

Assignment-

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1 Question 1

Code for R

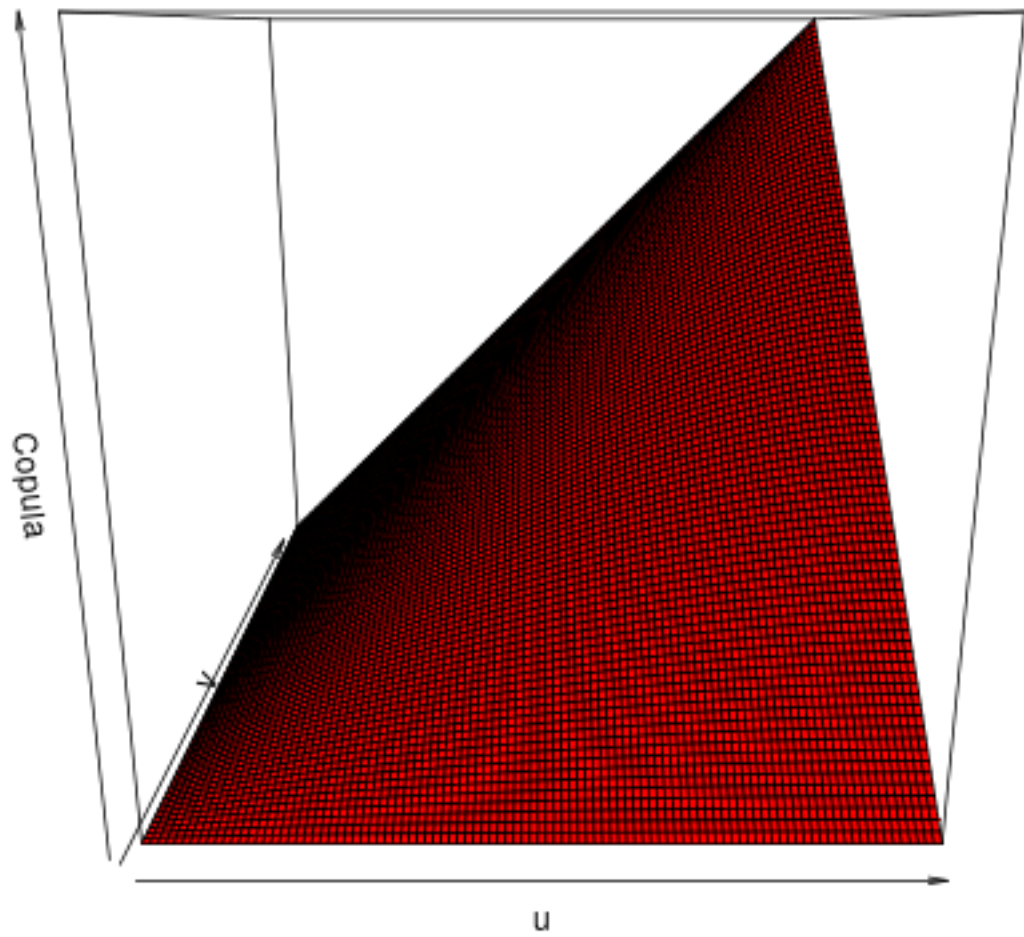
```
1 library(mvtnorm)
2 surfGumbel <- function(theta) {
3   copula <- function(u, v) {
4     y = exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta));
5     return (y);
6   }
7   n = 100;
8   X = seq(0, 1, length.out = n);
9   Y = X;
10  Z = numeric();
11  for (i in 1:n) {
12    for (j in 1:n) {
13      Z = c(Z, copula(X[i], Y[j]));
14    }
15  }
16
17  Z = matrix(Z, nrow = n, ncol = n);
18  persp(X, Y, Z, xlab = "u", ylab = "v", zlab = "Copula", col = "red",
19    main = "Surface plot of bivariate gumbel copula with parameter 1.5");
20  dev.copy(png, "plots/plot_q1-1.png"); dev.off ();
21 }
22
23 surfNormal <- function(theta) {
24   copula <- function(u, v) {
25     x.up = qnorm(u); y.up = qnorm(v);
26     Sig = matrix(c(1, theta, theta, 1), nrow=2, ncol=2);
27     pmvnorm(lower = c(-Inf, -Inf), upper = c(x.up, y.up), mean = c(0, 0), corr = Sig);
28     # pdf <- function(x, y) {
29     #   X = matrix(X, nrow=2, ncol=1);
30     #   ans = det(2*pi*Sig)^(-1/2) * exp(-t(X) %*% Sig^(-1) %*% X / 2);
```

```

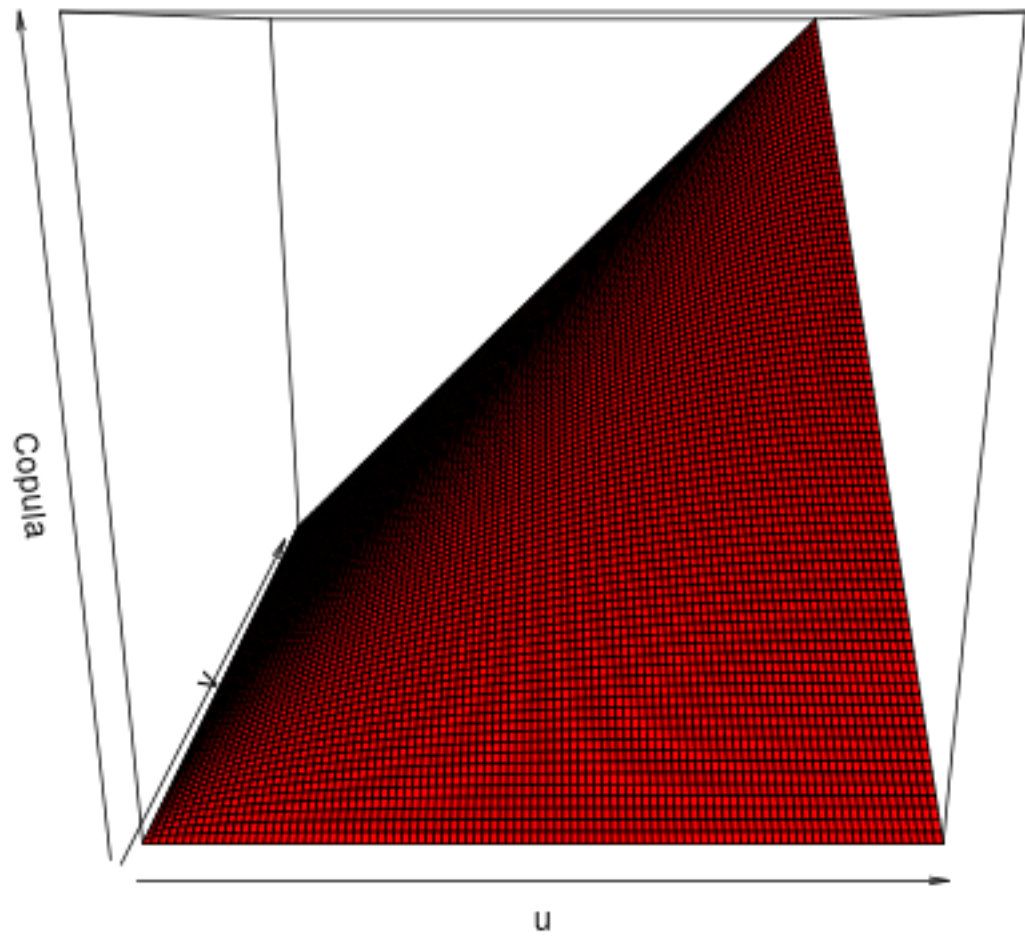
31     # return (ans)
32     # }
33     # integrate(function(y) {
34     #     sapply(y, function(y) {
35     #         integrate(function(x) {
36     #             sapply(x, function(x) pdf(x, y))}, -10, x_up)$value
37     #         })
38     #     }, -10, y_up)
39 }
40
41 n = 100;
42 X = seq(0, 1, length.out = n);
43 Y = X;
44 Z = numeric();
45 for (i in 1:n) {
46     for (j in 1:n) {
47         Z = c(Z, copula(X[i], Y[j]));
48     }
49 }
50
51 Z = matrix(Z, nrow = n, ncol = n);
52 persp(X, Y, Z, xlab = "u", ylab = "v", zlab = "Copula", col = "red",
53     main = "Surface plot of bivariate normal copula with parameter 0.7");
54 dev.copy(png, "plots/plot_q1_2.png"); dev.off ();
55 }
56
57 surfGumbel(1.5);
58 surfNormal(0.7);

```

Surface plot of bivariate gumbel copula with parameter 1.5



Surface plot of bivariate normal copula with parameter 0.7



2 Question 2

Code for R

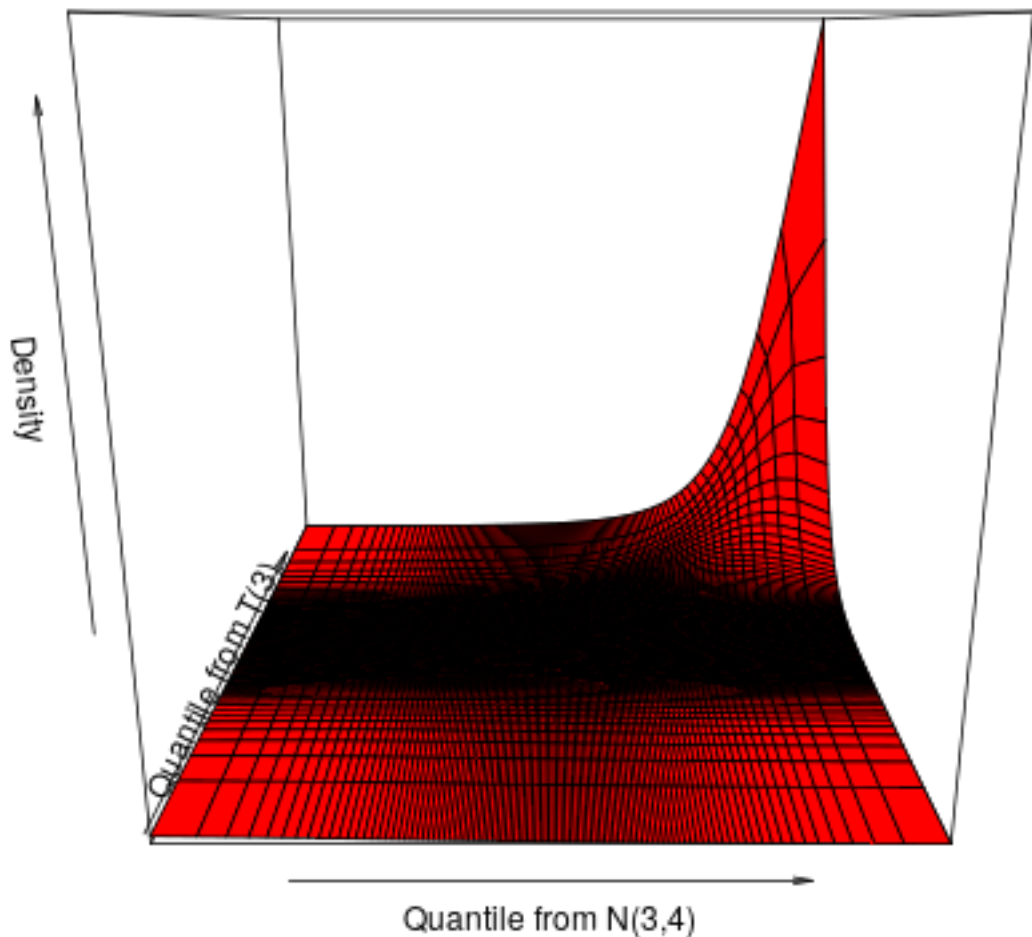
```
1 contGumbel <- function(theta , mu, sig , df) {
2   copula <- function(u, v) {
3     y = exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta));
4     return (y);
5   }
6   pdf_copula <- function(u, v) {
7     y = (dnorm(qnorm(u, mean = mu, sd = sig), mean = mu, sd = sig) *
8       dt(qt(v, df = df), df = df) *
9       (exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta))*(-log(u))^(theta - 1)*(-log(v))
10        ^ (theta - 1)*((-log(u))^theta + (-log(v))^theta)^(2/theta - 2))/(u*v) - (theta*
11        exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta))*(-log(u))^(theta - 1)*(-log(v)
12        ))^(theta - 1)*(1/theta - 1)*((-log(u))^theta + (-log(v))^theta)^(1/theta - 2))/(
13        u*v));
14   }
15   n = 100;
16   X_ = seq(1/n, 1 - 1/n, length.out = n);
17   Y_ = X_;
18   Z = numeric();
19   for (i in 1:n) {
20     for (j in 1:n) {
21       Z = c(Z, pdf_copula(X_[i], Y_[j]));
22     }
23   }
24   X = qnorm(X_, mean = mu, sd = sig);
25   Y = qt(Y_, df = df);
26   # print(X); print(Y); print(Z);
27   Z = matrix(Z, nrow = n, ncol = n, byrow = TRUE);
28   persp(X, Y, Z, xlab = "Quantile from N(3,4)", ylab = "Quantile from T(3)", zlab = "Density"
29     ,
30     main = "Density of bivariate gumbel copula with parameter 1.4");
31   dev.copy(png, "plots/plot_q2_1.png"); dev.off ();
32   contour(X, Y, Z, main = "Density of bivariate gumbel copula with parameter 1.4");
33   dev.copy(png, "plots/plot_q2_2.png"); dev.off ();
34
35   Z = numeric();
36   for (i in 1:n) {
37     for (j in 1:n) {
38       Z = c(Z, copula(X_[i], Y_[j]));
39     }
40   }
41   Z = matrix(Z, nrow = n, ncol = n, byrow = TRUE);
42   persp(X, Y, Z, xlab = "Quantile from N(3,4)", ylab = "Quantile from T(3)", zlab = "CDF",
43     main = "CDF of bivariate gumbel copula with parameter 1.4");
```

```

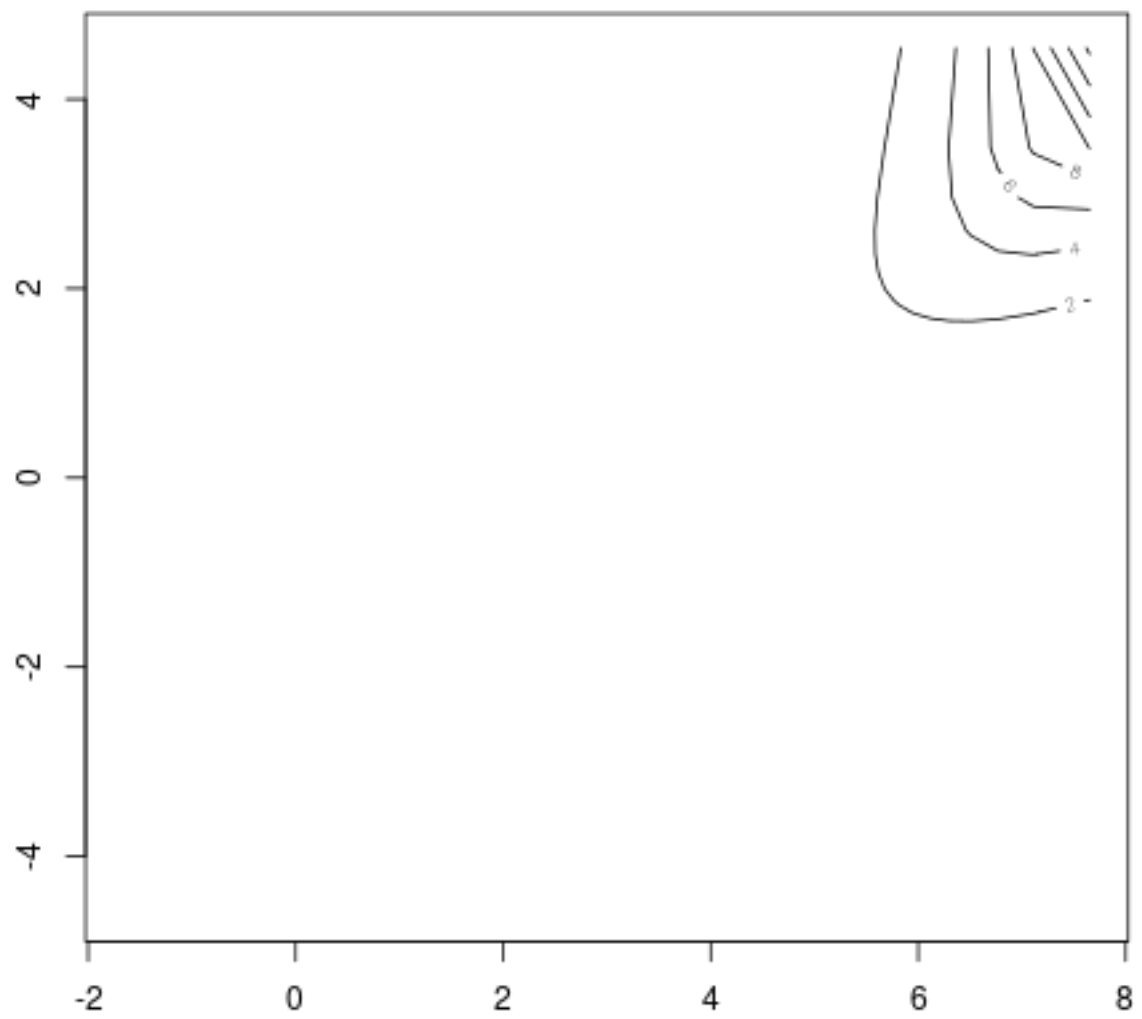
40 dev.copy(png, "plots/plot_q2-3.png"); dev.off ();
41 contour(X, Y, Z, main = "CDF of bivariate gumbel copula with parameter 1.4");
42 dev.copy(png, "plots/plot_q2-4.png"); dev.off ();
43 }
44
45
46 theta = 1.4;
47 mu = 3;
48 sig = 2;
49 df = 3;
50 contGumbel(theta, mu, sig, df);

```

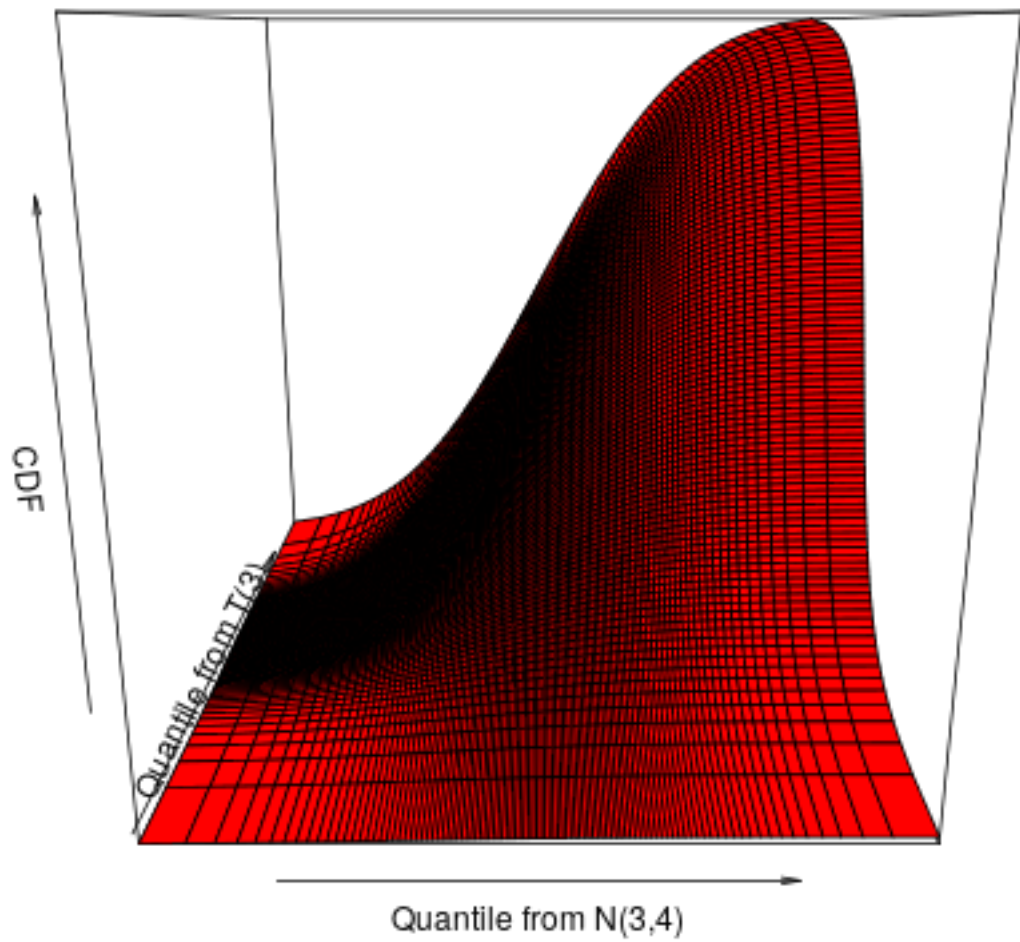
Density of bivariate gumbel copula with parameter 1.4



Density of bivariate gumbel copula with parameter 1.4



CDF of bivariate gumbel copula with parameter 1.4



CDF of bivariate gumbel copula with parameter 1.4

