

# The R package VineCopula

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- Successor of the CDVine package (Brechmann and Schepsmeier, 2012)
- First version on CRAN in June 2012
- Many former authors and contributors

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- Current version on CRAN: 2.0.4

1 Bivariate copula modeling

2 Vine copula modeling

3 Further remarks

### EDA

[BiCopKDE](#)

[BiCopLambda](#)

[BiCopChiPlot](#)

[BiCopKPlot](#)

[BiCopCompare](#)

### Inference

[BiCopEst](#)

[BiCopSelect](#)

[BiCopGofTest](#)

[BiCopVuongClarke](#)

[BiCopIndepTest](#)

### Properties

[BiCopPDF](#)

[BiCopCDF](#)

[BiCopSim](#)

[BiCopPar2Tau/Tau2Par](#)

[BiCopPar2TailDep](#)

[BiCopDeriv](#)

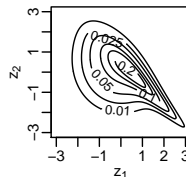
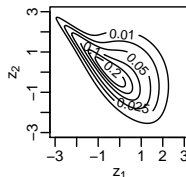
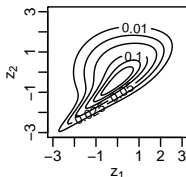
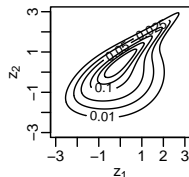
...and more!

### Families are encoded into numbers

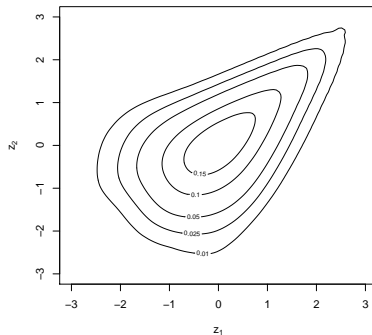
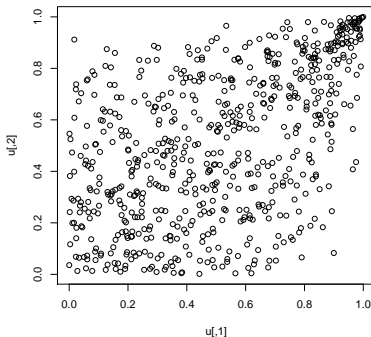
|           |              |            |         |              |
|-----------|--------------|------------|---------|--------------|
| 0: Indep. | 1: Gaussian  | 3: Clayton | 7: BB1  | 104: Tawn I  |
|           | 2: Student t | 4: Gumbel  | 8: BB6  | 204: Tawn II |
|           |              | 5: Frank   | 9: BB7  |              |
|           |              | 6: Joe     | 10: BB8 |              |

### For rotations add multiples of 10

```
> contour(BiCop(family = 104, par = 3, par2 = 0.5))  
> contour(BiCop(family = 114, par = 3, par2 = 0.5))  
> contour(BiCop(family = 124, par = -3, par2 = 0.5))  
> contour(BiCop(family = 134, par = -3, par2 = 0.5))
```



```
# rank transform to pseudo observations
> u <- pobs(dat)
# scatter plot
> plot(u)
# plot kernel contours (with normal margins)
> BiCopKDE(u[, 1], u[, 2])
```



```
> fit1 <- BiCopEst(u[, 1], u[, 2], family = 4)
> summary(fit1)

...
Name:    Gumbel

Parameter(s)
-----
par:    1.6    (SE = 0.05)

Dependence measures
-----
Kendall's tau:    0.38 (empirical = 0.37, p value < 0.01)
Upper TD:        0.46
Lower TD:        0

Fit statistics
-----
logLik:    145.48
AIC:      -288.96
BIC:      -284.48
```

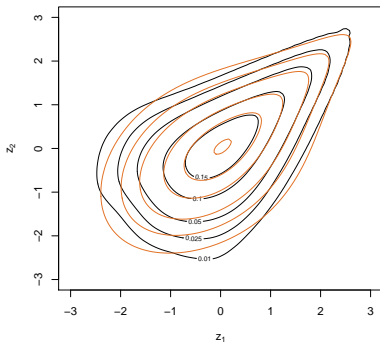
```
> fit1 <- BiCopEst(u[, 1], u[, 2], family = 4)
> BiCopGofTest(u[, 1], u[, 2], fit1)
```

```
$statistic
      [,1]
[1,] 3.529642

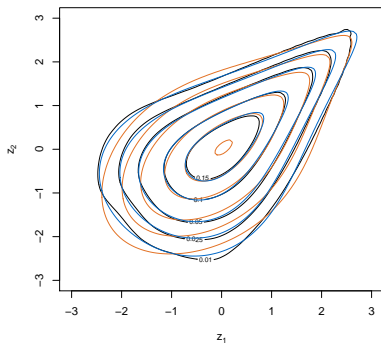
$p.value
[1] 0.04
```



```
> BiCopKDE(u[, 1], u[, 2])  
> contour(fit1, col = 2, add = TRUE, drawlabels = FALSE)
```



```
> fit2 <- BiCopSelect(u[, 1], u[, 2])  
Bivariate copula: Survival Clayton (par = 1.16, tau = 0.37)  
  
> contour(fit2, col = 3, add = TRUE, drawlabels = FALSE)
```



```
> fit2 <- BiCopSelect(u[, 1], u[, 2])  
Bivariate copula: Survival Clayton (par = 1.16, tau = 0.37)  
  
> BiCopGofTest(u[, 1], u[, 2], fit2)
```

```
$statistic  
      [,1]  
[1,] 0.1163686  
  
$p.value  
[1] 0.8
```

# Bivariate copula modeling

Code example: EDA and inference

```
> BiCopCompare(u[, 1], u[, 2])
```



**Useful for conditional copula modeling:** Many BiCop- functions are vectorized w.r.t family and parameters.

**Example:** Given covariate  $X$ , simulate  $(U, V)$  from Clayton copula with Kendall's  $\tau$  equal to  $X^2$

```
UV.X <- BiCopSim(500,  
                 family = 3,  
                 par = BiCopTau2par(family = 3, tau = X^2))
```

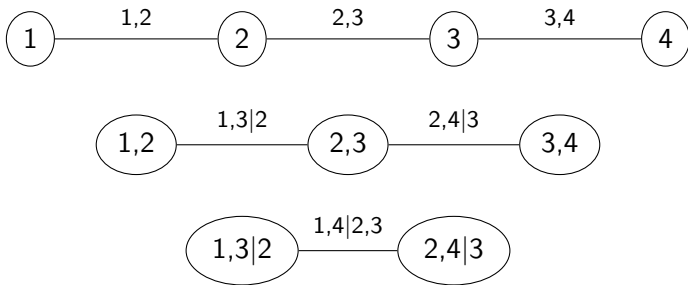
1 Bivariate copula modeling

2 Vine copula modeling

3 Further remarks

## Vine copulas

- ... build a model for the dependence from (conditional) pairs.
- ... can be represented as a graphical model (a *vine*).
- ... link each edge to a bivariate copula function.



### EDA

`pairs.copuladata`  
`TauMatrix`

### Inference

`RVineMLE/SeqEst`  
`RVineCopSelect`  
`RVineStructureSelect`  
`RVineGofTest`  
`RVineVuongTest`

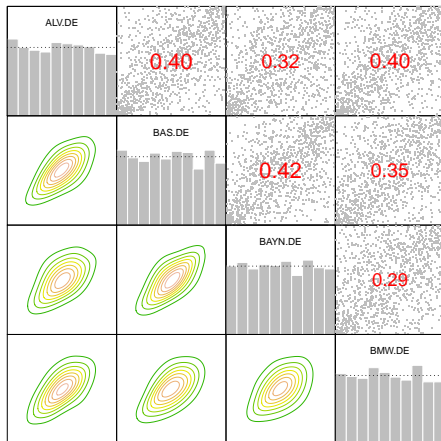
### Properties

`RVinePDF`  
`RVineGrad`  
`RVineHessian`  
`RVineSim`

...and more!



```
data(daxreturns)
u <- daxreturns[, 1:4]
pairs.copuladata(u)
```

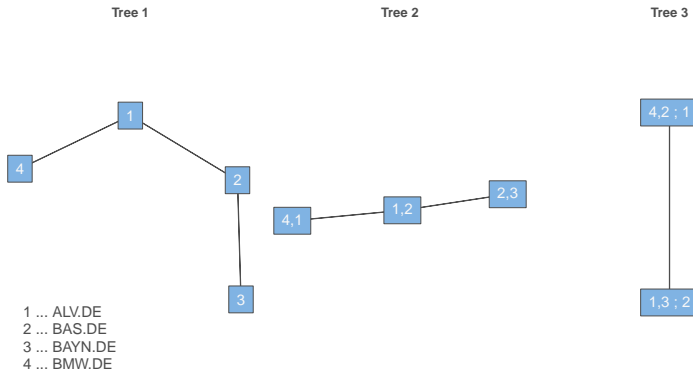


```
> vinefit <- RVineStructureSelect(u)
> summary(vinefit)
```

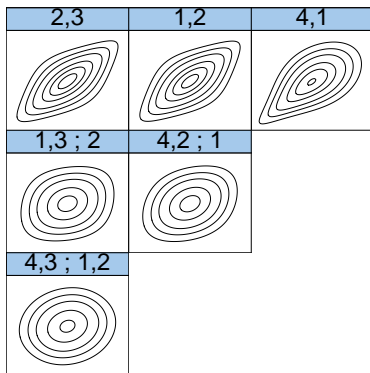
| tree | edge    | No. | family | par  | par2  | tau  | UTD  | LTD  |
|------|---------|-----|--------|------|-------|------|------|------|
| 1    | 2,3     | 2   | t      | 0.61 | 4.62  | 0.42 | 0.29 | 0.29 |
|      | 1,2     | 2   | t      | 0.59 | 4.61  | 0.40 | 0.28 | 0.28 |
|      | 4,1     | 14  | SG     | 1.61 | 0.00  | 0.38 | -    | 0.46 |
| 2    | 1,3;2   | 2   | t      | 0.18 | 10.21 | 0.12 | 0.02 | 0.02 |
|      | 4,2;1   | 2   | t      | 0.27 | 14.41 | 0.17 | 0.01 | 0.01 |
| 3    | 4,3;1,2 | 5   | F      | 0.65 | 0.00  | 0.07 | -    | -    |

---  
type: D-vine      logLik: 868      AIC: -1716      BIC: -1665.46  
---  
1 <-> ALV.DE,    2 <-> BAS.DE,    3 <-> BAYN.DE,    4 <-> BMW.  
DE

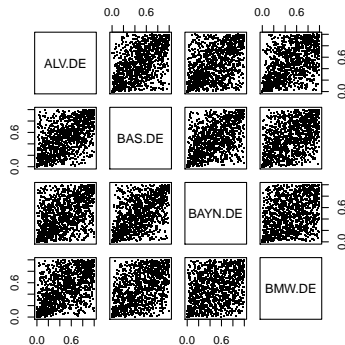
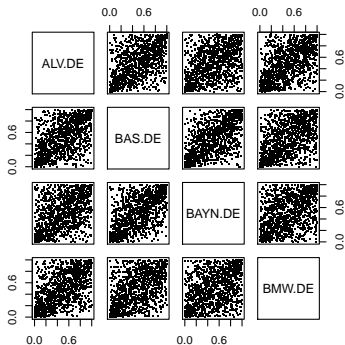
```
> plot(vinefit, type = 2)
```



```
> contour(vinefit, type = 2)
```



```
> usim <- RVineSim(1158, vinefit)
> pairs(u, pch = ".")
> pairs(usim, pch = ".")
```



1 Bivariate copula modeling

2 Vine copula modeling

**3 Further remarks**

- Most functions can handle NAs

```
> BiCopSelect(u[, 1], u[, 2])  
Bivariate copula: Clayton (par = 2.85, tau = 0.59)  
Warning message:  
In BiCopSelect: 37 observations (7.4%) contain NAs.  
Only complete observations are used.
```

- Functions C2RVine/D2RVine for easy transition from CDVine package
- Interface to copula package makes additional families and vines accessible for rCopula etc.

- CDVine (Brechmann and Schepsmeier, 2013)
- copula (Hofert et al., 2016)
- gamCopula (Vatter and N, 2016)
- kdecopula (N, 2016a)
- kdevine (N, 2016b)



- Package is available on CRAN or

`github.com/tnagler/VineCopula`

- Bug reports and feature requests via mail to

`thomas.nagler@tum.de`

- Feel free to cite the package in your paper

```
> citation("VineCopula")
```

Brechmann, E. C. and Schepsmeier, U. (2013).

Modeling Dependence with C- and D-Vine Copulas: The R Package CDVine.

*Journal of Statistical Software*, 52(3):1–27.

Hofert, M., Kojadinovic, I., Maechler, M., and Yan, J. (2016).

*copula: Multivariate Dependence with Copulas*.

R package version 0.999-15, URL: <http://CRAN.R-project.org/package=copula>.

Nagler, T. (2016a).

*kdecopula: Kernel Smoothing for Bivariate Copula Densities*.

R package version 0.6.0, URL: <http://CRAN.R-project.org/package=kdecopula>.

Nagler, T. (2016b).

*kdevine: Multivariate Kernel Density Estimation with Vine Copulas*.

R package version 0.2.1, URL: [github.com/tnagler/kdevine](https://github.com/tnagler/kdevine).

Vatter, T. and Nagler, T. (2015).

*gamCopula: Generalized Additive Models for Bivariate Conditional Dependence Structures and Vine Copulas*.

R package version 0.0-1, URL: [github.com/tvatter/gamCopula](https://github.com/tvatter/gamCopula).