# GAL Buckle 95

François Pelletier

27 mai 2014

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# Chapitre 1

# Initialisation

## 1.1 Chargement des paquets

```
> setwd("~/maitrise/GAL-Buckle95/")
> library(actuar)
> library(MASS)
> library(xtable)
> library(parallel)
> library(moments)
> library(FourierStuff)
> library(GeneralizedAsymmetricLaplace)
> library(GMMStuff)
> library(OptionPricingStuff)
> library(QuadraticEstimatingEquations)
```

## 1.2 Constantes et données

```
> #Nombre de décimales affichées
> options(digits=6)
> #Marge pour intervalles de confiance
> alpha.confint <- 0.05
> #Marge pour test d'hypothèses
> alpha.test <- 0.05
> #Chargement des données
> RETURNS <- head(read.csv("abbeyn.csv",sep="\t",header=TRUE)[,1],-1)
> #Taille de l'échantillon
> n <- length(RETURNS)
> #Nom de l'échantillon
> strData <- "Buckle95"
```

## 1.3 Test de normalité

```
> EppsPulley.test(RETURNS)

Epps-Pulley Normality test

 T: 0.626033
 T*: 0.635568
p-value: 0.007178

$Tstat
[1] 0.626033

$Tmod
[1] 0.635568
```

```
$Zscore
[1] 2.44824

$Pvalue
[1] 0.00717788

$Reject
[1] TRUE
```

# Chapitre 2

# Estimation

## 2.1 Données mises à l'échelle

```
> sRET <- as.vector(scale(RETURNS))
```

## 2.2 Première estimation par QEE

```
> ## Point de départ
> pt.depart <- startparamGAL(sRET)
> ## Fonctions pour les moments
> meanQEE <- function(param) mGAL(param,1)
> varianceQEE <- function(param) cmGAL(param,2)
> sdQEE <- function(param) sqrt(cmGAL(param,2))
> skewnessQEE <- function(param) cmGAL(param,3)
> kurtosisQEE <- function(param) cmGAL(param,4)
> ## Fonctions pour les dérivées
> dmeanQEE <- function(param) dmGAL(param,1)
> dsdQEE <- function(param) dmGAL(param,2)
> ## Estimation gaussienne
> optim1 <- optim(pt.depart,obj.gauss,gr=NULL,sRET,
+                 meanQEE,varianceQEE,dmeanQEE,dsdQEE)
> pt.optim1 <- optim1$par
> ## Estimation de crowder
> optim2 <- optim(pt.depart,obj.Crowder,gr=NULL,sRET,
+                 meanQEE,varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE)
> pt.optim2 <- optim2$par
> ## Estimation de crowder modifiée
> optim3 <- optim(pt.depart,obj.Crowder.Mod,gr=NULL,sRET,
+                 meanQEE,varianceQEE,dmeanQEE,dsdQEE)
> pt.optim3 <- optim3$par
```

## 2.3 Résultats de la première estimation par QEE

```
> cov.optim1 <- covariance.QEE(M.gauss(pt.optim1,sRET,
+                                meanQEE,varianceQEE,dmeanQEE,dsdQEE),
+                 V.gauss(pt.optim1,sRET,meanQEE,varianceQEE,
+                                skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),n)
> cov.optim2 <- covariance.QEE(M.Crowder(pt.optim2,sRET,
+                                varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),
+                 V.Crowder(pt.optim2,sRET,varianceQEE,
+                                skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),n)
> cov.optim3 <- covariance.QEE(M.Crowder.Mod(pt.optim3,sRET,
+                                varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),
+                 V.Crowder.Mod(pt.optim3,sRET,varianceQEE,dmeanQEE,dsdQEE),n)
> confidence.interval.QEE(pt.optim1,cov.optim1,n)
```

```
         LOWER  ESTIMATE     UPPER
[1,] -0.780018 -0.726048 -0.672077
[2,]  0.436002  0.596316  0.756630
[3,]  0.262650  0.359186  0.455722
[4,]  1.994757  2.021370  2.047982

> confidence.interval.QEE(pt.optim2,cov.optim2,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.694457 -0.627404 -0.560351
[2,]  0.413764  0.640292  0.866820
[3,]  0.232650  0.334028  0.435405
[4,]  1.839966  1.878296  1.916626

> confidence.interval.QEE(pt.optim3,cov.optim3,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.765288 -0.711439 -0.657589
[2,]  0.455485  0.606642  0.757798
[3,]  0.264669  0.362932  0.461195
[4,]  1.932691  1.960299  1.987906
```

## 2.4 Seconde estimation par QEE

```
> ## Estimation gaussienne
> optim4 <- optim(pt.optim1,obj.gauss,gr=NULL,sRET,
+                 meanQEE,varianceQEE,dmeanQEE,dsdQEE,
+                 ginv(V.gauss(pt.optim1,sRET,meanQEE,
+                                              varianceQEE,skewnessQEE,kurtosisQEE,
+                                              dmeanQEE,dsdQEE)))
> pt.optim4 <- optim4$par
> ## Estimation de crowder
> optim5 <- optim(pt.optim2,obj.Crowder,gr=NULL,sRET,
+                 meanQEE,varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE,
+                 ginv(V.Crowder(pt.optim2,sRET,varianceQEE,skewnessQEE,
+                                              kurtosisQEE,dmeanQEE,dsdQEE)))
> pt.optim5 <- optim5$par
> ## Estimation de crowder modifiée
> optim6 <- optim(pt.optim3,obj.Crowder.Mod,gr=NULL,sRET,
+                 meanQEE,varianceQEE,dmeanQEE,dsdQEE,
+                 ginv(V.Crowder.Mod(pt.optim3,sRET,varianceQEE,
+                                              dmeanQEE,dsdQEE)))
> pt.optim6 <- optim6$par
```

## 2.5 Résultats de la seconde estimation par QEE

```
> cov.optim4 <- covariance.QEE(M.gauss(pt.optim4,sRET,
+                                 meanQEE,varianceQEE,dmeanQEE,dsdQEE),
+                 V.gauss(pt.optim4,sRET,meanQEE,varianceQEE,
+                                 skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),n)
> cov.optim5 <- covariance.QEE(M.Crowder(pt.optim5,sRET,
+                                 varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),
+                 V.Crowder(pt.optim5,sRET,varianceQEE,skewnessQEE,
+                                 kurtosisQEE,dmeanQEE,dsdQEE),n)
> cov.optim6 <- covariance.QEE(M.Crowder.Mod(pt.optim6,sRET,
+                                 varianceQEE,skewnessQEE,kurtosisQEE,dmeanQEE,dsdQEE),
+                 V.Crowder.Mod(pt.optim6,sRET,varianceQEE,dmeanQEE,dsdQEE),n)
> confidence.interval.QEE(pt.optim4,cov.optim4,n)
```

```
         LOWER  ESTIMATE     UPPER
[1,] -0.779792 -0.725853 -0.671914
[2,]  0.436017  0.596319  0.756622
[3,]  0.262456  0.358969  0.455482
[4,]  1.995452  2.022048  2.048644

> confidence.interval.QEE(pt.optim5,cov.optim5,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.692712 -0.625874 -0.559036
[2,]  0.414139  0.640445  0.866750
[3,]  0.231568  0.332845  0.434122
[4,]  1.842116  1.880376  1.918636

> confidence.interval.QEE(pt.optim6,cov.optim6,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.766288 -0.712450 -0.658612
[2,]  0.455051  0.606193  0.757334
[3,]  0.264972  0.363196  0.461419
[4,]  1.934050  1.961614  1.989178
```

## 2.6 Estimation par GMM

```
> ## GMM régulier
> optim7 <- optim.GMM(pt.depart,
+                 conditions.vector=meanvariance.gmm.vector,
+                 data=sRET,W=diag(2),
+                 meanf=meanQEE,variancef=varianceQEE)
> pt.optim7 <- optim7$par
> cov.optim7 <- mean.variance.GMM.gradient.GAL(pt.optim7,sRET) %*%
+                 covariance.GMM(pt.optim7,meanvariance.gmm.vector,sRET,
+                                 meanf=meanQEE,variancef=varianceQEE) %*%
+                 t(mean.variance.GMM.gradient.GAL(pt.optim7,sRET)) / n
> ## GMM itératif
> optim8 <- iterative.GMM(pt.depart,
+                 conditions.vector=meanvariance.gmm.vector,
+                 data=sRET,W=diag(2),
+                 meanf=meanQEE,variancef=varianceQEE)
> pt.optim8 <- optim8$par
> cov.optim8 <-  mean.variance.GMM.gradient.GAL(pt.optim8,sRET) %*%
+                 optim8$cov %*%
+                 t(mean.variance.GMM.gradient.GAL(pt.optim8,sRET)) / n
> confidence.interval.QEE(pt.optim7,cov.optim7,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.878702 -0.641646 -0.404589
[2,] -0.469225  0.625908  1.721040
[3,] -0.192234  0.326366  0.844965
[4,]  1.696121  1.965995  2.235869

> confidence.interval.QEE(pt.optim8,cov.optim8,n)

         LOWER  ESTIMATE     UPPER
[1,] -0.874031 -0.636980 -0.399929
[2,] -0.473292  0.626346  1.725984
[3,] -0.193600  0.322895  0.839390
[4,]  1.704166  1.972716  2.241265
```

# Chapitre 3

# Comparaison des résultats

```
> # Aggrégation des estimateurs (pour simplifier les calculs)
> pts.estim <- cbind(pt.optim1,pt.optim2,pt.optim3,pt.optim4,
+                 pt.optim5,pt.optim6,pt.optim7,pt.optim8)
> l.pts.estim <- as.list(data.frame(pts.estim))
```

## 3.1 Fonction de répartition

```
> # Points d'évaluation
> xi <- seq(2*min(sRET),2*max(sRET),length.out=2^6)
> # Fonction de répartition par intégration de la fonction caractéristique
> dist1 <- cbind(cftocdf(xi,cfGAL,param=pt.optim1),
+                 cftocdf(xi,cfGAL,param=pt.optim2),
+                 cftocdf(xi,cfGAL,param=pt.optim3),
+                 cftocdf(xi,cfGAL,param=pt.optim4),
+                 cftocdf(xi,cfGAL,param=pt.optim5),
+                 cftocdf(xi,cfGAL,param=pt.optim6),
+                 cftocdf(xi,cfGAL,param=pt.optim7),
+                 cftocdf(xi,cfGAL,param=pt.optim8))
> # Fonction de répartition par point de selle
> dist2 <- cbind(psaddleapproxGAL(xi,pt.optim1),
+                 psaddleapproxGAL(xi,pt.optim2),
+                 psaddleapproxGAL(xi,pt.optim3),
+                 psaddleapproxGAL(xi,pt.optim4),
+                 psaddleapproxGAL(xi,pt.optim5),
+                 psaddleapproxGAL(xi,pt.optim6),
+                 psaddleapproxGAL(xi,pt.optim7),
+                 psaddleapproxGAL(xi,pt.optim8))
> # Fonction de répartition par intégration de la fonction de densité
> dist3 <- cbind(pGAL(xi,pt.optim1),
+                 pGAL(xi,pt.optim2),
+                 pGAL(xi,pt.optim3),
+                 pGAL(xi,pt.optim4),
+                 pGAL(xi,pt.optim5),
+                 pGAL(xi,pt.optim6),
+                 pGAL(xi,pt.optim7),
+                 pGAL(xi,pt.optim8))
```

### 3.1.1 Graphiques

```
> for (i in 1:8)
+ {
+         file<-paste(strData,"-repart-",i,".pdf",sep="")
+         pdf(file=file,paper="special",width=6,height=6)
+         plot.ecdf(sRET,main=paste("Fonction de répartition ",i))
+         lines(xi,dist1[,i],col="green")
+         lines(xi,dist2[,1],col="red")
+         lines(xi,dist3[,1],col="pink")
+         lines(xi,pnorm(xi),type="l",col="blue")
+         dev.off()
+         cat("\\includegraphics[height=4in,width=4in]{",
+                         file,"}\n",sep="")
+ }
```

| | |
|---|---|
| Buckle95-repart-1.pdf | Buckle95-repart-2.pdf |

Buckle95-repart-3.pdf

Buckle95-repart-4.pdf

Buckle95-repart-5.pdf

Buckle95-repart-6.pdf

Buckle95-repart-7.pdf

Buckle95-repart-8.pdf

### 3.1.2 Statistiques

Test du $\chi^2$, Méthode avec intégration

```
> chisquare.test1 <- function(param,DATA.hist,FUN,method)
+ {
+         chisquare.test(DATA.hist,FUN,param,method=method)
+ }
> xtable(do.call(rbind,lapply(l.pts.estim,chisquare.test1,hist(sRET),
+                                                 cfGAL,"integral")),digits=6)
```

| | chisquare.stat | df | p.value |
|---|---|---|---|
| pt.optim1 | 5.473824 | 6.000000 | 0.484626 |
| pt.optim2 | 5.329673 | 6.000000 | 0.502277 |
| pt.optim3 | 5.388158 | 6.000000 | 0.495076 |
| pt.optim4 | 5.474310 | 6.000000 | 0.484567 |
| pt.optim5 | 5.337004 | 6.000000 | 0.501372 |
| pt.optim6 | 5.390662 | 6.000000 | 0.494769 |
| pt.optim7 | 5.454256 | 6.000000 | 0.487003 |
| pt.optim8 | 5.476963 | 6.000000 | 0.484245 |

Test du $\chi^2$, Méthode avec point de selle

```
> xtable(do.call(rbind,lapply(l.pts.estim,chisquare.test1,hist(sRET),
+                                                 pGAL,"saddlepoint")),digits=6)
```

Statistique de Kolmogorov-Smirnov

```
> ks.test1 <- function(param,x,y) ks.test(x,y,param)
> xtable(do.call(rbind,mclapply(l.pts.estim,ks.test1,sRET,"pGAL")),digits=6)
```

Statistique de distance minimale

```
> tvariate1 <- seq(-.1,.1,by=0.01)
> xtable(do.call(rbind,mclapply(l.pts.estim,
+                                                 md.test,sRET,tvariate1,cfGAL,empCF)),digits=6)
```

| | chisquare.stat | df | p.value |
|---|---|---|---|
| pt.optim1 | 9.293574 | 6.000000 | 0.157728 |
| pt.optim2 | 8.345592 | 6.000000 | 0.213862 |
| pt.optim3 | 9.050625 | 6.000000 | 0.170751 |
| pt.optim4 | 9.292836 | 6.000000 | 0.157767 |
| pt.optim5 | 8.344140 | 6.000000 | 0.213959 |
| pt.optim6 | 9.062381 | 6.000000 | 0.170100 |
| pt.optim7 | 8.616379 | 6.000000 | 0.196330 |
| pt.optim8 | 8.610490 | 6.000000 | 0.196698 |

| | statistic | p.value | alternative | method | data.name |
|---|---|---|---|---|---|
| pt.optim1 | 0.158220 | 0.171912 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim2 | 0.140346 | 0.289345 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim3 | 0.156772 | 0.179751 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim4 | 0.158159 | 0.172235 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim5 | 0.139916 | 0.292753 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim6 | 0.156960 | 0.178718 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim7 | 0.141230 | 0.282437 | two-sided | One-sample Kolmogorov-Smirnov test | x |
| pt.optim8 | 0.140016 | 0.291954 | two-sided | One-sample Kolmogorov-Smirnov test | x |

## 3.2 Fonction de densité

Intégration de la fonction de densité approximée avec le point de selle, pour la normaliser en fonction qui intègre à 1.

```
> f_integrale_saddle <- function(param,f,lower,upper)
+         integrate(f,lower,upper,param)$value
> norm_int_saddle <- sapply(l.pts.estim,f_integrale_saddle,
+                 f=dsaddleapproxGAL,lower=-Inf,upper=Inf)
```

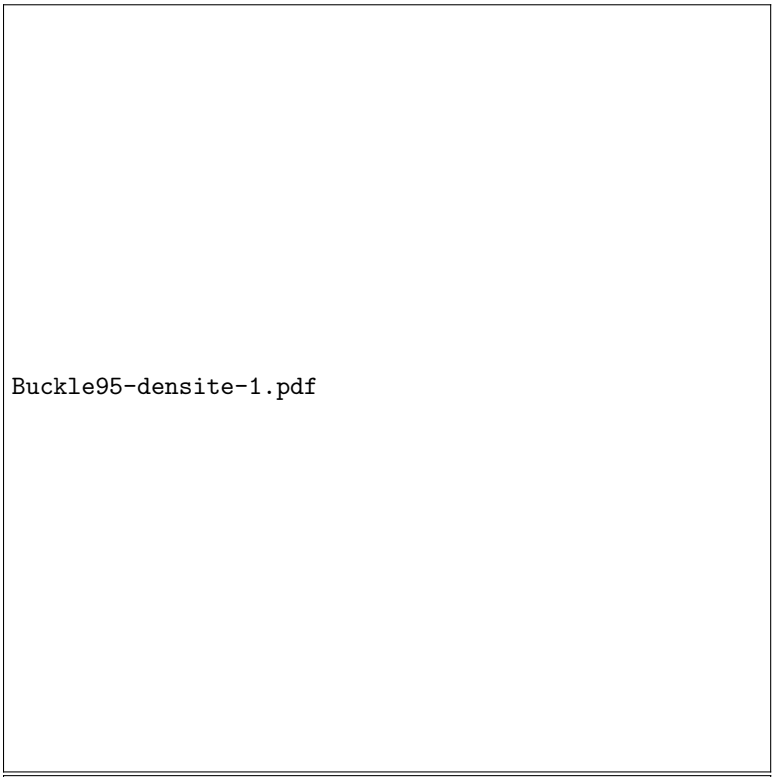
Séquence de points pour les graphiques

```
> x_sRET <- seq(min(sRET)-sd(sRET),max(sRET)+sd(sRET),length.out=50)
```

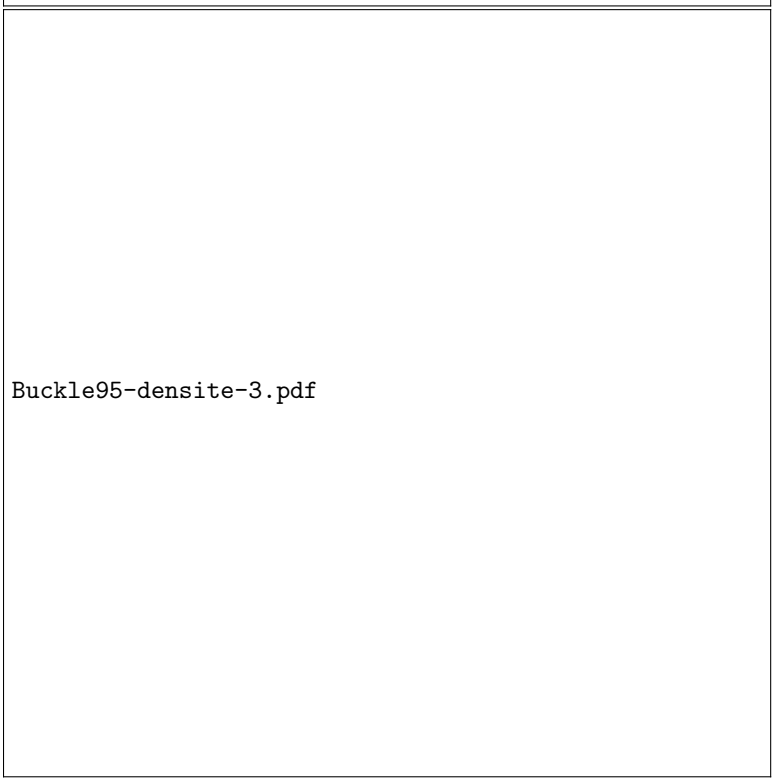
Graphique de la fonction de densité

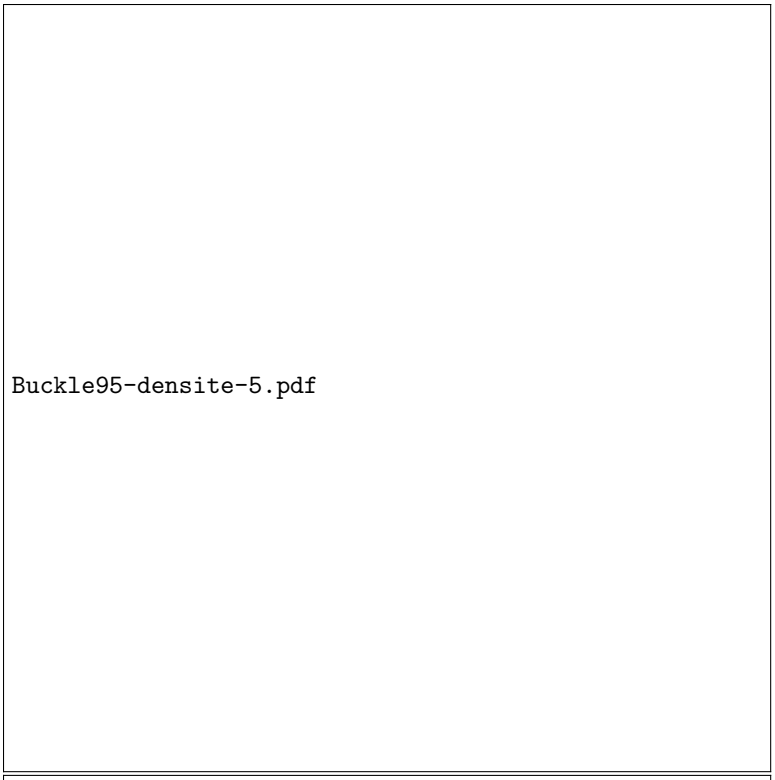
```
> colors2=c("black","red","green","blue","grey")
> for (i in 1:dim(pts.estim)[2])
+ {
+         file=paste(strData,"-densite-", i, ".pdf", sep="")
+         pdf(file=file, paper="special", width=6, height=6)
+         plot(density(sRET),ylim=c(0,.7),type="l",
+                         main=paste("Densité de",strData, i),xlab=strData,
+                         ylab="f",lwd=2,lty=1)
+         points(x_sRET,
+                         dGAL(x_sRET,pts.estim[,i]),
+                         type="b",ylim=c(0,4),col="red",pch=19,lwd=2,lty=2)
+         points(x_sRET,
+                         dsaddleapproxGAL(x_sRET,pts.estim[,i])/norm_int_saddle[i],
+                         type="b",ylim=c(0,4),col="green",pch=20,lwd=2,lty=3)
+
+         lines(x_sRET,dnorm(x_sRET),type="b",col="blue",
+                         pch=21,lwd=2,lty=4)
+         points(seq(-2,4,length.out=1000)[seq(40,1000,by=40)],
+                         cftodensity.fft(cfGAL,1000,-2,4,pts.estim[,i])$dens[seq(40,1000,by=40)],
+                         type="b",col="grey",pch=23,lty=6)
+         legend(quantile(sRET,0.9),0.7, c("emp","est.GAL","pt.selle","appx.nrm","fft"),
+                         cex=0.8, col=colors2, pch=c(NA,19:23), lty=1:6, title="Courbes")
+         dev.off()
+         cat("\\includegraphics[height=4in, width=4in]{"
+                         ,file, "}\n", sep="")
+ }
```

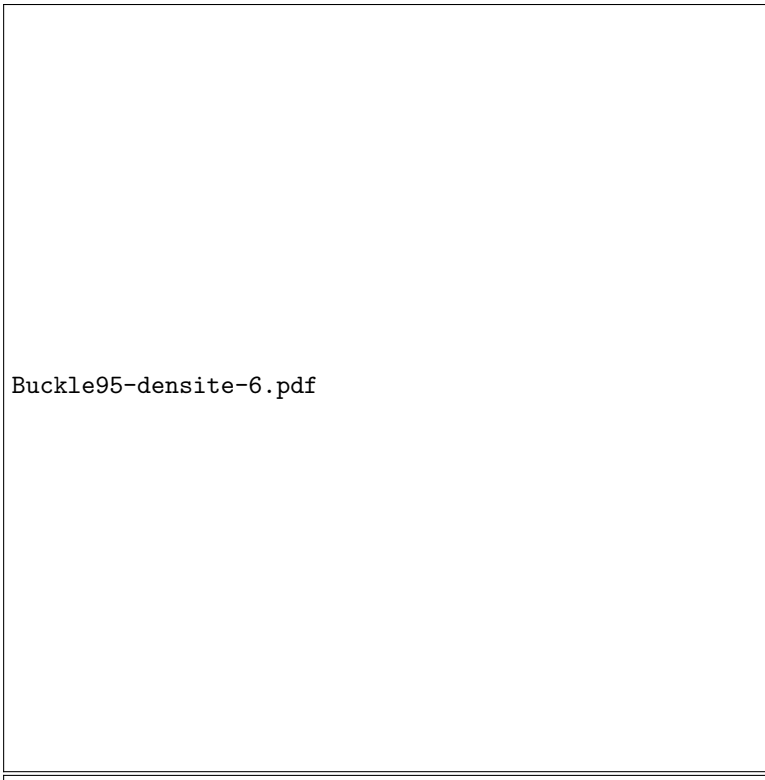
| | md.stat | df | p.value |
|---|---|---|---|
| pt.optim1 | 0.000422 | 21.000000 | 0.000000 |
| pt.optim2 | 0.120174 | 21.000000 | 0.000000 |
| pt.optim3 | 0.001384 | 21.000000 | 0.000000 |
| pt.optim4 | 0.000388 | 21.000000 | 0.000000 |
| pt.optim5 | 0.123295 | 21.000000 | 0.000000 |
| pt.optim6 | 0.001451 | 21.000000 | 0.000000 |
| pt.optim7 | 0.007980 | 21.000000 | 0.000000 |
| pt.optim8 | 0.010416 | 21.000000 | 0.000000 |

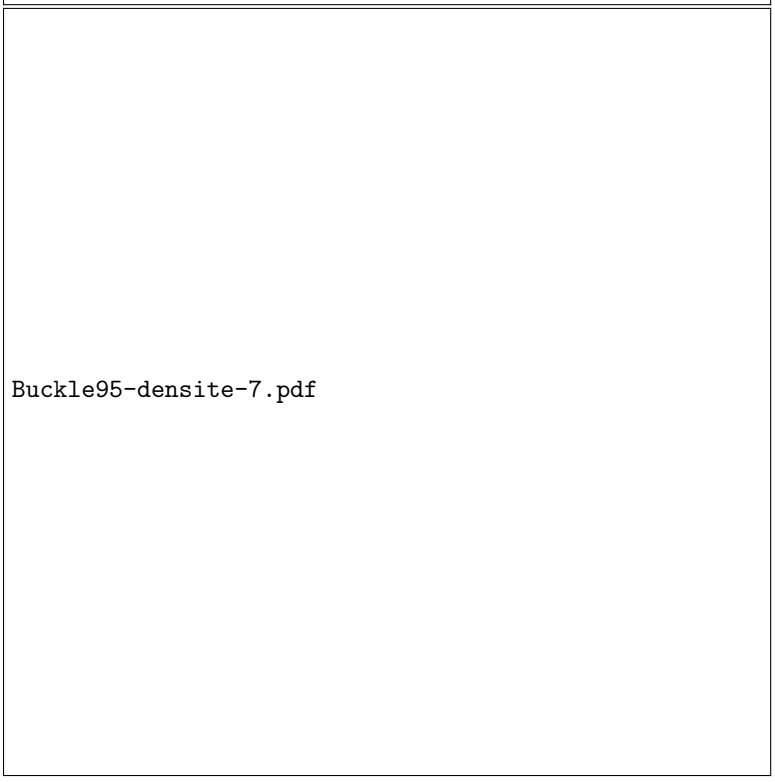


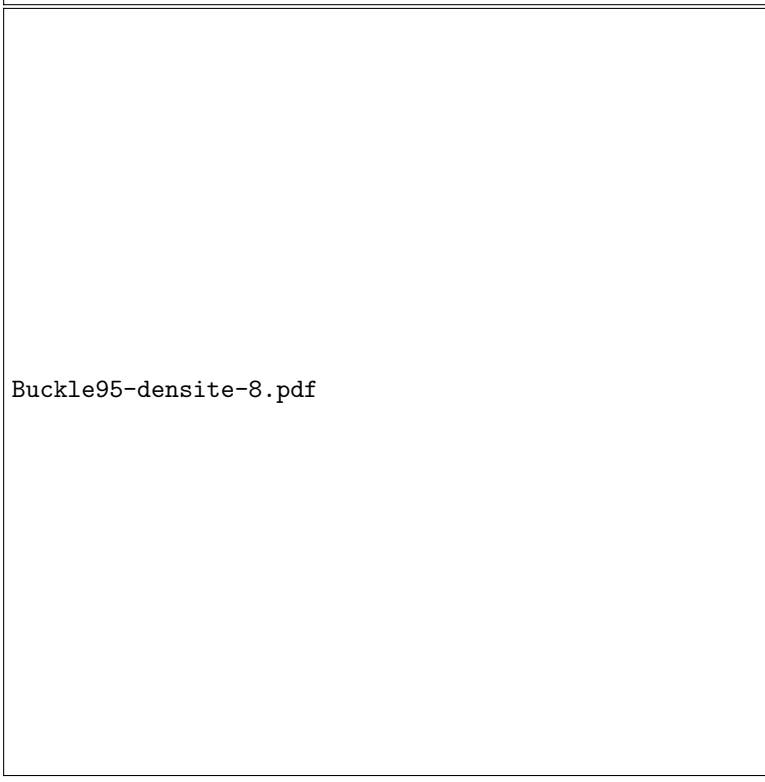





### 3.2.1 Tests avec contraintes

Test de Wald

```
> R <- matrix(c(0,0,1,0,
+                                0,0,0,1),ncol=4)
> r <- matrix(c(0,0),ncol=1)
> V <- lapply(l.pts.estim,covariance.GMM,meanvariance.gmm.vector,
+                 sRET,meanQEE,varianceQEE)
> D <- lapply(l.pts.estim,mean.variance.GMM.gradient.GAL,sRET)
> xtable(mapply(Wald.Test,l.pts.estim,n,list(R),list(r),V,D),
```

```
+                caption="Test de Wald", digits=2)

% latex table generated in R 3.1.0 by xtable 1.7-3 package
% Tue May 27 23:05:26 2014
\begin{table}[ht]
\centering
\begin{tabular}{rrrrrrrrr}
  \hline
 & pt.optim1 & pt.optim2 & pt.optim3 & pt.optim4 & pt.optim5 & pt.optim6 & pt.optim7 & pt.optim8 \\
  \hline
wald.stat & 1861.21 & 1796.75 & 1690.26 & 1865.01 & 1814.81 & 1690.62 & 2111.08 & 2175.45 \\
  p.value & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\
  reject & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\
   \hline
\end{tabular}
\caption{Test de Wald}
\end{table}
```

### 3.2.2 Vrais paramètres

Comme nous avons estimé avec des données centrées et réduites, nous utilisons une propriété de la distribution GAL qui nous permet d'obtenir les paramètres des rendements non réduits.

```
> pts.estim.ns <- apply(pts.estim,2,scaleGAL,type="mu",
+                mean(RETURNS),sd(RETURNS))

>         xtable(pts.estim.ns,
+                        caption="Paramètres des données non centrées et réduites",
+                        digits=4)
```

| | pt.optim1 | pt.optim2 | pt.optim3 | pt.optim4 | pt.optim5 | pt.optim6 | pt.optim7 | pt.optim8 |
|---|---|---|---|---|---|---|---|---|
| 1 | -0.0092 | -0.0080 | -0.0090 | -0.0092 | -0.0079 | -0.0091 | -0.0081 | -0.0081 |
| 2 | 0.0078 | 0.0083 | 0.0079 | 0.0078 | 0.0083 | 0.0079 | 0.0081 | 0.0081 |
| 3 | 0.0033 | 0.0031 | 0.0033 | 0.0033 | 0.0031 | 0.0033 | 0.0030 | 0.0030 |
| 4 | 2.0214 | 1.8783 | 1.9603 | 2.0220 | 1.8804 | 1.9616 | 1.9660 | 1.9727 |

TABLE 3.1 – Paramètres des données non centrées et réduites

## 3.3 Prix d'options

### 3.3.1 Données de base

```
> #Taux sans risque
> rfrate <- .05/365
> #Échéance
> T <- 30
> #Pas de discrétisation courbe des prix
> pas <- 0.005
> #Prix initial
> stock0 <- 299
> #Prix d'exercice dans le cours (put)
> strike1 <- stock0*seq(0.98,1,pas)
> #Prix d'exercice hors le cours (put)
> strike2 <- stock0*seq(1+pas,1.02,pas)
> #Prix d'exercice combinés
> strike <- c(strike1,strike2)
> #Damping parameter
> alpha <- 3
```

### 3.3.2 Paramètres neutres au risque

```
> pts.estim.ns.rn <- apply(pts.estim.ns,2,riskneutralparGAL,rfrate)
> l.pts.estim.ns.rn <- as.list(data.frame(pts.estim.ns.rn))

> xtable(pts.estim.ns.rn,caption="Paramètres neutres au risque",digits=4)
```

| | pt.optim1 | pt.optim2 | pt.optim3 | pt.optim4 | pt.optim5 | pt.optim6 | pt.optim7 | pt.optim8 |
|---|---|---|---|---|---|---|---|---|
| 1 | -0.0066 | -0.0057 | -0.0065 | -0.0066 | -0.0057 | -0.0065 | -0.0058 | -0.0058 |
| 2 | 0.0078 | 0.0083 | 0.0079 | 0.0078 | 0.0083 | 0.0079 | 0.0081 | 0.0081 |
| 3 | 0.0033 | 0.0031 | 0.0033 | 0.0033 | 0.0031 | 0.0033 | 0.0030 | 0.0030 |
| 4 | 2.0214 | 1.8783 | 1.9603 | 2.0220 | 1.8804 | 1.9616 | 1.9660 | 1.9727 |

TABLE 3.2 – Paramètres neutres au risque

### 3.3.3 Méthode de Epps

```
>         f_putEpps <- function(param,strikeprice,char.fn,eval.time,expiry.time,rate,...)
+                 putEpps(strikeprice,char.fn,param,eval.time,expiry.time,rate,...)
>         prix_put_Epps <- as.data.frame(cbind(strike/stock0,sapply(l.pts.estim.ns.rn,f_putEpps,strike/stock0,

>         xtable(prix_put_Epps,caption="Prix unitaire de l'option de vente, Méthode de Epps",digits=6)
```

| | V1 | pt.optim1 | pt.optim2 | pt.optim3 | pt.optim4 | pt.optim5 | pt.optim6 | pt.optim7 | pt.optim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.980000 | 0.015415 | 0.015785 | 0.015431 | 0.015417 | 0.015794 | 0.015427 | 0.015792 | 0.015819 |
| 2 | 0.985000 | 0.017360 | 0.017737 | 0.017377 | 0.017362 | 0.017746 | 0.017372 | 0.017742 | 0.017770 |
| 3 | 0.990000 | 0.019456 | 0.019838 | 0.019474 | 0.019458 | 0.019847 | 0.019469 | 0.019843 | 0.019871 |
| 4 | 0.995000 | 0.021705 | 0.022090 | 0.021724 | 0.021707 | 0.022099 | 0.021719 | 0.022093 | 0.022122 |
| 5 | 1.000000 | 0.024107 | 0.024492 | 0.024126 | 0.024109 | 0.024501 | 0.024121 | 0.024495 | 0.024523 |
| 6 | 1.005000 | 0.026661 | 0.027044 | 0.026681 | 0.026663 | 0.027053 | 0.026676 | 0.027046 | 0.027074 |
| 7 | 1.010000 | 0.029365 | 0.029745 | 0.029385 | 0.029367 | 0.029753 | 0.029381 | 0.029745 | 0.029773 |
| 8 | 1.015000 | 0.032217 | 0.032591 | 0.032238 | 0.032219 | 0.032600 | 0.032233 | 0.032591 | 0.032617 |
| 9 | 1.020000 | 0.035214 | 0.035580 | 0.035235 | 0.035216 | 0.035589 | 0.035231 | 0.035579 | 0.035605 |

TABLE 3.3 – Prix unitaire de l'option de vente, Méthode de Epps

## 3.4 Méthode de Carr-Madan

```
>         f_callCarrMadan <- function(param,strikeprice,char.fn,eval.time,expiry.time,rate,alpha,...)
+         {
+                 callCarrMadan(strikeprice,char.fn,param,eval.time,expiry.time,rate,alpha,...)
+         }
>         prix_call_CarrMadan <- as.data.frame(cbind(strike/stock0,sapply(l.pts.estim.ns.rn,f_callCarrMadan,st

>         xtable(prix_call_CarrMadan,caption="Prix unitaire de l'option d'achat, Méthode de Carr-Madan",digits=
```

| | V1 | pt.optim1 | pt.optim2 | pt.optim3 | pt.optim4 | pt.optim5 | pt.optim6 | pt.optim7 | pt.optim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.980000 | 0.044899 | 0.045144 | 0.044912 | 0.044900 | 0.045150 | 0.044909 | 0.045145 | 0.045163 |
| 2 | 0.985000 | 0.041847 | 0.042096 | 0.041860 | 0.041848 | 0.042102 | 0.041857 | 0.042096 | 0.042114 |
| 3 | 0.990000 | 0.038895 | 0.039148 | 0.038909 | 0.038896 | 0.039153 | 0.038906 | 0.039147 | 0.039165 |
| 4 | 0.995000 | 0.036045 | 0.036300 | 0.036059 | 0.036046 | 0.036306 | 0.036056 | 0.036299 | 0.036317 |
| 5 | 1.000000 | 0.033297 | 0.033555 | 0.033312 | 0.033298 | 0.033560 | 0.033309 | 0.033553 | 0.033571 |
| 6 | 1.005000 | 0.030653 | 0.030912 | 0.030668 | 0.030654 | 0.030918 | 0.030665 | 0.030910 | 0.030928 |
| 7 | 1.010000 | 0.028114 | 0.028375 | 0.028130 | 0.028115 | 0.028381 | 0.028126 | 0.028372 | 0.028390 |
| 8 | 1.015000 | 0.025681 | 0.025943 | 0.025697 | 0.025682 | 0.025949 | 0.025694 | 0.025940 | 0.025958 |
| 9 | 1.020000 | 0.023356 | 0.023618 | 0.023373 | 0.023357 | 0.023624 | 0.023369 | 0.023615 | 0.023633 |

TABLE 3.4 – Prix unitaire de l'option d'achat, Méthode de Carr-Madan