R-code for Chapter 4: Pair copula decompositions and constructions

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Contents

Required R-packages

- VineCopula
- rafalib

Section 4.1: Illustration in three dimensions

Example 4.3: WINE3: Pair copula constructions.

Read in data and set column names, create copula data

```r
reddata<-read.csv(file="winequality-red.csv",sep=";")
n<-length(reddata[,1])
colnames(reddata)<-c("acf","acv","acc","sugar","clor","sf","st",
                     "den","ph","sp","alc","quality")
acf<-reddata[,1]
acv<-reddata[,2]
```

```
acc<-reddata[,3]
udata<-reddata
for(i in 1:12){
udata[,i]<-rank(reddata[,i])/(n+1)
}
```

Example 4.3 (PCC1)

- 1,2,3=acf,acv,acc
- want to fit vine with 13,23,12;3
- 13 Gumbel (family=4) using original data
- 23 Frank (family=5) using original data
- 12;3 using pseudo obs.

Table 4.2: WINE3: Three pair copula constructions together with empirically chosen pair copula families, their estimated Kendall's $\hat{\tau}$ and their estimated parameter $\hat{\theta}$ for PCC1

```
options(digits=2)
theta.acfacv<-BiCopTau2Par(34,cor(acf,acv,method="kendall"))
theta.acfacc<-BiCopTau2Par(4,cor(acf,acc,method="kendall"))
theta.acvacc<-BiCopTau2Par(5,cor(acv,acc,method="kendall"))
h13<-BiCopHfunc(udata[,1],udata[,3],family=4,par=theta.acfacc)$hfunc2
h23<-BiCopHfunc(udata[,2],udata[,3],family=5,par=theta.acvacc)$hfunc2
theta.12.3<-BiCopTau2Par(1,cor(h13,h23,method="kendall"))
pcc1.theta<-c(theta.acfacc,theta.acvacc,theta.12.3)
pcc1.fam<-c("Gumbel","Frank","Gauss")
pcc1.lab<-c("(acf,acv)","(acv,acc)","(acf,acc;acv)")
pcc1.tau<-c(cor(acf,acc,method="kendall"),
cor(acv,acc,method="kendall"),
cor(h13,h23,method="kendall"))
pcc1<-data.frame(pcc1.lab,pcc1.fam,pcc1.tau,pcc1.theta)
print(pcc1)
```

```
##           pcc1.lab pcc1.fam pcc1.tau pcc1.theta
## 1        (acf,acv)   Gumbel     0.48        1.9
## 2        (acv,acc)    Frank    -0.43       -4.6
## 3    (acf,acc;acv)    Gauss     0.13        0.2
```

Figure 4.3: WINE3: Empirical (first column) based on pseudo copula data and normalized contour plots (second column) for a Gaussian conditional pair copula $C_{acf;acv;acc}$ needed for PCC1 (top right)

```
bigpar(1,2)
BiCopKDE(h13,h23,main="empirical contours",kde.pars=list(mult=2))
# empirical contours of pseudo data look like Gauss
obj<-BiCop(family=1,par = theta.12.3)
contour(obj, main=paste("Gauss:tau=",round(cor(h13,h23,method="kendall"),digits=2)))
```

empirical contours   **Gauss:tau= 0.13**

Example 4.3 (PCC2)

- 1,2,3=acf,acv,acc
- want to fit vine with 12,32,13;2
- 12 rotated Gumbel (34)
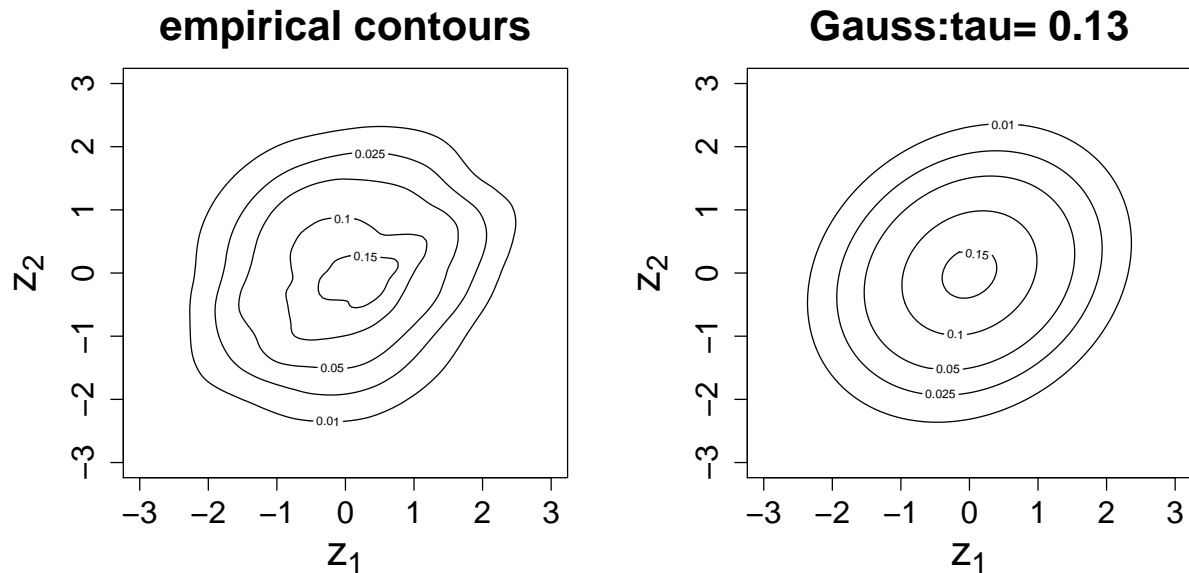- 32 Frank (5) +pseudo obs. for 13;2:

Table 4.2: WINE3: Three pair copula constructions together with empirically chosen pair copula families, their estimated Kendall's $\hat{\tau}$ and their estimated parameter $\hat{\theta}$ for PCC2

```
h12<-BiCopHfunc(udata[,1],udata[,2],family=34,par=theta.acfacv)$hfunc2
h32<-BiCopHfunc(udata[,3],udata[,2],family=5,par=theta.acvacc)$hfunc2
theta.13.2<-BiCopTau2Par(4,cor(h12,h32,method="kendall"))
cor(h12,h32,method="kendall")
```

```
## [1] 0.4526781
```

```
theta.13.2
```

```
## [1] 1.827078
```

```
pcc2.theta<-c(theta.acfacv,theta.acvacc,theta.13.2)
pcc2.fam<-c("Gumbel 270","Frank","Gumbel")
pcc2.lab<-c("(acf,acv)","(acv,acc)","(acf,acc;acv)")
pcc2.tau<-c(cor(acf,acv,method="kendall"),
cor(acv,acc,method="kendall"),
cor(h12,h32,method="kendall"))
pcc2<-data.frame(pcc2.lab,pcc2.fam,pcc2.tau,pcc2.theta)
print(pcc2)
```

```
##       pcc2.lab   pcc2.fam   pcc2.tau pcc2.theta
## 1    (acf,acv) Gumbel 270 -0.1851969  -1.227290
```

```
## 2      (acv,acc)      Frank -0.4283545  -4.565314
## 3 (acf,acc;acv)      Gumbel  0.4526781   1.827078
```

Figure 4.3: WINE3: Empirical (first column) based on pseudo copula data and normalized contour plots (second column) for a Gaussian conditional pair copula a 270 degree rotated Gumbel copula $C_{acf;acc;acv}$ needed for PCC2 (middle right)

```
bigpar(1,2)
BiCopKDE(h12,h32,main="empirical contours",kde.pars=list(mult=2))
# empirical contours look like Gumbel
obj<-BiCop(family=4,par = theta.13.2)
contour(obj, main=paste("Gumbel :tau=",round(cor(h12,h32,method="kendall"),
digits=2)))
```
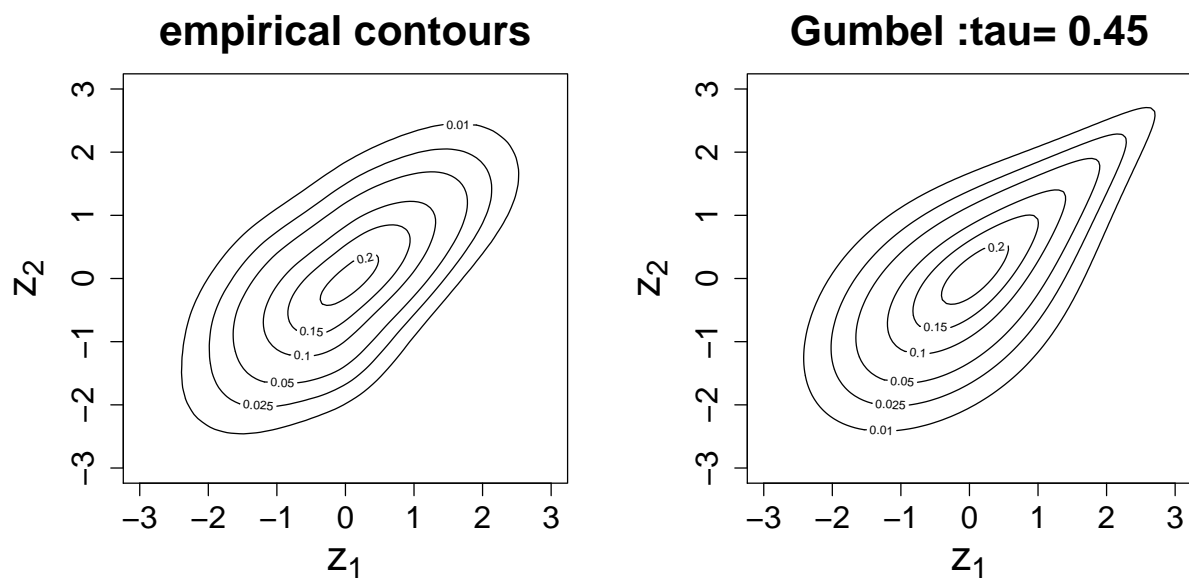

Example 4.3 (PCC3)

- 1,2,3=acf,acv,acc
- want to fit vine with 21,31,23;1
- 12 rotated Gumbel (34)
- 13 Gumbel (4)
- pseudo obs. for 23;1:

Table 4.2: WINE3: Three pair copula constructions together with empirically chosen pair copula families, their estimated Kendall's $\hat{\tau}$ and their estimated parameter $\hat{\theta}$ for PCC3.

```
h21<-BiCopHfunc(udata[,2],udata[,1],family=34,par=theta.acfacv)$hfunc2
h31<-BiCopHfunc(udata[,3],udata[,1],family=4,par=theta.acfacc)$hfunc2
theta.23.1<-BiCopTau2Par(5,cor(h21,h31,method="kendall"))
```

```
#cor(h21,h31,method="kendall")
pcc3.theta<-c(theta.acfacv,theta.acfacc,theta.23.1)
pcc3.fam<-c("Gumbel 270","Gumbel","Frank")
pcc3.lab<-c("(acf,acv)","(acf,acc)","(acv,acc;acf)")
pcc3.tau<-c(cor(acf,acv,method="kendall"),
cor(acf,acc,method="kendall"),
cor(h21,h31,method="kendall"))
pcc3<-data.frame(pcc3.lab,pcc3.fam,pcc3.tau,pcc3.theta)
print(pcc3)
```

```
##         pcc3.lab    pcc3.fam    pcc3.tau pcc3.theta
## 1     (acf,acv) Gumbel 270 -0.1851969  -1.227290
## 2     (acf,acc)     Gumbel  0.4842712   1.939004
## 3 (acv,acc;acf)      Frank -0.3845807  -3.952359
```

Figure 4.3: WINE3: Empirical (first column) based on pseudo copula data and normalized contour plots (second column) Frank copula $C_{acv;acc;acf}$ needed for PCC3 (bottom right).

```
bigpar(1,2)
BiCopKDE(h21,h31,main="empirical contours")
# empirical contours look like Frank
obj<-BiCop(family=5,par = theta.23.1)
contour(obj, main=paste("Frank:tau=",round(cor(h21,h31,method="kendall"),digits=2)))
```