Projet N°1 : Provisionnement Non Vie

Outils

In [1]:

```
# # Installation des packages
# install.packages("ChainLadder")
# install.packages("readxl")
# install.packages("scales")
# install.packages("ggplot2")
# install.packages('IRkernel')
# install.packages('knitr', dependencies = TRUE)
# install.packages("kableExtra")

# Les packages
require(ChainLadder)
suppressPackageStartupMessages(library(ChainLadder))
library(readxl)
library(scales)
library(ggplot2)
library(repr)
library(knitr)
library(kableExtra)
library(IRdisplay)

# Fixer la taille des figures
options(repr.plot.width=15, repr.plot.height=12)

# Eliminer les warnings
options(warn=-1)
```

```
Loading required package: ChainLadder


Welcome to ChainLadder version 0.2.11

Type vignette('ChainLadder', package='ChainLadder') to access
the overall package documentation.

See demo(package='ChainLadder') for a list of demos.

More information is available on the ChainLadder project web-site:
https://github.com/mages/ChainLadder

To suppress this message use:
suppressPackageStartupMessages(library(ChainLadder))
```

In [2]:

```
# Une fonction qui sert à l'affichage des estimations
display_estimations = function(df){
    cs_dt <- df[]
    row.names(cs_dt) = row.names(df)
    colnames(cs_dt) = cell_spec(colnames(cs_dt),  bold = TRUE, font_size = "medium", color = "black",align = "justify")
    rownames(cs_dt) = cell_spec(rownames(cs_dt),  bold = TRUE, font_size = "medium", color = "black",align = "justify")

    for (i in 1:10){
        for (j in 1:10){
            cs_dt[i,j] = cell_spec(format(round(df[i,j]), big.mark=" "), background = ifelse( i==2  & j==10 |
                                                                        i==3  & j==9  | i==3  & j==10 |
                                                                        i==4  & j==8  | i==4  & j==9  | i==4  & j==10 |
                                                                        i==5  & j==7  | i==5  & j==8  | i==5  & j==9  | i==5  & j==10 |
                                                                        i==6  & j==6  | i==6  & j==7  | i==6  & j==8  | i==6  & j==9  | i==6  & j==10 |
                                                                        i==7  & j==5  | i==7  & j==6  | i==7  & j==7  | i==7  & j==8  | i==7  & j==9  | i==7  & j==10 |
                                                                        i==8  & j==4  | i==8  & j==5  | i==8  & j==6  | i==8  & j==7  | i==8  & j==8  | i==8  & j==9 |  i
                                                                        i==9  & j==3  | i==9  & j==4  | i==9  & j==5  | i==9  & j==6  | i==9  & j==7  | i==9  & j==8  | i
                                                                        i==10 & j==2  | i==10 & j==3  | i==10 & j==4  | i==10 & j==5  | i==10 & j==6  | i==10 & j==7  | i

                                                                  "#e5df4c","white"),align = "c",font_size="medium")

}
}

kbl(cs_dt, escape = F) %>%
  kable_paper(full_width = F)%>%
  as.character() %>%
  display_html()
}
```

Contenu

Chargement et Analyse des triangles

Chargement des triangles

In [3]:

```
# Cahargement du triangle des ouvertures
NB = read_excel("Data.xlsx", sheet = "NB")
rows = NB$NB
NB$NB = NULL
row.names(NB) = rows

# Chargement du triangle des reglements
REG = read_excel("Data.xlsx", sheet = "REG")
REG$REG = NULL
row.names(REG) = rows
```

```r
# Chargement du triangle des charges
SAP = read_excel("Data.xlsx", sheet = "SAP")
SAP$SAP = NULL
row.names(SAP) = rows
```

Calcul du cumul

In [4]:

```r
# triangle des ouvertures
nb = incr2cum(NB)
format(nb, big.mark=" ")
# triangle des reglements
reg = incr2cum(REG)
format(reg, big.mark=" ")
# triangle des charges
tri_charge = reg+SAP
format(tri_charge, big.mark=" ")
```

Out[4]:

A matrix: 10 × 10 of type chr

	1	2	3	4	5	6	7	8	9	10
2005	31 116	33 092	33 280	33 344	33 356	33 360	33 360	33 362	33 362	33 362
2006	31 198	33 120	33 246	33 282	33 294	33 298	33 298	33 298	33 298	NA
2007	35 850	37 760	37 892	37 948	37 960	37 970	37 974	37 976	NA	NA
2008	37 860	39 864	40 004	40 066	40 074	40 078	40 082	NA	NA	NA
2009	31 142	33 112	33 290	33 352	33 358	33 362	NA	NA	NA	NA
2010	32 930	34 724	34 908	34 948	34 964	NA	NA	NA	NA	NA
2011	36 808	38 638	38 824	38 908	NA	NA	NA	NA	NA	NA
2012	37 568	39 790	39 956	NA	NA	NA	NA	NA	NA	NA
2013	37 966	40 400	NA	NA	NA	NA	NA	NA	NA	NA
2014	36 480	NA	NA	NA	NA	NA	NA	NA	NA	NA

Out[4]:

A matrix: 10 × 10 of type chr

	1	2	3	4	5	6	7	8	9	10
2005	932 885.1	4 170 107.6	5 178 741.3	5 895 582.6	6 101 204.1	6 142 991.4	6 201 205.8	6 339 424.5	6 340 571.9	6 359 225.8
2006	754 417.4	3 466 602.5	5 314 858.1	5 765 461.0	5 929 663.4	6 059 290.4	6 091 617.6	6 149 260.3	6 156 665.2	NA
2007	978 419.0	5 103 958.3	6 778 747.0	7 246 933.5	7 464 957.2	7 583 026.3	7 609 861.5	7 696 705.5	NA	NA
2008	1 316 441.5	6 021 787.6	7 555 658.3	8 053 227.9	8 327 442.5	8 449 895.1	8 497 100.4	NA	NA	NA
2009	1 515 113.7	7 237 752.8	8 623 381.4	9 198 258.7	9 396 272.9	9 521 142.4	NA	NA	NA	NA
2010	2 228 111.4	8 471 438.7	10 040 083.8	10 577 748.5	10 784 701.5	NA	NA	NA	NA	NA
2011	2 444 956.4	10 146 801.5	12 415 451.1	12 882 217.8	NA	NA	NA	NA	NA	NA
2012	2 270 647.8	11 959 203.7	14 344 968.2	NA	NA	NA	NA	NA	NA	NA
2013	2 591 381.9	11 791 984.0	NA	NA	NA	NA	NA	NA	NA	NA
2014	2 045 750.8	NA	NA	NA	NA	NA	NA	NA	NA	NA

Out[4]:

A data.frame: 10 × 10

	1	2	3	4	5	6	7	8	9	10
	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>	<I<chr>>
2005	9 507 579	9 509 400	9 649 835	8 196 995	7 328 808	7 251 425	7 221 812	7 143 342	7 126 992	7 061 740
2006	10 035 217	8 977 878	9 166 818	7 055 943	6 960 307	6 879 378	6 787 966	6 906 810	6 828 271	NA
2007	11 648 405	11 989 432	11 313 405	9 391 193	9 479 657	9 337 734	9 223 029	8 716 294	NA	NA
2008	12 973 407	12 592 678	12 424 984	10 701 676	10 355 875	10 333 477	10 339 700	NA	NA	NA
2009	13 679 208	15 263 639	14 679 525	12 757 313	12 258 505	12 027 302	NA	NA	NA	NA
2010	16 380 847	17 115 457	16 516 950	13 274 230	13 285 078	NA	NA	NA	NA	NA
2011	18 480 776	19 425 857	17 946 691	15 319 054	NA	NA	NA	NA	NA	NA
2012	22 345 606	22 699 530	22 066 408	NA	NA	NA	NA	NA	NA	NA
2013	24 430 824	23 358 362	NA	NA	NA	NA	NA	NA	NA	NA
2014	23 679 537	NA	NA	NA	NA	NA	NA	NA	NA	NA

Triangle des cadences

In [5]:

```r
# une fonction qui prend en input le triangle et retourne son triangle des cadences
triangle_des_cadences <- function(df) {
    cad = matrix(, nrow = 10, ncol = 10)
    rownames(cad) = rownames(df)
    colnames(cad) = colnames(df)
    for (i in 1:9){
        for (j in 1:9){
            if (is.na(df[i,j])){
                cad[i,j] = NA
            } else{
                cad[i,j+1] = round(df[i,j+1]/df[i,j]*100, digit = 2)
            }
        }
    }
    cad
}
```

In [6]:

```r
print("Triangle des ouvertures")
cad_nb = triangle_des_cadences(nb)
cad_nb

print("Triangle des reglements")
cad_reg = triangle_des_cadences(reg)
cad_reg

print("Triangle des charges")
cad_charge = triangle_des_cadences(tri_charge)
cad_charge
```

```
[1] "Triangle des ouvertures"
```

Out[6]:

A matrix: 10 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
2005	NA	106.35	100.57	100.19	100.04	100.01	100.00	100.01	100	100
2006	NA	106.16	100.38	100.11	100.04	100.01	100.00	100.00	100	NA
2007	NA	105.33	100.35	100.15	100.03	100.03	100.01	100.01	NA	NA
2008	NA	105.29	100.35	100.15	100.02	100.01	100.01	NA	NA	NA
2009	NA	106.33	100.54	100.19	100.02	100.01	NA	NA	NA	NA

	1	2	3	4	5	6	7	8	9	10
2010	NA	105.45	100.53	100.11	100.05	NA	NA	NA	NA	NA
2011	NA	104.97	100.48	100.22	NA	NA	NA	NA	NA	NA
2012	NA	105.91	100.42	NA	NA	NA	NA	NA	NA	NA
2013	NA	106.41	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

```
[1] "Triangle des reglements"
```

Out[6]:

A matrix: 10 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
2005	NA	447.01	124.19	113.84	103.49	100.68	100.95	102.23	100.02	100.29
2006	NA	459.51	153.32	108.48	102.85	102.19	100.53	100.95	100.12	NA
2007	NA	521.65	132.81	106.91	103.01	101.58	100.35	101.14	NA	NA
2008	NA	457.43	125.47	106.59	103.41	101.47	100.56	NA	NA	NA
2009	NA	477.70	119.14	106.67	102.15	101.33	NA	NA	NA	NA
2010	NA	380.21	118.52	105.36	101.96	NA	NA	NA	NA	NA
2011	NA	415.01	122.36	103.76	NA	NA	NA	NA	NA	NA
2012	NA	526.69	119.95	NA	NA	NA	NA	NA	NA	NA
2013	NA	455.05	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

```
[1] "Triangle des charges"
```

Out[6]:

A matrix: 10 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
2005	NA	100.02	101.48	84.94	89.41	98.94	99.59	98.91	99.77	99.08
2006	NA	89.46	102.10	76.97	98.64	98.84	98.67	101.75	98.86	NA
2007	NA	102.93	94.36	83.01	100.94	98.50	98.77	94.51	NA	NA
2008	NA	97.07	98.67	86.13	96.77	99.78	100.06	NA	NA	NA
2009	NA	111.58	96.17	86.91	96.09	98.11	NA	NA	NA	NA
2010	NA	104.48	96.50	80.37	100.08	NA	NA	NA	NA	NA
2011	NA	105.11	92.39	85.36	NA	NA	NA	NA	NA	NA
2012	NA	101.58	97.21	NA	NA	NA	NA	NA	NA	NA
2013	NA	95.61	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Analyse des cadences

In [7]:

```r
# Une fonction qui calcule le coefficient de variation
coef_var = function(x){
    pop.sd(x)/mean(x, na.rm=TRUE)*100
}

# Une fonction qui calcule l'ecart-type de la population
pop.sd<-function(x){sqrt(sum((x-mean(x, na.rm=TRUE))^2,
                                 na.rm=TRUE)/sum(!is.na(x)))}

# Une fonction qui retourne une description du triangle des cadences
summary_cad = function(cad_tri){

    # moyenne
    avg = round(apply(cad_tri,2,mean,na.rm=TRUE), digits = 2)

    # ecart-type
    sd = round(apply(cad_tri,2,pop.sd), digits = 2)
    # coef_variance
    coef_var = round(apply(cad_tri,2,coef_var), digits=2)

    # Min
    min = round(avg-sd, digits=2)

    # Max
    max = round(avg+sd, digits=2)

    summary = rbind(Moyenne = avg, Ecart_type = sd, Coeff_variation = coef_var, Min = min, Max = max)
    summary
}
```

In [8]:

```r
print("Triangle des ouvertures")
summary_cad(cad_nb)
print("Triangle des reglements")
summary_cad(cad_reg)
print("Triangle des charges")
summary_cad(cad_charge)
```

```
[1] "Triangle des ouvertures"
```

Out[8]:

A matrix: 5 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
Moyenne	NaN	105.80	100.45	100.16	100.03	100.01	100.00	100.01	100	100
Ecart_type	NaN	0.52	0.08	0.04	0.01	0.01	0.01	0.00	0	0
Coeff_variation	NaN	0.49	0.08	0.04	0.01	0.01	0.00	0.00	0	0
Min	NaN	105.28	100.37	100.12	100.02	100.00	99.99	100.01	100	100
Max	NaN	106.32	100.53	100.20	100.04	100.02	100.01	100.01	100	100

```
[1] "Triangle des reglements"
```

Out[8]:

A matrix: 5 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
Moyenne	NaN	460.03	126.97	107.37	102.81	101.45	100.60	101.44	100.07	100.29
Ecart_type	NaN	43.66	10.85	2.96	0.58	0.48	0.22	0.56	0.05	0.00
Coeff_variation	NaN	9.49	8.54	2.76	0.56	0.48	0.22	0.56	0.05	0.00
Min	NaN	416.37	116.12	104.41	102.23	100.97	100.38	100.88	100.02	100.29
Max	NaN	503.69	137.82	110.33	103.39	101.93	100.82	102.00	100.12	100.29

```
[1] "Triangle des charges"
```

Out[8]:

A matrix: 5 × 10 of type dbl

	1	2	3	4	5	6	7	8	9	10
Moyenne	NaN	100.87	97.36	83.38	96.99	98.83	99.27	98.39	99.32	99.08
Ecart_type	NaN	6.00	3.10	3.31	3.79	0.56	0.58	2.98	0.45	0.00
Coeff_variation	NaN	5.94	3.19	3.97	3.91	0.56	0.58	3.03	0.46	0.00

	1	2	3	4	5	6	7	8	9	10
Min	NaN	94.87	94.26	80.07	93.20	98.27	98.69	95.41	98.87	99.08
Max	NaN	106.87	100.46	86.69	100.78	99.39	99.85	101.37	99.77	99.08

Méthode de Chain Ladder

Triangle des ouvertures

In [9]:

```
# calcul des facteurs
n = 10
f_nb <- sapply(1:(n-1),
function(i){
sum(nb[c(1:(n-i)),i+1])/sum(nb[c(1:(n-i)),i])
}
)

# Estimation
nb_cl = nb
for(k in 1:(n-1)){
nb_cl[(n-k+1):n, k+1] = nb_cl[(n-k+1):n,k]*f_nb[k]
}

# Nombre probable de tardifs
NB_tardifs <- rep(NA, 10)
for (i in 1:n){
    NB_tardifs[i] = nb_cl[i,10] - nb_cl[i,n-i+1]
}



# Affichage
print("Les facteurs")

kbl(
rbind(colnames(nb_cl)[1:9], f_nb = label_percent()(f_nb))
) %>%
  kable_paper(full_width = F) %>%
   row_spec(2, bold = T, color = "white", background = "#0284d0") %>%
    as.character() %>%
  display_html()

print("Estimation par la methode de Chain Ladder")
display_estimations(nb_cl)



print("Nombre probable de tardifs")

kbl(cbind(c(row.names(nb_cl),"Total"),
      NB_tardifs = format(c(round(NB_tardifs), round(sum(NB_tardifs))), big.mark=" ")
     )
) %>%
  kable_paper(full_width = F) %>%
   row_spec(11, bold = T, color = "white", background = "#D7261E") %>%
    as.character() %>%
  display_html()
```

[1] "Les facteurs"

Out[9]:

	1	2	3	4	5	6	7	8	9
f_nb	**105.7810%**	**100.4481%**	**100.1607%**	**100.0310%**	**100.0146%**	**100.0055%**	**100.0038%**	**100.0000%**	**100.0000%**

[1] "Estimation par la methode de Chain Ladder"

Out[9]:

	1	2	3	4	5	6	7	8	9	10
2005	31 116	33 092	33 280	33 344	33 356	33 360	33 360	33 362	33 362	33 362
2006	31 198	33 120	33 246	33 282	33 294	33 298	33 298	33 298	33 298	33 298
2007	35 850	37 760	37 892	37 948	37 960	37 970	37 974	37 976	37 976	37 976
2008	37 860	39 864	40 004	40 066	40 074	40 078	40 082	40 084	40 084	40 084
2009	31 142	33 112	33 290	33 352	33 358	33 362	33 364	33 365	33 365	33 365
2010	32 930	34 724	34 908	34 948	34 964	34 969	34 971	34 972	34 972	34 972
2011	36 808	38 638	38 824	38 908	38 920	38 926	38 928	38 929	38 929	38 929
2012	37 568	39 790	39 956	40 020	40 033	40 038	40 041	40 042	40 042	40 042
2013	37 966	40 400	40 581	40 646	40 659	40 665	40 667	40 669	40 669	40 669
2014	36 480	38 589	38 762	38 824	38 836	38 842	38 844	38 845	38 845	38 845

[1] "Nombre probable de tardifs"

Out[9]:

	NB_tardifs
2005	0
2006	0
2007	0
2008	2
2009	3
2010	8
2011	21
2012	86
2013	269
2014	2 365
Total	**2 755**

Triangle des reglements

In [10]:

```
# Calcul des facteurs
n = 10
f_reg <- sapply(1:(n-1),
function(i){
sum(reg[c(1:(n-i)),i+1])/sum(reg[c(1:(n-i)),i])
}
)

# Estimation
reg_cl = reg
for(k in 1:(n-1)){
reg_cl[(n-k+1):n, k+1] <- reg_cl[(n-k+1):n,k]*f_reg[k]
```

```
}

# PSAP_REG
PSAP_REG <- rep(NA, 10)
for (i in 1:n){
    PSAP_REG[i] = reg_cl[i,10] -reg_cl[i,n-i+1]
}


# Affichage
print("Les facteurs")
kbl(
rbind(colnames(reg_cl)[1:9], f_reg = label_percent()(f_reg))
) %>%
  kable_paper(full_width = F) %>%
   row_spec(2, bold = T, color = "white", background = "#0284d0") %>%
    as.character() %>%
  display_html()


print("Estimation par la methode de Chain Ladder")
display_estimations(reg_cl)

print("PSAP_REG")


kbl(
cbind(
    c(row.names(reg_cl),"Total"),
    PSAP_REG = format(c(round(PSAP_REG),round(sum(PSAP_REG))), big.mark=" "))
) %>%
  kable_paper(full_width = F) %>%
   row_spec(11, bold = T, color = "white", background = "#D7261E") %>%
    as.character() %>%
  display_html()
```

[1] "Les facteurs"

Out[10]:

	1	2	3	4	5	6	7	8	9
f_reg	**454.816%**	**124.169%**	**106.641%**	**102.711%**	**101.442%**	**100.583%**	**101.420%**	**100.068%**	**100.294%**

[1] "Estimation par la methode de Chain Ladder"

Out[10]:

	1	2	3	4	5	6	7	8	9	10
2005	932 885	4 170 108	5 178 741	5 895 583	6 101 204	6 142 991	6 201 206	6 339 424	6 340 572	6 359 226
2006	754 417	3 466 602	5 314 858	5 765 461	5 929 663	6 059 290	6 091 618	6 149 260	6 156 665	6 174 778
2007	978 419	5 103 958	6 778 747	7 246 933	7 464 957	7 583 026	7 609 861	7 696 706	7 701 976	7 724 635
2008	1 316 441	6 021 788	7 555 658	8 053 228	8 327 443	8 449 895	8 497 100	8 617 797	8 623 698	8 649 069
2009	1 515 114	7 237 753	8 623 381	9 198 259	9 396 273	9 521 142	9 576 641	9 712 671	9 719 322	9 747 917
2010	2 228 111	8 471 439	10 040 084	10 577 748	10 784 702	10 940 246	11 004 016	11 160 321	11 167 964	11 200 820
2011	2 444 956	10 146 801	12 415 451	12 882 218	13 231 450	13 422 283	13 500 521	13 692 288	13 701 664	13 741 975
2012	2 270 648	11 959 204	14 344 968	15 297 548	15 712 260	15 938 872	16 031 780	16 259 501	16 270 636	16 318 504
2013	2 591 382	11 791 984	14 641 985	15 614 289	16 037 587	16 268 892	16 363 723	16 596 159	16 607 524	16 656 384
2014	2 045 751	9 304 401	11 553 179	12 320 370	12 654 371	12 836 881	12 911 707	13 095 110	13 104 077	13 142 629

[1] "PSAP_REG"

Out[10]:

	PSAP_REG
2005	0
2006	18 113
2007	27 930
2008	151 968
2009	226 774
2010	416 119
2011	859 757
2012	1 973 536
2013	4 864 400
2014	11 096 878
Total	**19 635 475**

Triangle des charges

In [11]:

```
# Calcul des facteurs
n = 10
f_sap <- sapply(1:(n-1),
function(i){
sum(tri_charge[c(1:(n-i)),i+1])/sum(tri_charge[c(1:(n-i)),i])
}
)

# Estimation
sap_cl = tri_charge
for(k in 1:(n-1)){
sap_cl[(n-k+1):n, k+1] <- sap_cl[(n-k+1):n,k]*f_sap[k]
}

# PSAP
PSAP <- rep(NA, 10)
for (i in 1:n){
    PSAP[i] = sap_cl[i,10] -sap_cl[i,n-i+1]
}

# PSAP_CHARG = Boni_Mali + PSAP_GEST
PSAP_GEST = rep(NA,10)
PSAP_CHARG = rep(NA,10)
for (i in 1:10){
    PSAP_GEST[i] = SAP[i,n-i+1]
    PSAP_CHARG[i] = as.integer(PSAP_GEST[i]) + PSAP[i]
}


# Affichage
print("Les facteurs")


kbl(
rbind(colnames(sap_cl)[1:9], f_sap = label_percent()(f_sap))
) %>%
  kable_paper(full_width = F) %>%
   row_spec(2, bold = T, color = "white", background = "#0284d0") %>%
```

```
    as.character() %>%
  display_html()

print("Estimation par la methode de Chain Ladder")
display_estimations(sap_cl)

print("PSAP")


kbl(
      cbind(c(row.names(sap_cl),"Total"),
      PSAP = format(c(round(PSAP), round(sum(PSAP))), big.mark=" "),
      PSAP_GEST = format(c(as.integer(PSAP_GEST), sum(as.integer(PSAP_GEST))), big.mark=" "),
      PSAP_CHARG = format(c(round(PSAP_CHARG), round(sum(PSAP_CHARG))), big.mark=" "))
) %>%
  kable_paper(full_width = F) %>%
   row_spec(11, bold = T, color = "white", background = "#D7261E") %>%
    as.character() %>%
  display_html()
```

[1] "Les facteurs"

Out[11]:

	1	2	3	4	5	6	7	8	9
f_sap	**101.0398%**	**96.7601%**	**83.6400%**	**97.2154%**	**98.8060%**	**99.3210%**	**97.9927%**	**99.3246%**	**99.0844%**

[1] "Estimation par la methode de Chain Ladder"

Out[11]:

	1	2	3	4	5	6	7	8	9	10
2005	9 507 579	9 509 400	9 649 835	8 196 995	7 328 808	7 251 425	7 221 812	7 143 342	7 126 992	7 061 740
2006	10 035 217	8 977 878	9 166 818	7 055 943	6 960 307	6 879 378	6 787 966	6 906 810	6 828 271	6 765 754
2007	11 648 405	11 989 432	11 313 405	9 391 193	9 479 657	9 337 734	9 223 029	8 716 294	8 657 427	8 578 163
2008	12 973 407	12 592 678	12 424 984	10 701 676	10 355 875	10 333 477	10 339 700	10 132 148	10 063 719	9 971 579
2009	13 679 208	15 263 639	14 679 525	12 757 313	12 258 505	12 027 302	11 945 640	11 705 851	11 626 794	11 520 343
2010	16 380 847	17 115 457	16 516 950	13 274 230	13 285 078	13 126 448	13 037 322	12 775 620	12 689 338	12 573 159
2011	18 480 776	19 425 857	17 946 691	15 319 054	14 892 478	14 714 655	14 614 746	14 321 379	14 224 658	14 094 422
2012	22 345 606	22 699 530	22 066 408	18 456 349	17 942 412	17 728 172	17 607 801	17 254 354	17 137 824	16 980 916
2013	24 430 824	23 358 362	22 601 579	18 903 966	18 377 564	18 158 128	18 034 839	17 672 819	17 553 463	17 392 750
2014	23 679 537	23 925 762	23 150 595	19 363 164	18 823 975	18 599 209	18 472 924	18 102 111	17 979 855	17 815 239

[1] "PSAP"

Out[11]:

	PSAP	PSAP_GEST	PSAP_CHARG
2005	0	702 514	702 514
2006	-62 517	671 606	609 089
2007	-138 131	1 019 588	881 457
2008	-368 121	1 842 600	1 474 479
2009	-506 959	2 506 160	1 999 201
2010	-711 919	2 500 376	1 788 457
2011	-1 224 632	2 436 836	1 212 204
2012	-5 085 492	7 721 440	2 635 948
2013	-5 965 612	11 566 378	5 600 766
2014	-5 864 298	21 633 786	15 769 488
Total	**-19 927 681**	**52 601 284**	**32 673 603**

Méthode de Mack Chain Ladder

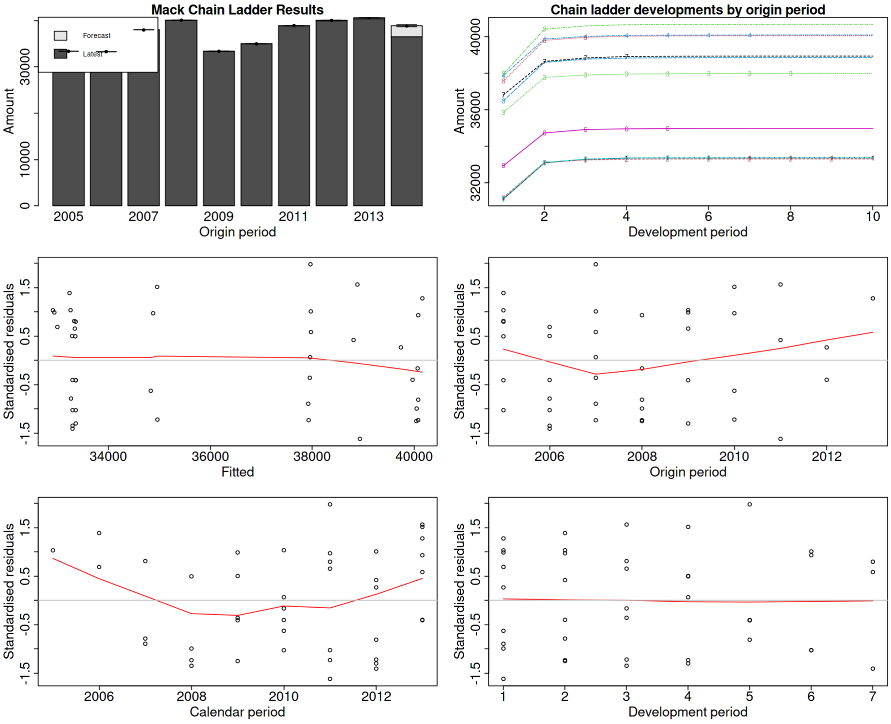
Triangle des ouvertures

In [12]:

```
tri_mack_nb = MackChainLadder(nb, est.sigma="Mack")

par(
cex.axis = 2,
cex.lab = 2,
cex.main = 2
)
plot(tri_mack_nb)
```

Out[12]:



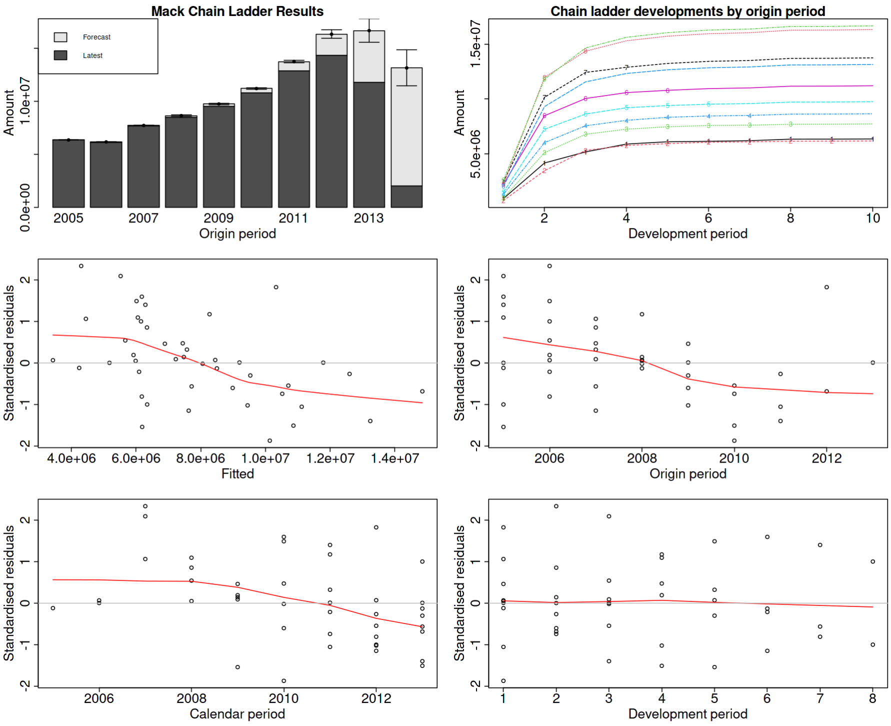
Triangle des reglements

In [13]:

```
tri_mack_reg = MackChainLadder(reg, est.sigma="Mack")

par(
cex.axis = 2,
cex.lab = 2,
cex.main = 2
)
plot(tri_mack_reg)
```

Out[13]:



Méthode de Bootstrap Chain Ladder

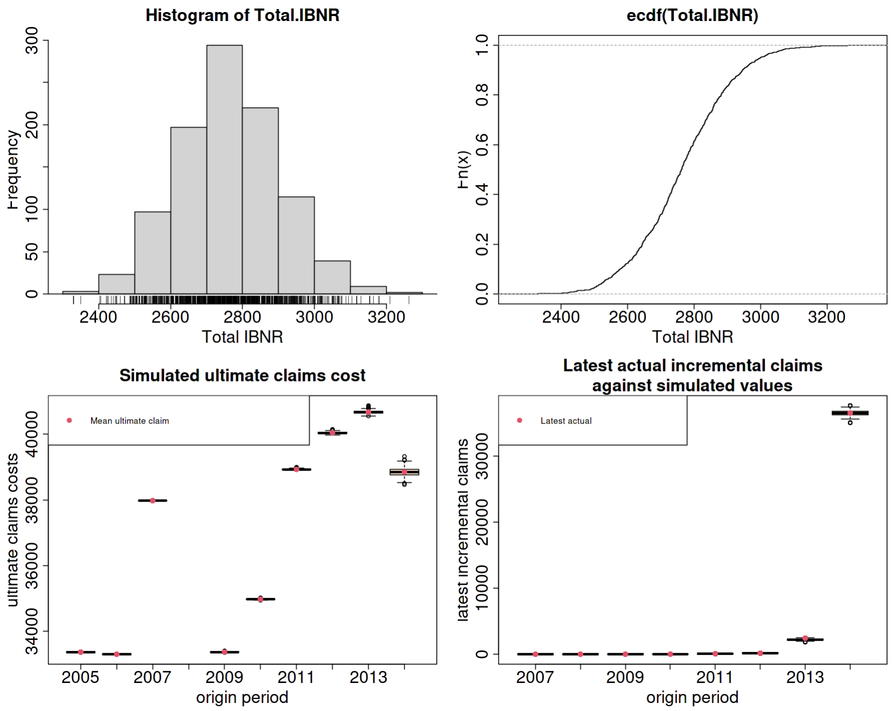
Triangle des ouvertures

In [14]:

```
tri_boot_nb = BootChainLadder(nb, R=999, process.distr="gamma")

par(
cex.axis = 2,
cex.lab = 2,
cex.main = 2
)
plot(tri_boot_nb)
```

Out[14]:



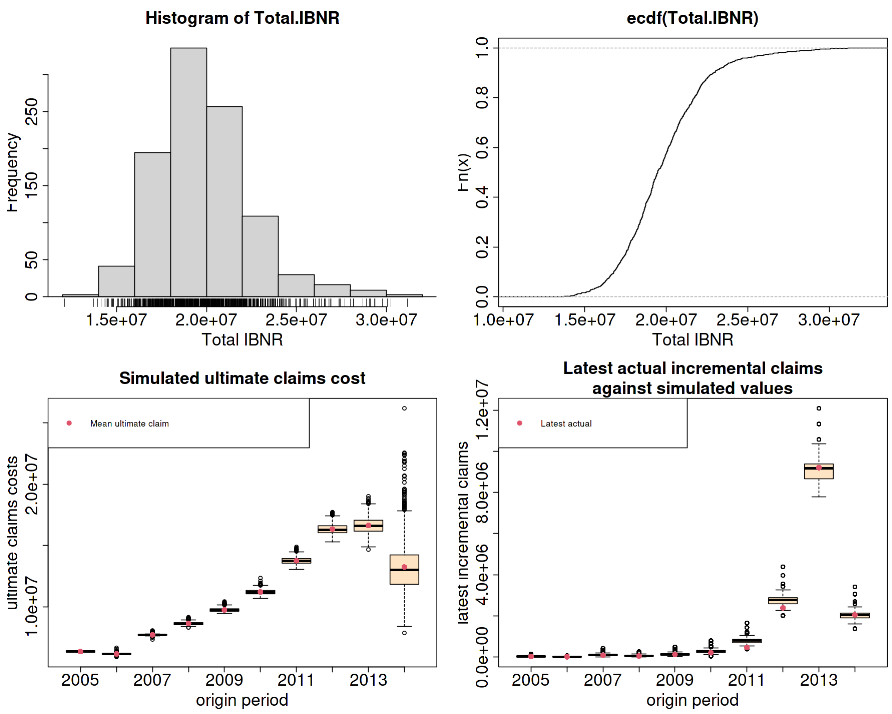
Triangle des reglements

In [15]:

```
tri_boot_reg = BootChainLadder(reg, R=999, process.distr="gamma")

par(
cex.axis = 2,
cex.lab = 2,
cex.main = 2
)
plot(tri_boot_reg)
```

Out[15]:



Calcul de la prime aquise et des S/P de chaque année

In [16]:

```
pc = rep(NA,10)
un = rep(NA,10)
for (i in 1:10){
    pc[i] = sum(reg_cl[1:(10-i+1),i]) / sum(reg_cl[1:(10-i+1),10])
    un[i] = 1-pc[i]

}

# Affichage
kbl(
rbind(colnames(reg_cl)[1:9],"pc" = paste(round(pc*100,digits = 2), "%",sep=""),
      "1-pc" = paste(round(un*100, digits = 2),"%",sep=""))
) %>%
  kable_paper(full_width = F) %>%
    row_spec(1, bold = T) %>%
    column_spec(1, bold = T) %>%
```

```
    as.character() %>%
  display_html()
```

Out[16]:

	1	2	3	4	5	6	7	8	9	1
pc	15.57%	70.8%	87.91%	93.74%	96.28%	97.67%	98.24%	99.64%	99.71%	100%
1-pc	84.43%	29.2%	12.09%	6.26%	3.72%	2.33%	1.76%	0.36%	0.29%	0%

In [17]:

```
loss.ratio.est = rep(NA,10)
loss.ratio.est[1] = 0.95
prime_aquise = rep(NA,10)
prime_aquise[1] = reg_cl[1,10]/(loss.ratio.est[1])
psap = rep(NA,10)
psap[1] = NA
for (i in 2:10){
    prime_aquise[i] = prime_aquise[i-1]*1.04
    loss.ratio.est[i] = reg_cl[i,(10-i+1)] / prime_aquise[i]
    psap[i] = rev(un)[i] * (prime_aquise[i]) * (loss.ratio.est[i])
}

# Affichage
mat = cbind("REG"=rownames(reg_cl),
            "1-pc" = paste(round(rev(un*100), digits = 2), "%", sep=""),
            "Prime aquise" = format(round(prime_aquise, digits = 2), big.mark=" "),
            "Loss Ratio Estimé"= paste(round(loss.ratio.est*100, digits = 2), "%", sep=""),
            "PSAP" = format(round(psap), big.mark=" ")
           )



kbl(
rbind(mat, "Total" = c("","","","",format(round(sum(psap[2:10])), big.mark=" ")))
) %>%
  kable_paper(full_width = F) %>%
    column_spec(c(1,2), bold = T) %>%
    column_spec(5,width = "7em") %>%
    column_spec(6, bold = T, color = "white", background = "green") %>%
    as.character() %>%
  display_html()
```

Out[17]:

	REG	1-pc	Prime aquise	Loss Ratio Estimé	PSAP
	2005	0%	6 693 922	95%	**NA**
	2006	0.29%	6 961 679	88.44%	**18 060**
	2007	0.36%	7 240 146	106.31%	**27 829**
	2008	1.76%	7 529 752	112.85%	**149 298**
	2009	2.33%	7 830 942	121.58%	**221 499**
	2010	3.72%	8 144 180	132.42%	**400 660**
	2011	6.26%	8 469 947	152.09%	**805 967**
	2012	12.09%	8 808 745	162.85%	**1 734 859**
	2013	29.2%	9 161 094	128.72%	**3 443 780**
	2014	84.43%	9 527 538	21.47%	**1 727 314**
Total					**8 529 265**

In [18]:

```
S.P = matrix(, nrow = 10, ncol = 10)
rownames(S.P) = rownames(reg)
colnames(S.P) = colnames(reg)

for (i in 1:10){
    for (j in 1:10){
        if (is.na(reg[i,j])){
            S.P[i,j] = ""
        }else{
            S.P[i,j] = paste(round(reg[i,j]/ prime_aquise[i]*100,2), "%", sep="")
        }
    }
}

# Affichage
kbl(
S.P
) %>%
  kable_paper(full_width = F) %>%
    column_spec(c(1), bold = T) %>%
    row_spec(c(1,2),color = "red") %>%
    as.character() %>%
  display_html()
```

Out[18]:

	1	2	3	4	5	6	7	8	9	10
2005	13.94%	62.3%	77.36%	88.07%	91.15%	91.77%	92.64%	94.7%	94.72%	95%
2006	10.84%	49.8%	76.34%	82.82%	85.18%	87.04%	87.5%	88.33%	88.44%	
2007	13.51%	70.5%	93.63%	100.09%	103.11%	104.74%	105.11%	106.31%		
2008	17.48%	79.97%	100.34%	106.95%	110.59%	112.22%	112.85%			
2009	19.35%	92.43%	110.12%	117.46%	119.99%	121.58%				
2010	27.36%	104.02%	123.28%	129.88%	132.42%					
2011	28.87%	119.8%	146.58%	152.09%						
2012	25.78%	135.77%	162.85%							
2013	28.29%	128.72%								
2014	21.47%									

In [0]: