

# R-code for Chapter 6: Simulating regular vine copulas and distributions

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## Required R-packages

- VineCopula
- rafalib

## Section 6.3: Simulating from C-vine copulas

### Example 6.4: Simulating from a five dimensional C-vine copula

**Table 6.1: R-vine specification: Chosen pair copula families, their family name abbreviations in VineCopula, parameter value and corresponding Kendall's  $\tau$  value.**

```
MatrixC = c(1,1,1,1,1, 0,2,2,2,2, 0,0,3,3,3, 0,0,0,4,4,0,0,0,5)
MatrixC = t(matrix(MatrixC,5,5))
MatrixC
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  1   1   1   1   1
## [2,]  0   2   2   2   2
## [3,]  0   0   3   3   3
## [4,]  0   0   0   4   4
## [5,]  0   0   0   0   5
```

```
familyC = c(0,1,3,24,4,0,0,23,24,1,0,0,0,4,1,0,0,0,0,3,0,0,0,0,0)
familyC = matrix(familyC,5,5)
familyC
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  0   0   0   0   0
## [2,]  1   0   0   0   0
## [3,]  3  23   0   0   0
## [4,] 24  24   4   0   0
## [5,]  4   1   1   3   0
```

```
parC = c(0,0.2,0.9,-6.5,3.9,0,0,-5.1,-2.6,0.9,0,0,0,1.9,0.5,
         0,0,0,0,4.8,0,0,0,0,0)
parC = matrix(parC,5,5)
parC
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,] 0.0 0.0 0.0 0.0  0
## [2,] 0.2 0.0 0.0 0.0  0
## [3,] 0.9 -5.1 0.0 0.0  0
## [4,] -6.5 -2.6 1.9 0.0  0
## [5,] 3.9 0.9 0.5 4.8  0
```

```
par2C = matrix(0,5,5)
```

```
RVMC = RVineMatrix(Matrix=MatrixC,family=familyC,par=parC,par2=par2C, names=c("V1","V2","V3","V4","V5"))
RVMC
```

```
## C-vine copula with the following pair-copulas:
```

```
## Tree 1:
```

```
## 1,5 Gumbel (par = 3.9, tau = 0.74)
## 1,4 Gaussian (par = 0.9, tau = 0.71)
## 1,3 Gaussian (par = 0.5, tau = 0.33)
## 1,2 Clayton (par = 4.8, tau = 0.71)
##
```

```
## Tree 2:
```

```
## 2,5;1 Rotated Gumbel 90 degrees (par = -6.5, tau = -0.85)
## 2,4;1 Rotated Gumbel 90 degrees (par = -2.6, tau = -0.62)
## 2,3;1 Gumbel (par = 1.9, tau = 0.47)
##
```

```
## Tree 3:
```

```
## 3,5;2,1 Clayton (par = 0.9, tau = 0.31)
## 3,4;2,1 Rotated Clayton 90 degrees (par = -5.1, tau = -0.72)
##
```

```
## Tree 4:
```

```
## 4,5;3,2,1 Gaussian (par = 0.2, tau = 0.13)
##
```

```
## ---
```

```
## 1 <-> V1, 2 <-> V2, 3 <-> V3, 4 <-> V4, 5 <-> V5
```

Figure 6.2: C-vine tree plots: Tree sequence with families and Kendall's  $\tau$  values

```
bigpar(2,2)
plot(RVMC,type=0, edge.labels = "family-par")
```

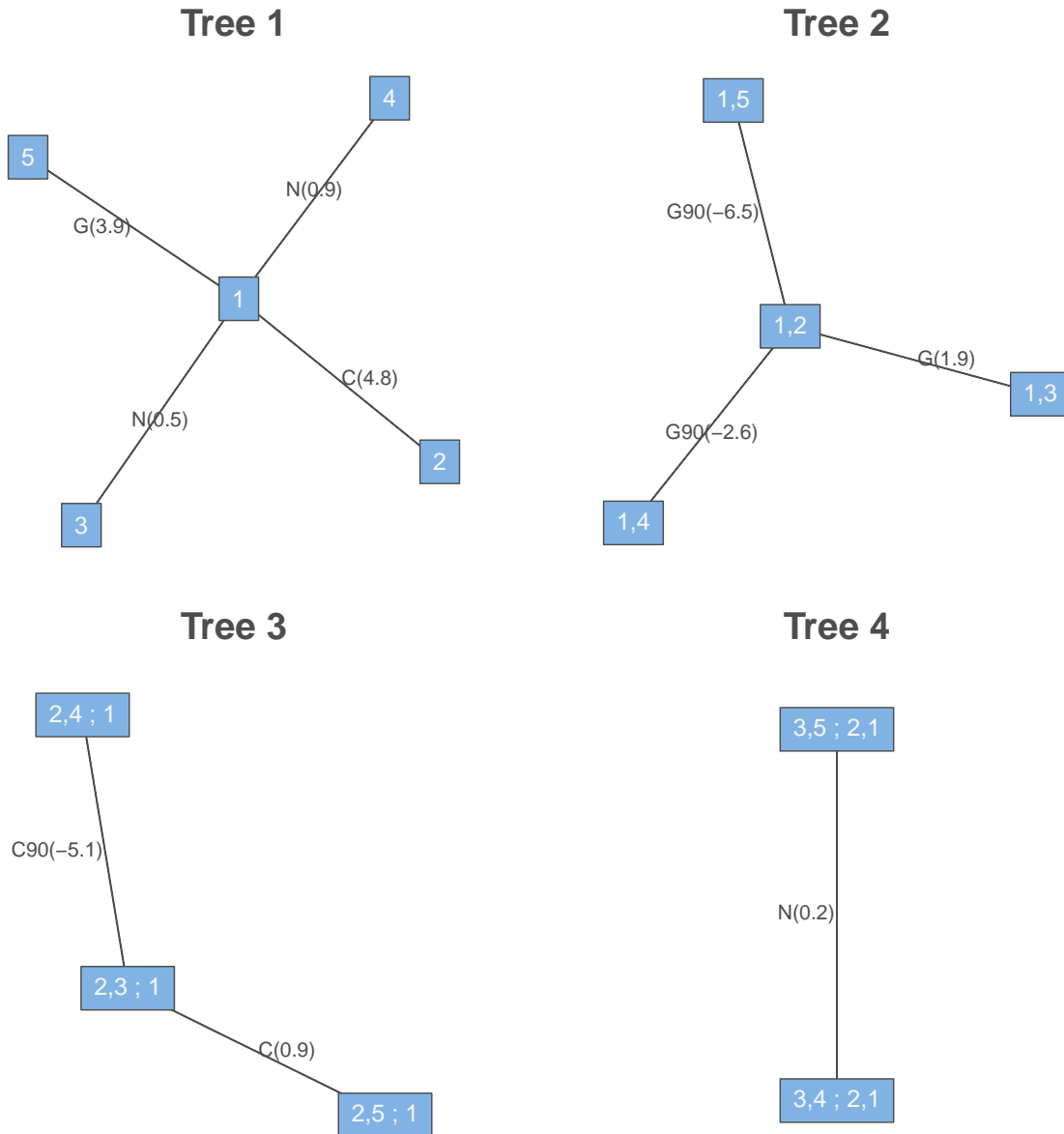


Figure 6.3: Normalized contours: Normalized theoretical contour plots of all pair copulas specified in the C-vine tree sequence given in Figure 6.2.

```
bigpar(2,2)
contour(RVMC)
```

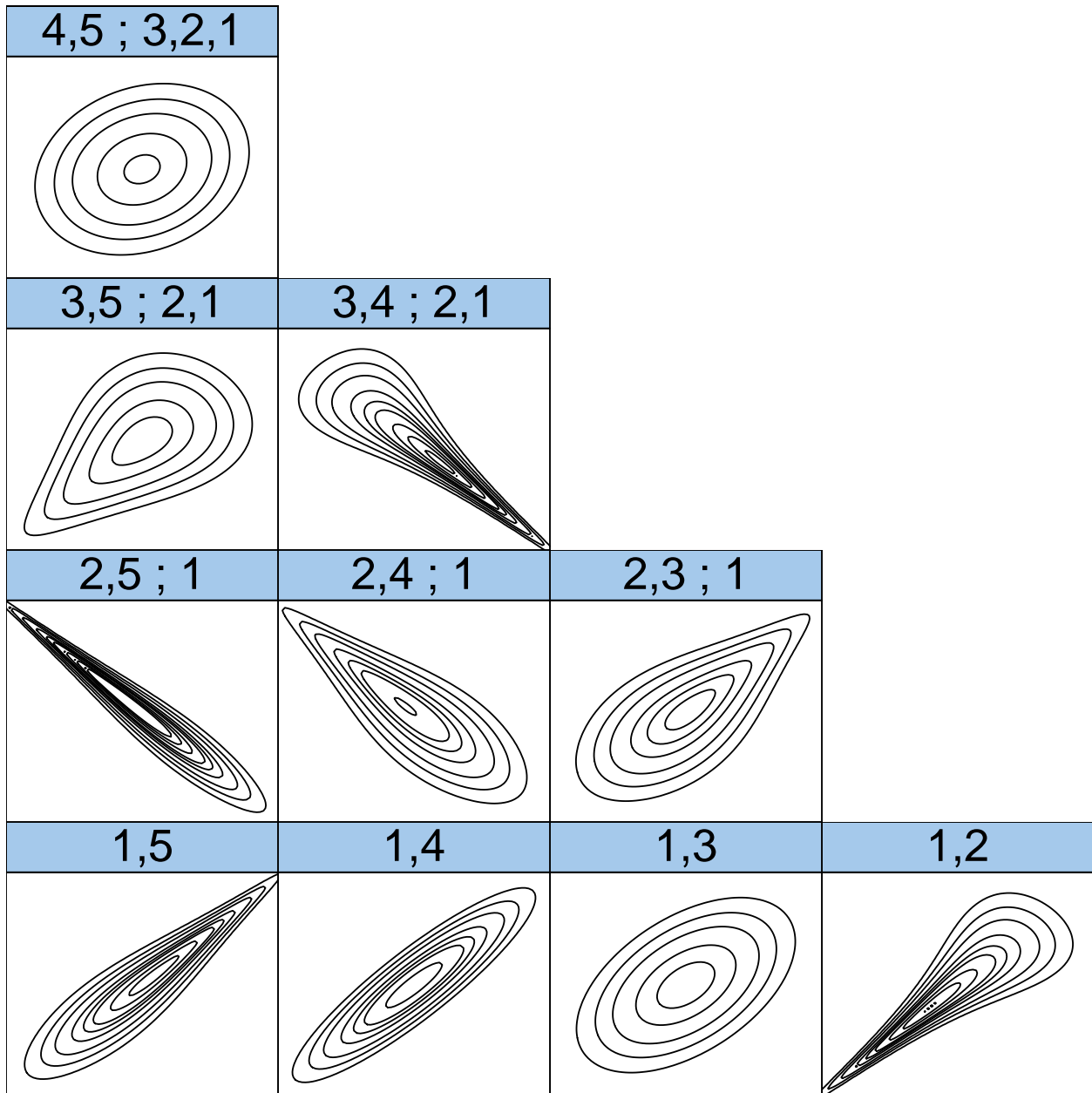
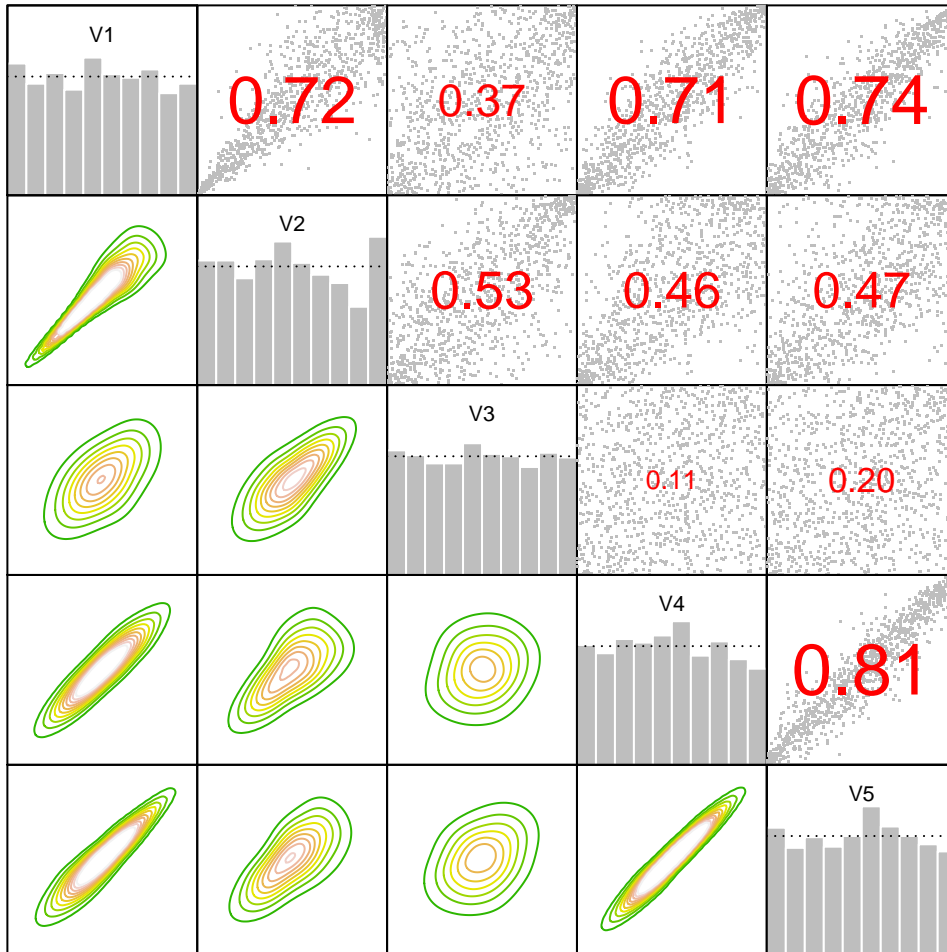


Figure 6.4: C-vine simulation: A simulated sample of size 1000 from the C-vine specified in Table 6.1 (upper triangle: pair scatter plot of copula data, diagonal: marginal histograms of copula data, lower triangle: empirical normalized contour plots).

```
cdata = as.copuladata(RVineSim(1000,RVMC))
pairs(cdata)
```



## Section 6.5: Simulating from regular vine copulas

Ex 6.7 Sampling from a specified R-vine copula.

Define 5-dimensional R-vine tree structure matrix

```
Matrix = c(2,5,3,1,4, 0,3,5,1,4, 0,0,4,5,1, 0,0,0,5,1,0,0,0,0,1)
Matrix = matrix(Matrix,5,5)
Matrix
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  2   0   0   0   0
## [2,]  5   3   0   0   0
## [3,]  3   5   4   0   0
## [4,]  1   1   5   5   0
```

```
## [5,] 4 4 1 1 1
```

### Define R-vine pair-copula family matrix

```
family = c(0,1,3,24,4,0,0,23,24,1,0,0,0,4,1,0,0,0,0,3,0,0,0,0,0)
family = matrix(family,5,5)
family
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  0   0   0   0   0
## [2,]  1   0   0   0   0
## [3,]  3  23   0   0   0
## [4,] 24  24   4   0   0
## [5,]  4   1   1   3   0
```

### Define R-vine pair-copula parameter matrix

```
par = c(0,0.2,0.9,-6.5,3.9,0,0,-5.1,-2.6,0.9,0,0,0,1.9,0.5,
        0,0,0,0,4.8,0,0,0,0,0)
par = matrix(par,5,5)
par
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,] 0.0  0.0  0.0  0.0  0
## [2,] 0.2  0.0  0.0  0.0  0
## [3,] 0.9 -5.1  0.0  0.0  0
## [4,] -6.5 -2.6  1.9  0.0  0
## [5,]  3.9  0.9  0.5  4.8  0
```

### Define second R-vine pair-copula parameter matrix

```
par2 = matrix(0,5,5)
```

### Define RVineMatrix object

```
RVM = RVineMatrix(Matrix=Matrix,family=family,par=par,par2=par2,
                  names=c("V1","V2","V3","V4","V5"))
```

```
RVM
```

```
## R-vine copula with the following pair-copulas:
## Tree 1:
## 4,2 Gumbel (par = 3.9, tau = 0.74)
## 4,3 Gaussian (par = 0.9, tau = 0.71)
## 1,4 Gaussian (par = 0.5, tau = 0.33)
## 1,5 Clayton (par = 4.8, tau = 0.71)
##
## Tree 2:
## 1,2;4 Rotated Gumbel 90 degrees (par = -6.5, tau = -0.85)
## 1,3;4 Rotated Gumbel 90 degrees (par = -2.6, tau = -0.62)
## 5,4;1 Gumbel (par = 1.9, tau = 0.47)
```

```
##  
## Tree 3:  
## 3,2;1,4 Clayton (par = 0.9, tau = 0.31)  
## 5,3;1,4 Rotated Clayton 90 degrees (par = -5.1, tau = -0.72)  
##  
## Tree 4:  
## 5,2;3,1,4 Gaussian (par = 0.2, tau = 0.13)  
##  
## ---  
## 1 <-> V1, 2 <-> V2, 3 <-> V3, 4 <-> V4, 5 <-> V5
```

Figure 6.5: R-vine tree plots: with copula families and Kendall's  $\tau$  values.

```
bigpar(2,2)  
plot(RVM,type=0, edge.labels = "family-par")
```

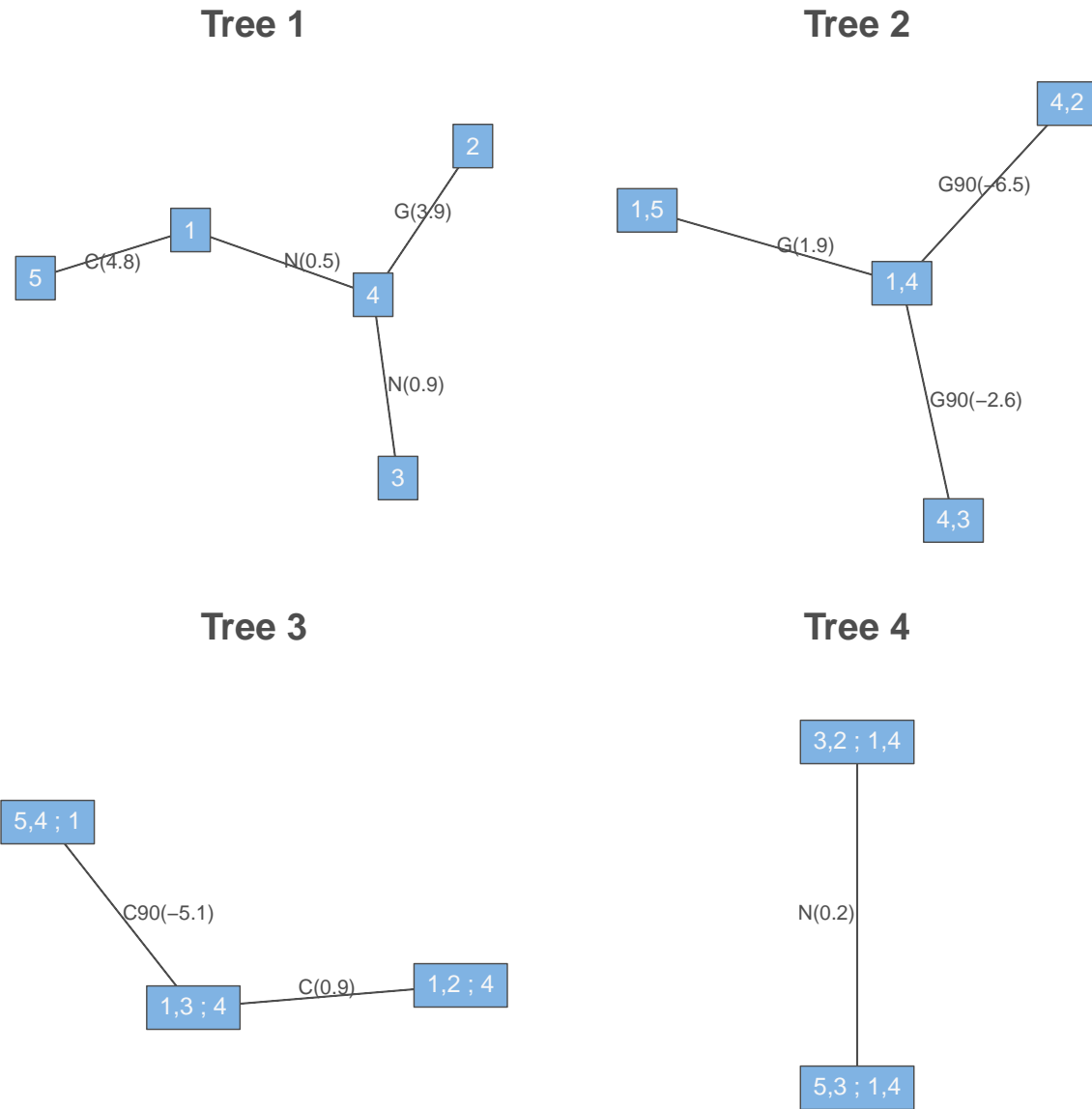


Figure 6.6: Normalized contours: Theoretical normalized contour plots of the specified pair copulas

```
bigpar(2,2)
contour(RVM)
```



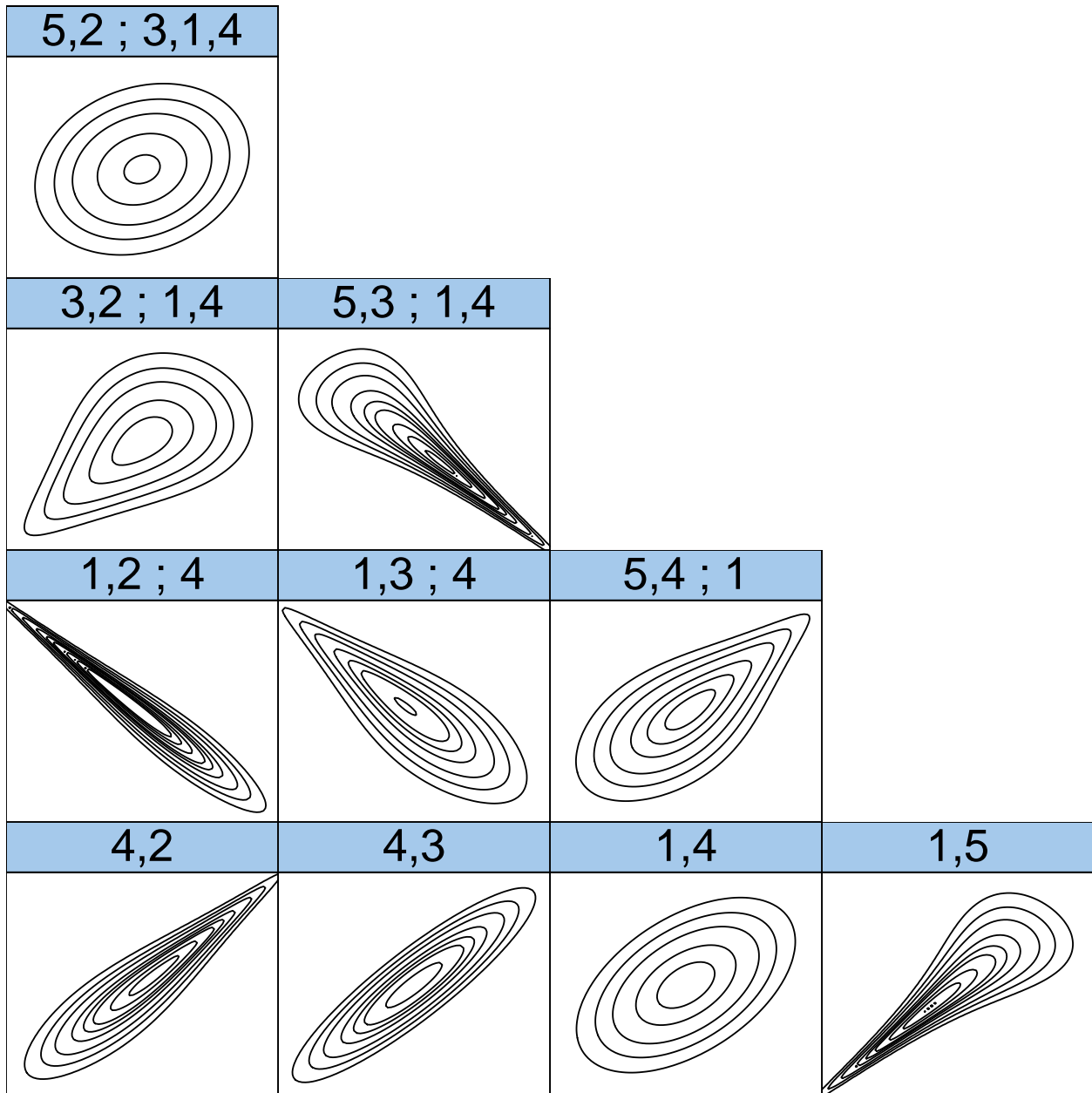


Figure 6.7: R-vine simulation: Pairwise scatter plots (upper triangular), marginal histograms (diagonal) and pairwise normalized contour plots (lower triangular) of 1000 simulated realizations of the R-vine copula specified in Example 6.7.

```
rdata = as.copuladata(RVineSim(1000,RVM))
pairs(rdata)
```

