10_2Q5

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10.2Q.5

a)

i)

$$\begin{aligned} F_{X_1,X_2}(X_1,X_2) &= P\big(X_1 \leq x_1, X_2 \leq x_2\big) \\ &= P\big(F_{X_1}^{-1}(U_1) \leq x_1, F_{X_2}^{-1}(U_2) \leq x_2\big) \\ &= P\big(U_1 \leq F_{X_1}(x_1), U_2 \leq F_{X_2}(x_2)\big) \\ &= C_\alpha^{AMH}\big(F_{X_1}(x_1), F_{X_2}(x_2)\big) \end{aligned}$$

ii)

```
alpha <- 0.9
densityCopule <- function(u1, u2) {
     (u1 * u2) / (1 - alpha * (1 - u1) * (1 - u2))
}
FXX <- function(x1, x2) {
     densityCopule(pexp(x1, 1 / 100), plnorm(x2, log(100) - 0.32, 0.8))
}
FXX(100, 100)
```

```
## [1] 0.4676594
```

```
FXX(200, 100)
```

```
## [1] 0.5915474
```

```
FXX(100, 300)
```

```
## [1] 0.6158082
```

b)

$$\begin{aligned} F_{X_1,X_2}(X_1,X_2) &= P\big(X_1 \leq x_1, X_2 \leq x_2\big) \\ &= P\big(F_{X_1}^{-1}(U_1) \leq x_1, F_{X_2}^{-1}(1-U_2) \leq x_2\big) \\ &= P\big(U_1 \leq F_{X_1}(x_1), 1-U_2 \leq F_{X_2}(x_2)\big) \\ &= P\big(U_1 \leq F_{X_1}(x_1), U_2 > 1-F_{X_2}(x_2)\big) \\ &= P\big(U_1 \leq F_{X_1}(x_1), U_2 > \overline{F}_{X_2}(x_2)\big) \\ &= 1-\overline{F}_{X_2}(x_2) - C_\alpha^{AMH}\big(F_{X_1}(x_1), \overline{F}_{X_2}(x_2)\big) \end{aligned}$$

ii)

```
FXX <- function(x1, x2) {
    1 - pexp(x1, 1 / 100, lower.tail = FALSE) - densityCopule(pexp(x1, 1 / 100),
    1 - plnorm(x2, log(100) - 0.32, 0.8))
}
FXX(100, 100)
```

```
## [1] 0.3539389
```

```
FXX(200, 100)
```

```
## [1] 0.5408711
```

```
FXX(100, 300)
```

```
## [1] 0.5967893
```

c)

$$
\begin{aligned}
F_{X_1,X_2}(X_1,X_2) &= P\big(X_1 \le x_1, X_2 \le x_2\big) \\
&= P\big(F_{X_1}^{-1}(1-U_1) \le x_1, F_{X_2}^{-1}(U_2) \le x_2\big) \\
&= P\big(1-U_1 \le F_{X_1}(x_1), U_2 \le F_{X_2}(x_2)\big) \\
&= P\big(U_1 > 1-F_{X_1}(x_1), U_2 \le F_{X_2}(x_2)\big) \\
&= P\big(U_1 > \overline{F}_{X_1}(x_1), U_2 \le F_{X_2}(x_2)\big) \\
&= 1-\overline{F}_{X_1}(x_1) - C_{\alpha}^{AMH}\big(\overline{F}_{X_1}(x_1), F_{X_2}(x_2)\big)
\end{aligned}
$$

ii)

```
FXX <- function(x1, x2) {
    1 - (1 - plnorm(x2, log(100) - 0.32, 0.8)) - densityCopule(pexp(x1, 1 /
    100, lower.tail = FALSE),
    plnorm(x2, log(100) - 0.32, 0.8))
}
FXX(100, 100)
```

```
## [1] 0.3555135
```

```
FXX(200, 100)
```

```
## [1] 0.5342197
```

```
FXX(100, 300)
```

```
## [1] 0.6002031
```

d)

$$
\begin{aligned}
F_{X_1,X_2}(X_1,X_2) &= P\big(X_1 \le x_1, X_2 \le x_2\big) \\
&= P\big(F_{X_1}^{-1}(1-U_1) \le x_1, F_{X_2}^{-1}(U_2) \le x_2\big) \\
&= P\big(1-U_1 \le F_{X_1}(x_1), 1-U_2 \le F_{X_2}(x_2)\big) \\
&= P\big(U_1 > 1-F_{X_1}(x_1), U_2 > 1-F_{X_2}(x_2)\big) \\
&= P\big(U_1 > \overline{F}_{X_1}(x_1), U_2 > \overline{F}_{X_2}(x_2)\big) \\
&= 1-\overline{F}_{X_1}(x_1)\overline{F}_{X_2}(x_2) + C_\alpha^{AMH}\big(\overline{F}_{X_1}(x_1), \overline{F}_{X_2}(x_2)\big)
\end{aligned}
$$

ii)

```
FXX <- function(x1, x2) {
    1 - (1 - plnorm(x2, log(100) - 0.32, 0.8)) - pexp(x1, 1 / 100, lower.tail = FALSE) +
    densityCopule(pexp(x1, 1 /
    100, lower.tail = FALSE),
    plnorm(x2, log(100) - 0.32, 0.8))
}
FXX(100, 100)
```

```
## [1] 0.5874505
```

```
FXX(200, 100)
```

```
## [1] 0.6412885
```

```
FXX(100, 300)
```

```
## [1] 0.9557328
```