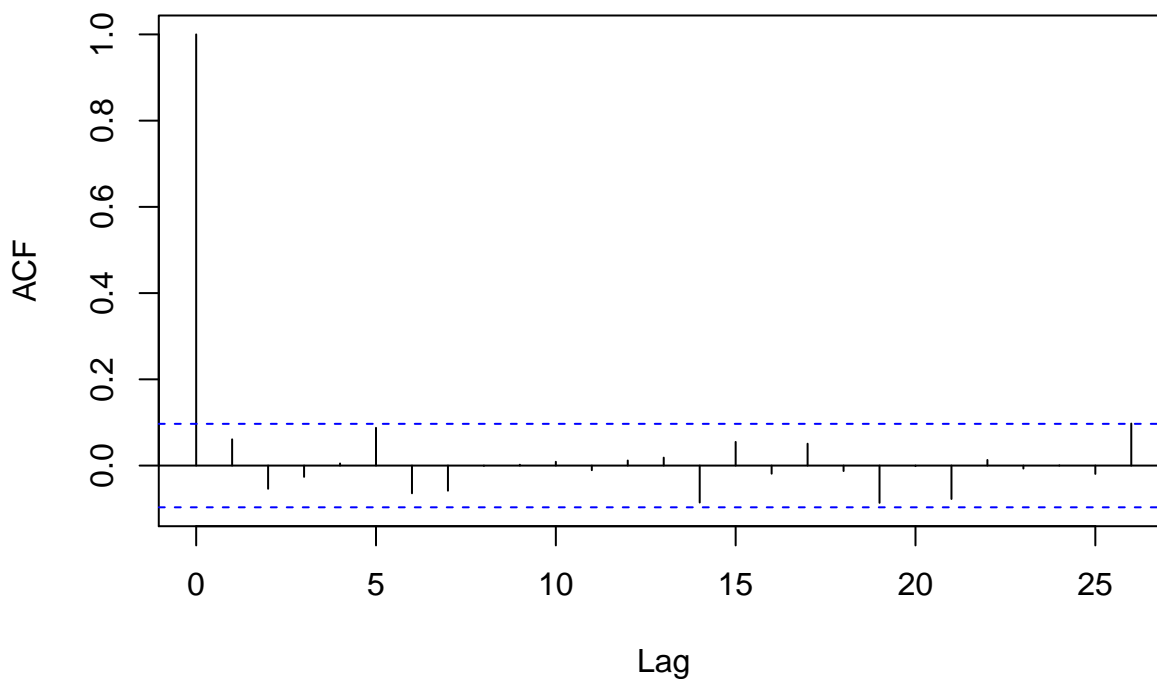
```
##
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-1.47120	0.40851	-3.601	0.000356 ***
cons	1.48582	0.40945	3.629	0.000321 ***
Lag(r9, 8)	-0.09691	0.04850	-1.998	0.046341 *

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.04564 on 407 degrees of freedom
## (8 observations deleted due to missingness)
## Multiple R-squared:  0.04195,    Adjusted R-squared:  0.03724
## F-statistic: 8.911 on 2 and 407 DF,  p-value: 0.0001631
```

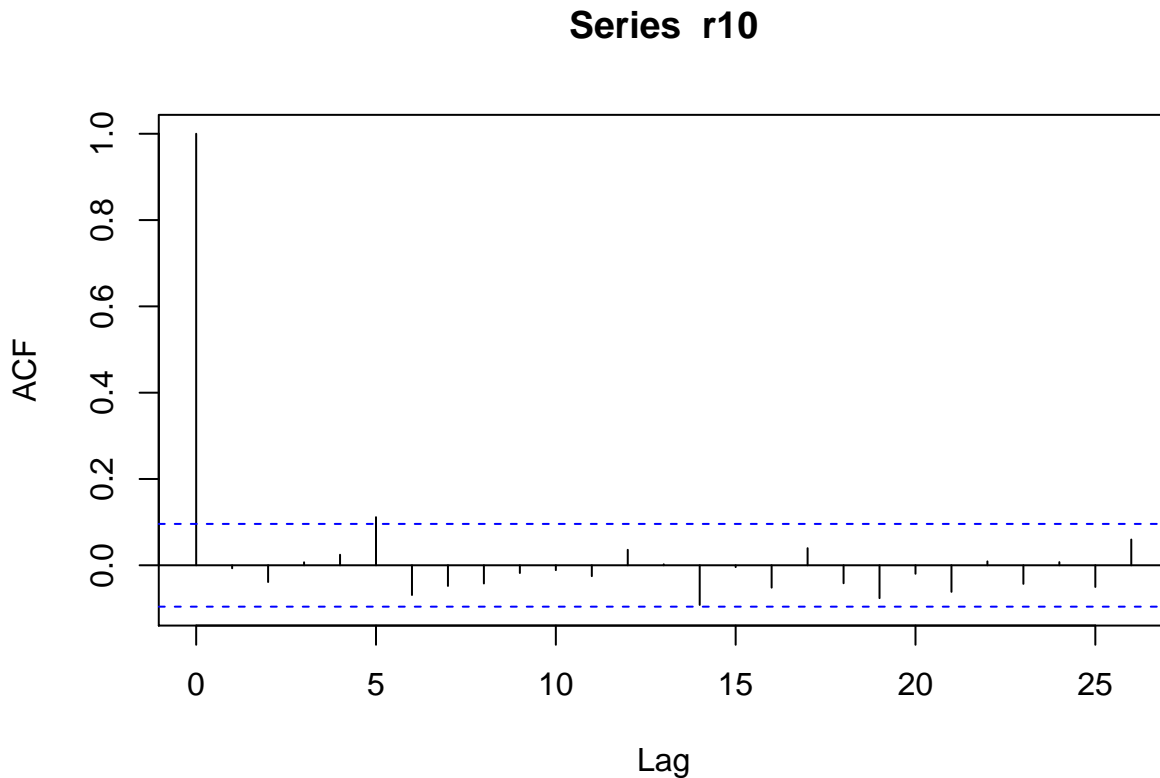
```
acf(residuals(m9))
```

### Series residuals(m9)





```
acf(r10)
```

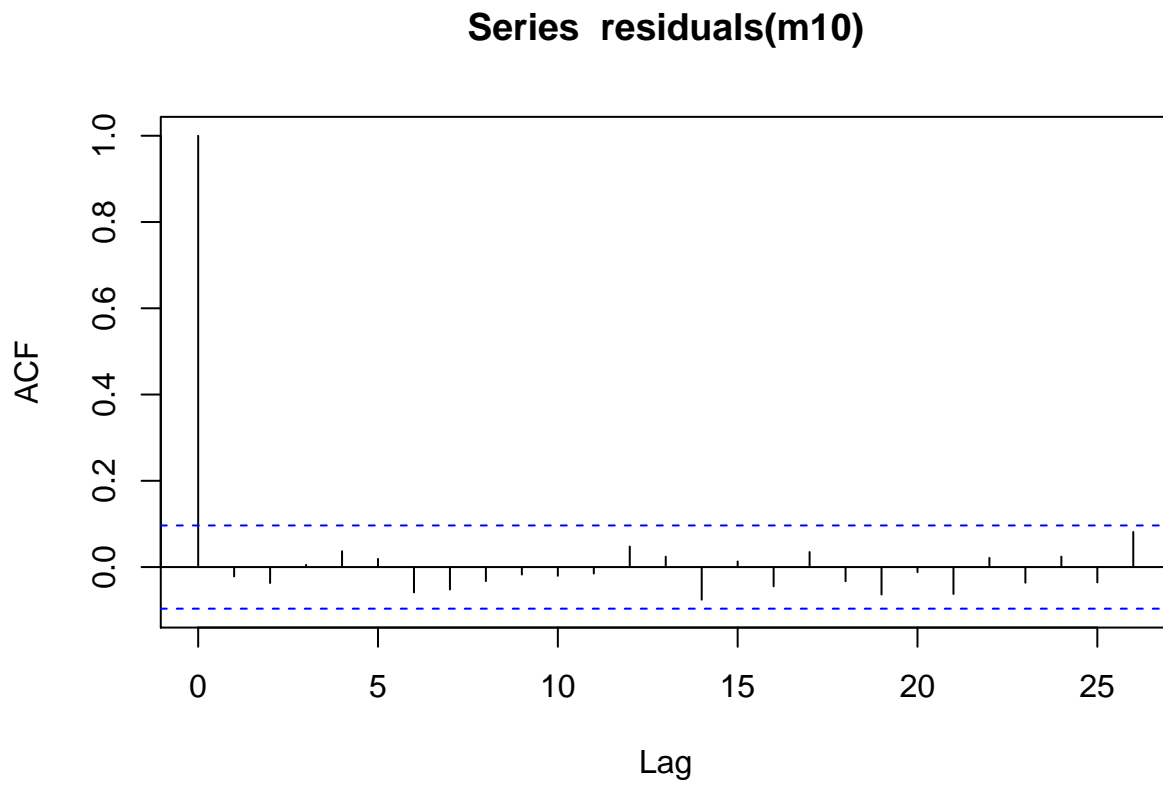


Autocorrelation with 5 month

```
m10 <- lm(r10 ~ cons + Lag(r10, 5))
summary(m10)
```

```
##
## Call:
## lm(formula = r10 ~ cons + Lag(r10, 5))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.209430 -0.022241 -0.000863  0.022702  0.178580
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.15677    0.36418  -3.176   0.0016 **
## cons         1.16700    0.36504   3.197   0.0015 **
## Lag(r10, 5)  0.10405    0.04853   2.144   0.0326 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.04078 on 410 degrees of freedom
## (5 observations deleted due to missingness)
## Multiple R-squared:  0.03652,    Adjusted R-squared:  0.03182
## F-statistic: 7.769 on 2 and 410 DF,  p-value: 0.0004877
```

```
acf(residuals(m10))
```



Based on summaries, beta (bigger risk, bigger return) values increased with a bigger company.  
Bigger companies have less influence of 1 and 12 months for autocorrelation.