

2023-01-19

```
library(stats4)
library(matlib)
maki = read.table("makiwaraboard.txt",header = TRUE)
head(maki)
```

```
##   WoodType BoardType Deflection
## 1   Cherry   Stacked    144.3
## 2   Cherry   Stacked    125.9
## 3   Cherry   Stacked    263.2
## 4   Cherry   Stacked    114.6
## 5   Cherry   Stacked    242.5
## 6   Cherry   Stacked    141.9
```

```
tail(maki)
```

```
##   WoodType BoardType Deflection
## 331     Oak   Tapered     56.6
## 332     Oak   Tapered    123.5
## 333     Oak   Tapered     12.0
## 334     Oak   Tapered     62.0
## 335     Oak   Tapered     73.3
## 336     Oak   Tapered     44.9
```

```
maki$WoodType = factor(maki$WoodType,labels=c(2,1,3,4))
maki$BoardType = factor(maki$BoardType,labels=c(1,2))
X1 = maki$WoodType
X2 = maki$BoardType
Y = maki$Deflection
# Building model without interactions
loglik1 = function(beta0,beta2,beta3,beta4,alpha2,mu,sigma) {
  R = Y - I(X1==2)*beta2 - I(X1==3)*beta3 - I(X1==4)*beta4 - I(X2==2)*alpha2 - beta0
  R = suppressWarnings(dnorm(R, mu, sigma))
  -sum(log(R))
}
m = mle(loglik1, start=list(beta0 = 100, beta2= 6.5,beta3=-17,beta4=-21,alpha2=-37, sigma=55,mu=
0))
summary(m)
```

```
## Warning in sqrt(diag(object@vcov)): NaNs produced
```

```
## Maximum likelihood estimation
##
## Call:
## mle(minuslogl = loglik1, start = list(beta0 = 100, beta2 = 6.5,
##   beta3 = -17, beta4 = -21, alpha2 = -37, sigma = 55, mu = 0))
##
## Coefficients:
##           Estimate Std. Error
## beta0    108.270322      NaN
## beta2     -6.538042    8.605201
## beta3    -23.620758    8.663445
## beta4    -27.781775    8.379743
## alpha2   -37.269039    6.087052
## mu         8.270322      NaN
## sigma    55.562630    2.143232
##
## -2 log L: 3653.325
```

```
# Building model with interactions
loglik2 = function(beta0,beta2,beta3,beta4,alpha2,gam22, gam32, gam42, mu,sigma) {
  R = Y - I(X1==2)*beta2 - I(X1==3)*beta3 - I(X1==4)*beta4 - I(X2==2)*alpha2 - beta0 - (I(X1==2)*I
(X2==2))*gam22 -(I(X1==3)*I(X2==2))*gam32 - (I(X1==4)*I(X2==2))*gam42
  R = suppressWarnings(dnorm(R, mu, sigma))
  -sum(log(R))
}
m_inter = mle(loglik2, start=list(beta0 = 100, beta2= 6.5,beta3=-17,beta4=-21,alpha2=-37, gam22=0,
gam32=0, gam42=0, sigma=55,mu=0))
summary(m_inter)
```

```
## Warning in sqrt(diag(object@vcov)): NaNs produced
```

```
## Maximum likelihood estimation
##
## Call:
## mle(minuslogl = loglik2, start = list(beta0 = 100, beta2 = 6.5,
##   beta3 = -17, beta4 = -21, alpha2 = -37, gam22 = 0, gam32 = 0,
##   gam42 = 0, sigma = 55, mu = 0))
##
## Coefficients:
##           Estimate Std. Error
## beta0    108.8703208         NaN
## beta2    -11.8640240     12.68251
## beta3    -23.6109606     12.87948
## beta4    -27.5924620     11.98833
## alpha2   -39.6436529     11.98822
## gam22      9.8407079     17.25916
## gam32      0.4930419     17.40421
## gam42     -0.5771224     16.75573
## mu         8.8703208         NaN
## sigma    55.5259043      0.00000
##
## -2 log L: 3652.858
```

```
# 2a
pred_42 = (coef(m)["beta0"] + coef(m)["beta4"] + coef(m)["alpha2"])
pred_42
```

```
##      beta0
## 43.21951
```

```
# 2b
# Testing for significance of interaction effect
K = rbind(matrix(c(0,0,0,0,0,1,0,0),nrow=1,ncol=8),matrix(c(0,0,0,0,0,0,1,0),nrow=1,ncol=8),matrix(
(c(0,0,0,0,0,0,0,1),nrow=1,ncol=8))
K # K matrix
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
## [1,]    0    0    0    0    0    1    0    0
## [2,]    0    0    0    0    0    0    1    0
## [3,]    0    0    0    0    0    0    0    1
```

```
# Wald Statistic
W = (((coef(m_inter)["sigma"]**2)*(336-8)) - ((coef(m)["sigma"]**2)*(336-5))/3)/(coef(m_inter)
["sigma"]**2)
W
```

```
##      sigma
## -1.145999
```

```
# 2c
diff = (coef(m_inter)["beta0"] + coef(m_inter)["beta4"] + coef(m_inter)["alpha2"] + coef(m_inter)
["gam42"])-coef(m_inter)["beta0"]
X = cbind(1,X1,X2)
V = (t(X)%*%X)
V= inv(V)
NewX = matrix(c(1,2,1))
s_err = (coef(m_inter)["sigma"])*sqrt(2 + t(NewX)%*%V%*%(NewX))
t_value = diff/s_err
t_value
```

```
##           [,1]
## [1,] -0.8620412
```

```
pt(t_value,df=328,lower.tail = FALSE)# Accept Null hypothesis as p_value > 0.05
```

```
##           [,1]
## [1,] 0.8053527
```