PDL

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Librerías a utilizar

```r
library(tidyr)
library(ggplot2)
library(dplyr)
```

Estimación Bayesiana

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

A representa el conjunto de obligadores por grado

B representa el conjunto de incumplimientos

$P(A|B) =$ Probabilidad de que un grado específico tenga un incumplimiento.

$P(B|A) =$ Tasa de incumplimiento para cada grado, o sea, $\frac{Número\ de\ incumplimientos\ de\ un\ grado}{Número\ de\ obligadores\ de\ grado}$

$P(A) =$ Proporción de obligadores en esa categoría respecto al total, $\frac{Número\ de\ obligadores\ de\ un\ grado}{Número\ total\ de\ obligadores}$

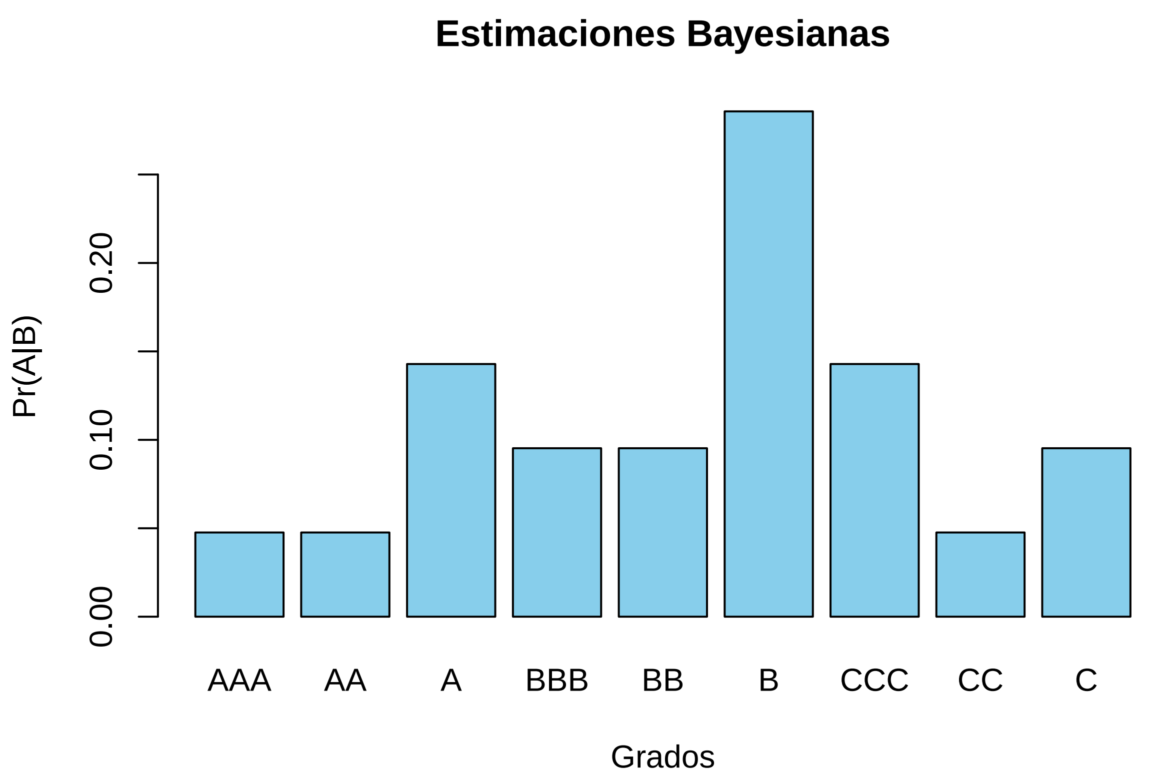
$P(B) =$ Probabilidad de incumplimiento, $\frac{Número\ total\ de\ incumplimientos}{Número\ total\ de\ obligadores}$

```r
Cla <- c("AAA", "AA", "A", "BBB", "BB", "B", "CCC", "CC", "C")
Obligadores <- c(34, 56, 119, 257, 191, 102, 50, 34, 12)
Incumplimientos <- c(1, 1, 3, 2, 2, 6, 3, 1, 2)

# dataframe
df1 <- data.frame(Obligadores, Incumplimientos, row.names = Cla)

# Tasa de incumplimiento para cada clasificación
PrBA <- df1$Incumplimientos/df1$Obligadores

# Proporción de obligadores de cada categoría respecto al total
PrA <- df1$Obligadores/sum(df1$Obligadores)

# Probabilidad de incumplimiento
```

```r
PrB <- sum(df1$Incumplimientos)/sum(df1$Obligadores)

# Probabilidad de A dado B
PrAB <- PrBA*PrA/PrB

Est_Bay <- round(cbind(df1, PrBA, PrA, PrAB), 7)

Est_Bay
```

```
##     Obligadores Incumplimientos      PrBA       PrA      PrAB
## AAA          34               1 0.0294118 0.0397661 0.0476190
## AA           56               1 0.0178571 0.0654971 0.0476190
## A           119               3 0.0252101 0.1391813 0.1428571
## BBB         257               2 0.0077821 0.3005848 0.0952381
## BB          191               2 0.0104712 0.2233918 0.0952381
## B           102               6 0.0588235 0.1192982 0.2857143
## CCC          50               3 0.0600000 0.0584795 0.1428571
## CC           34               1 0.0294118 0.0397661 0.0476190
## C            12               2 0.1666667 0.0140351 0.0952381
```

```r
# Gráfico de Estimación Bayesiana

barplot(Est_Bay$PrAB, names.arg = rownames(Est_Bay),
  main = "Estimaciones Bayesianas", xlab = "Grados",
  ylab = "Pr(A|B)", col = "skyblue")
```



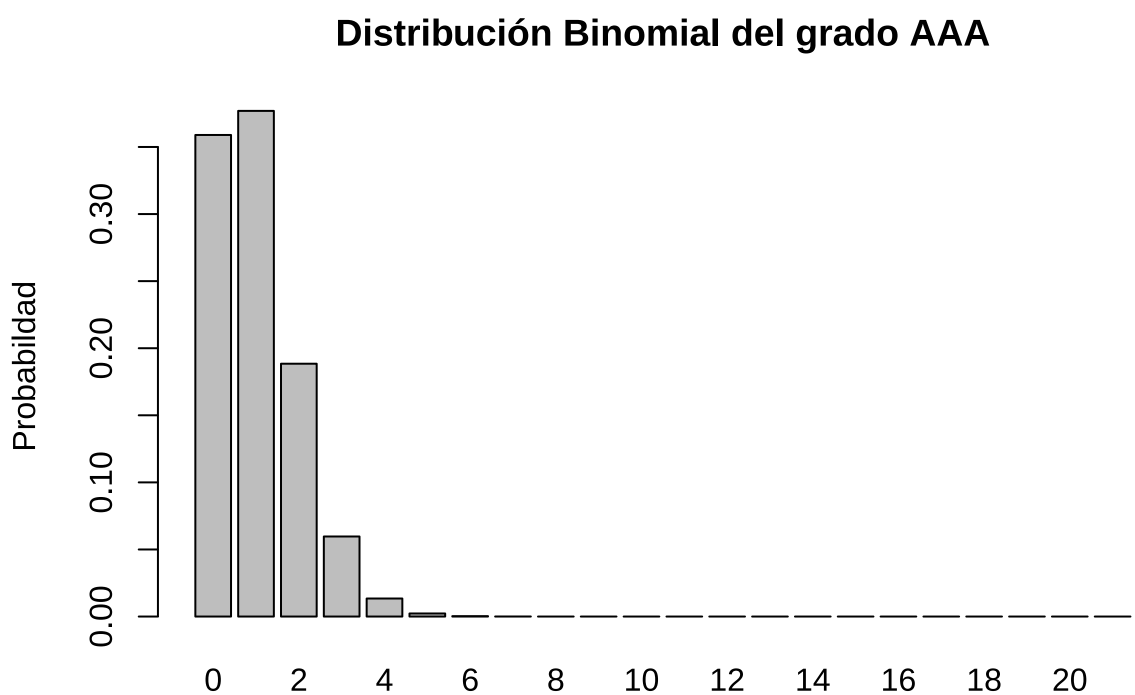
Distribución Binomial

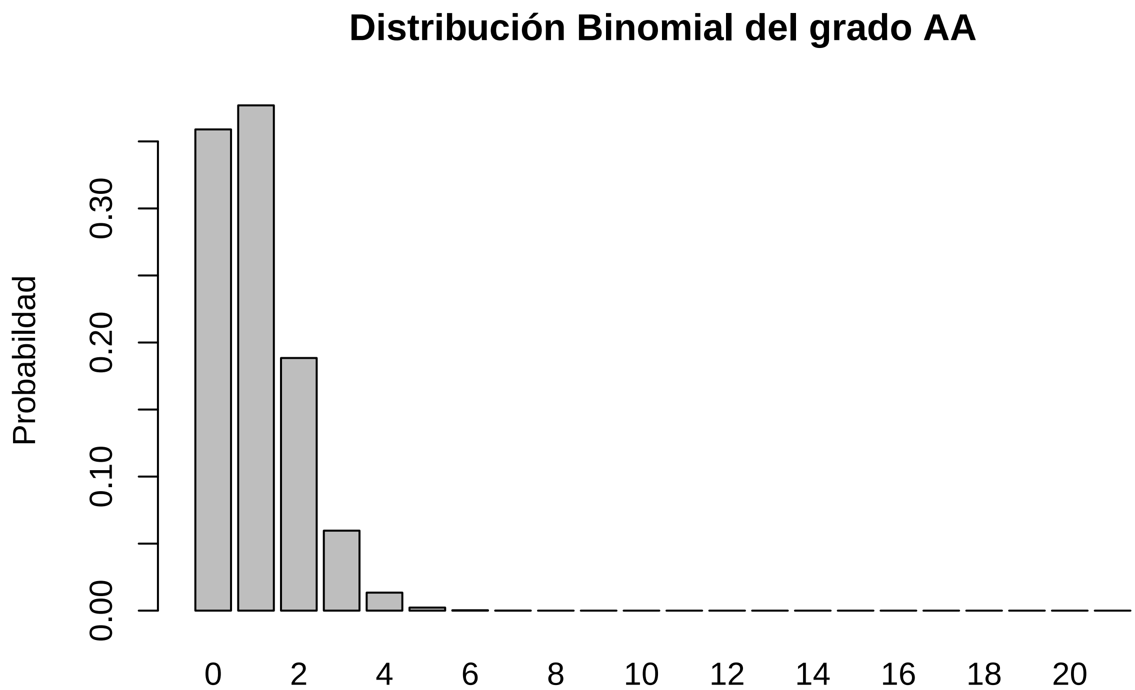
```r
dist_bin <- data.frame(matrix(nrow = 22, ncol = 9))

for (i in 1:9) {
  dist_bin[,i]  <- round(dbinom(0:21, sum(Incumplimientos), Est_Bay[i,5]), 8)
  colnames(dist_bin)[i] <- Cla[i]
  row.names(dist_bin) <- c(0:21)
}

dist_bin
```

```
##           AAA         AA          A        BBB         BB          B        CCC
## 0  0.35894274 0.35894274 0.03927515 0.12224198 0.12224198 0.00085371 0.03927515
## 1  0.37688948 0.37688948 0.13746298 0.27021913 0.27021913 0.00717118 0.13746298
## 2  0.18844454 0.18844454 0.22910489 0.28444121 0.28444121 0.02868471 0.22910489
## 3  0.05967404 0.05967404 0.24183286 0.18962748 0.18962748 0.07266793 0.24183286
## 4  0.01342665 0.01342665 0.18137458 0.08982355 0.08982355 0.13080228 0.18137458
## 5  0.00228253 0.00228253 0.10277889 0.03214738 0.03214738 0.17789111 0.10277889
## 6  0.00030434 0.00030434 0.04567949 0.00902383 0.00902383 0.18975053 0.04567949
## 7  0.00003261 0.00003261 0.01631410 0.00203545 0.00203545 0.16264332 0.01631410
## 8  0.00000285 0.00000285 0.00475828 0.00037495 0.00037495 0.11385034 0.00475828
## 9  0.00000021 0.00000021 0.00114551 0.00005701 0.00005701 0.06578020 0.00114551
## 10 0.00000001 0.00000001 0.00022910 0.00000720 0.00000720 0.03157450 0.00022910
## 11 0.00000000 0.00000000 0.00003818 0.00000076 0.00000076 0.01262980 0.00003818
## 12 0.00000000 0.00000000 0.00000530 0.00000007 0.00000007 0.00420993 0.00000530
## 13 0.00000000 0.00000000 0.00000061 0.00000000 0.00000000 0.00116583 0.00000061
## 14 0.00000000 0.00000000 0.00000006 0.00000000 0.00000000 0.00026647 0.00000006
## 15 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00004974 0.00000000
## 16 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000746 0.00000000
## 17 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000088 0.00000000
## 18 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000008 0.00000000
## 19 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 20 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 21 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
##            CC          C
## 0  0.35894274 0.12224198
## 1  0.37688948 0.27021913
## 2  0.18844454 0.28444121
## 3  0.05967404 0.18962748
## 4  0.01342665 0.08982355
## 5  0.00228253 0.03214738
## 6  0.00030434 0.00902383
## 7  0.00003261 0.00203545
## 8  0.00000285 0.00037495
## 9  0.00000021 0.00005701
## 10 0.00000001 0.00000720
## 11 0.00000000 0.00000076
## 12 0.00000000 0.00000007
## 13 0.00000000 0.00000000
## 14 0.00000000 0.00000000
## 15 0.00000000 0.00000000
```

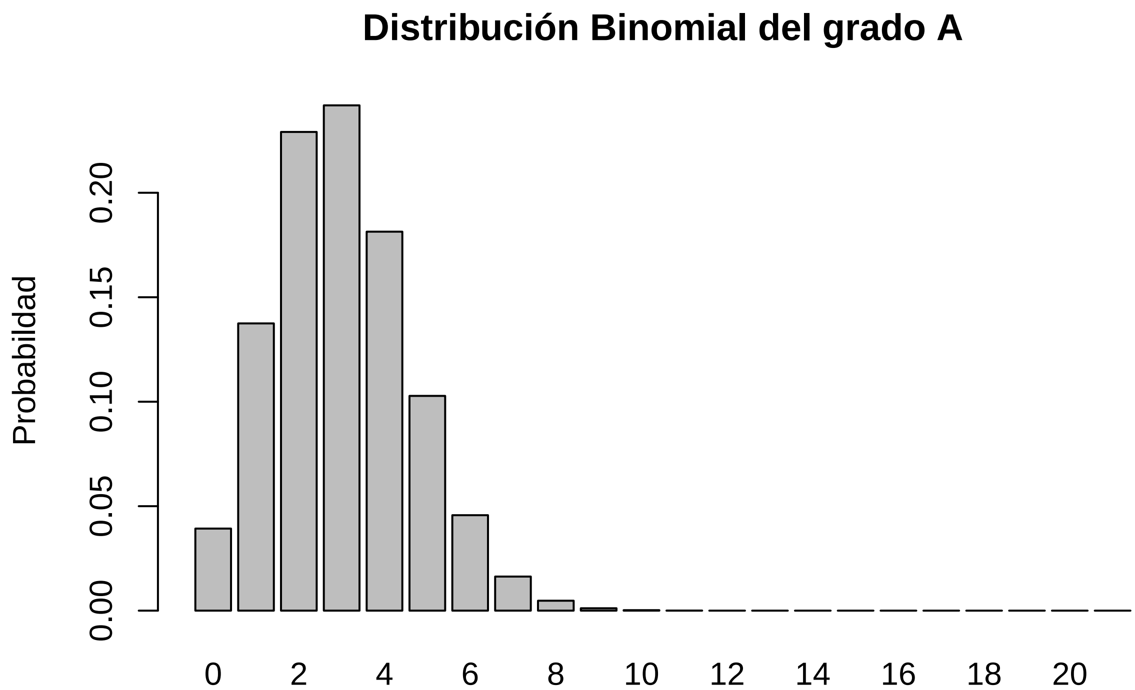
```
## 16 0.00000000 0.00000000
## 17 0.00000000 0.00000000
## 18 0.00000000 0.00000000
## 19 0.00000000 0.00000000
## 20 0.00000000 0.00000000
## 21 0.00000000 0.00000000
```

```
for (i in 1:ncol(dist_bin)) {
  barplot(dist_bin[,i], names.arg = 0:21,
          main = paste("Distribución Binomial del grado", Cla[i]),
          ylab = "Probabildad")
}
```

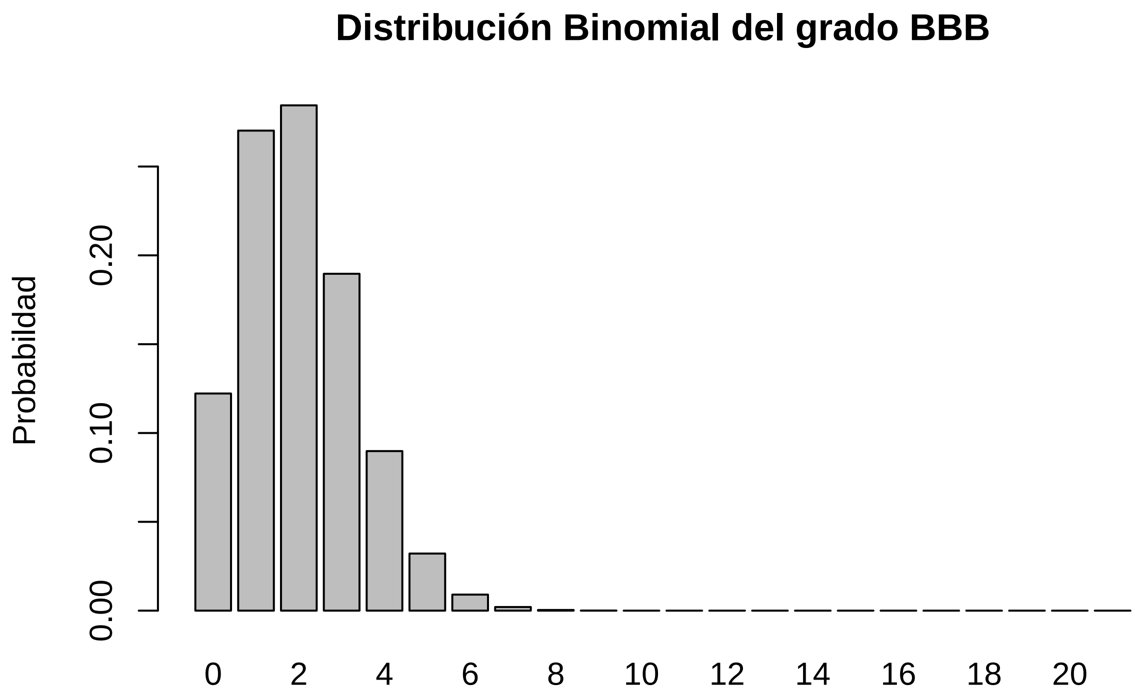


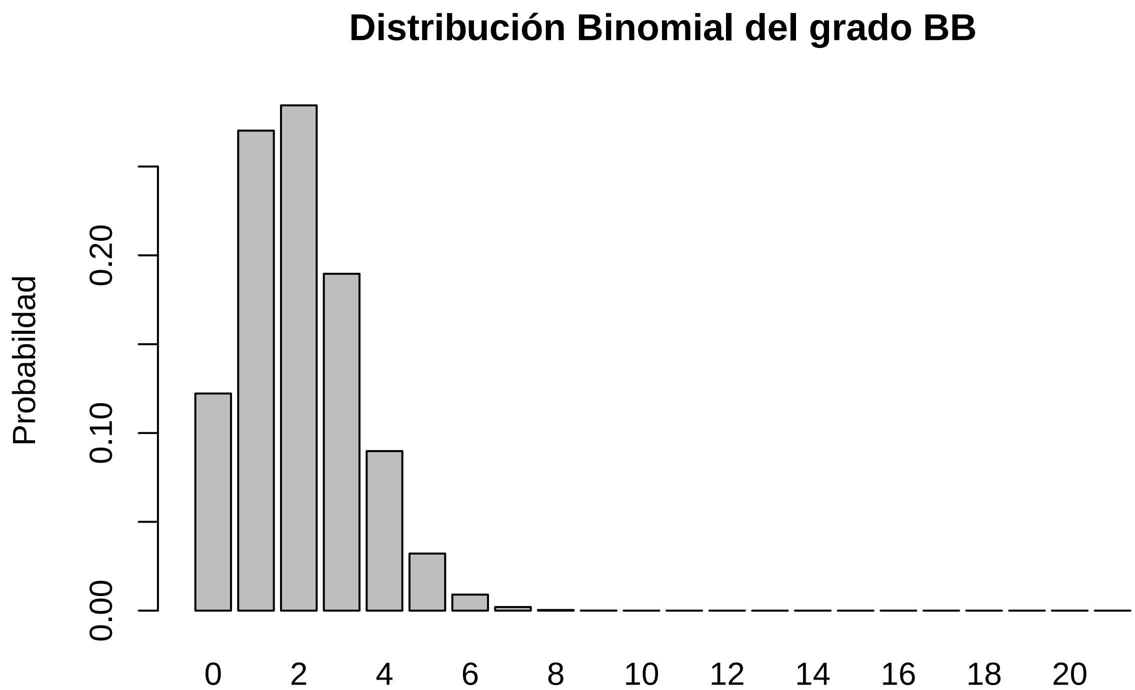


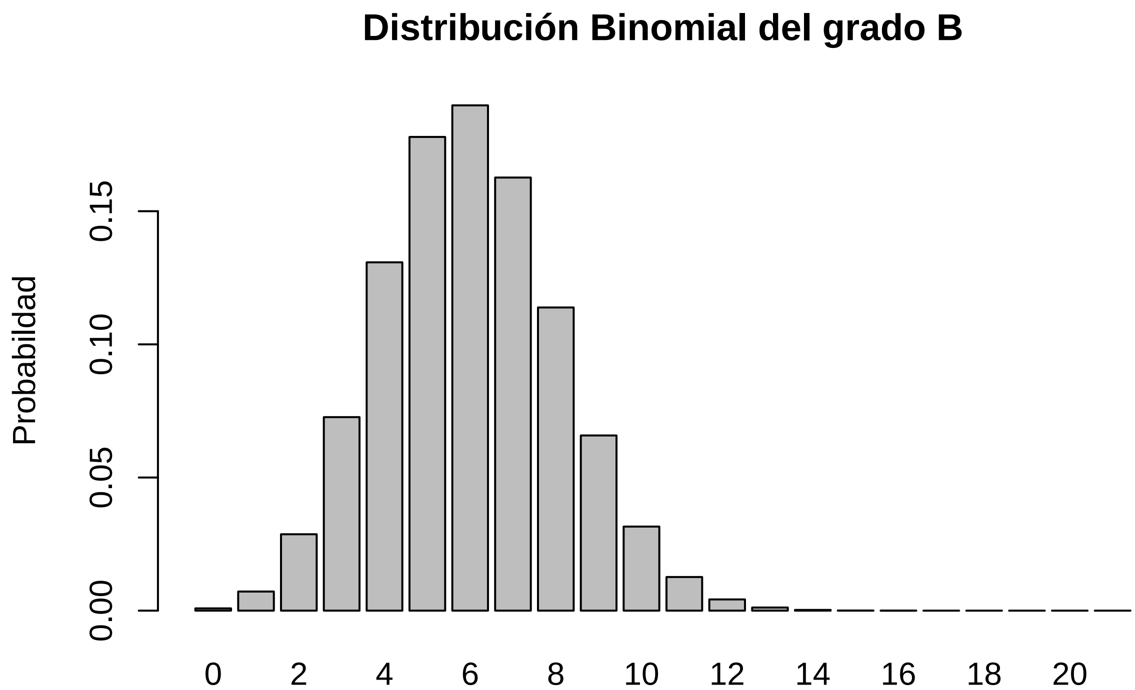
Distribución Binomial del grado AA
Probabildad
0.00
0.10
0.20
0.30
0
2
4
6
8
10
12
14
16
18
20

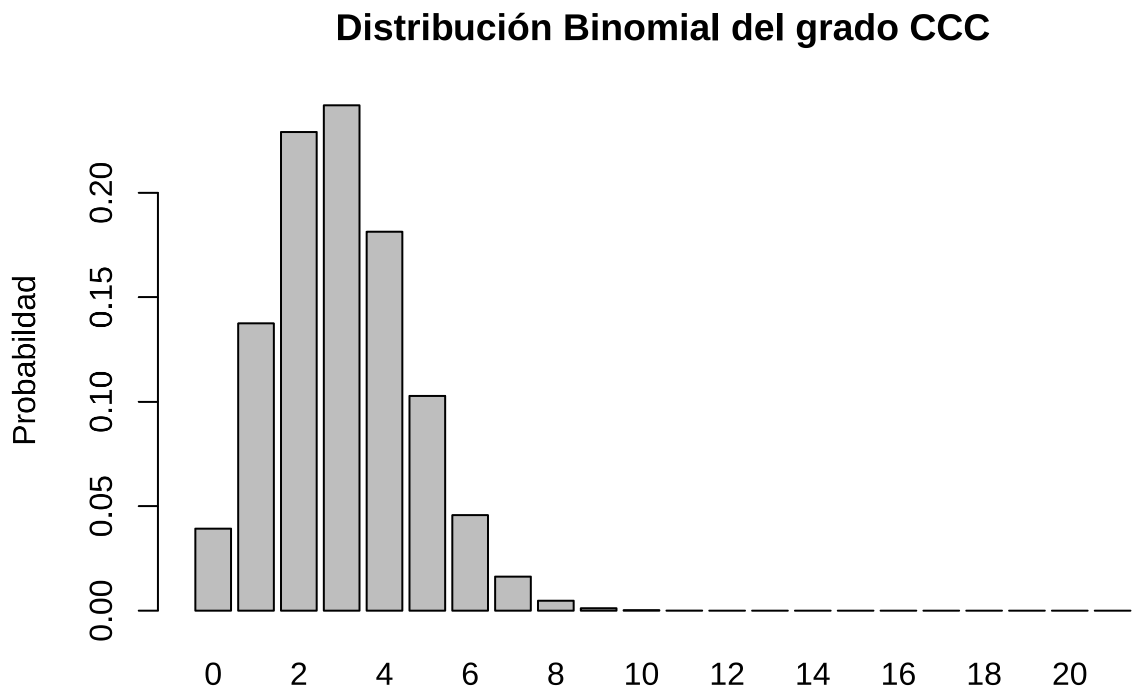


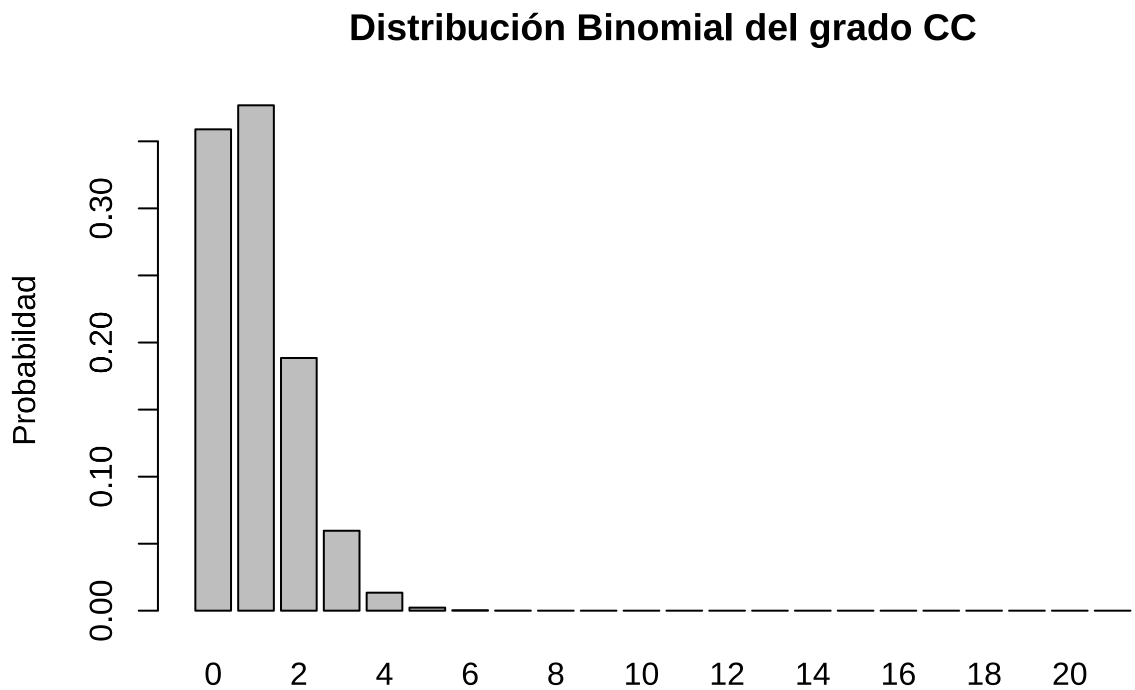
Distribución Binomial del grado A
Probabildad
0.00
0.05
0.10
0.15
0.20
0
2
4
6
8
10
12
14
16
18
20

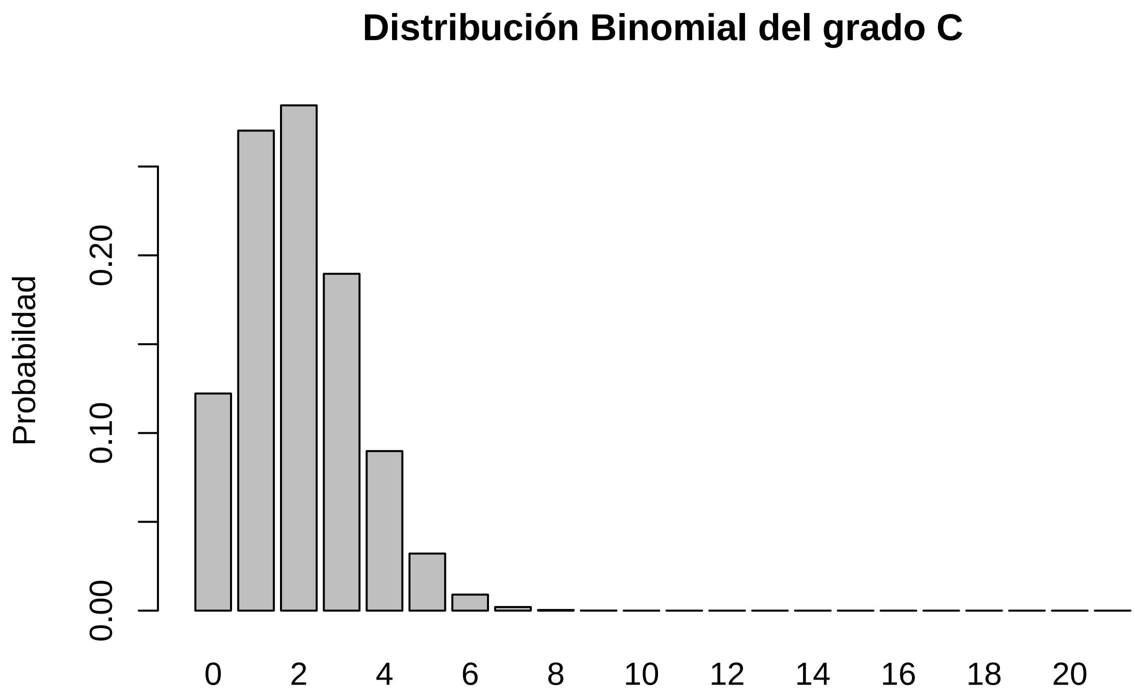

Distribución Binomial del grado BBB
Probabildad
0.00
0.10
0.20
0
2
4
6
8
10
12
14
16
18
20


Distribución Binomial del grado BB
Probabildad
0.00
0.10
0.20
0
2
4
6
8
10
12
14
16
18
20


Distribución Binomial del grado B
Probabildad
0.00
0.05
0.10
0.15
0
2
4
6
8
10
12
14
16
18
20


Distribución Binomial del grado CCC
Probabildad
0.00
0.05
0.10
0.15
0.20
0
2
4
6
8
10
12
14
16
18
20


Distribución Binomial del grado CC
Probabildad
0.00
0.10
0.20
0.30
0
2
4
6
8
10
12
14
16
18
20



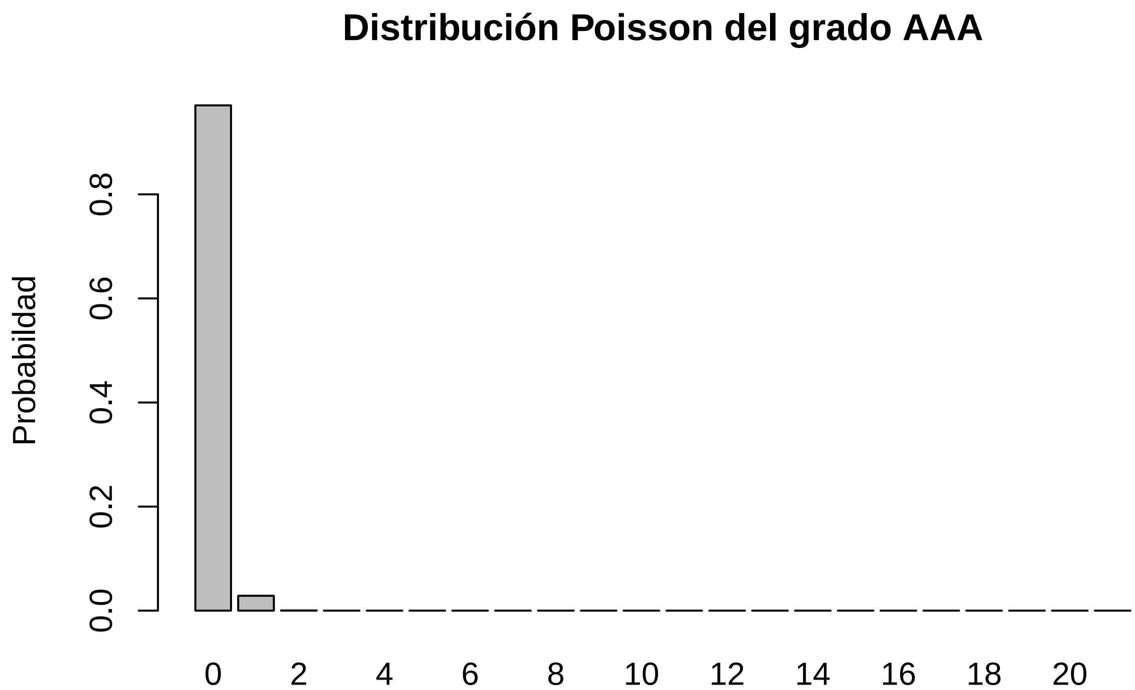
Distribución Poisson

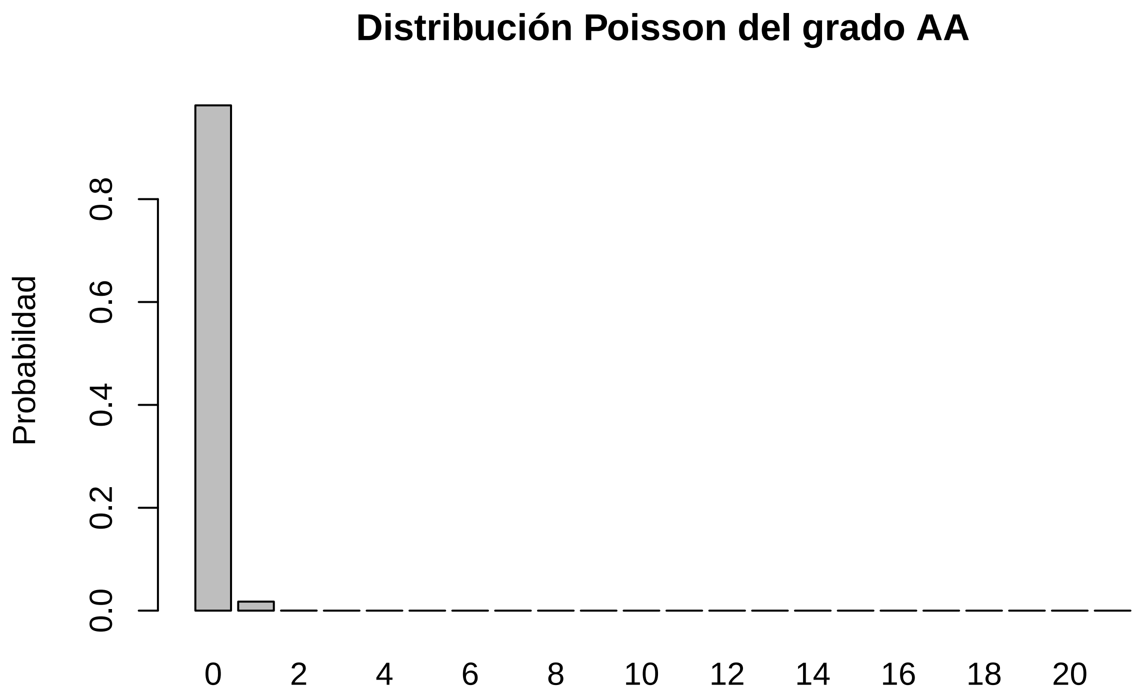
```
dist_poi <- data.frame(matrix(nrow = 22, ncol = 9))

for (i in 1:9) {
  dist_poi[,i]  <- round(dpois(0:21, Est_Bay[i,3]), 8)
  colnames(dist_poi)[i] <- Cla[i]
  row.names(dist_poi) <- c(0:21)
}

dist_poi
```

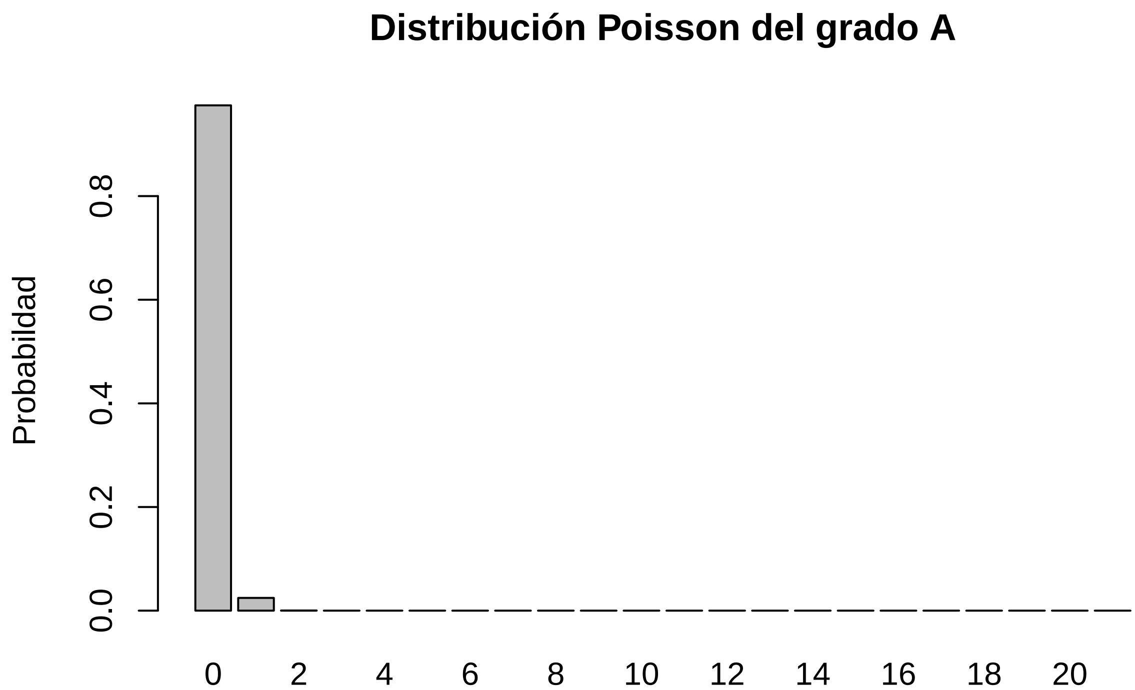
```
##           AAA         AA          A        BBB         BB          B        CCC
## 0  0.97101652 0.98230139 0.97510502 0.99224810 0.98958343 0.94287317 0.94176453
## 1  0.02855934 0.01754105 0.02458250 0.00772177 0.01036213 0.05546310 0.05650587
## 2  0.00041999 0.00015662 0.00030986 0.00003005 0.00005425 0.00163127 0.00169518
## 3  0.00000412 0.00000093 0.00000260 0.00000008 0.00000019 0.00003199 0.00003390
## 4  0.00000003 0.00000000 0.00000002 0.00000000 0.00000000 0.00000047 0.00000051
## 5  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000001 0.00000001
## 6  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 7  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 8  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 9  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
```

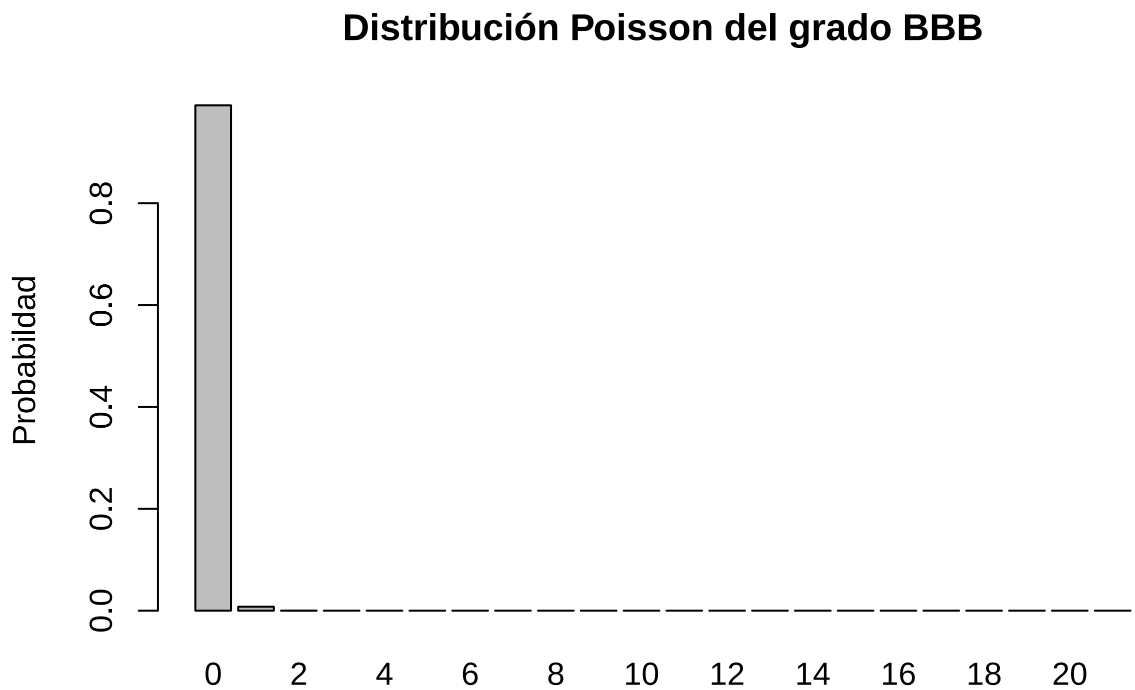
```
## 10 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 11 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 12 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 13 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 14 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 15 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 16 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 17 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 18 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 19 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 20 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 21 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
##            CC          C
## 0  0.97101652 0.84648170
## 1  0.02855934 0.14108031
## 2  0.00041999 0.01175669
## 3  0.00000412 0.00065315
## 4  0.00000003 0.00002721
## 5  0.00000000 0.00000091
## 6  0.00000000 0.00000003
## 7  0.00000000 0.00000000
## 8  0.00000000 0.00000000
## 9  0.00000000 0.00000000
## 10 0.00000000 0.00000000
## 11 0.00000000 0.00000000
## 12 0.00000000 0.00000000
## 13 0.00000000 0.00000000
## 14 0.00000000 0.00000000
## 15 0.00000000 0.00000000
## 16 0.00000000 0.00000000
## 17 0.00000000 0.00000000
## 18 0.00000000 0.00000000
## 19 0.00000000 0.00000000
## 20 0.00000000 0.00000000
## 21 0.00000000 0.00000000
```

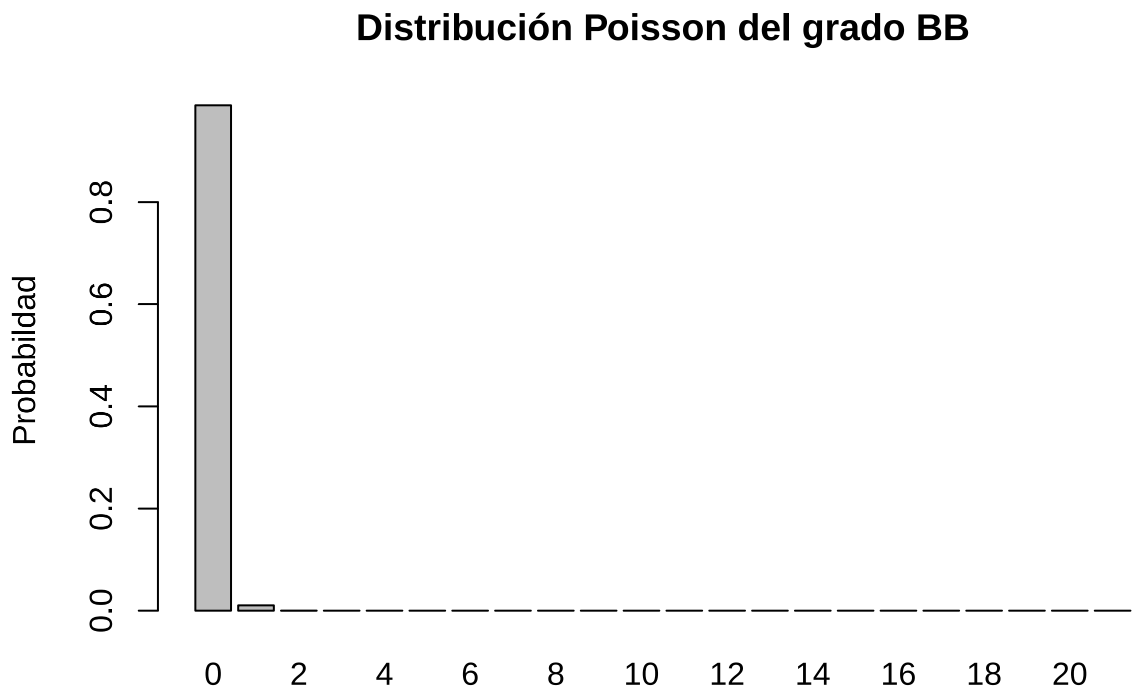
```r
for (i in 1:ncol(dist_poi)) {
  barplot(dist_poi[,i], names.arg = 0:21,
          main = paste("Distribución Poisson del grado", Cla[i]),
          ylab = "Probabildad")
}
```

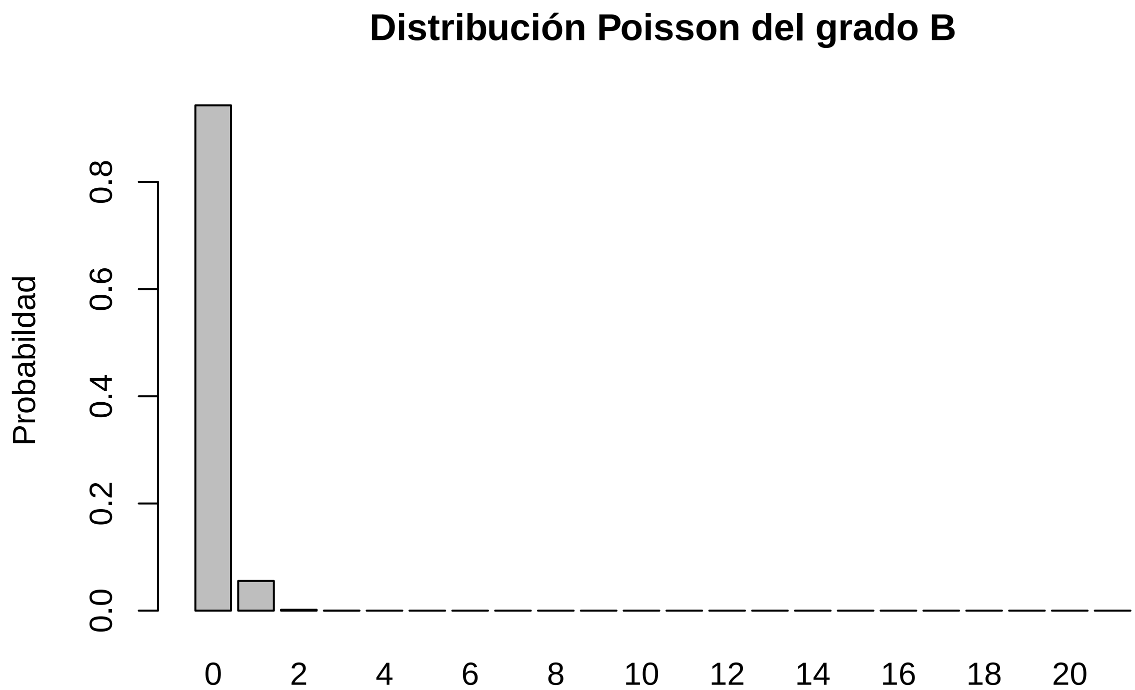

Distribución Poisson del grado AAA
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20

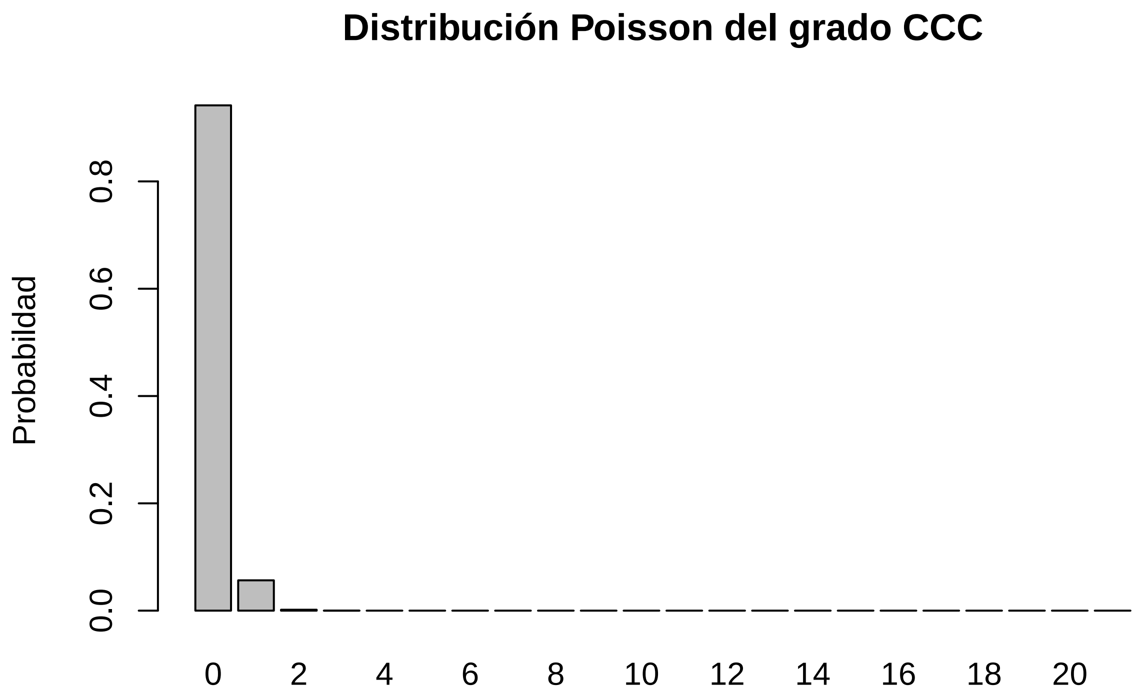

Distribución Poisson del grado AA
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20


Distribución Poisson del grado A
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20

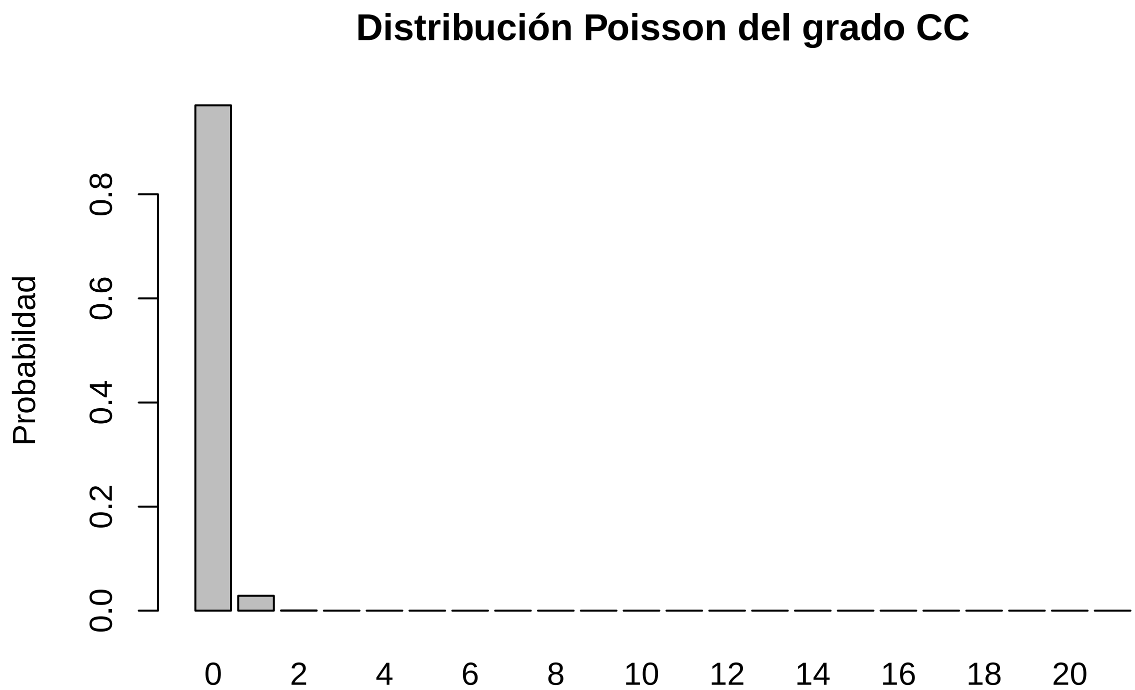

Distribución Poisson del grado BBB
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20

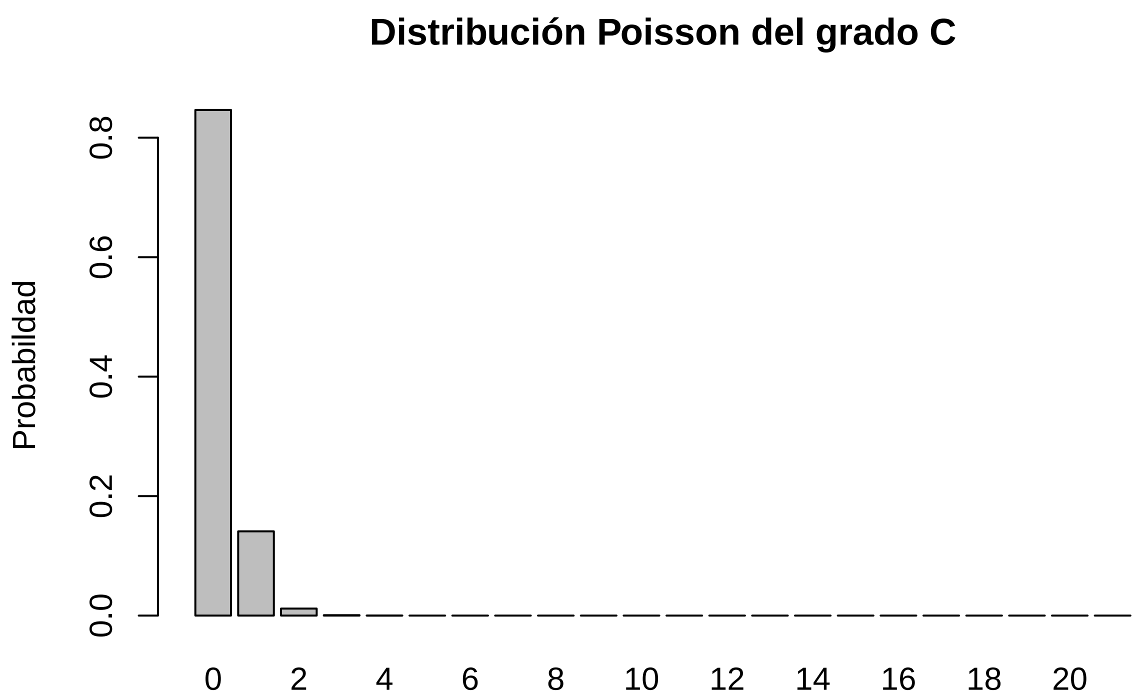

Distribución Poisson del grado BB
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20


Distribución Poisson del grado B
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20



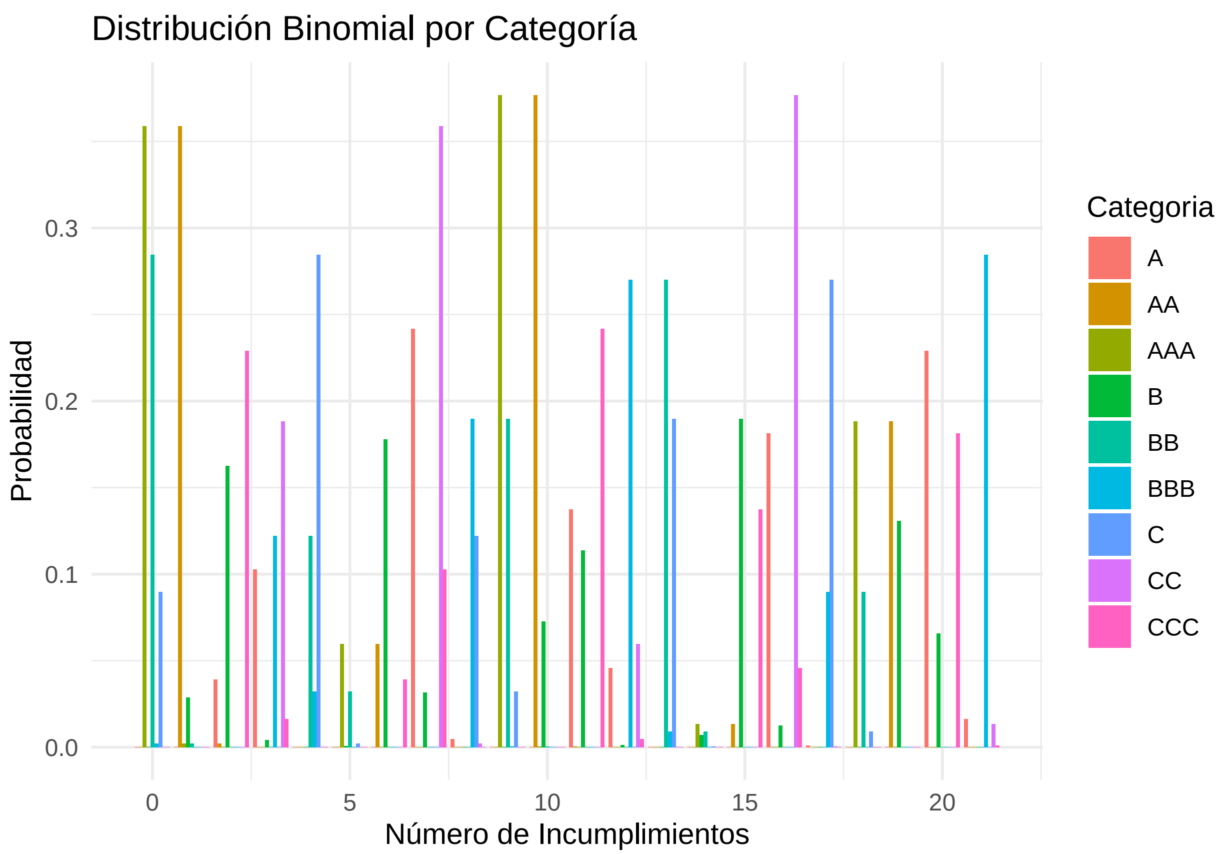
Distribución Poisson del grado CCC
Probabilidad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20


Distribución Poisson del grado CC
Probabildad
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
12
14
16
18
20

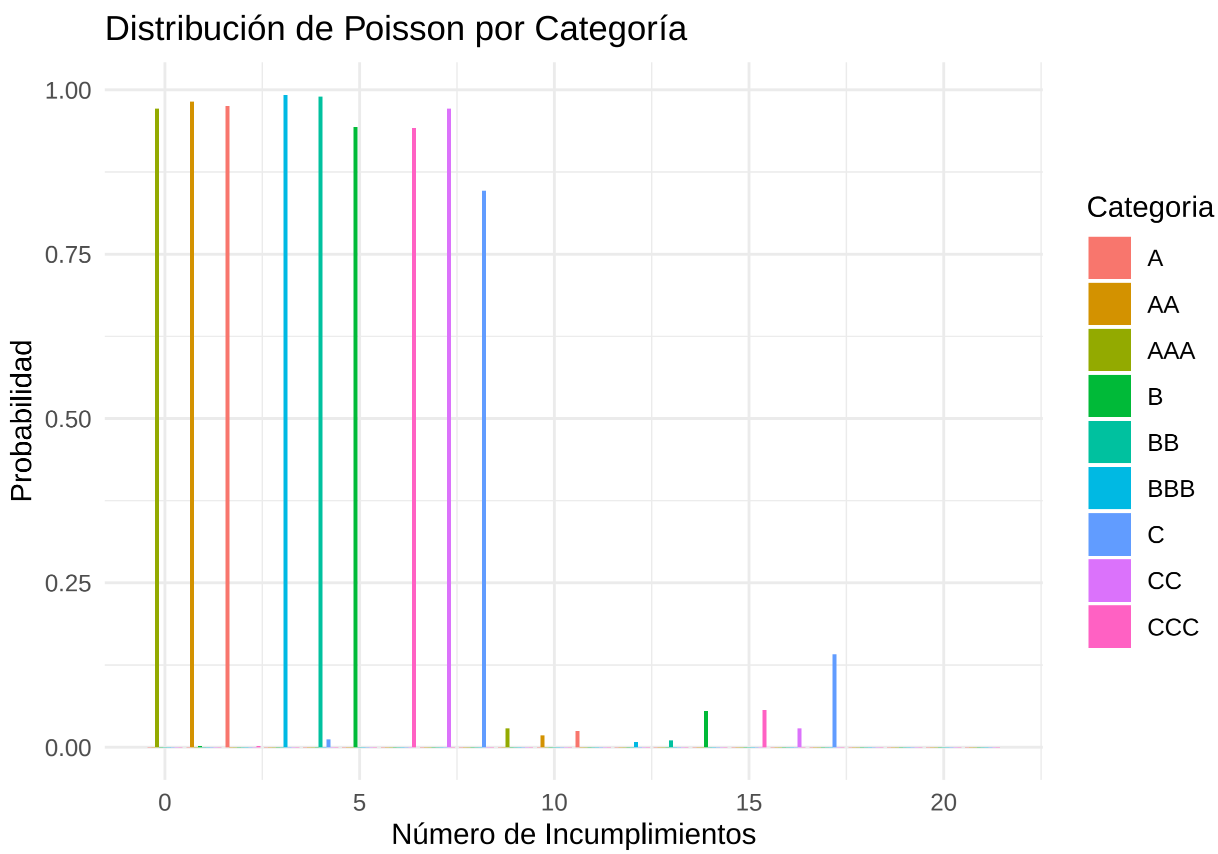


Gráficos de la binomial y Poisson

```
df_bin_long <- dist_bin %>%
  pivot_longer(cols = everything(),
               names_to = "Categoria",
               values_to = "Probabilidad") %>%
  mutate(Num_Incumplimientos = rep(0:21, length(Cla)))

df_poi_long <- dist_poi %>%
  pivot_longer(cols = everything(),
               names_to = "Categoria",
               values_to = "Probabilidad") %>%
  mutate(Num_Incumplimientos = rep(0:21, length(Cla)))

# Gráfico combinado para dist_bin
ggplot(df_bin_long, aes(x = Num_Incumplimientos, y = Probabilidad, fill = Categoria)) +
  geom_bar(stat = "identity", position = "dodge") +
  labs(title = "Distribución Binomial por Categoría",
       x = "Número de Incumplimientos",
       y = "Probabilidad") +
  theme_minimal()
```




```r
# Gráfico combinado para dist_poi
ggplot(df_poi_long, aes(x = Num_Incumplimientos, y = Probabilidad, fill = Categoria)) +
  geom_bar(stat = "identity", position = "dodge") +
  labs(title = "Distribución de Poisson por Categoría",
       x = "Número de Incumplimientos",
       y = "Probabilidad") +
  theme_minimal()
```


Distribución de Poisson por Categoría
Probabilidad
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
Número de Incumplimientos
Categoria
A
AA
AAA
B
BB
BBB
C
CC
CCC

Convolución

$$P(Z = z) = \sum_{x} P(X = x) \cdot P(Y = z - x)$$

Ejemplo:

Soporte	X	Y
0	.2	.7
1	.3	.2
2	.5	.1

$$\begin{aligned} P(Z = 0) &= [P(X = 0) \cdot P(Y = 0 - 0)] + [P(X = 1) \cdot P(Y = 0 - 1)] \\ &= [P(X = 0) \cdot P(Y = 0)] + [P(X = 1) \cdot P(Y = -1)] \\ &= P(X = 0) \cdot P(Y = 0) \end{aligned}$$

$$\begin{aligned} P(Z = 1) &= [P(X = 0) \cdot P(Y = 1 - 0)] + [P(X = 1) \cdot P(Y = 1 - 1)] + [P(X = 2) \cdot P(Y = 1 - 2)] \\ &= [P(X = 0) \cdot P(Y = 1)] + [P(X = 1) \cdot P(Y = 0)] + [P(X = 2) \cdot P(Y = -1)] \\ &= P(X = 0) \cdot P(Y = 1) + P(X = 1) \cdot P(Y = 0) \end{aligned}$$

$$\begin{aligned} P(Z = 2) &= [P(X = 0) \cdot P(Y = 2 - 0)] + [P(X = 1) \cdot P(Y = 2 - 1)] + [P(X = 2) \cdot P(Y = 2 - 2)] + [P(X = 3) \cdot P(Y = 2 - 3 \\ &= [P(X = 0) \cdot P(Y = 2)] + [P(X = 1) \cdot P(Y = 1)] + [P(X = 2) \cdot P(Y = 0)] + [P(X = 3) \cdot P(Y = -1)] \\ &= P(X = 0) \cdot P(Y = 2) + P(X = 1) \cdot P(Y = 1) \ + P(X = 2) \cdot P(Y = 0) \end{aligned}$$

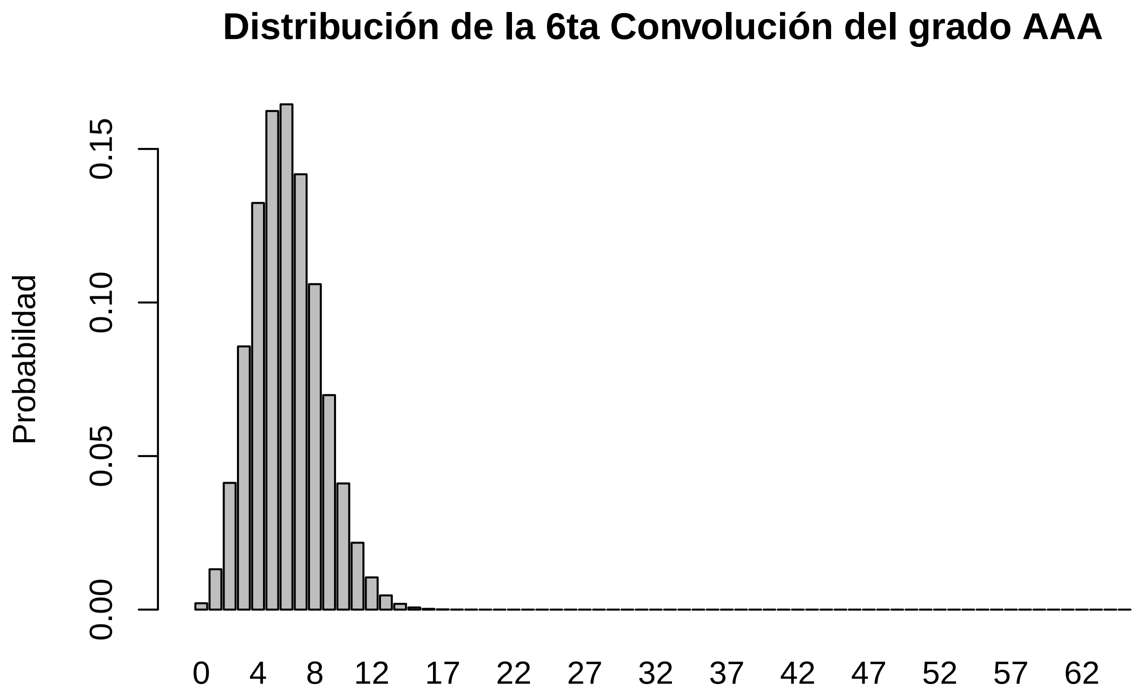
$$\begin{aligned} P(Z = 3) = [P(X = 0) \cdot P(Y = 3)] + [P(X = 1) \cdot P(Y = 2)] \ + [P(X = 2) \cdot P(Y = 1)] \\ + [P(X = 3) \cdot P(Y = 0)] \end{aligned}$$

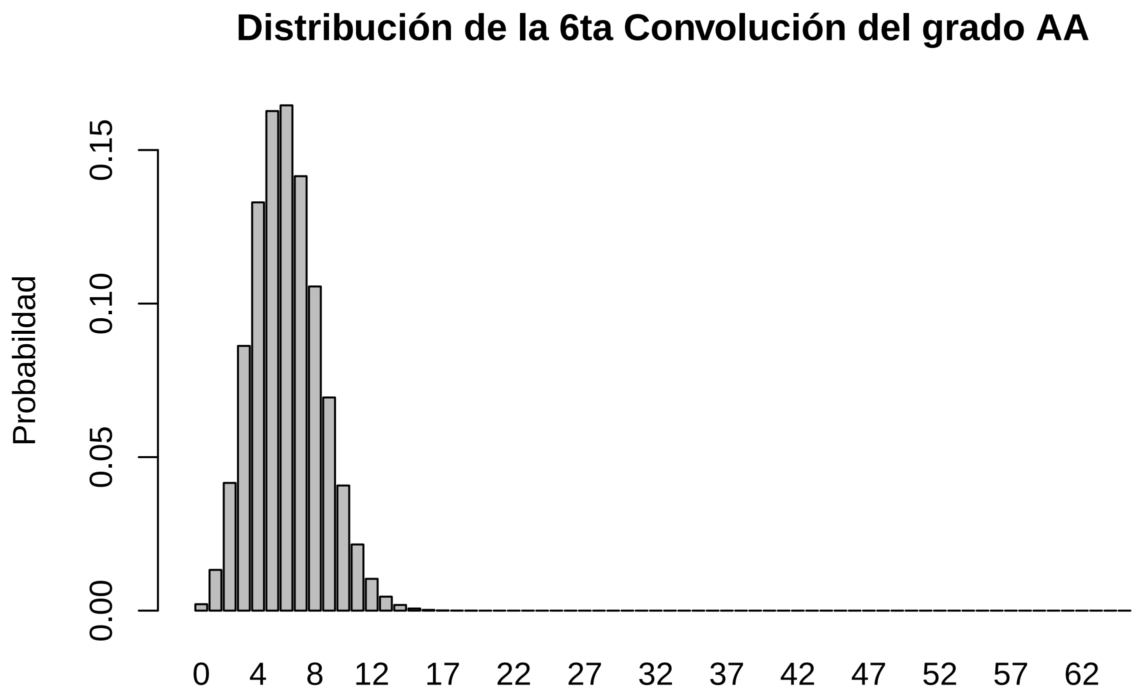
Soporte	X	Y	Z
0	.2	.7	.14
1	.3	.2	.25
2	.5	.1	.43
3	0	0	.13
4	0	0	.05

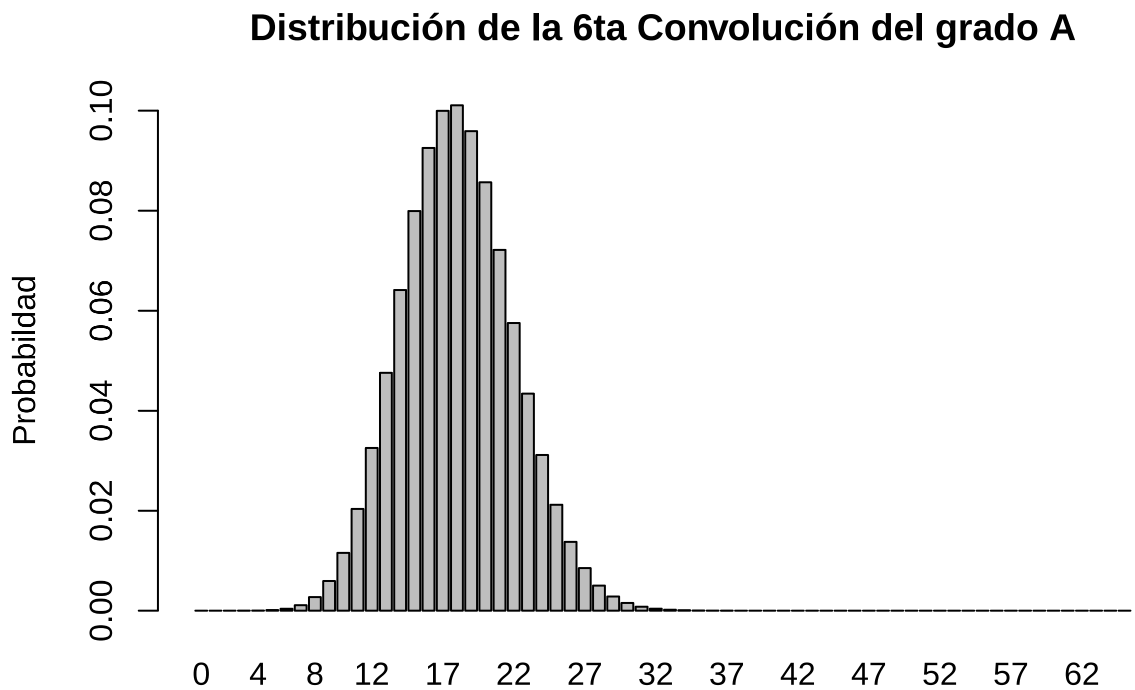
```r
# Primera Convolución: Binomial y Poisson

Convolucion1 <- data.frame(matrix(nrow = 43, ncol = 9))

for (i in 1:9) {
  Convolucion1[,i] <- round(convolve(dist_bin[,i], rev(dist_poi[,i]), type = "open"), 8)
  colnames(Convolucion1)[i] <- Cla[i]
  row.names(Convolucion1) <- c(0:42)
}


# Segunda Convolución: Primera convolución con binomial
```

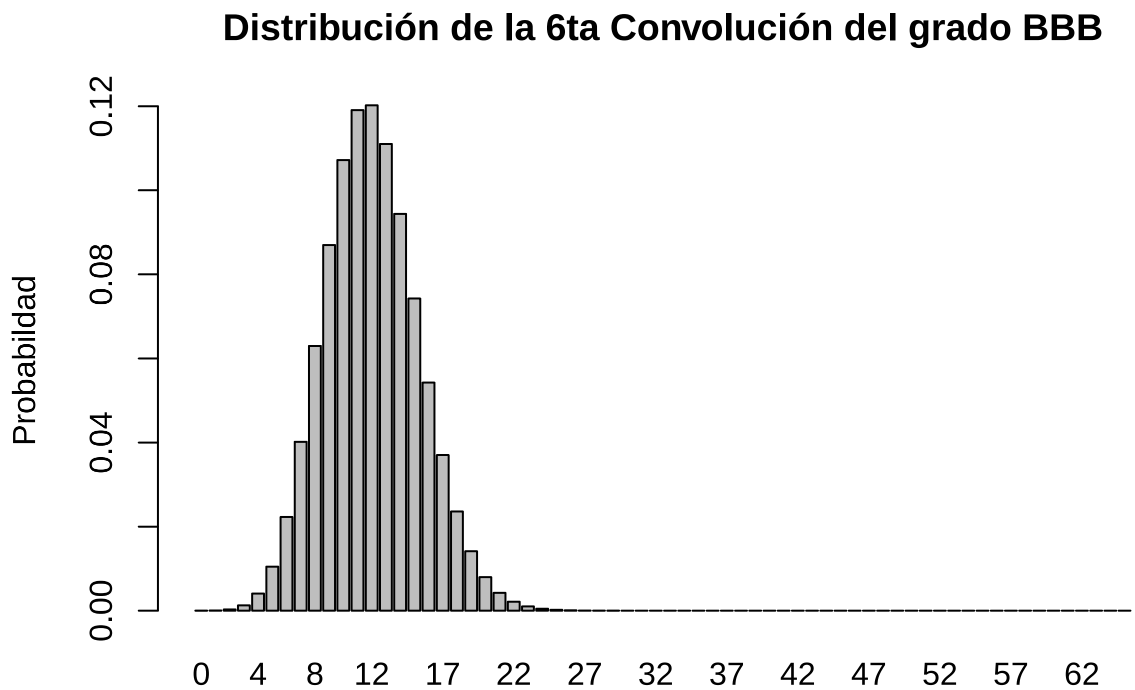
```r
Convolucion2 <- data.frame(matrix(nrow = 64, ncol = 9))

for (i in 1:9) {
  Convolucion2[,i] <- round(convolve(Convolucion1[,i], rev(dist_bin[,i]), type = "open"), 8)
  colnames(Convolucion2)[i] <- Cla[i]
  row.names(Convolucion2) <- c(0:63)
}

# Tercera Convolución: Segunda convolución con binomial

Convolucion3 <- data.frame(matrix(nrow = 85, ncol = 9))

for (i in 1:9) {
  Convolucion3[,i] <- round(convolve(Convolucion2[,i], rev(dist_bin[,i]), type = "open"), 8)
  colnames(Convolucion3)[i] <- Cla[i]
  row.names(Convolucion3) <- c(0:84)
}

# Cuarta Convolución: Tercera convolución con binomial

Convolucion4 <- data.frame(matrix(nrow = 106, ncol = 9))

for (i in 1:9) {
  Convolucion4[,i] <- round(convolve(Convolucion3[,i], rev(dist_bin[,i]), type = "open"), 8)
  colnames(Convolucion4)[i] <- Cla[i]
  row.names(Convolucion4) <- c(0:105)
}

# Quinta Convolución: Cuarta convolución con binomial

Convolucion5 <- data.frame(matrix(nrow = 127, ncol = 9))

for (i in 1:9) {
  Convolucion5[,i] <- round(convolve(Convolucion4[,i], rev(dist_bin[,i]), type = "open"), 8)
  colnames(Convolucion5)[i] <- Cla[i]
  row.names(Convolucion5) <- c(0:126)
}

# Sexta Convolución: Quinta convolución con binomial

Convolucion6 <- data.frame(matrix(nrow = 148, ncol = 9))

for (i in 1:9) {
  Convolucion6[,i] <- round(convolve(Convolucion5[,i], rev(dist_bin[,i]), type = "open"), 8)
  colnames(Convolucion6)[i] <- Cla[i]
  row.names(Convolucion6) <- c(0:147)
}

# Graficar la Sexta Convolución

for (i in 1:ncol(Convolucion6)) {
  barplot(Convolucion6[c(1:66),i], names.arg = 0:65,
          main = paste("Distribución de la 6ta Convolución del grado", Cla[i]),
```

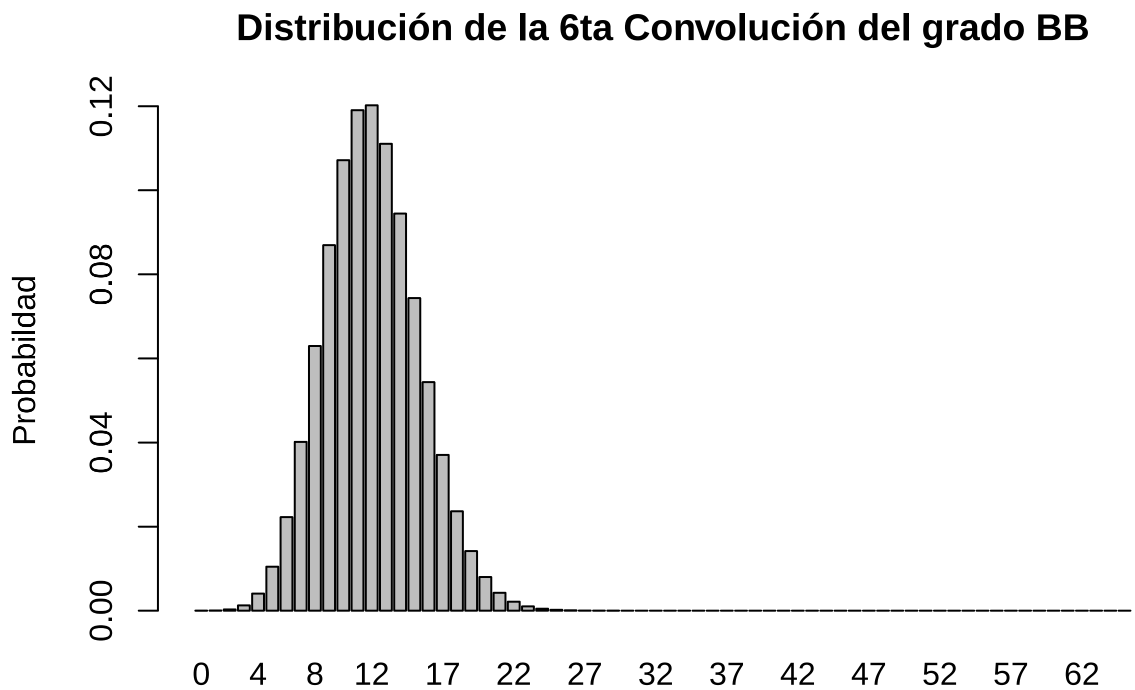
```
            ylab = "Probabildad")
}
```

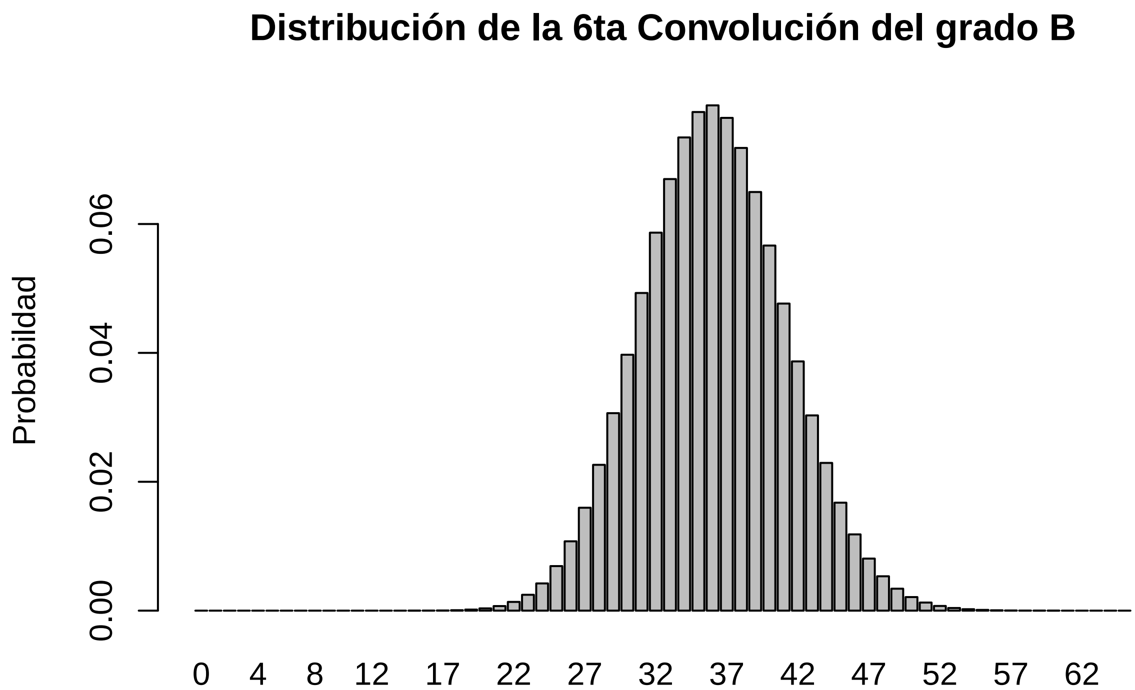


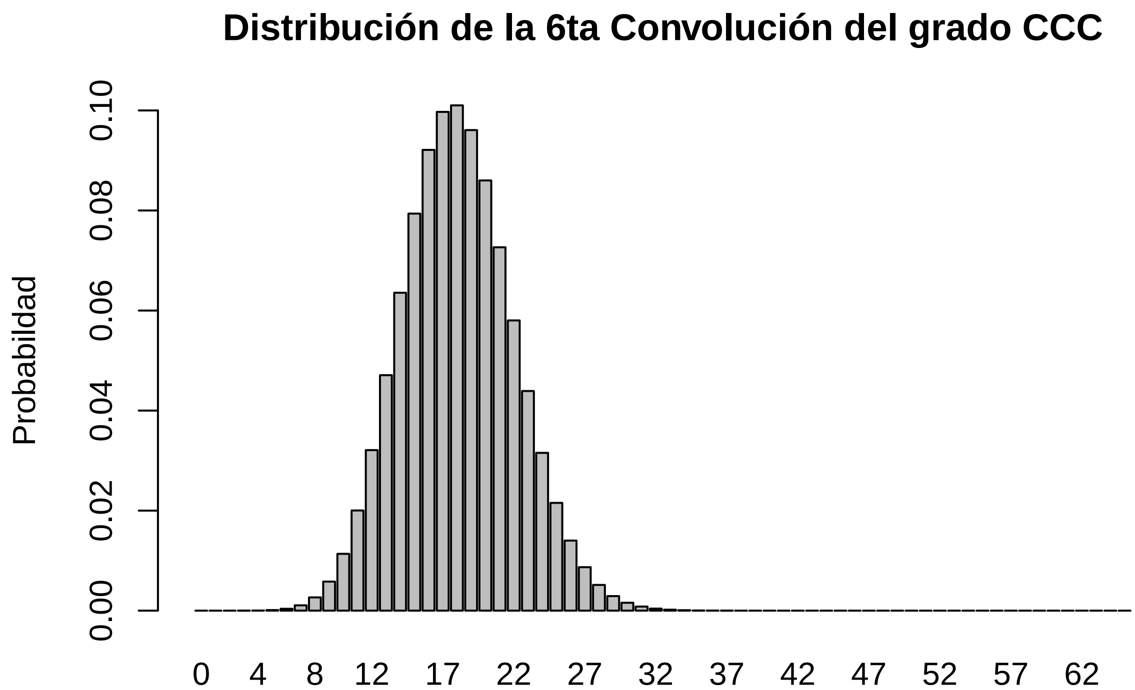

Distribución de la 6ta Convolución del grado AA
Probabildad
0.00
0.05
0.10
0.15
0
4
8
12
17
22
27
32
37
42
47
52
57
62

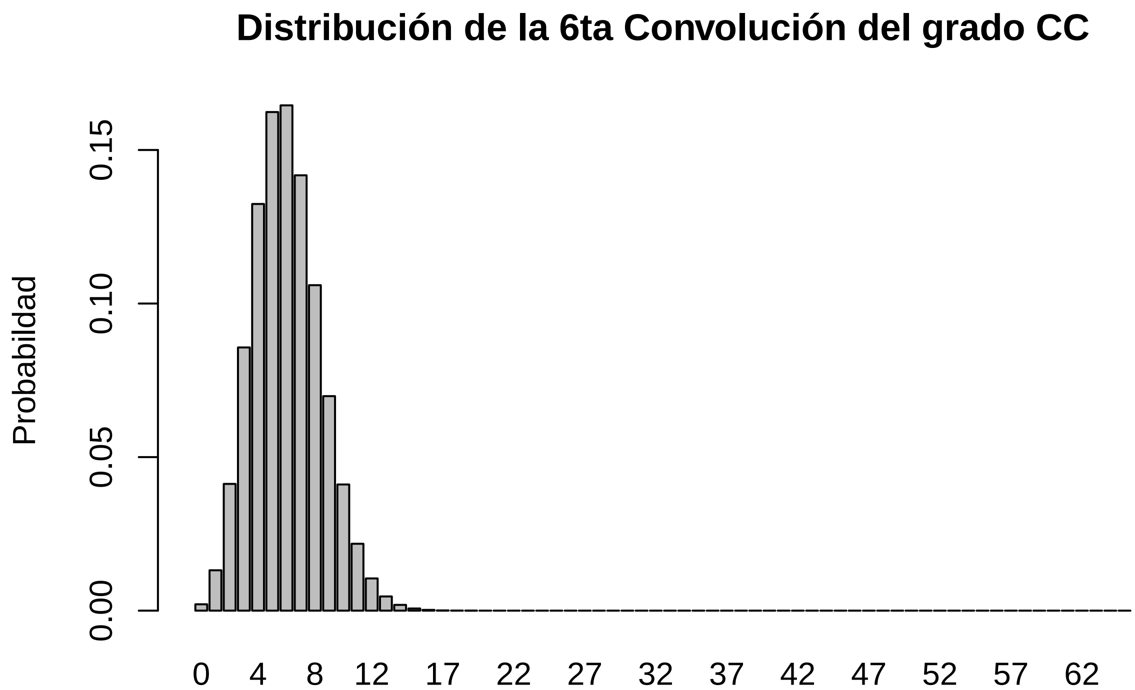

Distribución de la 6ta Convolución del grado A
Probabildad
0.00
0.02
0.04
0.06
0.08
0.10
0
4
8
12
17
22
27
32
37
42
47
52
57
62


Distribución de la 6ta Convolución del grado BBB
Probabildad
0.00
0.04
0.08
0.12
0
4
8
12
17
22
27
32
37
42
47
52
57
62

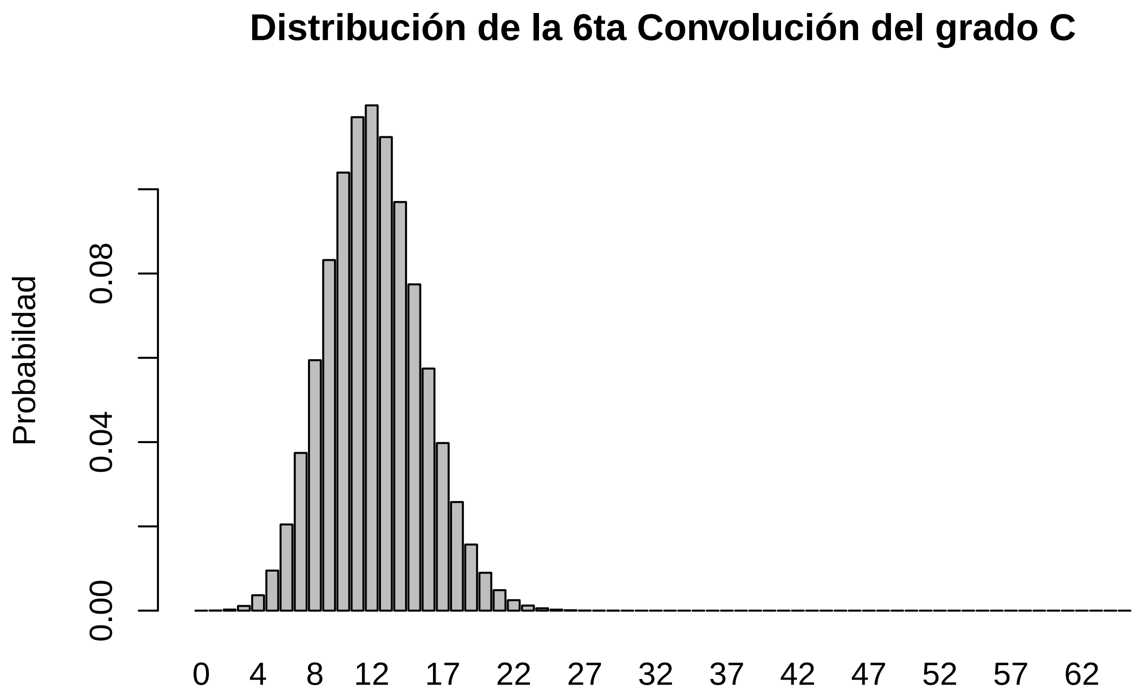

Distribución de la 6ta Convolución del grado BB
Probabildad
0.00
0.04
0.08
0.12
0
4
8
12
17
22
27
32
37
42
47
52
57
62


Distribución de la 6ta Convolución del grado B
Probabilidad
0.00
0.02
0.04
0.06
0 4 8 12 17 22 27 32 37 42 47 52 57 62


Distribución de la 6ta Convolución del grado CCC
Probabildad
0.00
0.02
0.04
0.06
0.08
0.10
0
4
8
12
17
22
27
32
37
42
47
52
57
62



Distribución de la 6ta Convolución del grado CC
Probabildad
0.00
0.05
0.10
0.15
0
4
8
12
17
22
27
32
37
42
47
52
57
62




```
Convolucion6
```

```
##          AAA        AA          A        BBB         BB          B
## 0   0.00207672 0.00210086 0.00000000 0.00000331 0.00000330 0.00000000
## 1   0.01314439 0.01327288 0.00000008 0.00004394 0.00004383 0.00000000
## 2   0.04127101 0.04159715 0.00000078 0.00028924 0.00028858 0.00000000
## 3   0.08570440 0.08621890 0.00000541 0.00125921 0.00125661 0.00000000
## 4   0.13241573 0.13295561 0.00002778 0.00407838 0.00407081 0.00000000
## 5   0.16235114 0.16269591 0.00011310 0.01048156 0.01046436 0.00000000
## 6   0.16453219 0.16455554 0.00038065 0.02226448 0.02223282 0.00000000
## 7   0.14175287 0.14148799 0.00108901 0.04020250 0.04015429 0.00000000
## 8   0.10597998 0.10556577 0.00270347 0.06299004 0.06292879 0.00000000
## 9   0.06984520 0.06942765 0.00591565 0.08699176 0.08692722 0.00000000
## 10  0.04108041 0.04074854 0.01155157 0.10721009 0.10715570 0.00000001
## 11  0.02177974 0.02155736 0.02033148 0.11909066 0.11905868 0.00000003
## 12  0.01049453 0.01036468 0.03252064 0.12021987 0.12021679 0.00000012
## 13  0.00462765 0.00456023 0.04759979 0.11105166 0.11107628 0.00000043
## 14  0.00187841 0.00184686 0.06412850 0.09442093 0.09446563 0.00000137
## 15  0.00070541 0.00069196 0.07992545 0.07426660 0.07432078 0.00000411
## 16  0.00024616 0.00024090 0.09255654 0.05427512 0.05432888 0.00001143
## 17  0.00008012 0.00007823 0.09997285 0.03699600 0.03704248 0.00002963
## 18  0.00002441 0.00002378 0.10106011 0.02360071 0.02363675 0.00007188
## 19  0.00000698 0.00000678 0.09589732 0.01413247 0.01415794 0.00016370
## 20  0.00000188 0.00000182 0.08565053 0.00796528 0.00798187 0.00035089
## 21  0.00000048 0.00000046 0.07217719 0.00423568 0.00424572 0.00070964
## 22  0.00000011 0.00000011 0.05751272 0.00212977 0.00213543 0.00135704
```

```
## 23  0.00000002 0.00000002 0.04341913 0.00101458 0.00101758 0.00245868
## 24  0.00000000 0.00000000 0.03111240 0.00045874 0.00046024 0.00422809
## 25  0.00000000 0.00000000 0.02119509 0.00019720 0.00019789 0.00691251
## 26  0.00000000 0.00000000 0.01374803 0.00008071 0.00008102 0.01076044
## 27  0.00000000 0.00000000 0.00850257 0.00003150 0.00003162 0.01597086
## 28  0.00000000 0.00000000 0.00502016 0.00001173 0.00001178 0.02262996
## 29  0.00000000 0.00000000 0.00283304 0.00000418 0.00000420 0.03064833
## 30  0.00000000 0.00000000 0.00152977 0.00000142 0.00000143 0.03971635
## 31  0.00000000 0.00000000 0.00079119 0.00000047 0.00000047 0.04929565
## 32  0.00000000 0.00000000 0.00039229 0.00000015 0.00000015 0.05865841
## 33  0.00000000 0.00000000 0.00018664 0.00000004 0.00000004 0.06697475
## 34  0.00000000 0.00000000 0.00008527 0.00000001 0.00000001 0.07343473
## 35  0.00000000 0.00000000 0.00003744 0.00000000 0.00000000 0.07737982
## 36  0.00000000 0.00000000 0.00001581 0.00000000 0.00000000 0.07841403
## 37  0.00000000 0.00000000 0.00000643 0.00000000 0.00000000 0.07646861
## 38  0.00000000 0.00000000 0.00000251 0.00000000 0.00000000 0.07180595
## 39  0.00000000 0.00000000 0.00000095 0.00000000 0.00000000 0.06496391
## 40  0.00000000 0.00000000 0.00000034 0.00000000 0.00000000 0.05665638
## 41  0.00000000 0.00000000 0.00000012 0.00000000 0.00000000 0.04765466
## 42  0.00000000 0.00000000 0.00000004 0.00000000 0.00000000 0.03867607
## 43  0.00000000 0.00000000 0.00000001 0.00000000 0.00000000 0.03030028
## 44  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.02292413
## 45  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.01675495
## 46  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.01183447
## 47  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00808071
## 48  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00533550
## 49  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00340758
## 50  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00210559
## 51  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00125910
## 52  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00072878
## 53  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00040838
## 54  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00022159
## 55  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00011644
## 56  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00005927
## 57  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00002922
## 58  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00001396
## 59  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000646
## 60  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000290
## 61  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000126
## 62  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000053
## 63  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000022
## 64  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000008
## 65  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000003
## 66  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000001
## 67  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 68  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 69  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 70  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 71  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 72  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
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## 88  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
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## 96  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 97  0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
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## 137 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 138 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 139 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 140 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 141 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 142 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 143 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 144 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 145 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 146 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
## 147 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
##            CCC         CC          C
## 0   0.00000000 0.00207672 0.00000283
## 1   0.00000007 0.01314439 0.00003793
## 2   0.00000076 0.04127101 0.00025274
## 3   0.00000526 0.08570440 0.00111391
## 4   0.00002701 0.13241573 0.00365307
## 5   0.00011018 0.16235114 0.00950829
## 6   0.00037145 0.16453219 0.02045906
## 7   0.00106463 0.14175287 0.03742957
## 8   0.00264784 0.10597998 0.05943148
## 9   0.00580486 0.06984520 0.08319595
## 10  0.01135695 0.04108041 0.10395325
## 11  0.02002792 0.02177974 0.11710083
## 12  0.03209864 0.01049453 0.11990641
## 13  0.04707694 0.00462765 0.11237815
## 14  0.06355436 0.00187841 0.09696728
## 15  0.07937544 0.00070541 0.07742174
## 16  0.09211520 0.00024616 0.05745105
## 17  0.09971170 0.00008012 0.03977389
## 18  0.10101847 0.00002441 0.02577722
## 19  0.09607316 0.00000698 0.01568634
## 20  0.08600393 0.00000188 0.00898722
## 21  0.07264396 0.00000048 0.00485960
## 22  0.05802216 0.00000011 0.00248541
## 23  0.04390978 0.00000002 0.00120470
## 24  0.03154162 0.00000000 0.00055441
## 25  0.02154156 0.00000000 0.00024265
## 26  0.01400861 0.00000000 0.00010115
## 27  0.00868639 0.00000000 0.00004022
## 28  0.00514238 0.00000000 0.00001527
## 29  0.00290991 0.00000000 0.00000555
## 30  0.00157565 0.00000000 0.00000193
## 31  0.00081723 0.00000000 0.00000064
## 32  0.00040638 0.00000000 0.00000020
## 33  0.00019391 0.00000000 0.00000006
## 34  0.00008886 0.00000000 0.00000002
## 35  0.00003914 0.00000000 0.00000000
```

```
## 36  0.00001658 0.00000000 0.00000000
## 37  0.00000676 0.00000000 0.00000000
## 38  0.00000265 0.00000000 0.00000000
## 39  0.00000100 0.00000000 0.00000000
## 40  0.00000036 0.00000000 0.00000000
## 41  0.00000012 0.00000000 0.00000000
## 42  0.00000004 0.00000000 0.00000000
## 43  0.00000001 0.00000000 0.00000000
## 44  0.00000000 0.00000000 0.00000000
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## 69  0.00000000 0.00000000 0.00000000
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## 71  0.00000000 0.00000000 0.00000000
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```

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## 90  0.00000000 0.00000000 0.00000000
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## 96  0.00000000 0.00000000 0.00000000
## 97  0.00000000 0.00000000 0.00000000
## 98  0.00000000 0.00000000 0.00000000
## 99  0.00000000 0.00000000 0.00000000
## 100 0.00000000 0.00000000 0.00000000
## 101 0.00000000 0.00000000 0.00000000
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## 107 0.00000000 0.00000000 0.00000000
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## 110 0.00000000 0.00000000 0.00000000
## 111 0.00000000 0.00000000 0.00000000
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## 114 0.00000000 0.00000000 0.00000000
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```

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## 144 0.00000000 0.00000000 0.00000000
## 145 0.00000000 0.00000000 0.00000000
## 146 0.00000000 0.00000000 0.00000000
## 147 0.00000000 0.00000000 0.00000000
```
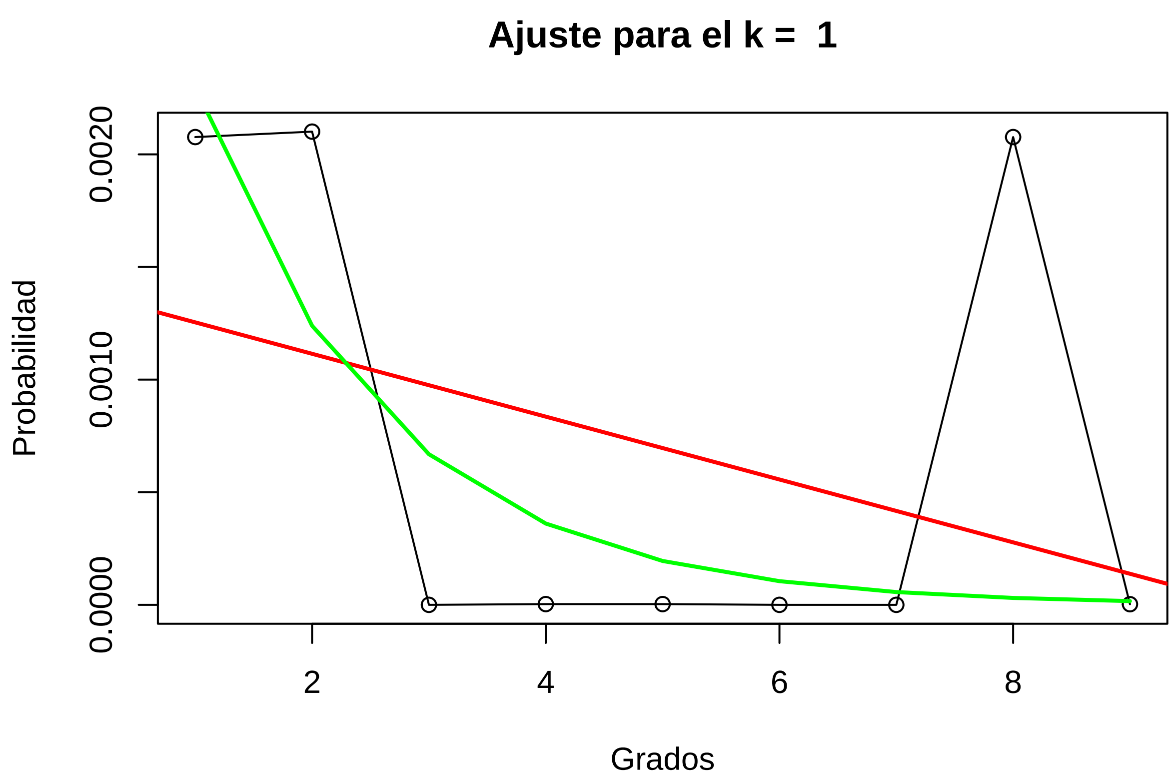
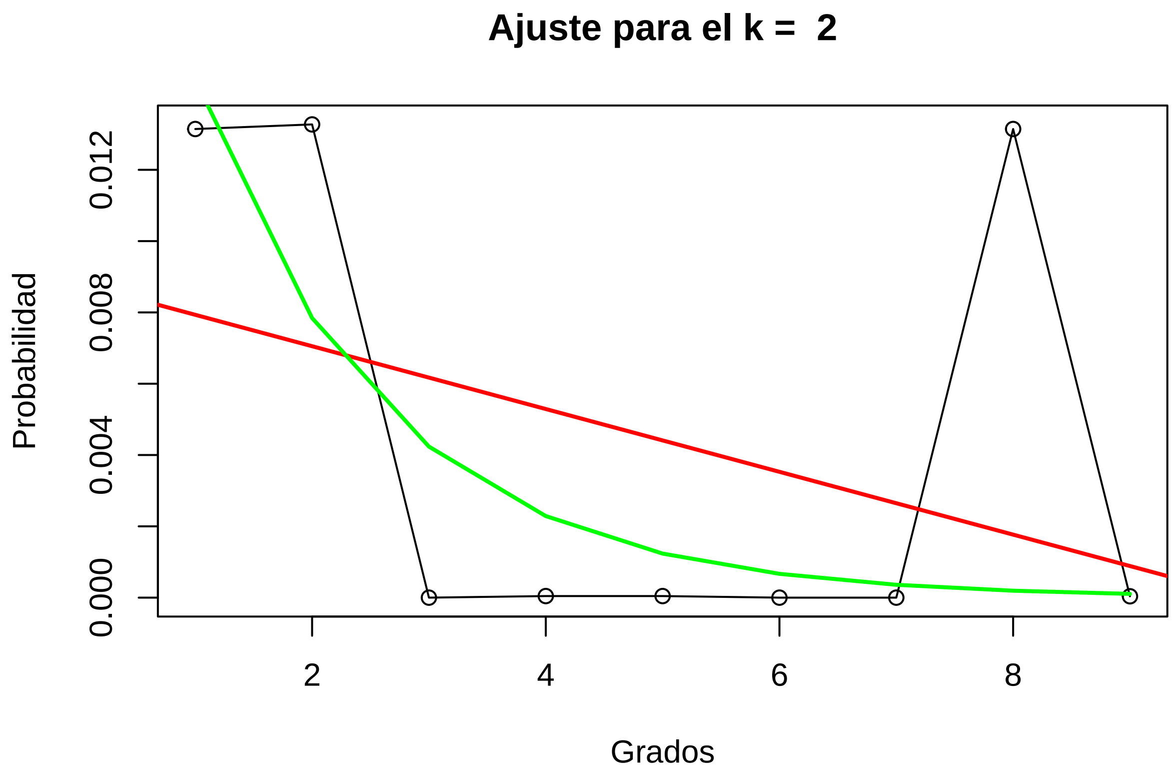
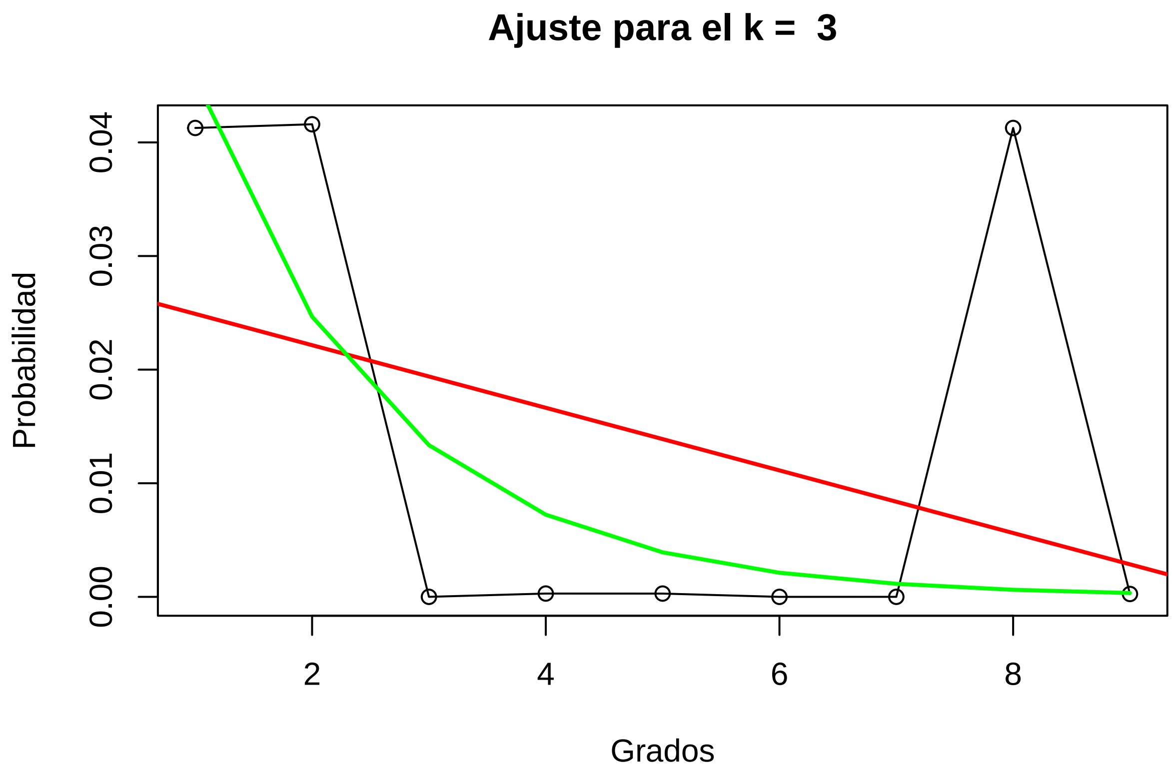
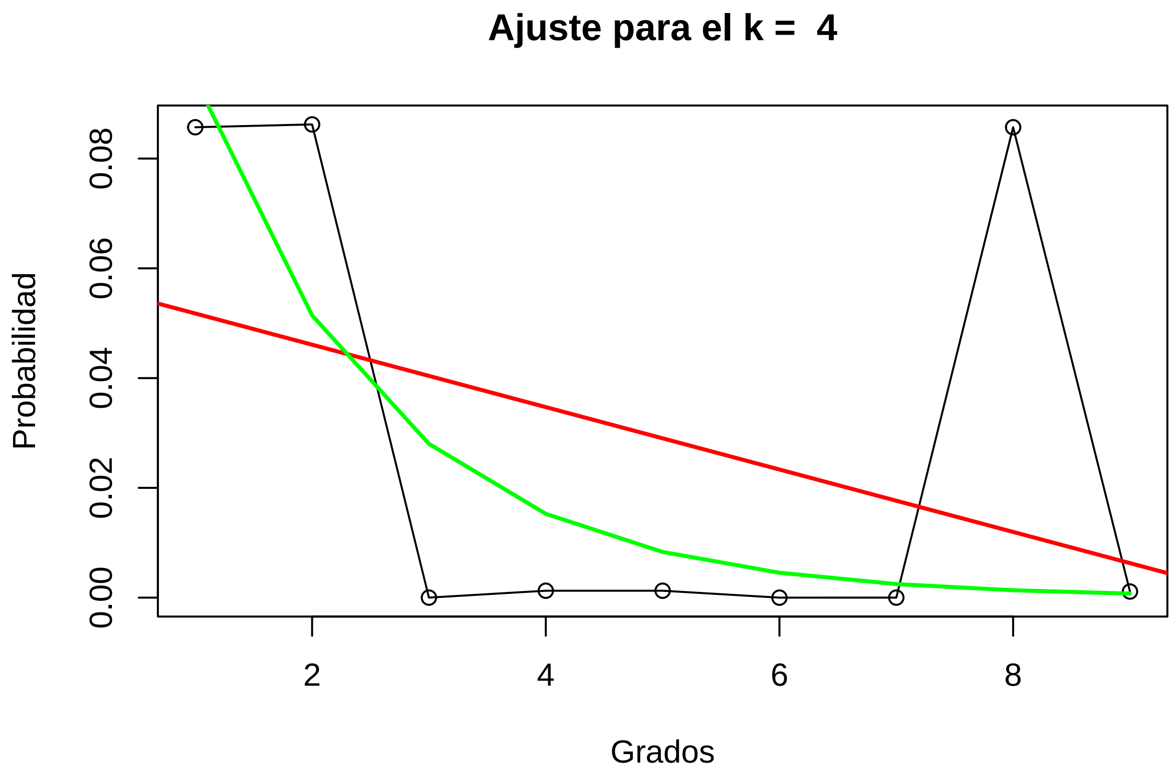
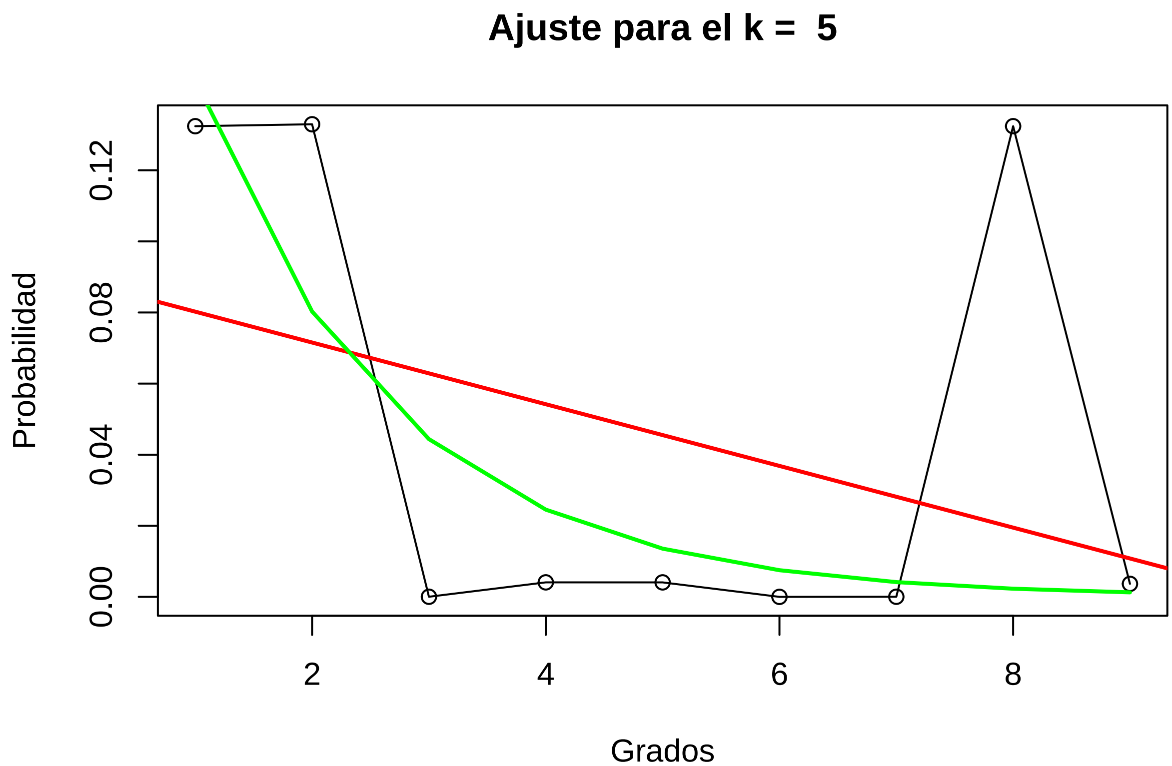

```
# Tratar de encontrar un k

for (i in 1:15) {
  z <- c(t(Convolucion6[i,]))
  plot(z, type = "o", main = paste("Ajuste para el k = ", i),
       xlab = "Grados", ylab = "Probabilidad")

  modelo_lm <- lm(z ~ seq_along(z))
  abline(modelo_lm, col = "red", lwd = 2)

  modelo_nl <- nls(z ~ a * exp(b * seq_along(z)), start = list(a = 1, b = 0.01))
  lines(seq_along(z), predict(modelo_nl), col = "green", lwd = 2)
}
```

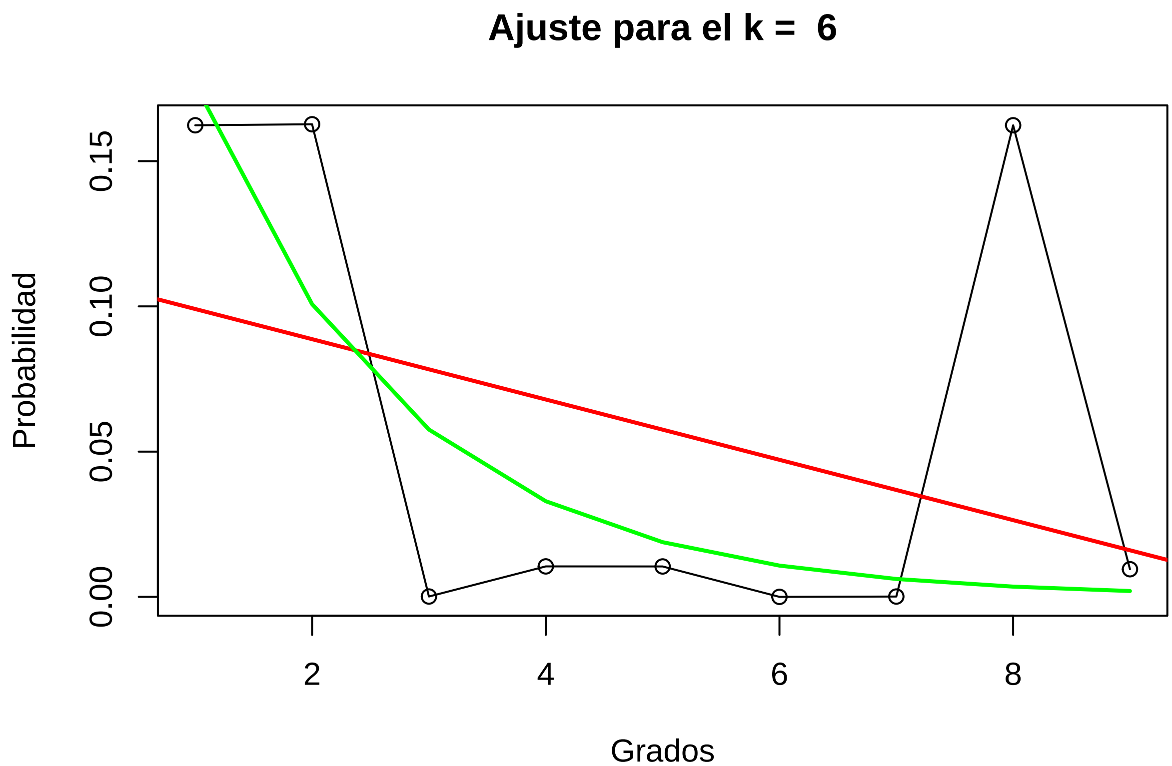


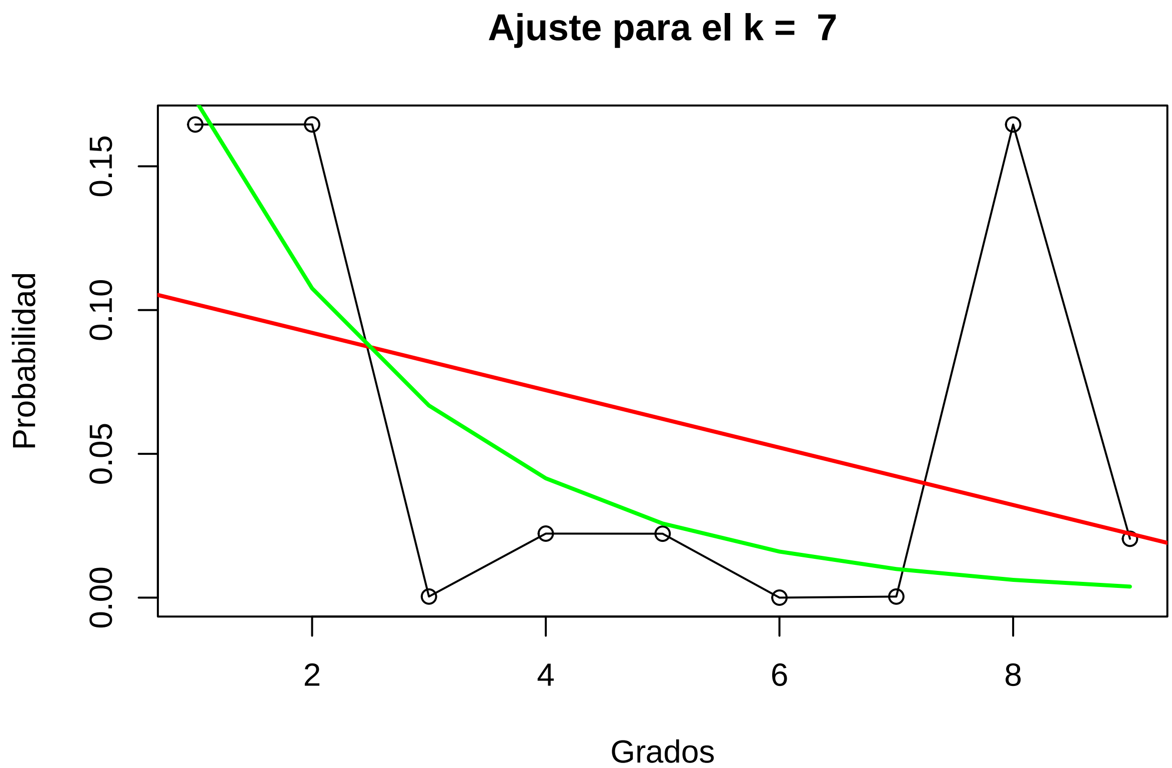

Ajuste para el k = 2
Probabilidad
0.000
0.004
0.008
0.012
2
4
6
8
Grados


Ajuste para el k = 3
Probabilidad
0.00
0.01
0.02
0.03
0.04
2
4
6
8
Grados

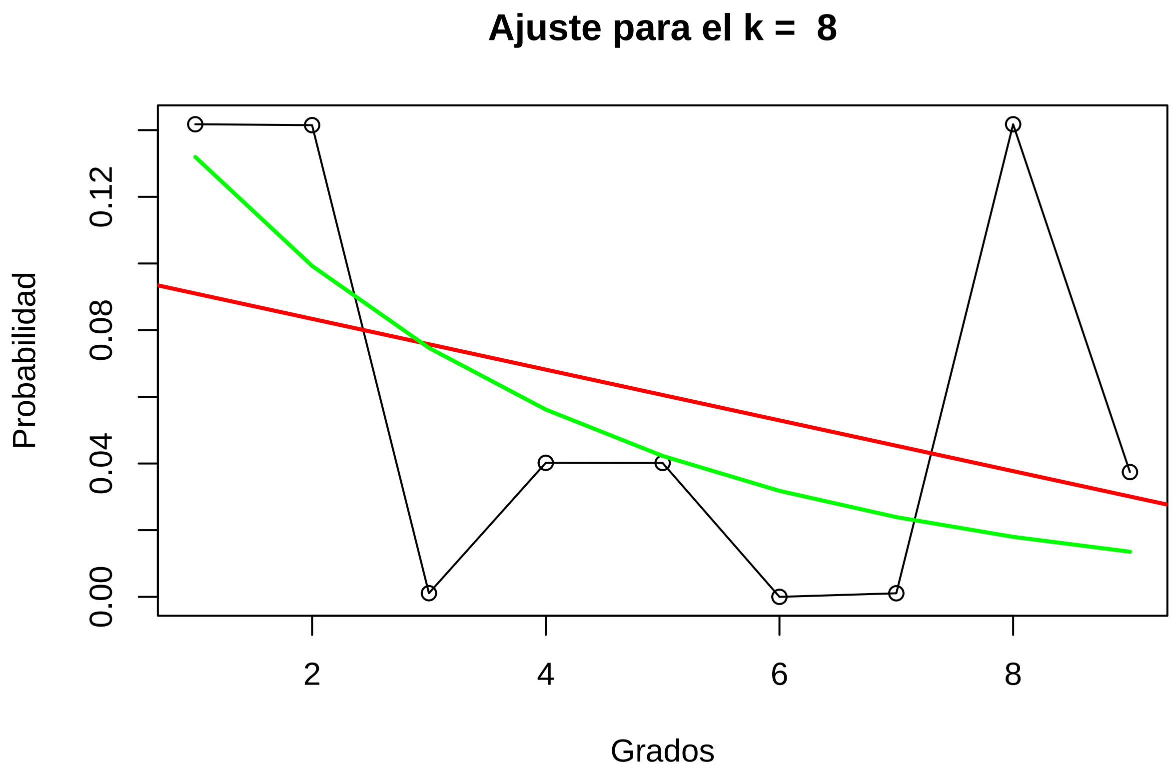

Ajuste para el k = 4
Probabilidad
0.00
0.02
0.04
0.06
0.08
2
4
6
8
Grados

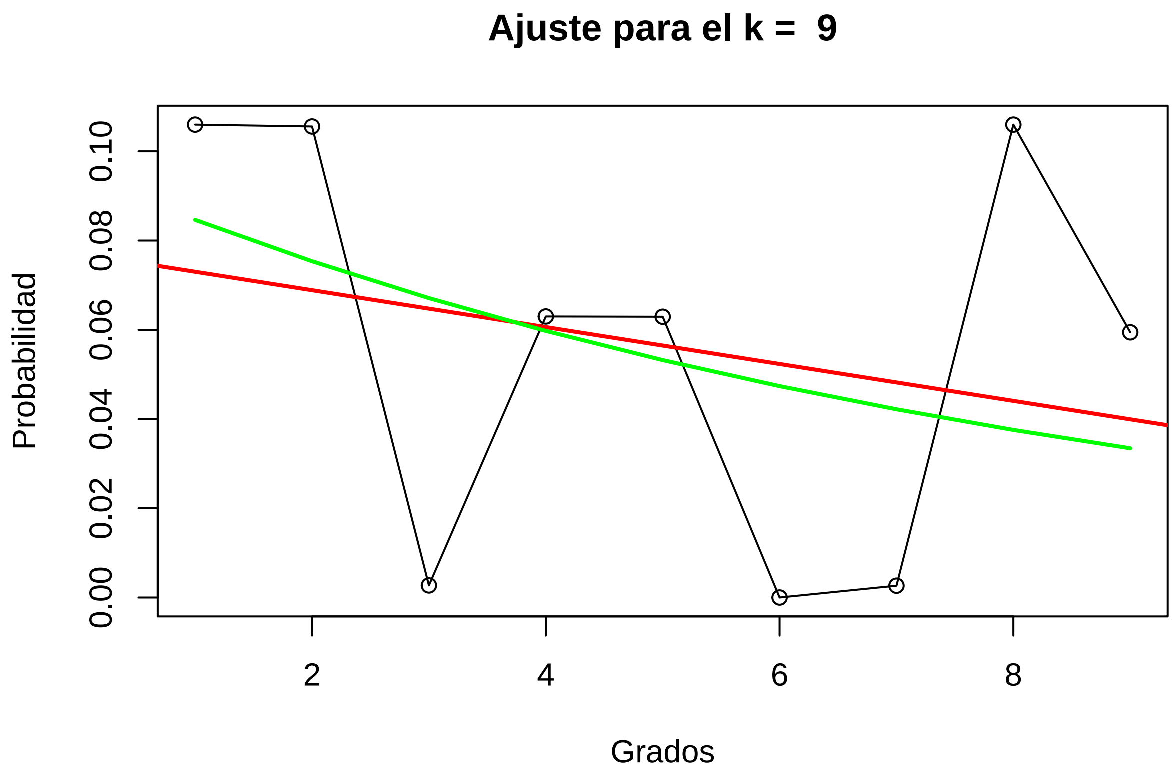

Ajuste para el k = 5
Probabilidad
0.00
0.04
0.08
0.12
2
4
6
8
Grados

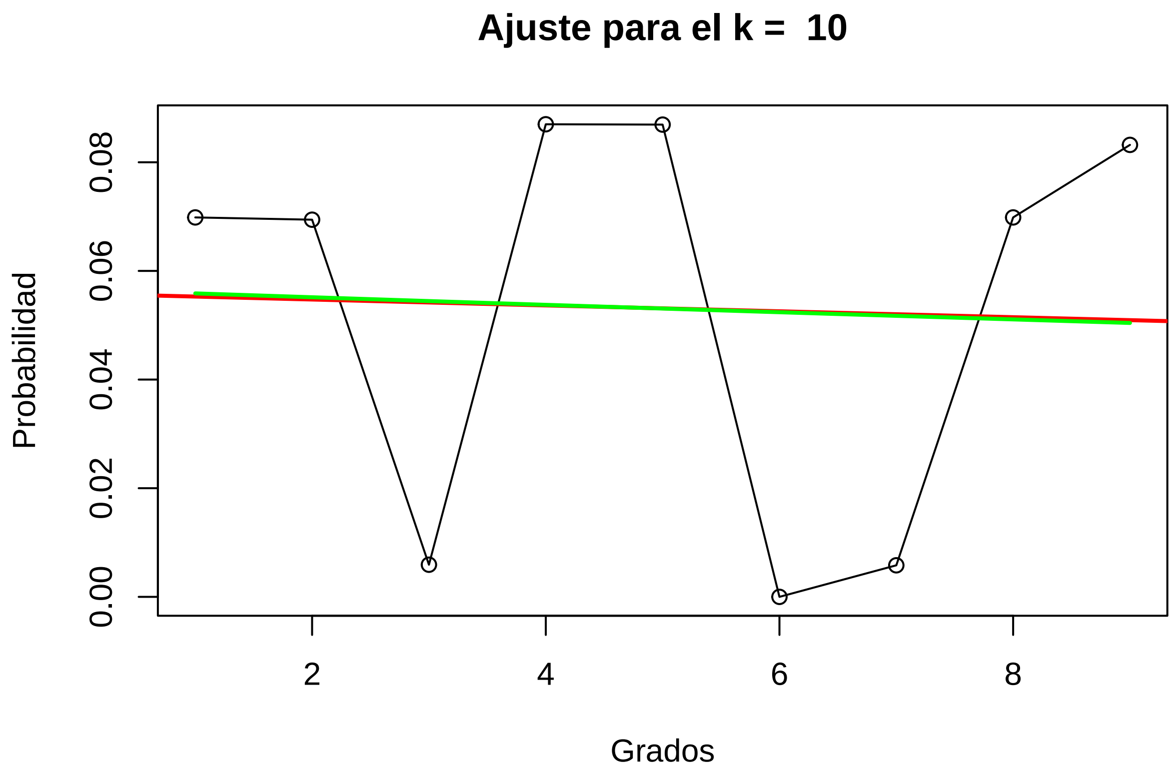

Ajuste para el k = 6
Probabilidad
0.00
0.05
0.10
0.15
2
4
6
8
Grados

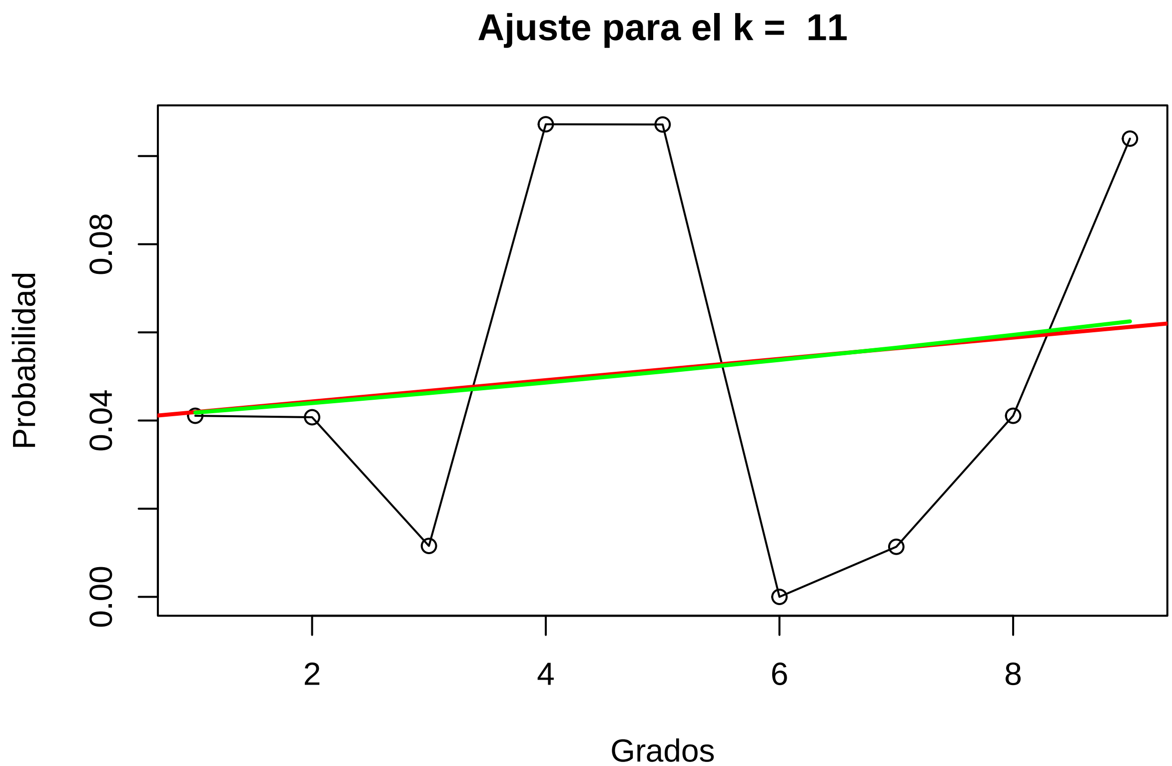


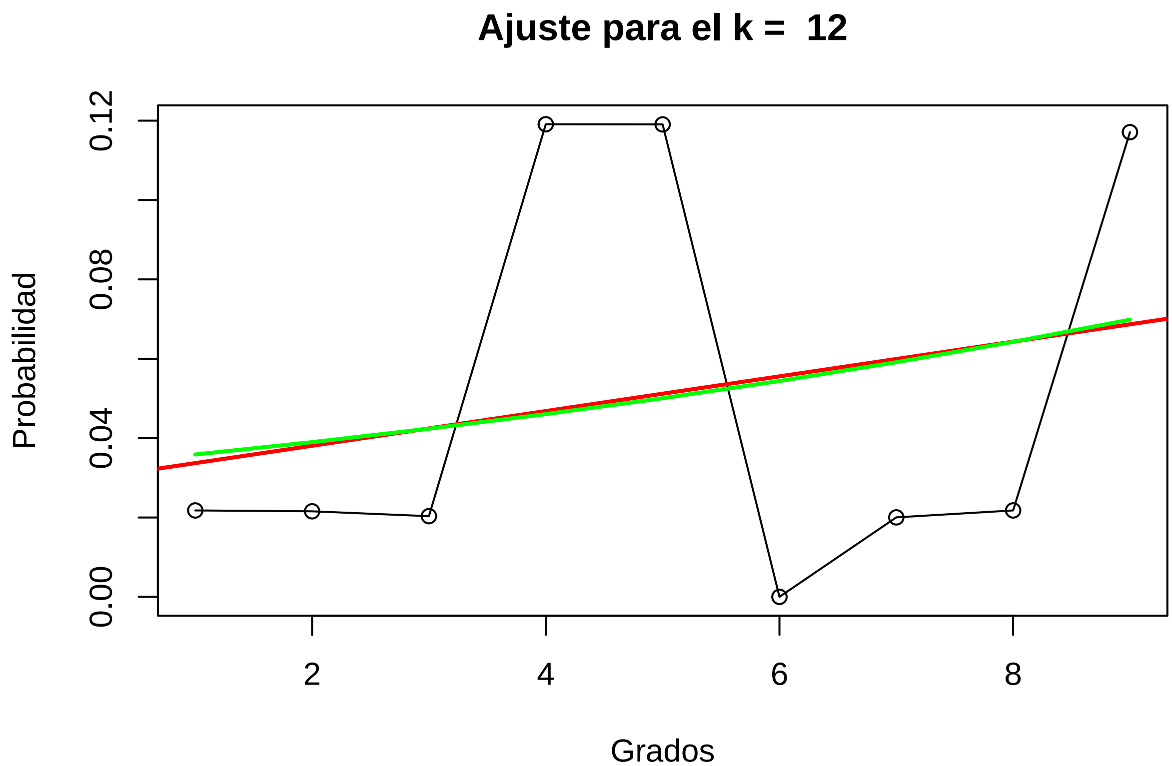
Ajuste para el k = 7
Probabilidad
0.00
0.05
0.10
0.15
2
4
6
8
Grados

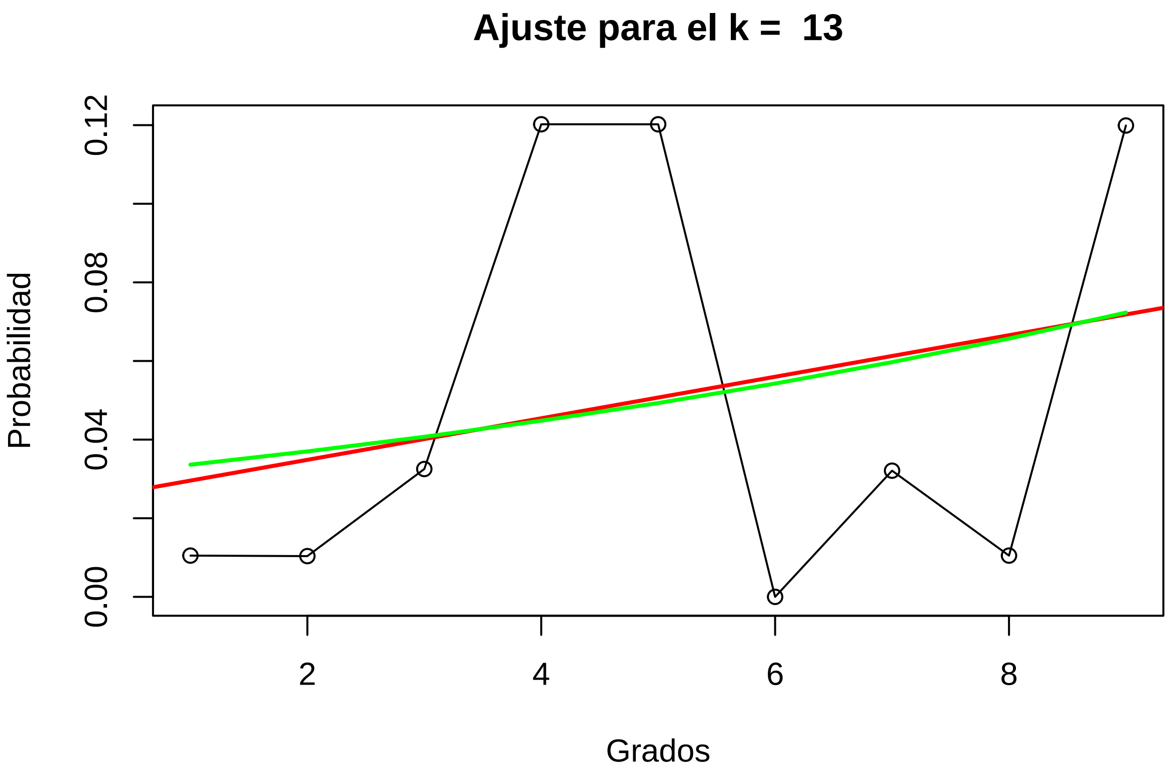

Ajuste para el k = 8
Probabilidad
0.00
0.04
0.08
0.12
2
4
6
8
Grados


Ajuste para el k = 9
Probabilidad
0.00
0.02
0.04
0.06
0.08
0.10
2
4
6
8
Grados


Ajuste para el k = 10
Probabilidad
0.00
0.02
0.04
0.06
0.08
2
4
6
8
Grados

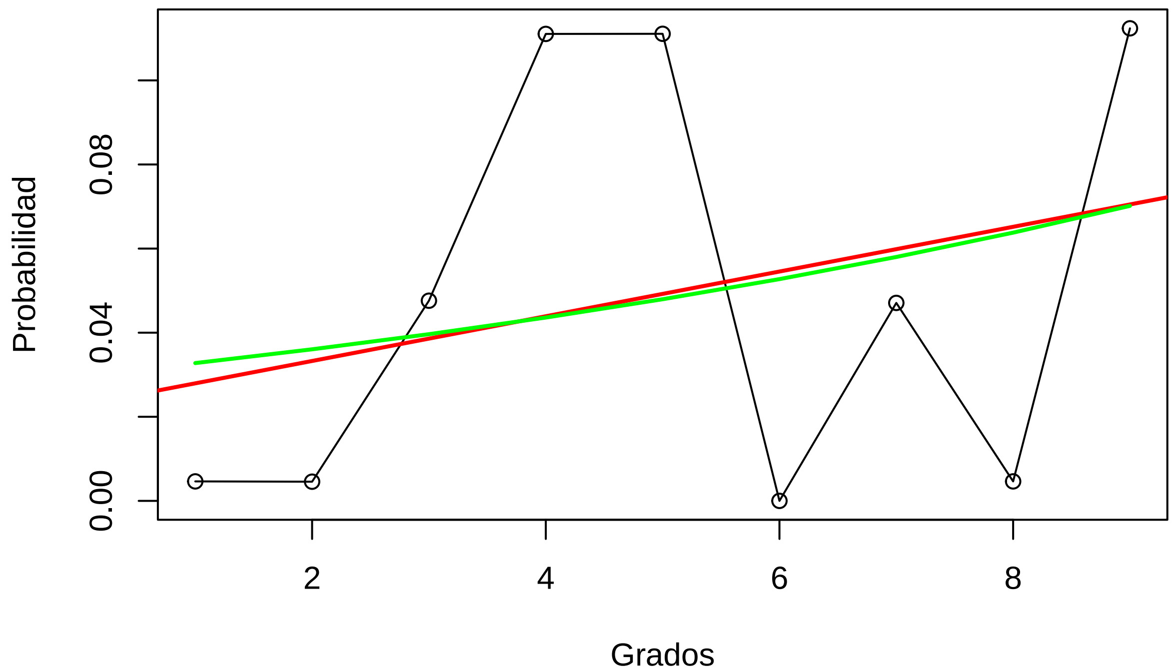

Ajuste para el k = 11
Probabilidad
0.00
0.04
0.08
2
4
6
8
Grados

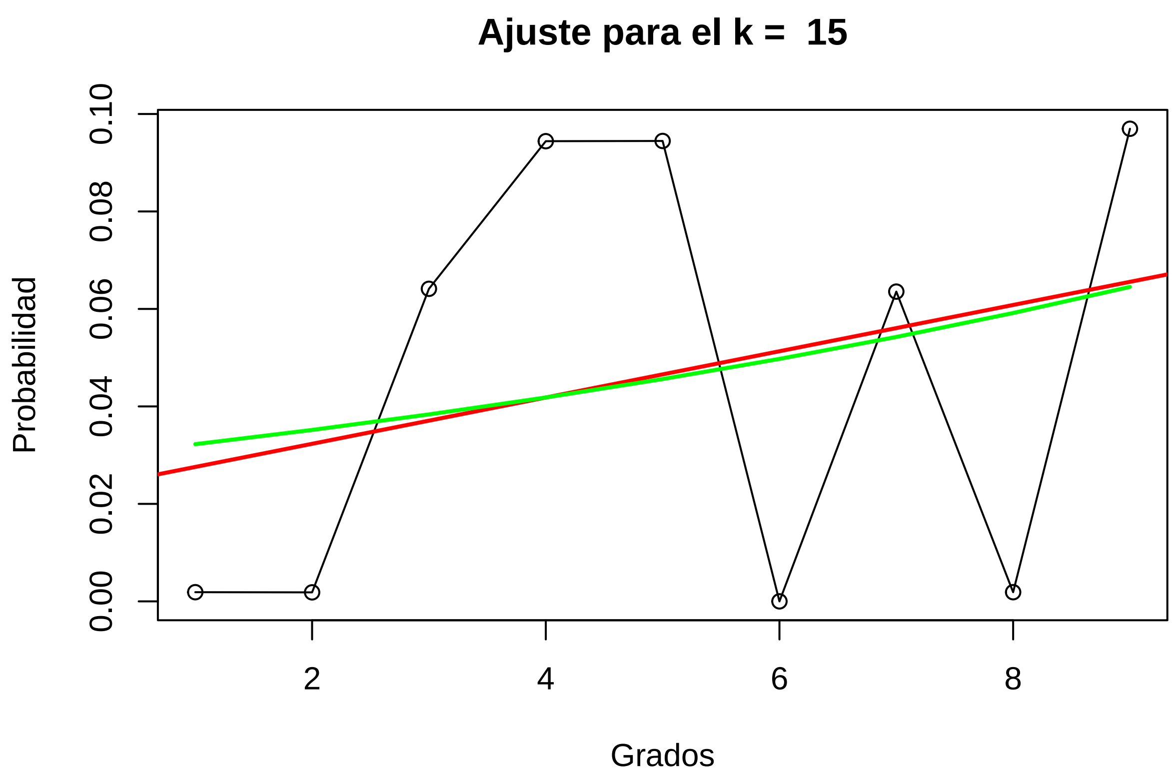

Ajuste para el k = 12
Probabilidad
0.00
0.04
0.08
0.12
2
4
6
8
Grados



Ajuste para el k = 13
Probabilidad
0.00
0.04
0.08
0.12
2
4
6
8
Grados

Ajuste para el k = 14






```r
# Definimos nuestras probabilidades de incumplimiento implicitas

AAA <- Convolucion6[2,1]
AA <- Convolucion6[2,2]
A <- Convolucion3[4,3]
BBB <- Convolucion3[3,4]
BB <- Convolucion3[3,5]
B <- Convolucion2[7,6]
CCC <- Convolucion2[4,7]
CC <- Convolucion4[2,8]
C <- Convolucion2[3,9]

PD <- c(AAA, AA, A, BBB, BB, B, CCC, CC, C)
PD
```

```
## [1] 0.01314439 0.01327288 0.01094179 0.03931620 0.03924290 0.01512097 0.07931160
## [8] 0.06817212 0.13017021
```

```r
# Graficamos las PD

plot(PD, type = "o", main = "Ajuste", xlab = "Índice", ylab = "Probabilidad")

modelo_nl <- nls(PD ~ a * exp(b * seq_along(PD)), start = list(a = min(PD), b = 0.1))

prediccion_exponencial <- predict(modelo_nl)
```

```r
lines(seq_along(PD), prediccion_exponencial, col = "green", lwd = 2)

modelo_lm <- lm(PD ~ seq_along(PD))
abline(modelo_lm, col = "red", lwd = 2)
```